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Contents

6.2 Hunter-Gatherers

6.3 Food Producers

1.1 Complex Polities

1.1 Burial Context

7. ROUND TABLE

From East to West: functional analysis and the analogical reasoning. A reflection on scientific practice

Foreword

In 2005 Verona became the centre for an event of particular importance for prehistoric archaeology, and in particular for functional studies. The international Congress "*Prehistoric Technology* : 40 years later. Functional Studies and the Russian Legacy" promoted by the Museo Civico di Storia Naturale in Verona and by the Università degli Studi di Verona, saw the participation of numerous scholars from all over the world, who engaged in a lively scientific debate, the outcome of which is contained in these Proceedings.

The proposal for a re-interpretation of the figure of S.A. Semenov, the pioneer and forerunner of the functional analysis, is a great achievement for the discipline of Prehistoric Studies, the merit of which goes to Laura Longo, scientific co-ordinator of the meeting, besides being, along with Natalia Skakun, the editor of the present publication.

Naturally, the conclusion of a Congress is the publication of the research results presented therein. In this case, the Museo di Storia Naturale in Verona, is proud to have contributed to the spreading and up-dating of functional studies throughout the world of prehistoric research. We wish these Proceedings may enhance the potentials of the discipline and become a useful tool in the hands of those, but not only, who are specialized in the field.

I would finally like to highlight the importance of the conferment, on behalf of Università degli Studi di Verona, of the *Laurea Honoris Causa* to Lewis Binford, pioneer of the "New Archaeology", of whom one of the earlier followers was the friend Amilcare Bietti who, although since very recently no longer with us, gave his humane and scientific contribution by granting his lively and constructive participation to the Congress.

Alessandra Aspes

Preface

A Congress dedicated to a pivotal/great/significantfigure of the 20th century archaeology, like Semenov, is not only a wonderful occasion to have an up-to-date panorama of the present research in this field, but, at the same time, as it is clear in many of the papers presented, an incomparable "window" on the intellectual life of a scholar and on the legacy he left us (in our case a powerful methodological tool, the functional analysis), all matters about which the Congress allowed us to have a clearer idea.

To me, a proto-history expert who frequently works on the history of prehistoric archaeology, Semenov was simply the man who, in the Fifties, with the help of the microscope, made the first researches on the weartraces, whose results were collected in the famous book *Prehistoric Technology* (Guidi 1988, pp.108,133-34).

When I wrote my book on the history of palethnology, I did not reflect about Semenov as a middle-aged person in the 1950s; as a matter of fact, his research in this field of enquiry began long before, at least in the 1930s.
This fact throws an extremely different light on him.

In the darker period of Soviet archaeology, caricaturated by Stalin and Marr as a sad and trite version of the orthodox "stage theory", Semenov belongs to a very selected patrol of great scholars, whose ideas anticipated many acquisitions of modern archaeology.

One of these man was Efimenko, with his fundamental Palaeolithic settlement excavations; other two outstanding figures were Tretjakov, who was the first scholar (1934) to study fingerprints on pottery to infer the residential rules in the prehistoric communities, and Vavilov the pioneer of every modern study on the origin and spread of agriculture (Vavilov 1926, 1935).

Semenov worked in that heavy political and intellectual climate; it is not a case that his research will be fully understood and applied only after the end of the Stalinist regime.
Today the functional analysis is a widely utilized methodological tool, overall between the Palaeolitchic archaeology scholars.

My idea is that this Congress Proceedings can be a wonderful starting point for a wider application of functional analysis in the study of too often neglected or badly interpreted problems of the Bronze and Iron Age archaeology, from the weartraces on swords and on other metal weapons to the use of grinding stones; moreover it can be usefully employed by Classical and Medieval archaeologists.

In the years to come we will need more and more functional analysis to test our explanations and/or to build new research projects.

We organized this first international Congress on this matter in Italy with a culpable delay; it is time for everyone (scholars and cultural institutions) to work hard in order to fill this unjustifiable gap!

Alessandro Guidi

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We wish to warmly thank Hugues Plisson, that apart from generously supplying his advice at all times, took upon him the task of translating from English into French a good part of the summaries.

In occasion of the Congress in April 2005, a CD reprint of the 1964 edition "Prehistoric Technology" translated by Thompson was produced. We are grateful to Dr. Michael W. Thompson for having allowed the reproduction of such a significant publication, now out of print, and we thank the Istituto Italiano di Preistoria e Protostoria for having financially sustained it.

Many thanks also to Dr. Alessandra Aspes, Director of the Museo di Storia Naturale di Verona, who has financially supported this publication as well as actively encouraged its realization.

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The INTAS grant (No. 03-69-441) allowed a very large delegation of Russian scholars (20) to take part to the Congress and the publication of the volume "The roots of use-wear: selected papers of S. A. Semenov" which included a series of articles by S.A. Semenov for the first time a precious translated into English by L. Vishnyatsky and published by the Museo di Storia Naturale in Verona.

A grant from Regione Veneto also contributed to the publication of these Proceedings.

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Without the financial support of all these institutions, and the synergy among colleagues and friends, only some of whom have been mentioned here, this publication would not have been possible.

Thank you again.

Laura Longo and Natalia Skakun

Introduction

5.1. Methodology

S.A. Semenov
and new perspectives on the experimental-traceological method

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Summary. *The paper elucidates the role of S.A. Semenov in the formation and development of experimental-traceological studies in archaeology. The author gives an overview of major Semenov's works and shows how they contributed to our understanding of prehistoric technology, economy and everyday life. Many of Semenov's ideas have received further elaboration in the works of his pupils at the Experimental-Traceological Laboratory of the Institute for the History of Material Culture.*

Résumé. *Cet article explicite le rôle de S.A. Semenov dans la formation et le développement des études expérimentalo-tracéologiques en archéologie. L'auteur donne un aperçu des travaux principaux de Semenov et montre comment ils contribuèrent à notre compréhension de la technologie, de l'économie et de la vie quotidienne préhistoriques. Nombre d'idées de Semenov ont trouvé des développements dans les travaux de ses élèves au laboratoire de tracéologie expérimentale à l'Institut d'Histoire de la Culture matérielle.*

Key words: experimental-traceological method, ancient tools, paleoeconomy.

After the publication of S.A. Semenov's main work "Prehistoric Technology" (1957, 1964), his further scientific activity was directed to the elaboration of the experimental-traceological method in archaeology. He conducted numerous experimental expeditions in Lithuania, Siberia, Central Asia, Crimea, Byelorussia, and other regions, aimed at solving different issues. The latter included the study of flintknapping technology, the manufacture of tools by means of various kinds of secondary treatment, the use of the tools in different operations associated with work on different materials, the manufacture of various means of water transportation, the building of dwellings and megalithic structures, the working of copper, the study of ceramic production, and so on. Particular attention was paid to the identification and documentation of use-wear traces on the experimental tools.

At the same time, Semenov continued to use microanalysis for the study of archaeological materials dating from different periods and coming from Russia, Central Asia, Africa, West Europe and other regions.

The scientific activity of S.A. Semenov proceeded in several directions and can be divided into a number of research blocks. The first block, associated with the experimental study of prehistoric technology, embraced a broad range of studies (Semenov 1961, 1965a). The large scale experiments conducted in the Kaunas, Angara, and Crimean expeditions of 1956-1958 were aimed, firstly, at the study of primary flaking and stone tool production technologies, and, secondly, to prove the contradiction of some traditional and erroneous views regarding these technologies. For instance, the results of these experiments allowed him to refute the idea of the low efficiency of ground stone tools (Semenov 1965a), which had been popular both in archaeological literature and history textbooks. It was shown that contrary to a widely held opinion, the manufacture of such tools took neither years nor months, but only several hours, depending on the hardness of the rock used as raw material.

Semenov tried to show also that the appearance of the microliths and inset tools had been the highest achievement in the development of the Paleolithic technology, which ensured the efficient and economic use of flint blanks. He showed that this had been a way to overcome the natural brittleness of flint and to obtain blanks with a straight profile, which was of great importance for manufacturing composite implements of various functions.

The researcher contributed greatly to the elaboration of the problem of the origins of abrasive technology, and demonstrated the important role it played in the manufacture of ground tools and in the raising of their efficiency and productivity (Semenov 1961). He considered different ways of abrasive working and different tools used for this. In the Upper Paleolithic, Neolithic, and even Bronze Age such tools helped to obtain standardized artefacts. In the Early Metal Period stone abrasives continued to be widely used for working stone, bone, antler, wood, shells, and metal.

Semenov's works demonstrated the universality and great potential of the experimental studies, their importance for solving moot questions of archaeology and for reconstructing various kinds of human activity from stone flaking to pottery making (studied in 1959 and 1978 expeditions in Lithuania, see Semenov and Korobkova 1983, pp.191-234), or manufacturing of antler straighteners for spear shafts.

The enigmatic objects known as *bâtons de commandements* are widely distributed in the Upper Paleolithic sites of Europe and Asia (Semenov 1968, pp.166-176). In Russia they were found at Kostenki 1, Mezin, Afontova gora, Buret, Kokorevo 1 and other sites.

Most of them are made of reindeer antler, less frequently of ivory, some are decorated, some retain carved images of heads of predators on their ends. Each of them has a round or, in single cases, oval hole in the upper part. There were about ten different hypotheses regarding the interpretation of these artefacts. According to one of these hypotheses, these objects must have served as straighteners of arrow and spear shafts. The majority of the objects under discussion are represented by fragments. By means of a series of experiments conducted with antler and wooden replicas of "*bâtons de commandements*" it was proved that they had served to straighten arrow and spear shafts. These experiments demonstrated also that the technology of bending of wooden artefacts existed as early as the Paleolithic period (Semenov and Korobkova 1983, pp.38-44).

The experimental works placed by Semenov on a broad footing led to the revision of many traditional views of the economy and culture of the past, especially as relates to the productiveness of labour and efficiency of ancient tools. A series of experiments carried out in sixteen special expeditions showed the importance of the experimental method for the study of functions and efficiency of tools and technological operations, and greatly contributed to our understanding of the ancient economic and productive activity. The experiment became for archaeologists an important source of new information, a means of identification and verification of tool functions and reconstruction of production processes, a basis for the development of the methodology of micro- and macro-analysis, etc.

The second group of Semenov's works is connected with the application of traceology to the study of archaeological materials. Special attention is given to the characteristic of use-wear traces on ancient tools (from the Palaeolithic to the Early Metal Period). A number of papers (Semenov 1961b, 1969, 1970, 1978) is devoted to the analysis of traces of work on retouchers, compressors, whittling knives, axes, adzes, sickles and other tools. In addition to the study of use-wear traces, the author gives numerous archaeological examples showing the differentiation of tools with the same function. Of high value are his observations regarding the difference between use-wear traces on compressors and retouchers (Semenov 1953, p.446), and the variability of retouchers. The works contain drawings, microphotographs, and detailed explanations of the formation and localization of the traces. How bright and convincing is the paper devoted to the right-handedness of Neanderthals based on archaeological evidence (bone and antler retouchers from Stalingradskaya) and experimental data (Semenov 1961b)! One cannot help mentioning also a brilliant brief paper on the functional purpose of the lens-shaped slate retouchers with traces of grinding from Kostenki IV (Semenov 1953, pp.451-454).

Thanks to the multi-sided, thorough, and well substantiated Semenov's works, archaeologists obtained a key to the understanding of functions of many different tools. Let us mention, for example, the Mousterian obsidian knives, retouchers and whittling knives from the Vorontsovskaya cave in the Caucasus (Semenov 1972). Most tools from Vorontsovskaya cave proved to be whittling knives made of small flakes and used to work wood, bone, and soft stone. The author revealed a number of diagnostic traces of work in the form of dents, polish, and striations. He described also the use-wear traces characteristic of a particular group of retouchers made of small flakes and designed for retouching small flint artefacts. In the same paper he analyses a group of point fragments with intensive polish and dense linear traces going in different directions. The latter are mainly confined to the protruding parts of the artefacts. Semenov succeeded in deciphering these traces and proved convincingly, that they had formed as a result of trampling.
Of equal interest are his observations and conclusions concerning the Stone Age tools for chopping from Vietnam (Semenov 1966). In Semenov's opinion these tools, represented by oval unifacially worked pebbles, served to extract molluscs from their shells and to split tubular bones in order to obtain marrow. In the same paper he considered also (from both traceological and technological point of view) grooved pebbles, shouldered axes and adzes of the Neolithic period, bamboo sleeve joints and some other bamboo tools.

Let us remember also a short paper devoted to the microanalysis of some tools from the Early Metal Period site of Khor-Daud in Egypt (Semenov 1964b). The tools were identified as end-scrapers for hides, sickle inserts, and a specific double-edged flint saw for working stone. The analysis was accompanied by the explanation of how the tools had been manufactured and hafted.

Of course, Semenov's research was not restricted to flint artefacts only. For example, one of his works is devoted to the study of obsidian tools from the burials in the crater of Ngorongoro Volcano in Tanzania, dated to 310 BC (Semenov 1972), and another to ceramic sickles from the 3rd millennium BC settlement of Eridu in Iraq (Semenov 1965). In both instances the functions of the studied tools are convincingly demonstrated. As for ceramic sickles, Semenov was the first who gave a functional and technological description of these tools. He identified the diagnostic traces of use and confirmed his conclusions with experimental data. This research was based on different kinds of evidence, including the results of the petrographic, X-ray-structural, and quantitative spectral analyses of the ceramic material. Such a complex approach allowed the researcher to describe in detail the character of the raw material, to establish the firing temperature, to reconstruct the manufacturing technology, and to assess the efficiency of the ceramic sickles, which proved to be much lower than the flint ones.

The stone sickles from the Bronze Age site of Dalverzin in Ferghana are similar in their shape, functions and productivity to the ceramic sickles from Eridu. They are made of volcanic rock and sandstone by means of abrasive working. The semi-lunar shape of these tools alone suggests their reaping functions, and the traceological analysis of their surfaces confirmed this hypothesis. Their use-wear traces are indicative of plant cutting (including cereals). The efficiency of these tools is just a little higher than that of the ceramic sickles (Semenov and Shirinov 1978).

When working with archaeological materials Semenov did not limit himself to just one task, like, for example, the identification of tool function(s). He tried to reproduce the manufacturing technology and to reconstruct, after traces of work, the whole process of production. Such a research was done with the artefacts from the Pazyryk barrows in Altai. In this work the reconstruction of the wood-working industry of the ancient Altaians was done despite the total absence of tools themselves, just after the traces left on the surfaces of wooden frameworks, tables, logs, coffins, benches, kitchen utensils, and art objects which had preserved rather well in permafrost conditions (Semenov 1956). The author gave a very bright and convincing picture of the wood-working technology practiced by the ancient Altaians. He retraced the succession of operations associated with working wood (chopping, splitting, hewing, hollowing, drilling, grinding, and decorative carving), and reconstructed the tools which had been used in every given operation. The latter included Celts, wedges to split logs, multifunctional adzes (which served as saws, planes, and knives) chisels, tools for drilling. Each operation was analysed in detail, including the most delicate technical nuances. Thus in this work Semenov demonstrated the efficiency of the traceological method, which opens the possibility to reconstruct ancient technologies after the traces left by tools and despite the absence of tools themselves. In this respect the capability of the traceological method is wider than that of "use-wear analysis".

A distinct group of works is devoted to the study of tools of the Early Metal Period. Semenov was the first to identify the functions of stone tools from Eneolithic and Bronze Age sites. Before then, traceology had mainly been preoccupied with the study of Stone Age tools represented by flint, quartzite, obsidian and other artefacts. Though at some Eneolithic and Early Bronze Age sites in Ukraine, Moldova and other regions flint still continues to remain the most widely used kind of raw material, the appearance of new branches of production had led to the broadening of the range of rocks involved into human economic activity. Functions of many stone tools from the Early Metal Period remained unclear and were defined differently. As a result of such confusion, production processes associated with these tools were interpreted incorrectly. This was the situation that made Semenov to apply his functional-traceological method to the study of the Early Metal Period stone tools. The results turned out to be startling. He studied the materials of the Valentine-Peresheek settlement in the Far East, the flint mines of Uchtut in Uzbekistan, the Dalverzin settlement and some other Bronze Age sites of Central Asia and Kazakhstan (Semenov 1969). Among the tools analysed in this work are hoes used to extract ore minerals, as well as hammers, mortars, pestles, anvils, etc. He divided the studied tools into a number of functional groups according to the use-wear traces and worked materials. For example, he distinguished hoes for land cultivation and for ore extraction, hacks, picks, hammers of different size and weight. The description of each group included the characteristic of manufacturing technology, methods of use, and wear traces.

Of equal interest is his analysis of wear traces on mortars and pestles for grain and ore, which is very important for the study of the Bronze Age economics. Thanks to this research archaeologists obtained new means which enabled them to identify such tools and avoid wrong conclusions about their functions. The same can be said about the identification of sledge-hammers. Before Semenov's work these had not been studied by traceologists, and therefore the question of the existence of cold working of metals had remained open.

In addition, he applied his methodology to the study of small jewellery artefacts of gold from the Bronze Age barrow of Chilikty in Kazakhstan (Semenov 1965c). The scrupulous microanalysis of their surfaces allowed him to reconstruct both the technology of their manufacture and the composition of implements that had been involved in this process. Among the reconstructed processes described are gold working into thin foils with figures in relief, granules, minute rings, wire, as well as soldering of precious metals, precious and semi-precious stone processing and setting on to gold ornaments. It should be stressed that in comparison to the other methods used in the study of metals (chemical, spectral, metallographic analyses, etc.), the traceological one supplies information about the character of tools employed in metal-working. Only traceology on the basis of work traces is able to reconstruct the composition of implements used in metallurgy and metal-working. Paradoxically, these implements are mostly represented by stone artefacts. The latter are more often found on ancient settlements, since metal implements, which were of high value, were rarely discarded, and the broken ones were subject to be re-cycled. This is why stone tools are the main source of information about ancient metallurgy and metal-working. Such a situation is typical not only for the Early Metal Period, but for later epochs too, as it is shown by our traceological studies of the Early Iron Age and Medieval materials (Korobkova 2003a, 2003b).

In all his works Semenov paid particular attention to the recognition of regularities in the creative activity of prehistoric people. He studied the development of working processes, the change between different dynamic loads and kinematics, and was able to retrace changes in the development of labour skills. An important place in his works was held by the study of the development of tools, techniques and technologies, which ensured exploitation of new territory which used to be inaccessible due to the low efficiency of tools. He considered questions connected with the transitions to new forms of economy, including the beginnings of economic differentiation and specialization (Semenov and Korobkova 1983).

Semenov's work remains an indispensable source of reference for those of us who are engaged in traceological research, experimental studies, further development of the methodology of macro- and microanalysis, the study of the economic and productive activity of ancient societies. Semenov's ideas have been taken up by his pupils and followers. The Experimental-Traceological Laboratory at the Institute for the History of Material Culture of the Russian Academy of Sciences has made fresh advances in the development of the experimental-traceological method and in its application, as well as the elaboration of new directions of research on the basis of micro- and macroanalysis, such as the intensification of technological studies, the formation of the functional-planigraphic analysis, the beginning of new wide-scale experimental works. In the course of the experimental expeditions headed by G.F. Korobkova we have succeeded in obtaining new data on the ways and techniques of hide- and skin-working, the development of different types of scrapers and their efficiency, the formation of traces of wear on the scrapers used to work dry and raw hides, the time necessary to work hides, etc. It has been shown how pebble scrapers and microlithic scrapers were used, and how the efficiency of scraping tools changed from the Mousterian to the Early Metal Period (Semenov and Korobkova, 1983, pp.135-190). Numerous experiments were devoted to the study of wear traces on sickles of different types, made of different materials (flint, obsidian, jasper, quartzite, quartz, sandstone, dolomite, rock crystal, chalcedony, jaws of cattle, etc.), and used to work different plants (domesticated and wild cereals, grass, cane, young shrubs, reed mace, stinging-nettle, and so on). As a result of this work a collection of standard traces of wear characteristic of different types of sickles was obtained (Korobkova 1978, 1993, 1994). Other series of experiments enabled us to establish the efficiency and productivity of earth-digging tools made of different materials (elk antler, reindeer antler, flint, volcanic rocks, wood) and applied to different soil types, to study how they could have been fastened to handles, and to reveal wear traces associated with different ways of hafting (Korobkova 1975).

N.N. Skakun studied traces of wear on experimental and archaeological inserts for threshing-sledges (Skakun 2001, 2003), which gave new information for the study of ancient agricultural implements.

V.E. Shchelinsky carried out a large experimental project devoted to the study of primary and secondary stone flaking and wood-working of the Mousterian epoch (Shchelinsky 1974, 1983). A similar research was done by A.E. Matyukhin on the Lower Paleolithic material (Matyukhin 1983). A.K. Filippov's works were aimed at the experimental-traceological study of ancient tools made of bone, antler, and ivory (Filippov 1983).

The wide-scale experimental works carried out in Moldavia were devoted to the study of the economic system of the Tripolye culture Early Metal Period . Experiments conducted under the motto "a Tripolian's day" embraced all types of economic activity from the manufacture of replicas of Tripolian tools to their use in specific tasks. The latter included working of different soil types, harvesting of large areas, cutting meat, cutting and cleaning fish, working skins and dressing leather, cutting and sewing clothes from leather and fur (after the depictions on the Tripolian vessels), building subterranean and semi-subterranean dwellings and a moat, and so forth. These experiments allowed us to obtain new data on the efficiency of the tools found at Tripolian settlements, the ways they could have been used, the time people had spent to construct different structures, etc. (Korobkova 1980). This information is of principal importance for paleoeconomic reconstructions.

A vast collection of replica tools made of different raw materials and used in different experiments has been accumulated in several years of experimental expeditions headed by G.F. Korobkova. At present such collection includes over 6000 items. This is a solid corpus of data, constituting the basis for further developments of micro- and macroanalysis (Korobkova and Shchelinsky 1996), identification of tool function, and reconstruction of past economic systems. In addition, this collection is used to train young traceologists, including participants of the International Traceological Schools.

All that has been said so far shows the exceptional role experimentation plays in archaeological and traceological research. It is a source of diverse information which is necessary to solve both local and global problems, from the identification of functions of individual tools to the reconstruction of prehistoric economic systems.

The study of mass archaeological materials made it possible to work out the functional typology of the Lower-Middle Paleolithic and Upper Paleolithic and Bronze Age tools (Korobkova 1987, 2002; Shchelinsky 1994; Korobkova and Shchelinsky 1996). This has enabled us to conduct cross-cultural and cross-regional comparative studies of ancient economic systems, to reveal both their specific and common features. Such a work has been carried out by G.F. Korobkova (on Ukrainian, Caucasian, and central Asian material), V.E. Shchelinsky (material from the Russian Plain, Crimea, and northern Caucasus), N.N. Skakun (Neolithic-Bronze Age material from Bulgaria, Ukraine, Moldova).

A noticeable place in the works of the Experimental-Traceological Laboratory is taken by the technological analysis of stone industries, elaborated by E.Yu. Girya (1997). This, alongside typology and traceology, has constituted the triad of methods designed to study lithic assemblages. It can be asserted with full confidence, that all these wide-scale traceological and experimental works would be impossible without the rich and powerful legacy S.A. Semenov left us with.

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Comprehensive analysis of prehistoric tools and its relevance for paleo-economic reconstructions

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Summary. *Social-economic reconstructions represent one of the most popular subjects in Russian archaeology. The traceological method created by S.A. Semenov in the middle of the 20th century gave new possibilities for the identification of tool functions and manufacturing technologies, and opened new ways for modeling many ancient production processes. The study of whole assemblages, including not only tools but also* debitage *production, in association with other archaeological data, is the basis for paleoeconomic reconstructions. The application of such a complex analysis to the inventory of the Chalcolithic culture of Varna in Bulgaria allowed to identify some new tools that had not been recognised before, and demonstrated the existence of different branches of crafts. The comprehension of these progressive economic phenomena contributed to the general development of the culture.*

Résumé. *Les reconstitutions sociaux-économiques représentent l'un des sujets les plus populaires de l'archéologie russe. La méthode traceologique créée par S.A. Semenov au milieu du 20ème siècle a donné de nouvelles possibilités pour l'identification du fonctionnement des outil et des technologies de fabrication et a ouvert de nouvelles façons de modéliser nombre de procédés de production antiques. L'étude d'importants corpus de matériel, incluant non seulement les outils typologiques mais également les déchets de fabrication, en association avec le traitement d'autres données archéologiques, sont la base des reconstructions paléo-économiques. L'application de ce type d'approche aux assemblages de la culture de chalcolithique de Varna en Bulgarie a permis l'identification de nouveaux outils, jusque là inconnus, et a démontré l'existence de différentes branches d'artisanat. Ces phénomènes économiques innovateurs contribuèrent au développement général de cette culture.*

Key words: experiments, traceology, methodology, tool functions, manufacturing technology, paleoeconomic reconstructions.

Ancient tools and implements are of prime importance for the study of prehistory. Their examination for a long time had been essentially restricted to technical and typological classifications followed by statistical analysis combined with the study of the archaeological context. Within this framework only obscure assumptions regarding tool function could be put forward, which constrained culture-historical reconstructions.

During the first half of the 20th century many archaeologists in Russia and abroad strove to discover the real function of prehistoric tools made of different raw materials. There was some information relevant to the technology of tool manufacture and rejuvenation as well as the identification of visible use-wear traces on artefacts, in the papers of Russian scholars. The same authors put forward tentative reconstructions of the implements use based on the study of traces on the surface of the materials treated, assumptions concerning the technology of the manufacture of ceramics, anthropomorphic statuettes, etc. (Bonch-Osmolovsky 1931, 1940; Gerasimov 1941; Voevodsky 1952; Efimenko and Boriskovsky 1953; Boriskovsky 1953; Gryaznov 1947). At the same time the apparent lack of adequate methodology for identification, description and analysis of use-wear and deformations patterns on prehistoric tools hindered this research.

Only the experimental-traceological method for identification of the tool functions put forward by Sergey A. Semenov (Fig. 1a) provided a highly useful insight into the history of technology and different aspects of paleoeconomy. Even his first papers (1940, 1941, 1949, 1950) demonstrated the fundamentals of his method, which later proved its relevance to the study of different tools of all periods and areas (Semenov 1957).

One of the main achievements of Semenov was the idea of comprehensive analysis of prehistoric tools, which should include the study of physical properties of the raw materials used (stone, antler, bone, shells, metals, etc.) and manufacturing techniques. Identification of different use-wear patterns includes the careful analysis of scratches, networks of short striations, polish, edge damage, abrasion and edge-rounding traces on tool backs, handles, etc. A special attention has been paid to the study of interrelationships between form and function, reconstruction of implements, devices and processing activities, and, finally, verification of the function estimates by experimental replicating and ethnographic evidence.

Such case-studies, which embrace large collections of both typologically defined tools and accompanying debitage production instead of particular unique or sampled artefacts, are of particular importance. The combination of the data from use-wear with contextual and planimetric information allows to reconstruct the whole technological processes, to trace the history of technology and to advance large-scale social and economic reconstructions (Semenov 1940, 1941, 1957, 1964, 1968, 1974a, 1974b, 1978; Semenov and Korobkova 1983). This approach has been developed mainly by the Russian school of use-wear studies. (Korobkova 1969, 1987, 2001; Matiukhin 1983; Filippov 1983; Schelinsky 1983, 1994, 2001; Schtchelinski and Giouruva 1994; Esakiya 1984; Arazova 1986; Sapozhnikova 1986; Skakun 1987, 1999, 2001, 2006;

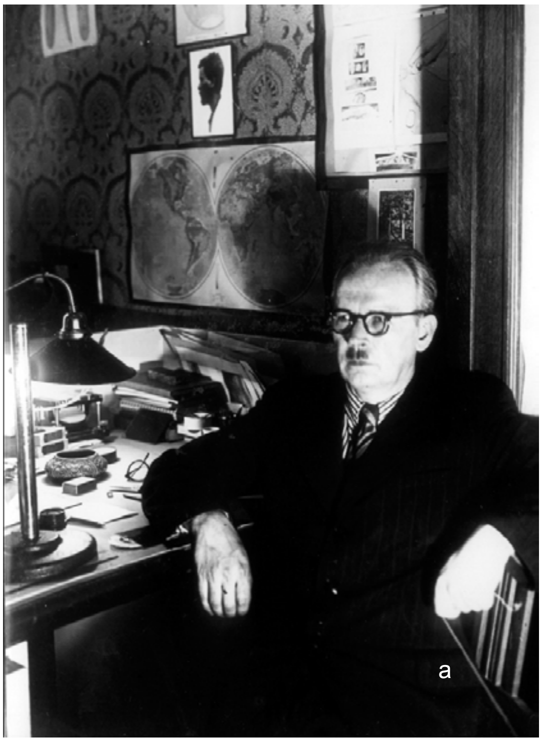

Fig. 1: a) Sergey Semenov; b) The staff, visiting scholars and Ph.D. students of the Laboratory of the Experimental and Use-Wear Studies. Leningrad, 1986.

Lollekova 1988; Kynchev 1990; Kazaryan 1993; Sharovskaya 1994; Chaikina 1994; Girya 1997; Gurova *et al.* 2002; Gurova 2002; Aleksashenko 2003; Poplevko 2003; etc.).

The appearance of the English version of Semenov's 'Prehistoric Technology' (Semenov 1964) obviously stimulated the development of this research in the West. Leaving aside those complicated issue as a comparison between approaches to the use-wear studies in Russia and the West, a few remarks should be mentioned. Our Western colleagues, greatly influenced by the ideas of Keeley (1980), achieved a certain progress in a sophisticated methodology for description of the wear patterns. At the same time they are less inclined to use research results as a basis for interpretations. Whereas we could list several intriguing case-studies combining the detailed description of the wear with reconstruction attempts (Anderson 1994, 2000; Anderson (ed.) 1999; Anderson *et al.* 1993; Astruc 2002; Beyries (ed.) 1988; Beyries and Plisson 1998; Clemente *et al.* 2001; Hurcombe 1992; Gassin 1996; van Gijn 1990; Knutson 1988; Moss 1988; Jensen 1993; Longo *et al.* 1997; Plisson and Mauger 1988; Plisson 1999; etc.). Nowadays one can see the gradual convergence of these two lines of research stimulated by the increase in contacts and information exchange. The role of Hugues Plisson (1988) in this process is hard to overestimate (Fig. 1b). Several important international meetings of the last years evidenced that the majority of specialists in the use-wear studies consider the identification of tools function not as an end in itself but rather as a source for culture-historical reconstructions (Korobkova1999; Skakun and Plisson (eds.) 2003; Golovnev (ed.) 2000; Clemente *et al.* 2001).

The results of our study of a large series of artefacts from the Chalcolithic of Bulgaria could be the best illustration of the potential of these studies. The artefacts under examination belong to the Varna culture (late 5th millennium BC) identified in the Pontic area of the country and widely known due to the famous discoveries of copper and gold artefacts (Fig. 2a) (Todorova 1986). More than 12,000 lithic, antler, bone and clay pieces were examined. We tried to conduct a really comprehensive analysis (Skakun 1980, 1982, 1985, 1987, 1999, 2001, 2006). It should be stressed that before our studies these artefacts (tools made of flint, other stones, as well as tools made of clay, antler, bone, etc.) attracted little attention of scholars. The reason of this ignorance was connected to the diversity and richness of other artefacts from the Late Stone Age of south-eastern Europe, including copper implements. The lithics were considered as a simple Neolithic survival. Meanwhile the typological, technological and functional studies of the lithic tools demonstrated the importance of these artefacts for the early farming societies of the Balkans.

The results of the study of flint artefacts are the definitely convincing. The bulk of the tools from the sites of different parts of Bulgaria were produced from the large pebbles of the high quality chalk flint (Fig. 2b). Its sources are located in the north-eastern corner of the country, in Dobrudga. The time span under consideration saw intensive exploitation of this variety of flint while

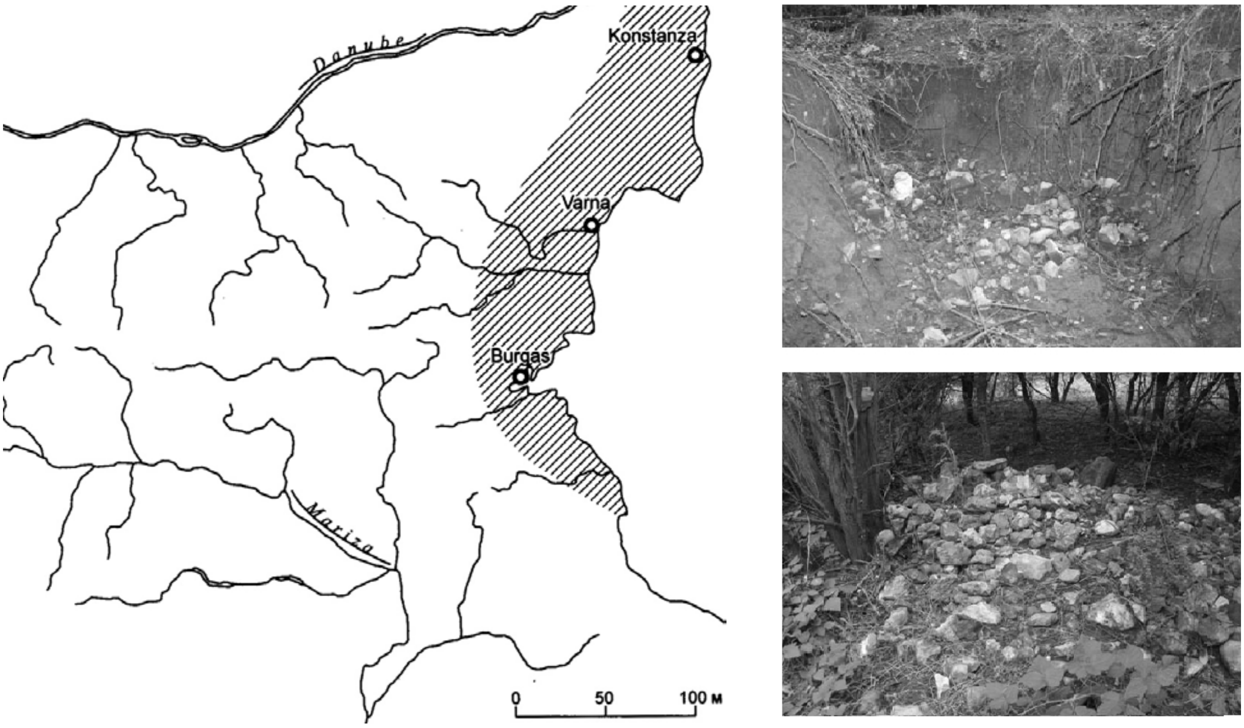

Fig. 2: a) The distribution of the Varna culture (after Todorova H., 1986); b) Chalk flint from Dobrudga.

local small-sized pebbles were the main toolmaking material during the Neolithic. The majority of the flint tools of the Varna culture are made on large long blades with regular outline and rectilinear profile (Fig. 3:27). Technological and typological studies combined with experiments demonstrated that this highly efficient kind of blank could be obtained only using indirect pressure technology (Pelegrin 2002), probably with an aid of a lever with a copper tip. The regular outline of the long blades led to the appearance of tools of standard shape and size. The typological layout includes drills (Fig. 3:1 to 10), borers (Fig. 3:11 to 14), end-scrapers at blades (Fig. 3:19 to 22), different inserts (Fig. 3:15 to 18 and 23 to 26), etc. All these tools constituted large series with only few transitional or deviated pieces (Fig. 3:1 to 26). Blanks and tools have nothing in common with the flint artefacts from the local flint production thus indicating the lack of ties between two cultures.

Two types of specialised flintknapping workshops could be discerned in the Chalcolithic of north-eastern Bulgaria as evidenced by the excavations and contextual data (Skakun 1984, 1985). Some workshops, located near the raw material sources, demonstrated the dominance of the flintknapping activities. The sites produced rich concentrations of core preforms, cores, cortical flakes, lithic debris and waste along with flint hammerstones. The others, associated with settlements located nearby, were the centres for tool production along with flintknapping. Apart from the cores, these workshops yielded antler and flint retouchers together with a series of blanks and prepared tools lacking in wear traces. Such flintworking organisation indicates the sophistication of this activity developing toward a true craft alongside with pottery manufacture and metallurgy. The products of these centres were traded in many areas along Danube and in the Balkans, including the settlements of the Varna culture. Sophisticated level of flintworking technology, serial production of standardised blanks and tools indicate the appearance of professional flintknappers (Skakun 1985, 1999).

Use-wear analysis revealed a rich and differentiated tool kit. In the majority of cases different portions of blades served as preforms for different tool classes. Even tough blank proximal portions were mostly used as preforms for end-scrapers, where high resistance to pressure during the work is needed. On the contrary, the axial parts of blades have been selected for mounted drills while medial rectilinear fragments of blades were intensively used for different inserts (such as inserts for sickles, threshing boards, planes for wood and skin working, Figure 3).

The data outlined above indicated that the long blade production appeared in the Chalcolithic-Early Bronze Age in different regions of the Old World (in Western and Eastern Europe, Anatolia, Near East, and northern India) was not restricted to the manufacture of prestigious grave goods (as it was once believed). Whereas, the burials of this period produced long blades which served as sacred items (the unique 44 cm long blade from the Varna cemetery is the best example), and remain rare pieces while the tools made of fragments of blades obtained through the same technology (but with smaller

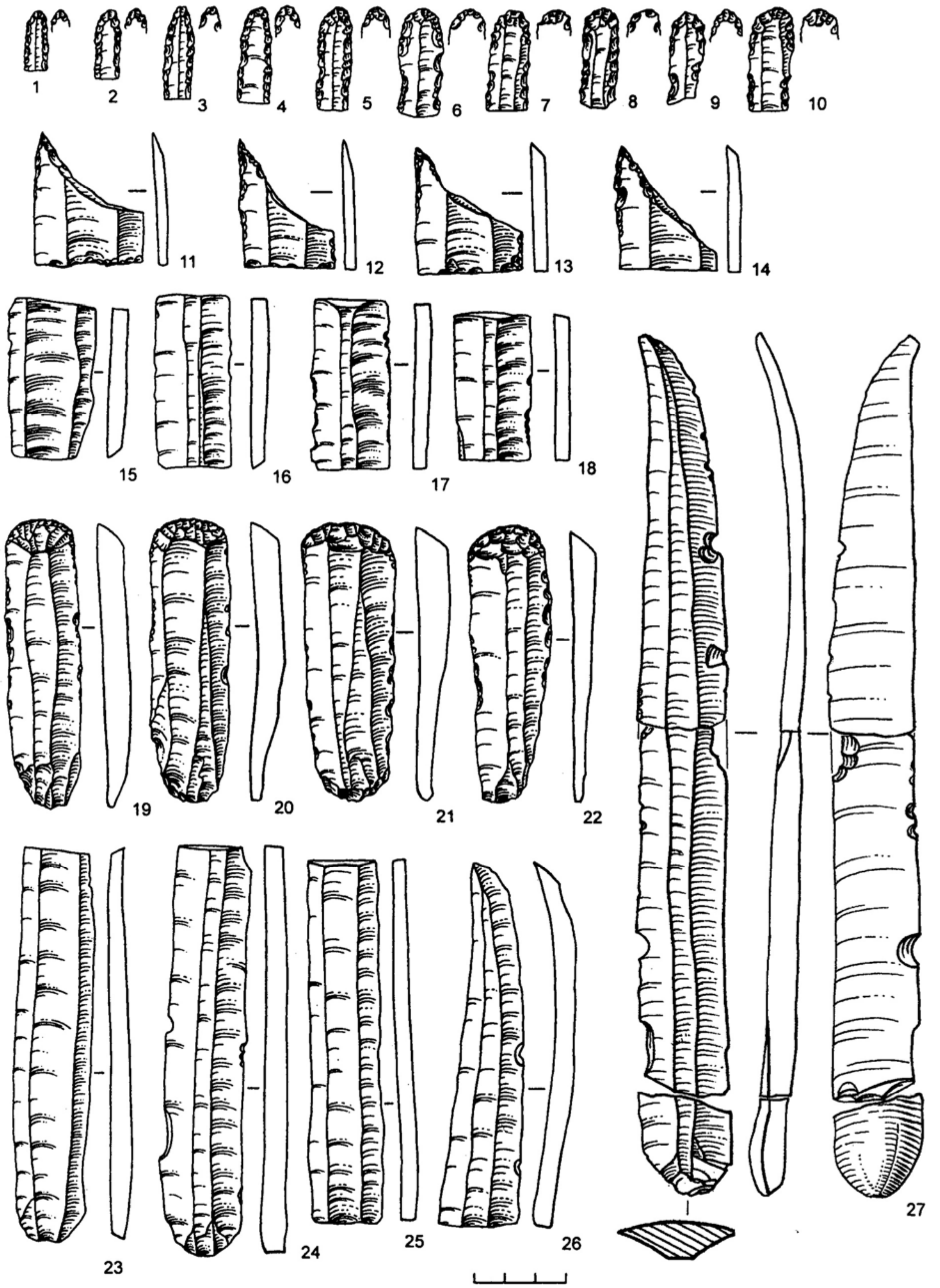

Fig. 3: Flint artefacts from the Chalcolithic settlements of the Varna Culture. 1 to 10: drills; 11 to 14: borers; 15 to 18, and 23 to 26: blade fragments; 19 to 22: endscrapers; 27: blade.

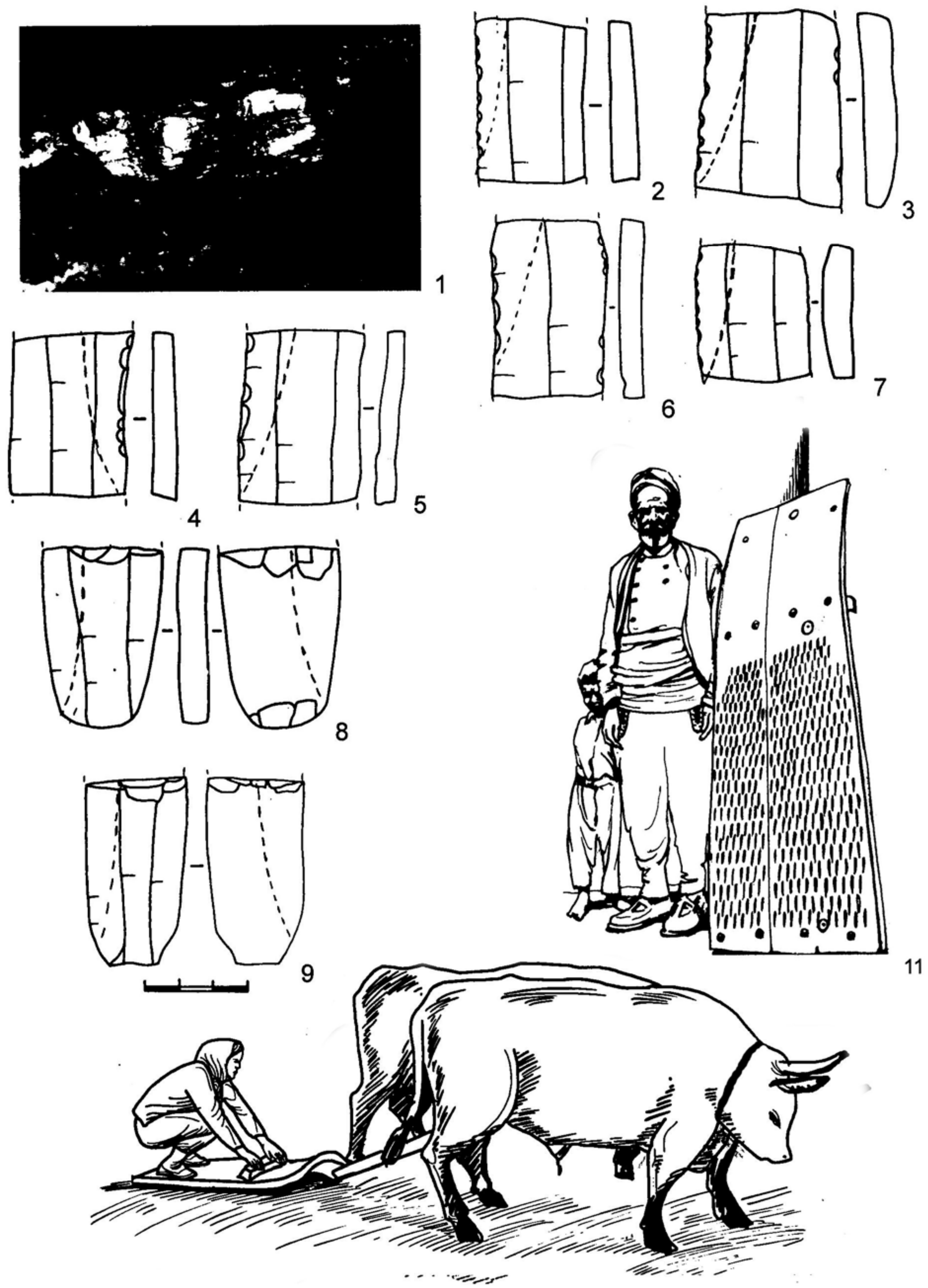

Fig. 4a: 1) working edge of the insert of the threshing sledge (100x); 2-9) inserts of the threshing sledge; 10) experimental threshing with the threshing sledge; 11) the threshing sledge of the and-19th century (Bulgaria).

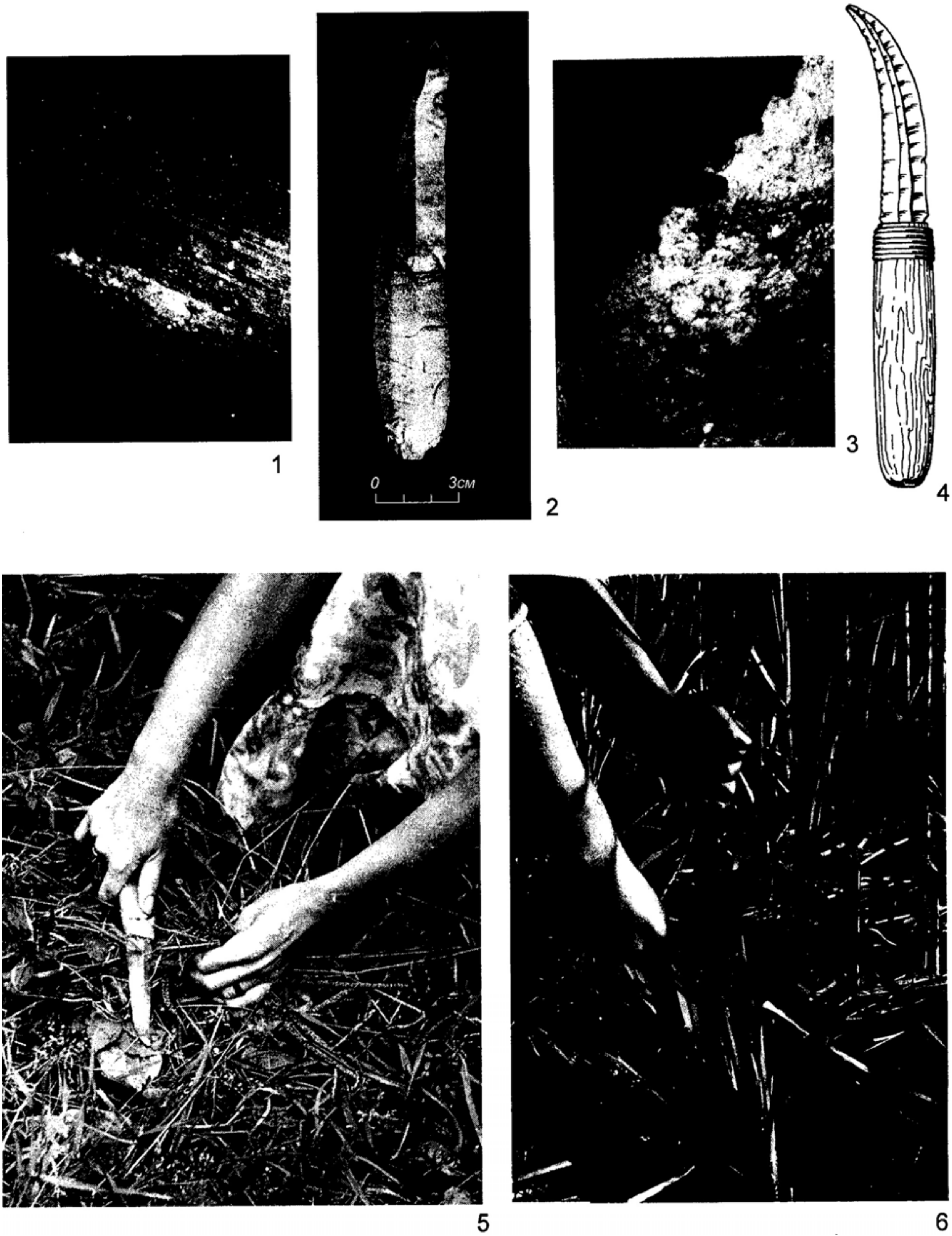

Fig. 4b: 1) working edge of a knife for grass cutting (100x); 2) reconstruction of the knife for grass cutting; 3) working edge of a knife for reed cutting (100x); 4) reconstruction of the knife for reed cutting; 5-6) experimental grass and reed cutting.

size) are among the most frequent discoveries at settlements.

Analysis of the tools evidences not only significant changes in flintworking but important advances in other areas of Chalcolithic economy. Due to the appearance of a new flint preform more efficient tools have been introduced while the function of some of these was identified by use-wear analysis. The majority of flint artefacts of the Varna culture show clearly visible use-wear. Among the tools different retouchers, sickle inserts, meat knives, skin scrapers, borers, scraper-planes, burins, saws, planing knives, drills for wood and bone, etc. have been identified. Only ca. 10% of the lithics lack in wear-traces caused by surface alterations, weakness of traces, etc. Full report of our study can be found elsewhere (Skakun 2006), in this paper I dwell on those tool varieties which attracted little attention in previous works and/or which were not identified in Bulgaria.

The unexpected discovery of flint inserts of threshing sledges is of particular interest for the re-consideration of Chalcolithic farming economy (Skakun 1981, 2001). Medial portions of large blades served as blanks for inserts (Fig. 4a: 2-9). The corners of inserts demonstrate heavy polish and striations (Fig. 4a:1) different from wear visible at sickle inserts (Skakun 1985, 1992). This fact has been revealed by the use-wear analysis and later corroborated by experiments and ethnographic evidence (Fig. 4a:10,11). A comparison of archaeological and ethnographic inserts with experimental replicas demonstrated the identical wear pattern. It is worth to mention that the use of a threshing sledge with flint inserts persisted in many regions of the Mediterranean and Balkans until very recently.

The microscopic examination of the collections from Bulgaria revealed, apart from the threshing sledges, antler ploughing tools. These new implements evidenced great technological advance in efficiency of farming, though leading to an increase of food-producing activity.

Among other tools, a series of knives for reed (Fig. 4b:3, 4 and 6) and grass cutting (Fig. 4b:1, 2 and 5) should be mentioned. These were made of long blade fragments and could be used both with and without straight handles. The wear on the knives is represented by fine striations located along the working edge or slightly inclined. Moreover, they demonstrate bifacial polish localised as a narrow strip along the edge (the knives for grass processing) or as wide glossy strip (the knives for reed processing).

Among the implements, the inserts of the two-handled scraper-planes for hide and skin processing devices have been identified among the medial fragments of large blades (Fig. 5a). Some of these pieces served as tools for final hide and skin processing after scraping (Fig. 5a:3, 4, 6, 7) while others were used in woodworking as scraper-planes and planing knives (Fig. 5b:3, 4). The reconstruction of planes for wood and skin processing are based on use-wear evidence, including the analysis of development degree and location of traces (Figs. 5a:1-7 and 5b:1-4).

Experimental specimens were manufactured by flint tools and intensively used. High efficiency and perfect treatment of materials have been demonstrated during the large set of experiments for hides processing, planing and scraping of wood (Figs. 5a:3, 6 and 5b:6, 7). The iron implements of similar shape were not only widely known from ethnographic sources but extensively used by local peasants until nowadays (Figs. 5a:5, 8 and 5b:5, 8). A hide processing device similar to those used by the Varna culture is known from ancient Egypt (Fig. 6a:9).

Apart from the planes, the woodworking drills should be mentioned among newly recognised Chalcolithic tools. Use-wear traces on the drills indicate their use as parts of mounted devices where clay discs (previously enigmatic artefacts) could be used as hand-wheels (Fig. 6).

Further experiments demonstrated important technological advances which took place during Chalcolithic period and resulted in the increase of labour efficiency (Fig. 7).

Distribution studies of the Varna culture settlements revealed that, apart from the lithics widely scattered in the culture-bearing strata or concentrated at the domestic areas, there are specialised concentrations of flint tools. For instance, the village of Durangulak yielded a great quantity of threshing sledge inserts concentrated between the houses. Conceivably we are dealing with the traces of a threshing sledge used by several households as it was practiced in the Bulgarian settlements still in the very recent past. The settlement of Golyamo-Delchive produced numerous hide processing tools in the sector without habitations, thus the existence of hide processing workshop could be deduced.

Comprehensive study of flint artefacts of Varna culture allows to identify the use of different agricultural implements, the tools used in processing the products of hunting and herding, stone, bone, and woodworking, ceramic manufacture. Some previously most recognised types of implements have been described.

The examination of the flint inventories from the Chalcolithic sites of Bulgaria revealed that the end of the Stone Age culture development witnessed a new flourishing of lithic processing instead of a decline. This time span saw the widespread use of the Dobrudga chalk flint and the lithic technology achieved unprecedented sophistication. Regular-sized long blades became main preforms, so flint tools could not be considered as a simple survival of earlier periods but rather as an important advance, which seems to exhaust the technical potential of lithic processing. Careful analysis of lithic technology and morphology revealed the great difference

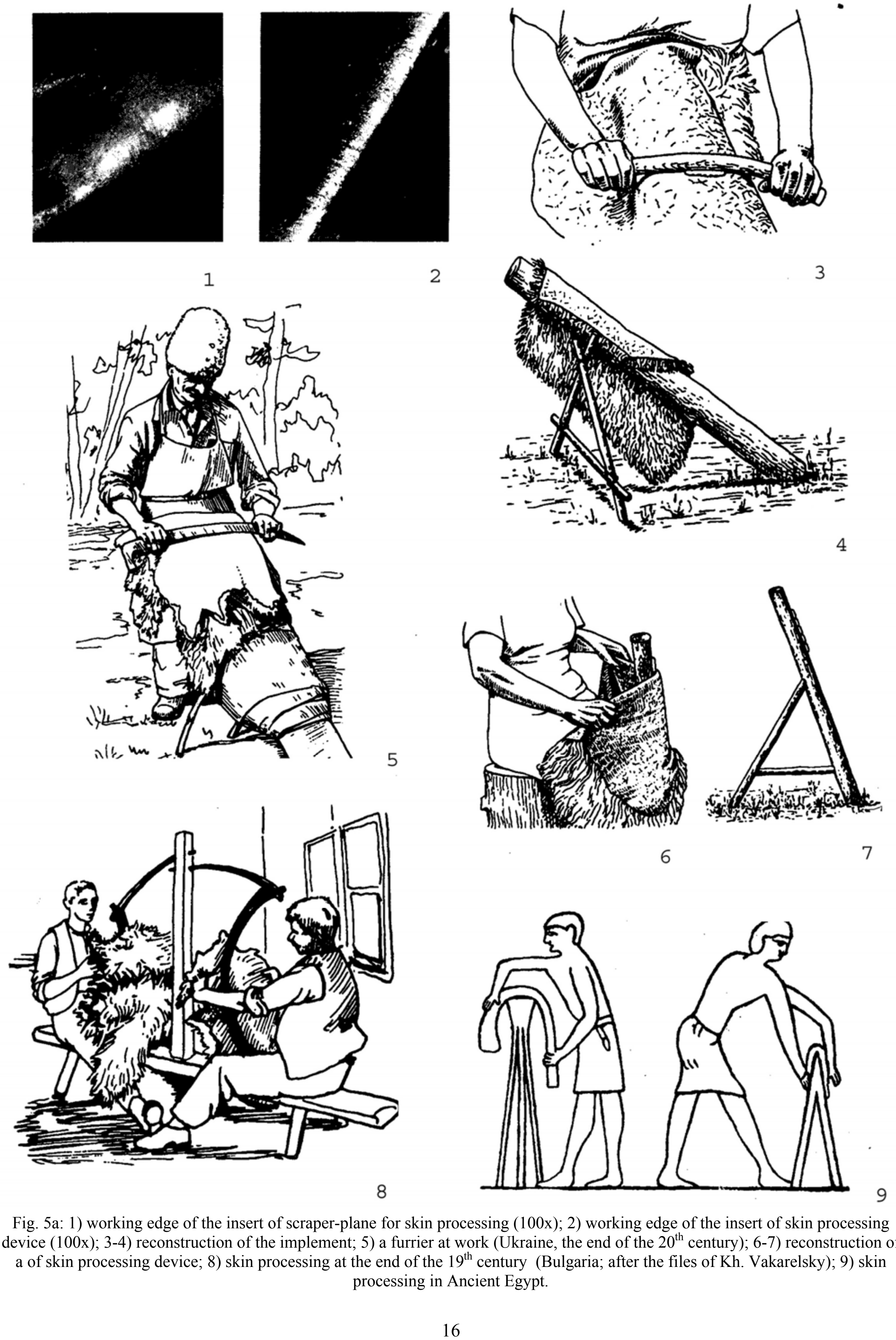

Fig. 5a: 1) working edge of the insert of scraper-plane for skin processing (100x); 2) working edge of the insert of skin processing device (100x); 3-4) reconstruction of the implement; 5) a furrier at work (Ukraine, the end of the 20th century); 6-7) reconstruction of a of skin processing device; 8) skin processing at the end of the 19th century (Bulgaria; after the files of Kh. Vakarelsky); 9) skin processing in Ancient Egypt.

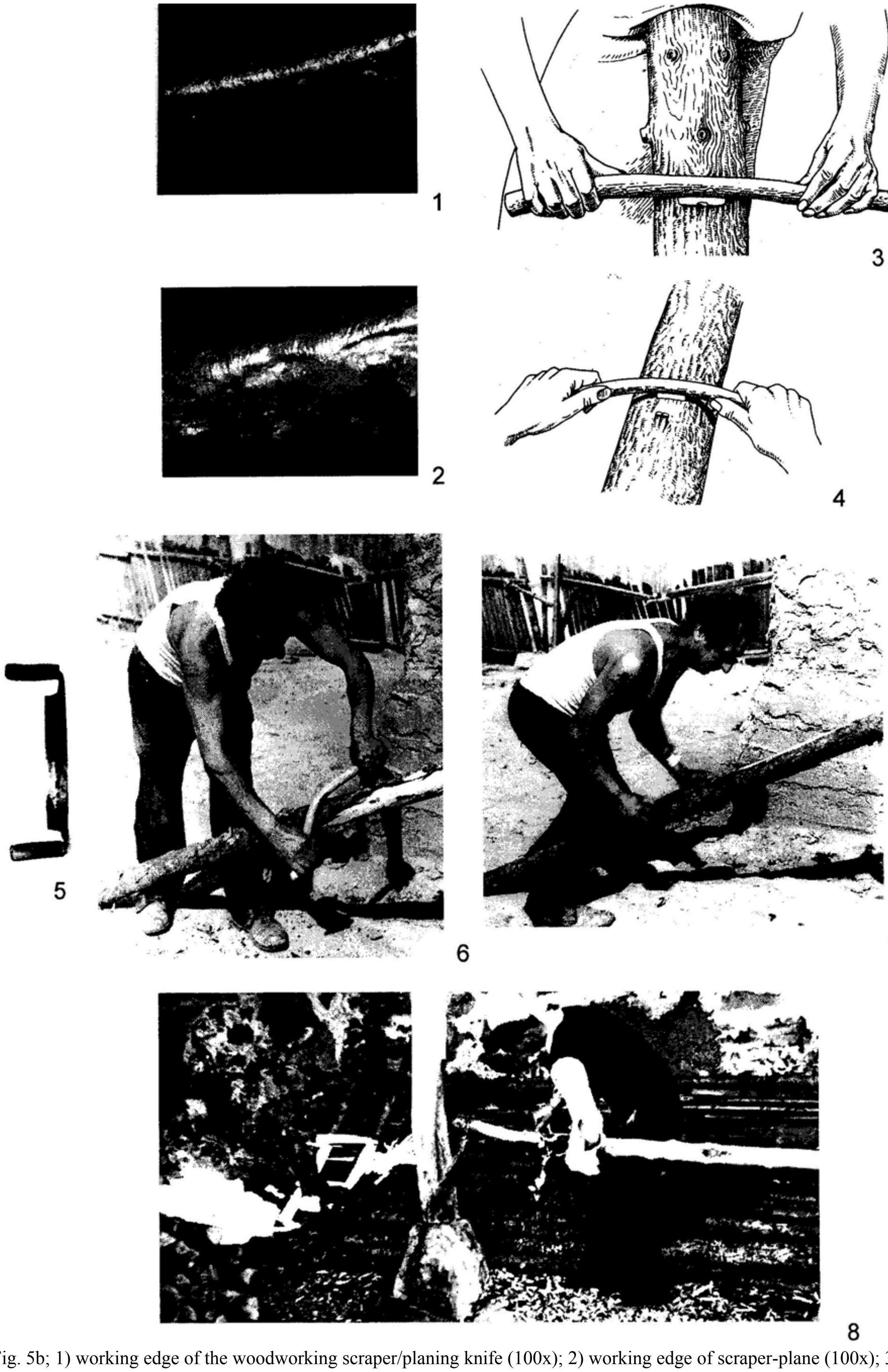

Fig. 5b; 1) working edge of the woodworking scraper/planing knife (100x); 2) working edge of scraper-plane (100x); 3-4) reconstruction of the implements; 5) iron woodworking plane (Bulgaria; after the files of Kh. Vakarelsky); 6) working with experimental scraper-plane; 7) working with experimental scraper/planing knife; 8) working with an iron plane in the end of the 19th century (Bulgaria; after the files of Kh. Vakarelsky).

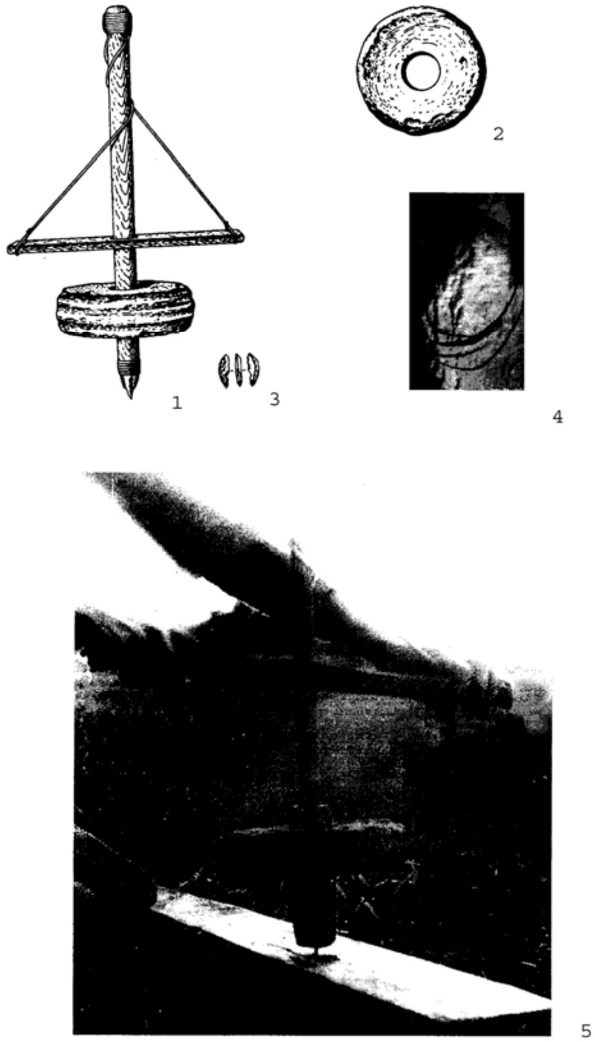

Fig. 6: 1) Reconstruction of the mounted drill; 2) flint drill; 3) clay handwheel; 4) working tip of a drill (100x); 5) working with an experimental drill.

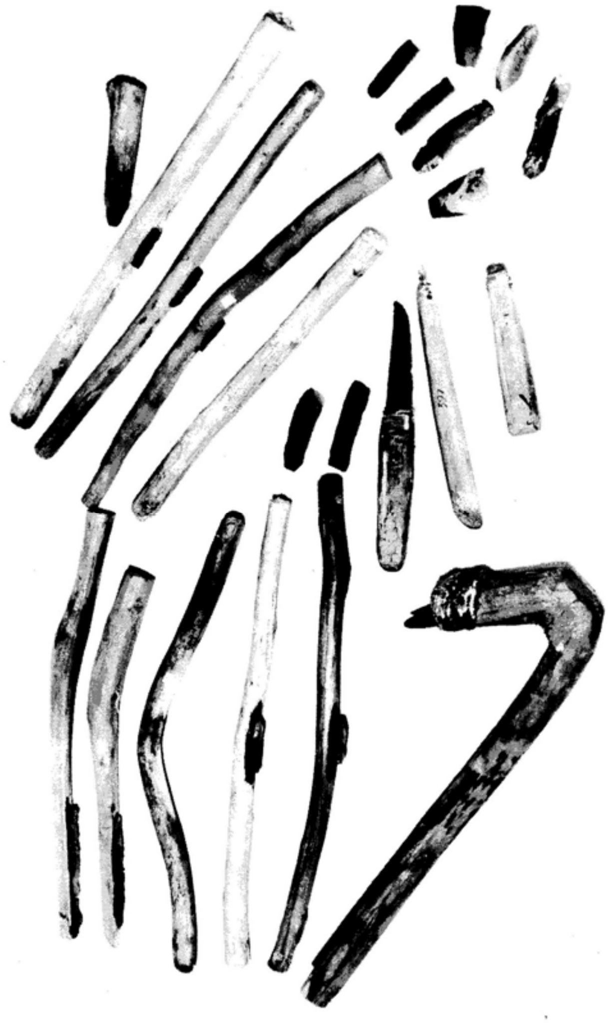

Fig. 7: Experimental implements.

between flint inventories of the Chalcolithic Varna culture of the Pontic area of Bulgaria and the preceding Neolithic cultures of the same area. All parameters, including the raw materials used, blanks and tool types, etc. are different (the local Neolithic industries were dominated by tools on flakes and medium-sized blades). Thus our data seem to corroborate the hypothesis argued for the intrusive character of the Chalcolithic in north-eastern Bulgaria and the role of Thracian cultures in this process (Todorova 1986).

The appearance of a new preform leads to standardization of tool types. As a result of a differentiation and specialization, a number of new implements appeared as evidenced by use-wear studies. Several decentralized domestic manufacturing activities which existed in the local Neolithic developed during the Chalcolithic into early household crafts with specialization and differentiation of the used tools. This time span saw the appearance of specialized workshops and labour division. These processes touched not only metallurgy and ceramic manufacture but flintworking, hide and wood processing as well. These innovations along with the introduction of plough agriculture and metallurgy could be considered as indicators of considerable technical progress that greatlcontributed to the culture flourishing of the Chalcolithic in the Balkans.

The results of the comprehensive analysis of flint industry from the Chalcolithic sites belonging to the Varna culture, including raw material analysis, technological studies, experimental and use-wear data combined with relevant ethnographic evidence and archaeological contextual information allow us to put forward new models for the cultural development among the early farming societies of south-eastern Europe.

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The contribution of ethno-archaeological macro- and microscopic wear traces to the understanding of archaeological hide-working processes

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Summary. *Ethno-archaeological data allow a better understanding of the hide-working process including parameters such as haft morphology, tool position and angle of insertion, tool fixation, thickness of the hide worked, the position of the hide/hide-worker, the precision of the gesture, etc. While these kinds of data are difficult to infer for archaeological tools when based on an experimental reference, we believe that it is possible if the analysis is based on a close examination of the wear traces produced in ethno-archaeological conditions. Based on different ethno-archaeological case studies, we propose criteria that – when applied in functional analyses of archaeological tools – allow a more complete understanding of the parameters involved in the archaeological hide-working process. It is concluded that this research demonstrates the importance of ethno-archaeology as a research tool in functional studies.*

Résumé. *Certaines données ethno-archéologiques peuvent contribuer à une meilleure compréhension du processus du travail des peaux, par exemple la morphologie du manche de l'outil, la position et l'angle de travail de l'outil, l'épaisseur de la peau, la position de la peau / l'artisan, la précision du geste, etc. En se fondant exclusivement sur des données expérimentales certaines de ces données sont difficilement accessibles. Cependant, les auteurs suggèrent qu'en s'appuyant sur une analyse détaillée des traces produites dans des conditions ethno-archéologiques les interprétations archéologiques peuvent être beaucoup plus précise. Cette recherche démontre l'importance de l'ethno-archéologie comme outil de recherche dans des études fonctionnelles.*

Key words: hide-working, hafting, ethno-archaeology, micro-wear.

Introduction

Based on ethno-archaeological studies, it is demonstrated that a detailed study of use-wear traces on the outer edge and inner surface of the working edge of once-hafted stone tools contributes to the understanding of the haft type used and the position of the hide and the hide-worker during processing. The presented examples are derived from groups that are currently still working hides with stone tools. The observations are made by the authors in British Columbia (Canada) and Siberia (North of Kamchatka) (Beyries 1997, 1999, 2002; Beyries 2003; Beyries *et al.* 2002; Beyries, *et al.* 2001) and Ethiopia (Rots in press; Rots and Williamson 2004).

Research Framework

For Siberia, observations were made with the *Chukchi* who use stone tools for the fleshing of dry reindeer hide, which is positioned on a wooden board. Stone tools are used hafted: the stone scraper is forced perpendicularly into a hole in the centre of a wooden transversal haft.

In British Columbia, fieldwork was performed with the *Athapascans*. They use stone scrapers for cleaning hides, in which case the size and weight of the tools varies depending on the thickness of the hide, and for the softening of thick hides. In all cases, the hide is stretched on a frame and the stone scraper is fixed on a bent handle with bindings.

For Ethiopia, field observations were made among the *Konso* and the scrapers of both the *Konso* and the *Gamo* were examined. Both groups are localised in southern Ethiopia and use hafted stone tools for processing of hides, mainly cow and goat-hides (Brandt 1996; Brandt and Weedman 2002; Weedman 2000). The *Konso* work hides when dry, either on the ground or against a hut. The stone scraper is fixed with resin in a small, straight wooden handle. In the case of the *Gamo*, the hide is worked still moist, and is suspended from or fixed on a frame. Two types of hafting arrangements are used. In one case, two stone scrapers are fixed with resin in a concavity at both sides of a double wooden handle, which is comparable to the *Konso* hafting arrangement. In the second case, the scraper is inserted in a split at the extremity of a straight wooden haft and fixed with bindings.

Results

In order to be able to identify the determining parameters in the functioning of a tool, it is essential to analyse each example individually.

1- ***Chukchi***: transversal handle, no resin, no bindings – hide on a wooden board – fleshing of dry hides (Fig. 1).

a) *Conditions of use*

The hide is positioned on a wooden board and the hide worker sits behind the board. The scraper is inserted under pressure in a transversal straight wooden haft. Size and weight of the tools are in proportion to the thickness of the hide that is to be worked and varies between 400 and 700 g.

During use the tool is held symmetrically with each hand on one extremity. The tool is thus perfectly centred. The use motion starts close to the hide worker with the tool

Fig. 1: Tchouktchi: Defleshing

placed on the hide and the tool is gradually pushed away in a downward motion. The working angle is very closed (20°). Scrapers are passed on from generation to generation and are rarely resharpened (Beyries 2002, 2004).

b) *Organisation of the use-wear traces on the working edge*

Position of the working edge on the hide	Traces observed on the working edge
Working edge centred on the hide	Use-wear traces centred on the active part
Closed working angle (20°)	Use-wear traces well-developed on the lower face
Resharpening is rare	Important rounding of working edge

2- ***Athapaskan***: bent handle, heavy, bindings – hide on frame – shaving of thick dry hides (Fig. 2) (Beyries 1997, 1999, 2002, 2003, 2004)

a) *Conditions of use*

The hide is large and fixed on a frame of 3,50 m wide. It is worked only when perfectly dry, which means that it is also extremely resistant. The tool used to shave and reduce hide is a scraper that is inserted in a bent handle in which it is fixed with bindings. The hide is thick and the tool used is heavy. The scraper-head can be 5 cm wide and the weight of the handle can exceed 500 g.

The artisan works while seated on his knees on the hide, which allows him to use the weight of his body as a

Fig. 2: Athapaskan: Hair removal (thick hide)

pressure on the active part of the tool. In this way, the centre of the working edge is in contact with the hide in a perpendicular direction. In order to have maximal efficiency at all times the tool is regularly resharpened.

b) *Organisation of the use-wear traces on the working edge*

Position of the working edge on the hide	Use-wear traces observed on the working edge
Working edge centred on the hide	Use-wear traces centred on active part
Open working angle (90 to 100°)	Use-wear traces are visible on the outer border of the working edge and hardly extend towards the upper face
Frequent resharpenings	Poorly rounded edges

3- ***Athapaskan***: bent handle, heavy, bindings – hide on a frame – softening (thick hide) (Fig. 3) (Beyries 1997, 1999, 2002, 2003, 2004).

a) *Conditions of use*

In order to be able to soften very thick hides, hides need to be stretched on a frame. The artisan then works upright in front of the hide. A similar tool as the one used for shaving is used. One of the hands is situated close to the working edge and provides the pressure; the other hand is positioned on the handle and gives the direction. The tool is moved in a downward motion on the hide. During the contact between the working edge and the hide, the tool leaves its working axis and scrapes the hide laterally. The actual contact is thus situated on the left part of the working edge when the left hand is responsible for the pressure and on the right part in the opposite case scenario.

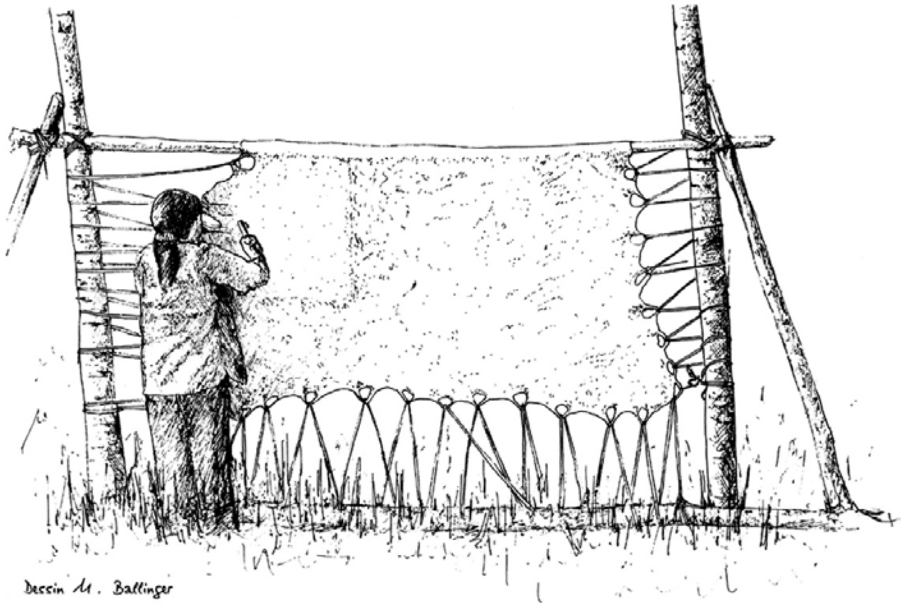

Fig. 3: Athapaskan: Softening (thick hide)

For the softening, the goal is not to remove material but to break the fibres in order to make the hide more flexible. A working edge that is too sharp would risk shearing the hide, which explains why the working edge is never resharpenend.

b) *Organisation of the use-wear traces on the working edge*

Position of the working edge on the hide	Traces observed on the working edge
Working edge is de-centred on the hide	Use-wear traces are de-centred on the active part
Open working angle (90 to 100°)	Use-wear traces are located on the outer working edge and only have a minor extension on the upper face
Rare resharpenings	Very rounded working edges

4- ***Athapaskan***: bent handle, light, bindings – hide on a frame – shaving (thin hide) (Fig. 4) (Beyries 1997, 1999, 2002, 2003, 2004).

a) *Conditions of use*

Hides with moderate thickness, like those of deer and roe deer are stretched on light frames: 1m wide and approximately 1.70 m high. The hide-worker stands in front of the hide. As for the large hides, the work is performed on a very dry hide. The scraper is inserted in a bent handle, in which it is fixed with bindings. The scraper-head is approximately 3.5 cm wide and the weight of the handle does not exceed 350 g. The goal of the tool is to remove material, so it is very sharp and it is resharpened frequently.

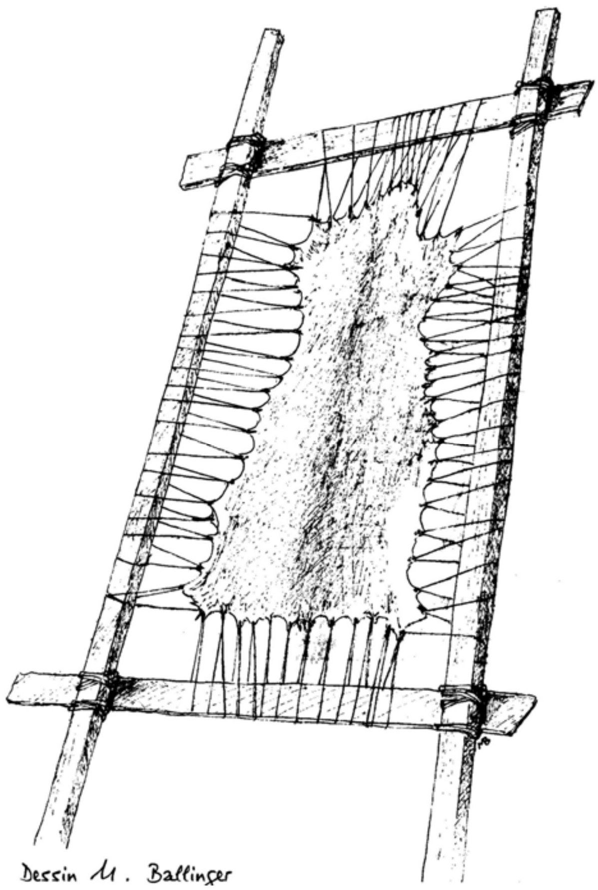

Fig. 4: Athapaskan: Hair removal (thin hide)

b) *Organisation of the use-wear traces on the working edge*

Position of the working edge on the hide	Traces observed on the working edge
Working edge de-centred on the hide	Use-wear traces de-centred on the active part
Open working angle (90 to 100°)	Use-wear traces are visible on the outer working edge with a limited extension on the upper face
Frequent resharpenings	Poorly rounded edges

5- ***Konso***: straight handle, scraper hafted perpendicularly, resin – hide on the ground – fleshing (Fig. 5).

Fig. 5: Konso: Defleshing

a) *Conditions of use* (Brandt 1996; Brandt and Weedman 2002).

The hide is positioned on the ground and slightly moisturised during use. The hide-worker sits on the hide, on her knees. The scraper is inserted latero-distally in a concavity in a small straight wooden handle that is no longer than 25 cm. Scrapers are small, about 1.5 to 2.5 cm.

After having positioned the tool perpendicularly on the hide, it is pulled towards the hide-worker. One of the hands is positioned on the distal extremity of the haft (where the scraper is inserted); it exerts a pressure on the working edge while pulling the tool. The other hand, positioned on the proximal extremity of the handle guides the movement. For the extremities of the hide, the tool is regularly turned around and held with one hand (with the palm on top of the scraper) in a pushing motion, while the other hand exerts a counter-pressure underneath the hide. As soon as the scraper looses its efficiency, it is resharpened until exhaustion. When exhausted, another hafted tool is used to continue the work. Given that a series of scrapers is hafted at once, before the work starts, the hide-worker can continue the hide processing without interruption. Several hafted scrapers are used to process one hide.

b) *Organisation of the use-wear traces on the working edge*

Position of the working edge on the hide	Traces observed on the working edge
Working edge centred on the hide	Use-wear traces centred on the active part
Open working angle (90 to 100°)	Use-wear traces visible on the outer working edge, with poor extension on the upper face
Frequent resharpenings	Poorly rounded working edges

6- ***Konso***: straight handle, scraper hafted perpendicularly, resin – hide suspended from hut – fleshing (Brandt 1996; Brandt and Weedman 2002), (Fig. 6).

Fig. 6: Konso: Defleshing

a) *Conditions of use*

The tools used have the same characteristics as the ones described earlier. The hide is fixed against the hut and hangs obliquely from it with one part resting on the ground. The hide-worker sits on the hide and works on the suspended hide. With her foot, she can adapt the tension of the hide. The way in which the tool is held is similar to the one observed with the *Athapascans* when they work fine hides, but hands are much closer together. The use motion involves a light percussion on the hide in a back-and-forth movement of the tool with variable pressure (i.e. more important in the downward motion, when the tool is pulled towards the hide-worker). The contact between the working edge and the hide is slightly de-centred. For the extremities of the hide, the tool is turned around and held with one hand positioned on the distal part of the tool and used while pushing it away from the hide-worker. The other hand exerts a counter-pressure underneath the hide. Again, scrapers are frequently resharpened and as soon as the tool looses efficiency, it is replaced with another one that was prepared in advance.

b) *Organisation of the use-wear traces on the working edge*

Position of the working edge on the hide	Use-wear traces observed on the working edge
Working edge slightly de-centred	Use-wear traces slightly de-centred
Open working angle (90 to 100°)	Use-wear traces visible on the outer working edge with a poor extension on the upper face
Frequent resharpenings	Poorly rounded working edge

7- ***Gamo***: straight handle, scraper fixed perpendicularly, resin – suspended hide – fleshing (Brandt and Weedman in press; Clark and Kurashina 1981; Gallagher 1974, 1977; Weedman 2000, 2002a, 2002b), (Fig. 7).

Fig. 7: Gamo: Defleshing

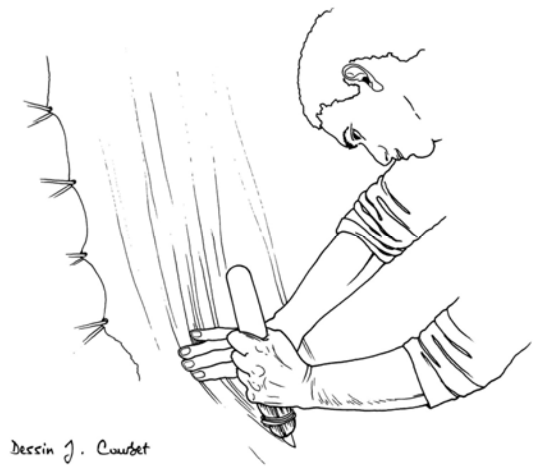

Fig. 8: Gamo: Defleshing

a) *Conditions of use*

The hide is suspended from one of its extremities. The other extremity is fixed to the foot of the hide-worker and the hide is worked while moist. The artisan is positioned in front of the hide. Two scrapers are hafted at the extremity of a double wooden handle, where they are inserted perpendicularly in a hole at the side of the haft and fixed with resin. The scraper is about 2.5cm wide. The tool is heavy, about 500g. The motion is a percussion motion with separated force and direction. At the moment that the working edge touches the hide, the artisan pulls the tool towards him, while the foot holds the chord that puts tension on the hide. The scrapers are regularly resharpened.

b) *Organisation of the use-wear traces on the working edge*

Position of the working edge on the hide	Use-wear traces observed on the hide
Working edge de-centred on the hide	Use-wear traces de-centred on the active part
Open working angle (90 to 100°)	Use-wear traces are visible on the outer working edge and extend poorly on the upper face
Frequent resharpenings	Poorly rounded working edge

8- ***Gamo***: straight handle, bindings – suspended hide – fleshing (Brandt and Weedman in press; Clark and Kurashina 1981; Gallagher 1974, 1977; Weedman 2000, 2002a, 2002b), (Fig. 8).

a) *Conditions of use*

The hide is fixed on a frame and is worked while moist. The scraper is inserted in the extremity of a split wooden haft in which it is fixed with bindings. (Brandt 1996; Gallagher 1977). The scraper is about 2.5 cm wide and the length of the handle varies between 30 and 45 cm (Weedman 2000).

The artisan is upright in front of the frame, which is positioned perpendicularly to the ground. The tool is held with one hand only and the use motion involves a linear percussion. At the moment of contact, the angle between the working edge and the hide is close to 150°. As before, the tool is replaced as soon as it looses its efficiency and can no longer be resharpened.

b) *Organisation of the use-wear traces on the working edge*

Position of the working edge on the hide	Traces observed on the working edge
Working edge is centred to slightly de-centred	Use-wear traces are centred to slightly de-centred
Very open working angle (150°)	Use-wear traces are well-developed on the upper face
Frequent resharpenings	Poorly rounded working edge

Comparative Analysis

The microscopic observations are summarised in the following table:

	Trace Localisation			**Trace Extension**			**State of the working edge**		**Width of the working edge**		**State of the hide**	
	centred	*slightly de-centred*	*de-centred*	*upper face*	*lower face*	*limited on upper face*	*rounded*	*poor rounding*	*small*	*wide*	*dry*	*moist*
1	X				X		X		X	X	X	
2	X					X		X		X	X	
3			X			X		X	X		X	
4			X			X	X			X	X	
5		X				X		X	X			X
6	X					X		X	X			X
7			X			X		X	X			X
8	X	X		X				X	X			X

1- Chukchi: transversal handle, no resin, no bindings – hide on board - *Fleshing*
2- Athapaskan: bent handle, heavy, bindings – hide on frame - *Shaving (thick hide)*
3- Athapaskan: bent handle, light, bindings – hide on frame - *Shaving (thin hide)*
4- Athapaskan: bent handle, light, bindings – hide on frame - *Softening (thick hide)*
5- Konso: straight handle with perpendicularly hafted scraper, resin – hide suspended from wall – *Fleshing*
6- Konso: straight handle with perpendicularly hafted scraper, resin – hide on ground – *Fleshing*
7- Gamo: straight handle with perpendicularly hafted scraper, resin – hide suspended vertically – *Fleshing*
8- Gamo: straight handle, bindings – hide on frame – *Fleshing*

When comparing the microscopic observations and interpretations, clear differences appear between the different scenarios suggesting that these distinctions would also be possible on an archaeological level. Depending on the cases in question, distinctions can be made based on one or more arguments.

It is clear that scenarios 1 and 8 are easy to identify based on one criterion only, being the use-wear extension. Indeed, the first example (*Chukchi*) is the only one in which the working angle is so closed that the use-wear traces are extremely extensive and developed on the lower face of the scraper-head. Scenario 8 (*Gamo – straight handle*) is in fact the opposite: the working angle is very open, which resulted in use-wear traces that are most extensive on the upper face of the scraper-head.

The six other scenarios have all use-wear traces that are poorly developed on the upper face, so another argument is necessary for their distinction. This can be found in the rounding intensity. Scenario 4 (*Athapaskan – softening*) is the only one in which the tool is used for softening, so the intense rounding of its working edge allows to distinguish this case from the other ones.

The remaining 5 scenarios all have limited edge roundings, but there are differences in terms of the exact localisation of the use-wear traces on the working edge. Scenario 2 (*Athapaskan – Shaving – thick hide*) and 6 (*Konso – Fleshing – hide on the ground*) are the only ones with centred use-wear traces, which allows a distinction from the other 3 remaining cases. Further internal distinctions can be made based on scraper size. In scenario 2 thick hides are worked, which implies that the tool needs to be heavy and the scraper large (about 5 cm wide). For case 6, the handle is very short and the scraper is very small (1.5 to 2.5 cm).

This leaves us with scenarios 3 (*Athapaskan – Shaving – thin hides*), 5 *(Konso –Fleshing – hide suspended from wall*) and 7 (*Gamo – Fleshing – hide suspended from wall*). Contrary to scenarios 3 and 7 where the use-wear traces are clearly de-centred as a consequence of the relative violence of the action, use-wear traces are only slightly de-centred in case 5. For scenarios 3 and 7, the use-wear organisation and the intensity of the rounding are essentially the same. The only way in which these two can be distinguished is based on the state of the hide at the moment of processing: in case 3, it is worked when dry, in case 7, it is worked while moist. Given that these types of determinations are detectable on the basis of use-wear traces, both scenarios can be distinguished. Arguments for such distinctions consist of the polish brightness, rounding, the amount and morphology of striations, etc. While dry hide working results in a dull polish with a distinct rounding and generally an abrasive component, moist hide working results in a brighter polish with more limited rounding and fewer striations.

Discussion

Consequently, each of the presented hide working scenarios results in a unique set of wear characteristics and tool sizes, aspects that are also interpretable at an archaeological level. This means that the exact distribution of use-wear traces over the tool's edge allows to infer the exact position of the tool with regard to the worked material and thus also the position of the hide-worker. Even though the presented overview of hide working scenarios is still incomplete and will need to be supplemented in the future with other examples, a transfer to archaeological cases is plausible. The important advantage is that this would allow insights that cannot be obtained through other means. Whereas determinations of the worked material and action are traditionally possible, a more detailed study of use-wear traces – in the line of the one presented here – would allow an understanding of other than the traditional aspects of the hide-working process, such as the position of the hide during processing and the position of the artisan. When in addition this use-wear analysis is combined with a hafting wear analysis (Rots 2002, 2003, 2005), it can provide a more profound insight of the hafting arrangement, in particular what concerns the handle type.

The potential of an application to archaeological hide-working tools was examined in a first small test that was performed on a set of scrapers from the site of *Verberie* (Buisson Campin, France) (Beyries and Rots in press). This test supports the assertion that new insights on the level of the functioning of the scrapers are possible, involving the position of the hide and the artisan, the way in which the tool was held, the handle morphology, etc. We therefore encourage a further elaboration of the corpus of existing hide-working scenarios and a more systematic and large-scale application of the presented analytical procedure to archaeological situations.

Finally, this research also demonstrates that functional analysis and ethno-archaeology (when based on precise research questions and an appropriate analytical method) are complementary methods. The combination of both approaches allows a closer investigation of the actual hide-working process, which in turn aids in gaining an insight in the cultural choices that were made.

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Functional analysis of grinding stones: the blind-test contribution

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Summary. *Western archaeology really adopted S.A. Semenov's use-wear analysis method (Semenov 1964), with the blind-test of M.H. Newcomer and L.H. Keeley in 1977 (Keeley et al. 1977). Today, functional analysis on grinding and abrading stone tools is a promising field of research, especially for Neolithic studies. It requires a re-evaluation of the framework initially created for flint tools. This paper proposes an evaluation, through a blind-test, of the framework of grinding tools functional analysis. In this aim, H. Plisson took in charge the crushing of calcite and dry bone, the grinding of naked wheat, fresh bone and cartilage, dry meat and roasted acorn as well as the softening of dry hide. On the other side, the observation of these fourteen tools by C. Hamon helped her proposing hypothesis on the position of the tool, their action, the transformed matter, their condition and duration of use. Comparison of the hypothesis proposed and the effective experimentations help us discuss the reliability of each of these criterion.*

Résumé. *L'archéologie occidentale n'a réellement adoptée la méthode d'analyse des traces d'usure, initiée par S. A. Semenov (Semenov 1964), qu'avec le test en aveugle de M.H. Newcomer and L.H. Keeley en 1977 (Keeley et al. 1977). Aujourd'hui, l'analyse fonctionnelle des outils de broyage et d'abrasion est peu à peu intégrée comme un champ d'étude prometteur, et ce particulièrement pour l'étude des sociétés néolithiques. Elle nécessite une ré-évaluation du cadre analytique créé initialement pour les outils en silex. Cet article propose d'évaluer, à l'aide d'un test-aveugle, un cadre d'analyse pour les outils de broyage et de concassage. Pour ce faire, H. Plisson s'est chargé du concassage de calcite et d'os sec, du broyage d'os frais et cartilage, de viande séchée et de glands grillés, ainsi que de l'assouplissement d'une peau sèche. De l'autre côté, les observations effectuées par C. Hamon sur les quatorze outils ainsi utilisés lui on permis de formuler des hypothèses relatives à la position des outils, leur mode d'action, la matière transformée, les conditions et la durée de l'utilisation. La comparaison des hypothèses proposées avec le contenu réel des expérimentations permet ainsi de discuter de la fiabilité de chacun de ces critères.*

Key words: grinding and abrading stones, blind test, analytical framework.

Stakes for a blind-test on grindingstone tools

Most of the archaeological reasoning is based on a comparison between past remains and models involving present or ethno-historical references. In these situations, similar material facts are connected to the technical, economical, morphological or symbolic systems they belong to, as elements linked by reciprocal relations. At the level of physico-chemical parameters, the safer inferences are not depending on cultural arbitrariness: in any place of the world, in any time, pure copper always melt at the same temperature. This is why technological studies are so common in archaeology and are now a major trend in prehistoric industries studies. Among them, and as shown by this congress, functional analysis is a dynamic and increasing mean of investigation.

Traceological analyses have to deal with the variations of many parameters before evidencing univocal meaningful cause-effect relationships. It is probably why, in our discipline more than in any other field of archaeological methodology, blind tests have played a so fundamental and regular role. The most famous one made by L.H. Keeley and M.H. Newcomer (Keeley *et al.* 1977), who really started traceological investigations in Western archaeology, demonstrated practically the validity of the methodology, of the selected criteria and of the experimental models involved in tool function identification. Since this historical blind test, this mode of evaluation has been used several times, either for methodological (Odell 1980, 1985; Newcomer *et al.* 1986; Unrath *et al.* 1986) or personal assessment (Plisson 1985; Shea 1987), with more or less satisfactory results.

Such tests do not reproduce the conditions of archaeological studies: no other data can put in perspective the conclusions or reduce the range of possible hypothesis. Besides, the limited number of artefacts emphasises any mistake. While not any archaeological conclusions are based on isolated results (see, for example, the evidencing of the oldest western threshing sledge insert carried out by integrating use wear analysis of a flint artefact with the cutting marks revealed on phytoliths from torchis of the same level - Khedhaier *et al.* 2003), the score of a blind test is a compilation of a finite number of binary results (true/false). The blind test principle itself is not unsuitable, but its realisation is, most of the time if not always, far from the archaeological reality, for obvious practical reasons: who is able to reproduce a complete Palaeolithic camp, for example? Consequently, the blind test gives a model, which is not more nor less "true" than any ethnoarchaeological or experimental model applied to an archaeological situation: the relationships that occur inside the model are not necessarily working in a larger, more complex and/or different context, and have to be discussed.

Nevertheless, if not ideal, the blind test allows checking the least basic parameters and helps methodological improvements.

In the spirit of this meeting, coming back to the initial conception of S.A. Semenov (Semenov 1964), functional studies have definitely enlarged their focus and are no longer restricted to flint tools. These last ten years, western traceology has progressively included new materials, such as quartz, obsidian, basalt or bone, but without any real re-evaluation of the framework previously adapted to flint tools analysis. Today, functional analysis of grinding stone tools is being integrated as a promising field of research, more especially for the study of Neolithic societies. However, most of our mental templates remain linked to the lithic cutting edges as done for the past twenty years by the Western school. The study of non-cutting tools, such as grinding tools, requires completely new references and produces images which are not so clearly understandable by other traceologists. Consequently, methodological assessment of this particular field of research may appear difficult from outside, because of the specificity of the criteria considered and of the relative inadequacy of the recording techniques.

This is the reason why the present blind test has been proposed to Caroline Hamon, who bravely accepted the challenge, without being sure to take advantage of such a risk.

Basis for a functional analysis of grinding stone tools

A methodological framework

Grinding stones, pounders and hammerstones as well as abrading and polishing tools play a great part in subsistence and technical processes from the beginning of the Neolithic. Examining Linearbandkeramik implements of the 5th millennium cal. BC. in the Paris basin, an experimental database was built using the same sandstones as the ones selected during the Neolithic for their highly natural abrasive properties (Hamon 2004). Our experimental referential consists of 92 working surfaces representing a number of activities and transformed materials: grinding cereals (wheat, hulled barley, spelt), legumes, hazelnuts and plants, crushing burnt flint and burnt bone for use as temper in ceramics, grinding clay and colouring, abrading dry or wet bone and antler, polishing shell, limestone and schist, defleshing and softening dry and wet skin (Hamon 2004).

Any functional approach must consider the whole system in which a tool participates, including all the interactions of the surfaces with which it comes into contact. From a tribological point of view, a grinding action involves two mineral surfaces and an intermediate substance, whereas in an abrading action, the stone and the substance transformed are directly in contact. Use-wear formation depends not only on one single raw material but also of its behaviour in the technical system. Use-wear can be described with several stages of observation on such tools, with the help of a stereoscopic microscope under 120x magnification (Adams 1998). The aspect, morphology and even nature of use-wear traces depend on the type of stone used (Dubreuil 2004; Procopiou 1998). The structural properties of sandstone help identify, at low magnification, distortions of the relief which are classified as use-wear traces on grinding stone tools (Hamon 2003). The main structural characteristics of sandstones are based on cohesiveness, texture and abrasiveness. Cohesiveness depends on the type of matrix and cement and on the proportion of pore spaces. Texture can be defined by the size and sorting of quartz grains. Natural abrasiveness is based upon the natural rounding of the grains and the proportion of the various minerals composing a rock (Adams *et al.* 1994, Schoumacker 1993).

As previously demonstrated (Hamon 2004), the morphological variations of use-wear features and their combination correspond to defined functional parameters, including both motions and transformed matters. Thrown percussion (*percussion lancée*) has the effect of crushing the stone surface, associated with a removal of the smallest grains from altered or low cohesive stones. Striations are created by removal of quartz grains in the case of low cohesiveness and a high proportion of pore spaces. At low magnification, use-wear appears as a smoothing of the surface, a levelling of the asperities due to rubbing. To the naked eye or at very low magnification (under 10x), a levelling of the surface can be described in terms of abrasion of the asperities and of removal of excess grains. At a second stage of observation, an indeterminate filling of the intergranular spaces can be distinguished. At higher magnification, distortions of the grains can be characterized by considering the modifications of their angles, edges and profiles.

At this stage of the research, the observer can determine the motion of the tool, the category (cereals, plant, hard or soft mineral, animal, etc.) and state of the transformed matter, and sometimes the duration of use. The aim of the present blind-test was to evaluate the reliability not only of criteria for use-wear identification but also of observation techniques, as well as our ability to determine the precise function of tools from archaeological contexts.

The blind-test procedure

The blind-test involved examination of samples from two experimental sessions, carried out by Hugues Plisson with the help of Selina Delgado in May 2004 and March 2005 (Fig. 1). Use-wear was identified by Caroline Hamon.

The tool blanks were chosen by C. Hamon from alluvial deposits in the main Paris Basin valleys where early Neolithic populations settled during the 6th millennium B.C. The blanks correspond both to the archaeological records and to the raw material used in C. Hamon's original experimental database. The blanks were roughly shaped out, mostly by pecking of the active surface or of the sides to make manipulation easier. Their morphology corresponds neither to a known type of archaeological tool, nor to one with a specific purpose. The sandstone is generally similar in its characteristics to the

N.	tool	raw material	action	duration	transformed matter	state	macroscopic avalaibility
1	lower grinding tool	compact altered sandstone	grinding	2h15	naked wheat	dry	-
2	grinding slab	compact altered sandstone	crushing and grinding	1h	bone and cartilage	fresh (marrow)	-
3	natural stone	compact sandstone	-	-	-	-	-
4	lower grinding tool	compact sandstone	grinding	2h15	naked wheat	dry	-
5	lower grinding tool	quartzitic sandstone	crushing and grinding	1h	bone and cartilage	fresh (marrow)	-
6	handstone tool	quartzitic sandstone	a) make supple b) depilation	2h	a) cow skin b) horse skin	a) inside b) non depilated, brain tanned	-
A	lower grinding tool	quartzitic sandstone	crushing	1h	beef bone	boiled and dried	central deformation
B	grinding slab	quartzitic sandstone	grinding powder making	1h	acorn	grilled in an oven	no clues
C'	cylindrical upper grinding tool	quartzitic sandstone	grinding powder making	1h	acorn	grilled in an oven	
C"	cylindrical upper grinding tool	quartzitic sandstone	grinding (throwing vertical percussion then circular and multidirectional grinding)	1h	pork meat	dried	-
D	lower grinding tool	compact sandstone	grinding	1h	pork meat	dried	-
F	lower grinding tool	compact sandstone	crushing powder making	less than 1 h	calcite	-	-
LKG	multifacetted handstone	calcareous sandstone	crushing powder making	less than 1 h	calcite	-	HCL altération ?
GH	multifacetted handstone	calcareous sandstone	crushing	1h	beef bone	boiled and dried	HCL altération ?

Fig. 1: Description of the experimental tests (1st and 2nd series).

archaeological samples, but in some cases had undergone slight alteration which may have affected preservation of the experimental traces.

Once shaped, the tools were sent to H. Plisson for use. The transformed matters were chosen for their compatibility with the environment of the early Neolithic of the Paris Basin. The experiments totalize fifteen work surfaces, shared between eight tools which include both lower and upper parts. After use, the tools were washed to eliminate any organic residue. After a full day in a hydrochloric acid solution, they were rinsed with water and then placed for a half-day in warm water containing washing-up liquid, using an ultrasonic bath for the smallest items, before brushing under water. After several hours in a fresh solution of chlorohydric acid solution, they were rinsed again with water.

The tools were then returned to C. Hamon, who observed location, extent, intensity, texture and aspect of use-wear polish and striations with the naked eye and at low magnification with a stereoscopic microscope (Nikon SMZ 800). The recognition of the activity was based on identification of the active zone(s), the type of object (upper or lower part, single or matched pairs use), kinematics (handling, gesture, angle, orientation, direction) and the transformed matter (texture, state, category, type). An evaluation of the duration of use was attempted for each working surface. Taking all these information into consideration, one or two plausible functional hypotheses were proposed. Once the diagnosis had been made, the real function of each surface was finally revealed.

Diagnosis of use-wear traces

The description of use-wear and functional hypothesis for each tool are available in Figure 2.

First series

Grinding naked wheat (lower tool 1 / upper tool 4)

Dry seeds of naked wheat were ground on a small lower grinding stone for 2 h and 15 m (Fig. 3a).

N	usewear traces	distribution of traces	intensity	microrelief	quartz grains	position	action	transformed matter	texture	condition	duration of use	notes	
1	polish	relief	polish	levelling and amalgamating grains	superficial alteration	lower	grinding	plant (cereals?)		green or wet			2:15 of dry naked wheat grinding (passive tool)
2	polish	relief	uniform, oily aspect		angulous, microfractured, superficial alteration	upper	softening	animal (hide or meat?)	soft	greasy			1:00 of fresh bone + marrow chrushing (passive tool)
3	"hard" polish	relief	levelling	no alteration of lower parts, separated grains	coarse fractures			undeterminated (rough middle hard material?)			very short		unused
4	smoothing and fine transversal striations		grey polish	levelling, superficial deposit, contiguous grains	superficial alteration		grinding	hard mineral (siliceous very abrasive matter)	hard				2:15 of dry naked wheat grinding (active tool)
5	use-wear		greasy aspect		well preserved, alteration of faces, coarse microfractures			animal (bone?)	half - hard				1:00 of fresh bone + marrow chrushing (active tool)
6	polish	asperities		amalgamating grains, full deposit	slightly altered		grinding	cereals					2:00 of dry skins graining (cow and horse)
A	coarse impacts	edges	superficial impacts	star or triangular impacts		lower, matched	crushing slab, precise throwing percussion	undeterminate	angulous fractions, crushing, hard matter	not greasy	1 h+	greasy touch	1.75kg of dry bone crushing (passive tool)
B	polish	circular	polish and hard levelling	levelling and amalgamating grains, uniformisation of surfaces	separated with a brilliant deposit and a greasy aspect	lower, matched	circular grinding	plant (between legumes and nuts)	greasy and compact		1 h?	organic deposit	4 l of grilled acorn grinding (passive tool)
C'	polish	central, asperities	low intensity and oily aspect	levelling and contiguous grains	smoothed and brilliant aspect with microfracturations	upper	grinding	hard mineral?		greasy	used ?		4 l of grilled acorn grinding (active tool)
C"	polish	asperities, smoothing of edges	well developed	levelling and well separated grains, contiguous	slighly altered faces and smoothed edges	upper, matched	softening (or grinding?)	animal matter (barely greasy, dry hide, or bone??)	fine particules, slightly abrasive		2 h?		1:00 of dry meat grinding (active tool)
D	polish and striations	smoothing of edges	greasy aspect	levelling but lubrification of grains (protected and reflexive)	separated grains, brilliant faces, smoothing of the grains, slight microfracturation	upper, matched	grinding	organic (plant?)	powder, fine particules	mostly greasy	2 h?	secondary mineral rubbing	1:00 of dry meat grinding (passive tool)
F	coarse impacts and percussion cupule		ovoid and coarse impacts	torn off grains		upper, matched with GJ surface	crushing, precise gesture	not bone crushing	solid and angulous matter but slight resistance	not greasy	low duration		1.2 kg of calcite crushing and grinding (passive tool)
G I J	polish		smoothing, even edges	levelling, amalgamating grains, superficial deposit	smoothed edges, angulous microfracturations	upper, matched with F surface	grinding	cereals?	hard		1 h -	strong alteration by HCL, not determinable use wear	1.2 kg of calcite crushing and grinding (active tool)
KL	polish	edges and corners	white smoothing	levelling of contiguous grains, superficial deposit	altered faces	upper	grinding	undeterminate			30 min	strong alteration by HCL	1.75 kg of dry bone crushing (active tool)

right   partial   false   determination

Fig. 2: Macroscopic and microscopic description of use-wear traces and proposal of a functional attribution.

Blind-test description and hypothesis –

(tool 1) the macroscopic polish of the asperities is due to a levelling of the relief and to a slight amalgamation of the quartz grains whose superficial faces are altered. This could correspond to grinding plants such as cereals**.**

(tool 4) Flat zones are associated with fine transverse striations. Contiguous grains, striations and a superficial deposit on the surface of the grain complete the strong levelling. The grinding of a hard mineral could have created such traces.

Grinding fresh bone and cartilage (lower tool 2 / upper tool 5)

A slab was used to crush and grind fresh bone for one hour (Fig. 3 b). The transformed matter consisted of cattle and sheep bone and cartilage. Marrow seems to have influenced the aspect of use-wear polish, which was difficult to distinguish with the naked eye.

Blind-test description and hypothesis –

(tool 2) To the naked eye, the asperities tend to be uniform without any real levelling; the pecking pits are

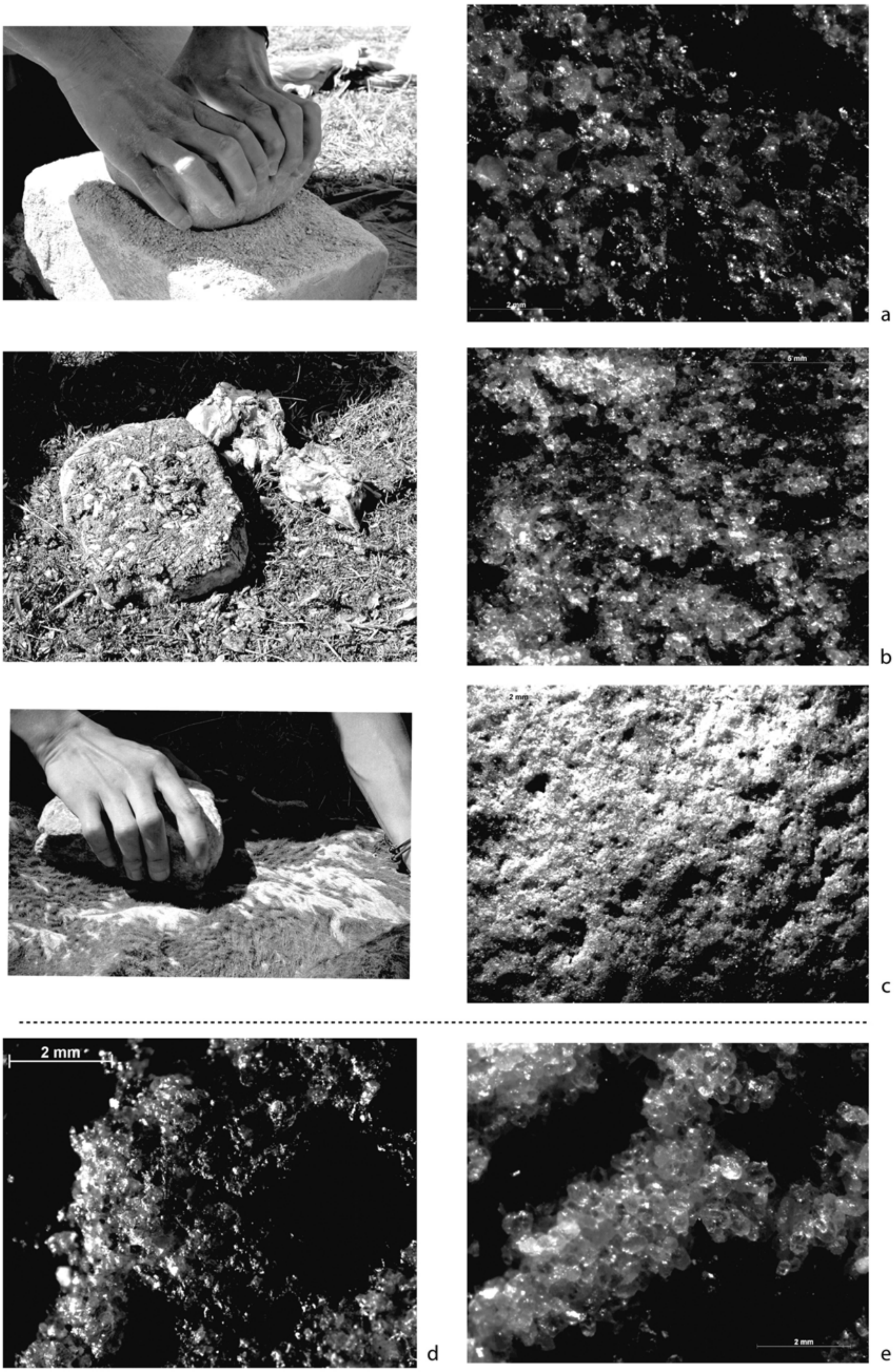

Fig. 3: Experimental tests, 1st serie: a) naked wheat grinding – tool 1 x30, see the surficial smoothing of the grains ; b) fresh bone and cartilage crushing – tool 2 x15, the grains are slighlty levelled and show a greasy aspect ; c) skin suppling and depilating – tool 6 x5, see the alteration of the upper asperities ; d) manipulation pollution of acorn use-wear initial traces, tool C' x15, observe the shiny and greasy aspect ; e) unused surface, tool 3 x30, the naturally smoothed grains don't show any transformation.

also altered. The quartz grains are still angular, the edges are well preserved even when altered by microfracturation: supple animal matter (hide or meat) may have been transformed; this matter must have been quite greasy.

(tool 5) Use-wear is not very well developed, and a quite greasy shine can be distinguished. Quartz grains are well preserved, well separated, but their faces are slightly altered: their edges are slightly levelled and coarsely microfractured. This kind of wear evokes semi-hard animal matter, such as bone.

Unused (upper tool 3)

Blind-test description and hypothesis –

The grains are well separated and brilliant, their edges are not altered, the lower pits show no alteration (Fig. 3e). The use is impossible to determine and may be of short duration. It could only have involved a semi-hard matter with coarse fractions.

Softening dry hide (upper tool 6)

This upper tool was used on the internal side of dry and very hard cattle hide for one hour and then on the external side of a horse hide, the hair of which had been preserved by brain tanning (Fig. 3c). The sandstone was too fine to break the fibres and de-hair the hide. The heating effect from rubbing generally helps make the main hide supple. Use-wear was easily distinguishable to the naked eye.

Blind-test description and hypothesis –

Use-wear shows a hard texture and is only developed on the upper zones. The grains are amalgamated, slightly altered and a slight superficial deposit can be identified. All these traces evoke cereal grinding, possibly of hulled seeds.

Second series

Crushing calcite (upper tool edge LKG / lower tool F)

A fist-sized block of calcite was crushed and turned into powder with a polyhedric grinder on a coarsely pecked lower grinding stone set on grassy ground. The movements were varied but not violent, due to the low resistance of the calcite. The block was wedged in a small depression in the middle of the grindingstone, which became enlarged through use. Both tools were used less than one hour and showed use-wear readily identifiable to the naked eye (Fig. 4a).

Blind-test description and hypothesis –

(tool F) The coarse and ovoid impacts of thrown percussion have been created by removal of quartz grains. They evoke a delimited action of (active?) crushing of a solid but low resistant matter with sharp edges. The duration of use should not have been more than two hours.

(tool LKG) The continuous smoothing of the edge is made by a continuous levelling of amalgamated grains: this wear could be created either by cereals or more probably by an alteration by the hydrochloric acid solution.

Crushing dry bone (upper tool edge KL / lower tool A)
Five slices of cattle bone were boiled and then dried for several days in the sun (Fig. 4b). They were crushed for an hour with a polyhedric grinder on a large lower grinding stone set on grassy ground. This action was sufficient to break the bone into small pieces but not to grind them. They were certainly too hard and the lower grinding stone too flat to obtain such a degree of fineness. The active surface became greasy here and there, due to a little fresh marrow still attached to the bone. Fairly violent thrown percussion broke the grinder edges. Also, the small depression on the lower surface, which trapped bone fragments, became enlarged. The active edges of the grinder became smoothed.

Blind-test description and hypothesis –

(tool A) Four distinct surfaces of use can be identified. Coarse impacts and a central depression lead us consider this tool as an anvil. Star shaped impacts of thrown percussion evoke semi-hard pieces of an angular matter. A slightly greasy touch is noted.

(*tool KL*) The smoothing seems to correspond to a superficial deposit or to a strong levelling of the surface. It may have been created by alteration from the hydrochloric acid solution.

Dry meat grinding (upper tool edge C’’/ lower tool D)

Strips of pork were dried in the shade at 10 °C with a cold air fan for several days. The flat surface of a cylindrical grinder was used on the convex face of a fully pecked lower grinding stone; the grinding stone was set in a plastic tray in order to recover the ground meat (Fig. 4c).

This one-hour work was effective as all the dry meat was turned into powder. The movement of the upper grinding tool was double: a vertical action to crush the meat fibres was followed by a turning movement to obtain powder. Both surfaces seemed worn at a macroscopic level.

Blind-test description and hypothesis –

(tool C’’) The well-developed polish runs over the edges. The levelling in process, the well-separated quartz grains whose faces are slightly altered and the rounding of their edges are associated with thin transverse striations. This use-wear corresponds to an active surface, used for the

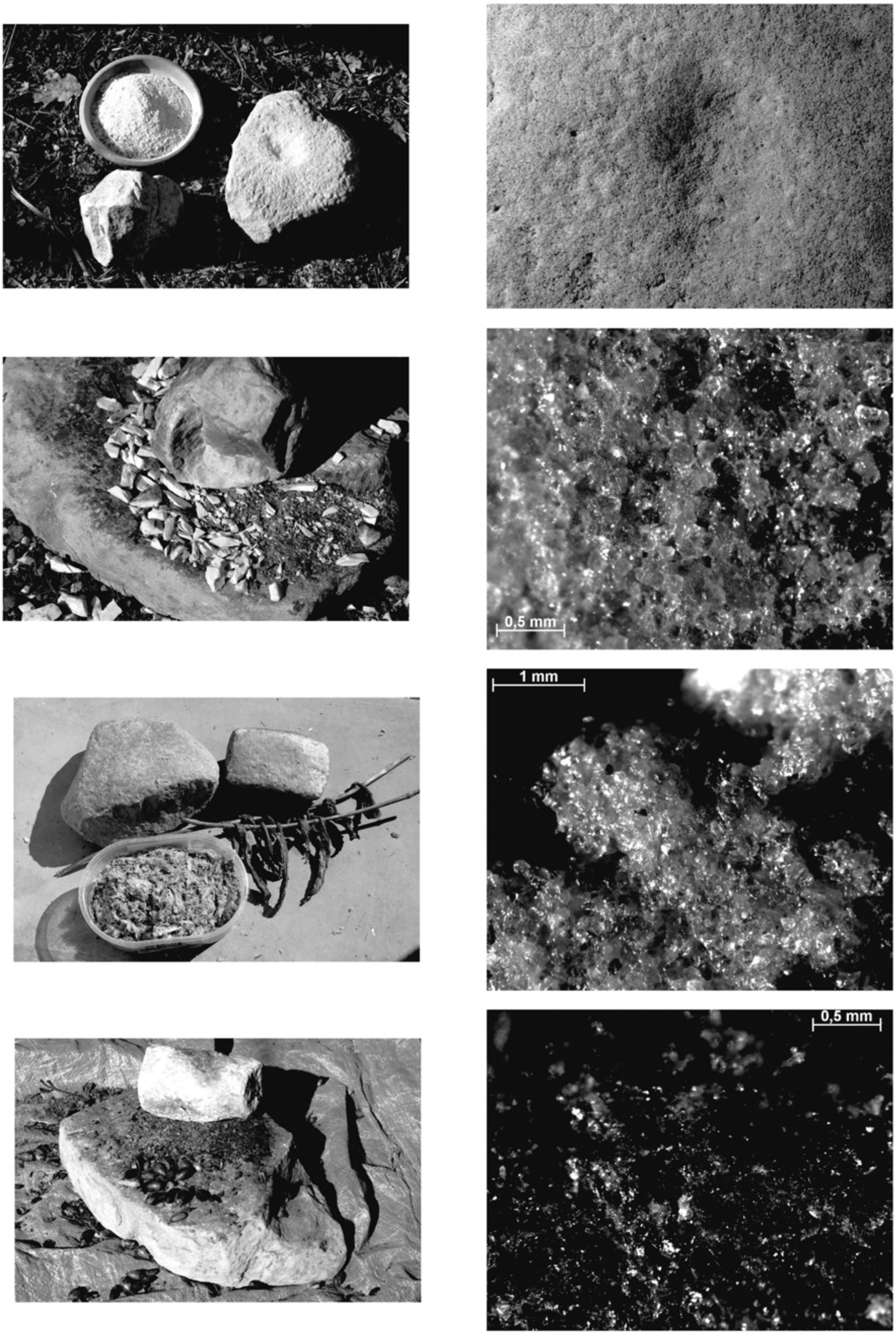

Fig. 4: Experimental tests, 2nd serie : a) Crushing and grinding tools for calcite – detail of face F and of the depression created by throwing percussion; b) Crushing of dry bone– chloryhydric acid alteration of face I x45, see the “dissolution” of the edges of quartz grains; c) Dry meat grinding, tools and powder – tool C” x30, see the smoothing of the grains and the formation of levelled asperities; d) Acorn grinding – tool B x45, watch the separated quartz grains and the opaque deposit wich give that dark effect.

transformation of a greasy animal matter. Fine abrasive particles may correspond to hide softening or grinding bone. The duration of use may have been two hours.

(tool D) A greasy aspect characterises the macroscopic alteration of the surface. It largely overflows the asperities, which indicates a grinding action to obtain a powder. Grains are still separated but show slight microfracturations. This could correspond to active grinding of a greasy organic matter (possibly a plant?) for two hours.

Grinding roasted acorns (upper tool edge C'/ lower tool B)

Autumn-picked acorns were roasted in an oven before grinding on a large flat slab (Fig. 4d). A cylindrical upper grinding stone was used with the same gesture as for grinding dry meat. For one hour, four litres of roasted acorn were easily reduced into powder, even though sorting of the residual husks was necessary. Only the upper grinding stone seemed to be slightly modified to the naked eye.

Blind-test description and hypothesis –

(tool C') The surface, used for less than an hour, nonetheless shows signs of grinding of a greasy matter. The levelling is in process, the grains are contiguous, the faces are flat. A secondary shiny aspect can be distinguished: it could be linked to manipulation of C'' during use (Fig. 3d). Lastly, this surface could have ground a mineral matter, but use-wear seems to have been polluted by secondary use or by manipulation.

(tool B) Use-wear associates both a polish and a general levelling of the surface. Whereas an opaque deposit on the well-separated quartz grains is clearly visible, the grain faces are very altered. This passive surface has been used for a circular grinding, shown by the location of polish. A vegetal greasy matter, certainly close to nuts or legumes (Dubreuil 2004), may have been ground and for a duration close to an hour.

Interpretation and research perspectives

Determination and results

The two series of tests contain four correct determinations (tools n° 1, 5, B, C"), five partial determinations (tools n° 2, A, D, F, KL) and five incorrect determinations (tools n° 3, 4, 6, C', GIJ), out of fourteen (Fig. 5). How can these results be interpreted?

Concerning the position of the tool, there is one incorrect attribution (tool n° 2) and two partial attributions (tools D and F). The functional hypothesis for tool n° 2 is false (upper tool used for softening) whereas the proposed transformed matter is almost correct (soft animal matter instead of fresh bone and marrow). Tools D and F were not used as upper handstones although the existence of a matched tool was correctly attributed. The proportion of correct determinations is of four out of five.

The two mistaken determinations of the action of the tools concern an inversion between grinding and softening (tools 2 and 6). For tool n° 2 the mistake only involves the functional parameters, whereas in the case of tool n° 6 the understanding of the whole activity is incorrect.

Recognition of the transformed matter seems the least reliable parameter, with seven false or absent, three partial and four correct answers. Two false cases can be explained by the washing with a hydrochloric acid solution (tools GIJ and KL). Tools 4, 6 and C' are unexplained mistakes, whereas tool A was not determined at all. On tool n° 3, no clear use-wear features were identified: the hesitation over its attribution to a specific matter can obviously be explained by the absence of use. If we examine the right answers, two levels can be distinguished: firstly, the category is determined and then a more precise matter is proposed. Finally, four out of seven mistakes are really unforgivable, whereas two matters absent from the previous experimental referential were almost recognised (dry meat and grilled acorn, tools B and C").

	position	action	transformed matter	texture	condition
right	7	9	4	5	4
partial	2	1	3	3	1
false	1	2	5	1	1
absent	4	2	2	5	8
total	14	7	12	10	5

Fig. 5: Synthesis of the score obtained for this blind-test for each critrion of determination.

The most reliable parameter, and also the one which shows the most surprising results, is the texture of the transformed matter. Here there is only one mistake (tool 4) and three approximate answers (tools 2, 5, GIJ), out of nine proposals. Two of the incomplete proposals (tools 2 and 5) are linked with grinding of a composite matter: pounding and grinding fresh bone and marrow produce two types of traces, i.e. impacts from the crushing of hard matter (bone) and the grinding of tender matter (marrow). For the other cases of transformed matters not included in previous experiments (tool GIJ), the calcite texture (between hard and tender) and the deformation due to hydrochloric acid solution may be the cause.

The state of the matters as well as the duration of use of the tools were also proposed. As these parameters rely for the moment on subjective criteria, we prefer to consider them as a complement, or as a regulation, for the main functional hypothesis. The recognition of a greasy state was generally correct (except C'), whereas the state of the cereals ground by tool 1 was mistaken (wet cereals). The duration of use was not too badly assessed, but many adjustments must be made before obtaining any real accuracy for this parameter.

In fact, gesture, motion and activities constitute the most reliable parameters of determination, followed by the determination of the texture of the transformed matter. The most perfectible field is still the transformed matter, even though the score shows four unforgivable mistakes.

Limits of the test and reliability of determination

The first difficulty with which we were confronted was the choice of suitable sandstones, as the blanks found in the alluvial deposits were often altered. This may have slightly modified the reaction of some surfaces during work, as well as the formation of some diagnostic use-wear traces.

Similarly, several alterations due to washing seem to have significantly altered the smoothed surfaces: the hydrochloric acid solution has modified the superficial aspect of the polish and even its characteristics at high magnification (tools GIJ and KL).

The duration of use also seems to be an important factor of variability. Considering all the variations linked with motion and the nature of the transformed matters, the tools show a generally low rate of use. This could have affected the development of various stages of use-wear traces.

In addition, several surfaces have only been partially defined: the non-recognition of thrown percussion impacts is due to a lack of experimental referentials.

Despite all these obstacles, many positive aspects deserve to be mentioned.

One pleasant surprise is the complementarity of information provided by the naked eye and the macroscopic or microscopic levels of observation. While motion and gesture can be deduced mainly from low magnification observations, the transformed matter is generally identifiable at higher magnification. The activity, motion and kinematics of the tools benefit from a good rate of determination, based on the first macroscopic clues. The hesitations concern only the surfaces used with two different gestures (firstly back-and-forth and then circular, for example).

The "real" mistakes generally involve incorrect interpretation of use-wear traces, even though their actual description is quite sound. Unworked surfaces were identified as such, although there was some hesitation about tool n° 3. The texture of the transformed matter was identified either by the polish texture or by the impacts of thrown percussion.

Of particular interest is the approximate identification of matters that were not in the experimental referential, such as the grinding of meat and bone, dry meat or the roasted acorns (tool 5, B, C"). In our opinion, this demonstrates the reliability of the method itself.

These remarks underline, if this is necessary, the importance not only of "sampling" in archaeological assemblages but also of the recording of experimental parameters. The analysis of an archaeological assemblage is guided by and depends on these methodological filters. The most astounding outcome of the test is the difficulty in identifying tools working in pairs: does this imply that use-wear develops in a very different way on upper and lower parts of a grinding system, or does this simply reflect the poorer quality of the sandstones chosen for the lower parts? The short length of time involved probably accentuates this difference.

Improvement of the method

This test proves the overall reliability of the identification method: the goal has been reached and some indication has been provided on the way accuracy could be improved. For more effective determination, we need more precise definitions of the associations of determination criteria and their degree of correspondence with one specific use. Some contradictory traces seem to characterize single surfaces: their origin could be identified through a better understanding of the mechanism of surface deformation and of its various stages. For example, do some actions possibly destroy or hidden previous use-wear traces? How does the addition of an intermediate substance condition and distort the appearance of some traces? Improvement of the method must also rely on use of higher magnifications, over 120 x, and the development of observation techniques. In order to obtain more accurate recognition of the transformed matter, these improvements must include precise criteria of determination, specific to each type of transformed matter.

Lastly, such a test should be extended to other raw materials and carried out in collaboration with other use-wear specialists working on grinding and abrading stone tools.

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SEM functional analysis and the mechanism of microwear formation

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Summary. *This paper focuses on wear processes on lithic artefacts. It is based on results from a wide-ranging experimental programme and systematic SEM (Scanning Electron Microscope) analysis. Sequential experiments provided evidence on the processes involved in the deformation of lithic surfaces in function of the raw materials, the worked matters and the actions performed. Study of these processes, based on a theoretical framework from Materials Sciences, led us to support an interpretive model in which use-wear is basically explained in terms of attritional phenomena, including the plastic deformation of lithic materials.*

Résumé. *Cet article est dédié aux processus d'usure des outils lithiques. Ce travail se base sur les résultats obtenus d'après un étendu programme expérimental et sur l'observation systématique à l'aide du MEB (Microscope Electronique à Balayage). Des expérimentations séquentielles ont fourni des évidences sur des processus entraînés dans la déformation des surfaces lithiques, en fonction des matières premières, des matériaux travaillées et des actions effectuées. L'étude de ces processus, réalisé dans un cadre théorique propre des Sciences des Matériaux, nous porte à soutenir un modèle interprétatif dans lequel les traces d'usure s'expliquent essentiellement par des phénomènes d'attrition, incluant la déformation plastique des matériaux lithiques.*

Key words: lithic technology, use-wear, SEM, experiment, deformation, tribology.

Introduction

The mechanisms involved in microwear formation on lithic tool surfaces were one of the main topics of discussion for traceologists during the 1980s. This reflected the natural evolution of a young discipline that was attempting to establish its theoretical bases and learn to face the method's application phase with confidence. This interesting period was followed by a phase without consensus among authors, in which the subject progressively lost its leading role and became eclipsed by an emerging interest in archaeological studies, new methods of quantification and the automatic identification of use-wear traces, and residue analysis (Grace 1996). The paper offered in this volume provides a good example of the current state of research in functional studies, where a false feeling has been generated as an issue that regarding the mechanisms behind microwear formation have been completely solved.

In this paper we describe some of the results of our experimental programme, which is based on a sequential control of processes using systematic SEM analysis. These results cast doubt on some of the main currently accepted models for explaining microwear formation and offer new lines of research for increasing knowledge in this area.

One of the main limitations to the study of the processes involved in microwear formation has traditionally been the design of experimental programmes. The greater number of variables considered and their expanded control have not been enough to improve information about the mechanisms of wear. The normal procedure was to analyse the surfaces after the experiment and try to infer the phenomena that produced the modifications and the role played by each variable in the final result. In some cases an indirect control was carried out, in which worn surfaces were compared with fresh fragments of rock from the same nodule as the experimental tool. This is a valid method for obtaining reference collections for identifying use-wear traces by analogy but it has clear limitations for studying the mechanisms of wear origin since it provides no direct data on the different phases of the process at a given point of the used edge appearance and any modifications during the process must be deduced from the final appearance of the surface. Yamada (1993, 2000) introduced a qualitative improvement in documentation methods by carrying out sequential experiments that enabled detailed observation of the modification process on the contact surface of lithic tools during utilisation. In these experiments, a series of points on the edge were monitored by SEM images before the work process began as well as at intervals throughout.

These improvements in the documentation and experimental control systems are closely related to the use of SEM. The technical advantages of this technique, basically the depth of field, the possibility of working at high magnifications, the high control and precision in the manoeuvrability of the samples, the quality of the images obtained, and the possibility of chemically analysing the surface observed (EDAX), enable detailed studies of the behaviour of lithic surfaces subjected to stress and friction to be conducted. In this sense, the possibilities provided by SEM are undoubtedly higher than those of optical microscopes.

Methods

The experimental samples used in this study are taken from a wider programme (Ollé 2003, Vergès 2003). All are from sequential experiments carried out with flint tools. In this type of experiment, several points on the active edge are documented at magnifications of x100, x250, x500 and x1,000, before utilisation and then at 5-minute intervals during the working process. Higher magnifications have been used when necessary.

We used a SEM JEOL JSM-6400 with microanalysis by electron probe (EDX) EXL II System Link Analytical (Oxford).

To accurately observe deformations on the flint surfaces caused by use, we followed a cleaning procedure that consisted of:

a) an ultrasonic bath in H_2O_2 for 10 minutes to eliminate organic residues from worked materials,
b) an ultrasonic bath in the neutral phosphate-free detergent Derquim®, with ionic and non-ionic surface-active agents, for 10-15 minutes,
c) an ultrasonic bath in pure acetone for 2 minutes to eliminate fatty residues resulting from handling.

This procedure was repeated before each microscopic observation.

To obtain satisfactory observation and micrographs we used a gold coating on the artefacts. Once each SEM analysis was finished, this coating was removed with *aqua regia* (an acid mixture containing 3 parts HCL and 1 part HNO_3). This procedure, as it was proven in experiments carried out on several siliceous rocks (Ollé 2003; Vergès 2003), does not cause any damage or microscopic alteration to flint surfaces.

During the sequential experiments we faced a serious problem: microscopic edge damage, which involves the removal of most of the control points during the first 5 minutes of work. To increase the number of long sequences, we used high definition casts of fresh edges. We therefore first selected the control points after the first interval of work and then checked their initial appearance on the cast of the fresh edge. We then managed to increase the number of sequences that survived until the 15' stage, though very few survived the 20' stage.

The replication technique involved silicone-based dental impression materials (*Provil® novo Light*) to make negative impressions or moulds, and bicomponent rigid polyurethane resin (*Synthesia* corp.) to make positive impressions or casts.

Experimental observations on the process of microwear generation

From the micrographs taken in the same areas at intervals during the working process we can analyse one of the key topics in the debate on microwear origin: which phases of the modification process are recorded on a lithic surface when it comes into dynamic contact with a second body?

Surface behaviour

As Yamada (1993, 2000) noted, one of the first observations is that there is no layer or deposit formation on the depressed zones on the contact surface of the tool derived from utilisation. In sequential experiments, the series of images show how the original depressions progressively disappear due to surface abrasion without any kind of depression in-fillings. The only matter to form a layer are residues of the worked material, which disappear after thorough cleaning.

These observations contradict one of the basic principles of the silica gel theory (Del Bene 1979; Anderson 1980b; Anderson-Gerfaud 1981; Hurcombe 1992): that a silica gel may displace on the surface under certain flow conditions. This phenomenon would involve the smoothing of the surface microrelief by means of gel redeposition, principally on depressions (*ibid*.). We also observed that holes recorded on deformed surfaces were actually the remains of original depressions on the stone surface, which invalidated their interpretation as corrosion effects as proposed by Sala (1997).

The only kind of displacement on surface recorded in our experimental programme occurred sporadically and was in all cases associated with high energy linear contacts. It sometimes appears, therefore, in small spots after manual working, often because of contact with hard particles in the interfacial medium. However, the more generalized features of this type are closely related to high-energy contacts, as in the case of hammerstone impacts when knapping. Here, the intensity of contact between surfaces causes displacements of matter towards the margins of the zone of the greatest effort. When the limit of the plastic deformation is exceeded, material is detached and translocated, and it is often then compacted and adhered by compression to the surface of the tool. This phenomenon can be fully explained in terms of the mechanical response of the rock with no need for chemical modifications.

The analysis of the so-called fern-like striations (see below) illustrates this process perfectly. High compression generated under the axis of contact between two bodies causes simultaneously the displacement of material towards the margins of the groove and the development of traction fissures perpendicular to the displacement of the incident body. This kind of striation incorporates material from the tool surface or from the hammerstone (or from both), and demonstrates the phenomena of detachment, dragging, translocation, and adhesion by compression. During cleaning with long ultrasonic baths, and in experiments on diagenetic modifications involving the immersion of samples in water, these deposits detach from the surface, thus demonstrating their strictly adhesive character (Fig. 1).

Depth behaviour

Several authors have suggested the formation of a layer on the worn surface with a clear accumulative character (Wittoft 1967; Anderson 1980a; Anderson-Gerfaud 1981, 1983, 1986; Vaughan 1981; Mansur-Franchomme 1983;

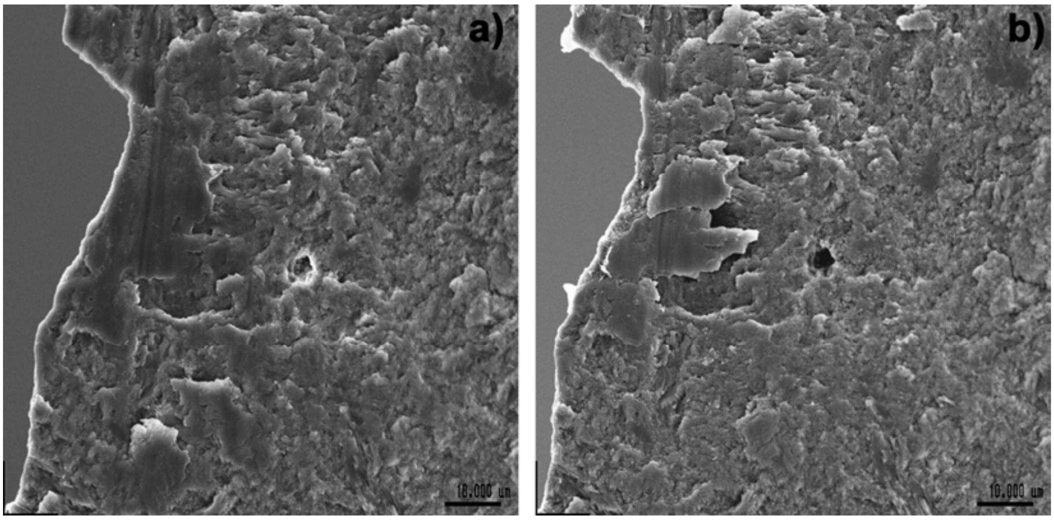


Fig. 1: a) Translocation and adhesion by compression of displaced material on an edge used in butchery activities; b) After one year of immersion in water, adhered material partially detaches from the surface, probably due to a differential hydration with respect to the substratum.

Plisson and Mauger 1988; Christensen and Walter 1991; Sala 1997; Christensen 1998). According to this suggestion, this layer increases in volume throughout the effort, either continuously or as a result of the superimposition of several generations of deposits. In this sense, abrasion either does not exist or is considered of secondary importance in polish formation.

To interpret the origin of microwear (polish) we need to know how it develops in depth. However, none of the supporters of the deposit theory carried out any specific probe to document it, and the subject remained on a strictly hypothetic level. Only Sala (Sala 1997, p.171), using SEM observation of sectioned experimental samples, responded to this question. This author identified a layer of superficial deposit that varied in thickness according to the worked material but never exceeded 4 µm, and a subjacent, also variable, zone with compression that was documented up to a maximum of 25 µm in depth.

Our sequential experiments showed, as Yamada (1993) also observed, that no growth in volume can be detected in areas of maximum microwear. Rather, in all cases we recorded a greater or lesser loss of material as a result of the smoothing of asperities of microrelief and the loss of a portion of the edge by fracture and polish. “Deposits” do not grow. Nor once formed do they constitute a solid and fixed surface that resists until the end of the work. Tool contact surfaces show a real dynamic behaviour. “Deposits” are continuously generated and destructed, so what we record through microscopic observation is the state at a given moment, not the final phase of an accumulative phenomenon.

The thickness and characterisation of the supposed superficial layer was already questioned by, for example, Masson *et al.* (1982) and Levi-Sala (1996), the supporters of the so-called mechanical model of wear. When applying X-Ray Diffraction on sickle blades, Masson and colleagues (*ibid.*, pp.45-46) detected neither amorphous opal nor opal CT (cristobalite-tridimite), changes of phase that would exist if there were a silica gel layer. These results led the authors to conclude that either this layer does not exist or it is so thin (just few angstroms) that it is impossible to detect by diffraction .

To illustrate the behaviour of deformations due to use, we include two examples from our experimental programme. One of these is a tool used to scrape dry hide (*Capreolus capreolus*) (Fig. 2) and the other is a tool used to cut wet graminoid (*Brachypodium phoenicoides*) (Fig. 3). We selected these examples because they represent extreme cases in terms of the conditions and characteristics of the worked material (basically, the presence or absence of silicon and water in its composition).

The holes, located in both cases in the bottom right of the images, are particularly interesting. In addition to the modifications on the perimeter of the cavities caused by wear, we can see how, after 20’ of work, the distance between the crystals inside and those on the surface has been reduced. We can also see the backward movement of the edge line as the action extends.

Although the final appearance of both worn surfaces is completely different, we can clearly see a loss of material, not an accumulation.

Striation formation

One of the common hypotheses about striation formation is the one proposed by Mansur-Franchomme (1983), according to which striations are caused by abrasive particles dragged over a silica gel layer. The presence or absence of striations, and their features, therefore depend

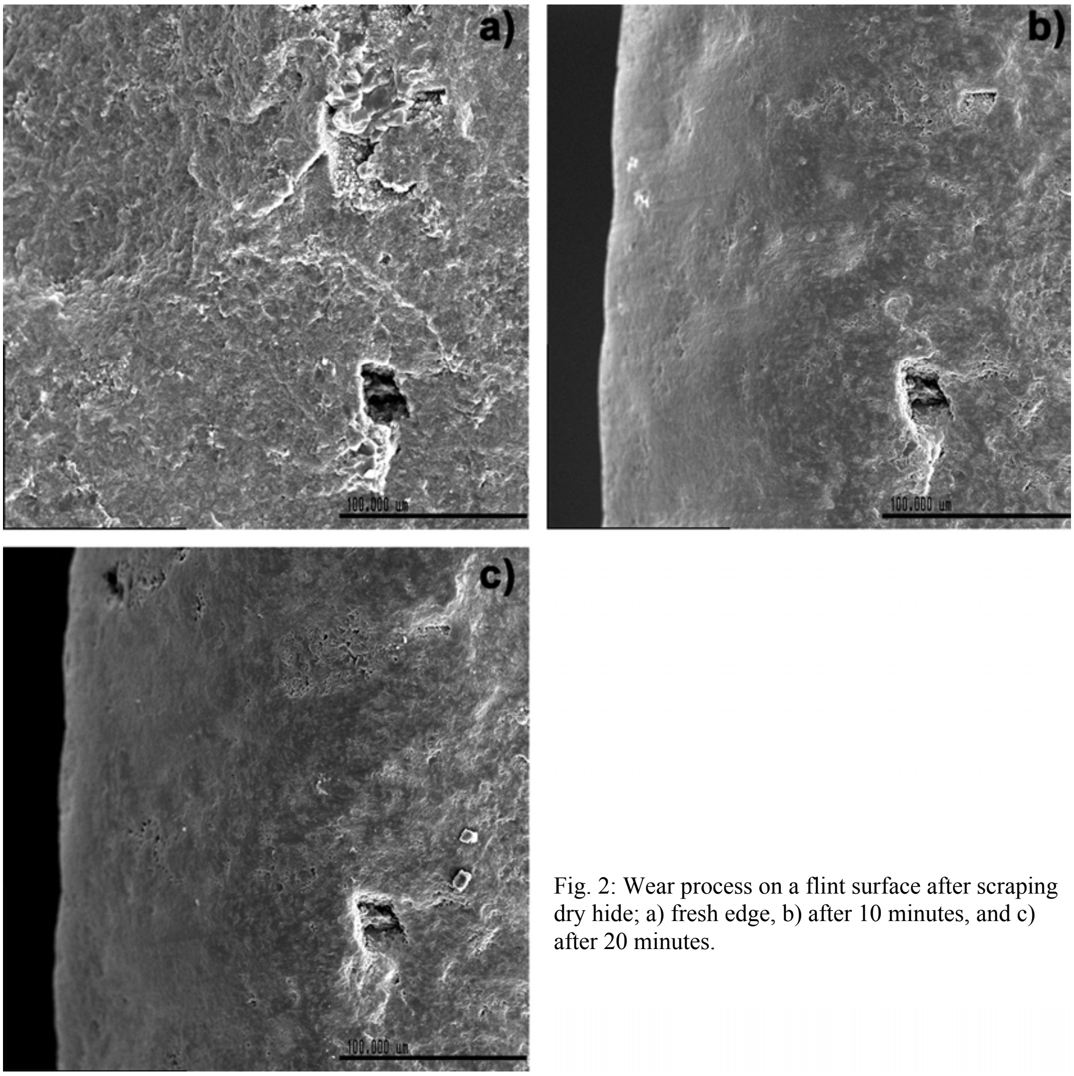


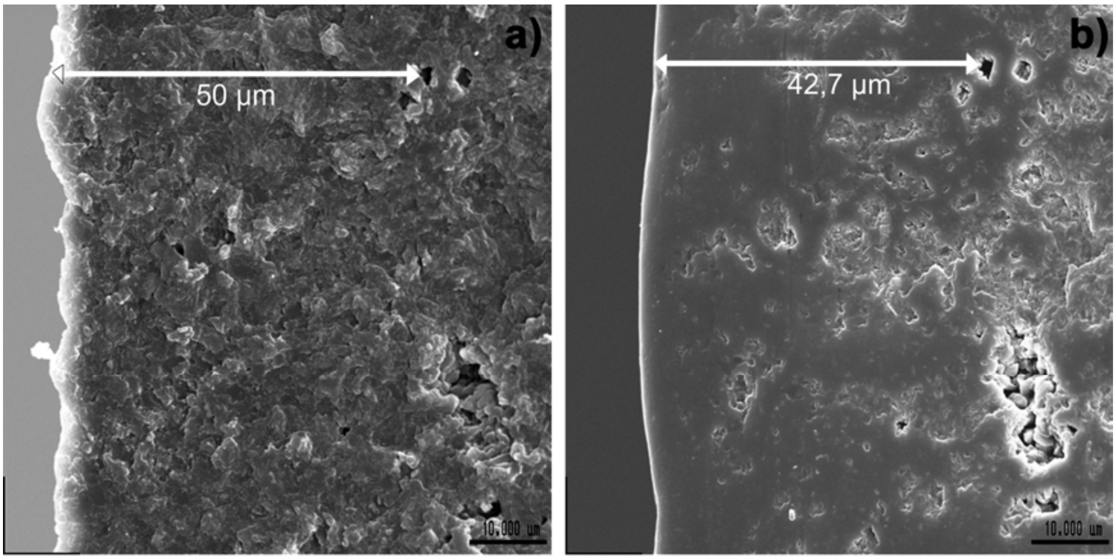
Fig. 2: Wear process on a flint surface after scraping dry hide; a) fresh edge, b) after 10 minutes, and c) after 20 minutes.

on the degree of gel fluidity during utilisation. After observing the striations in detail, we find it difficult to support this hypothesis. Firstly, we can reject the process proposed for the formation of the *filled-in* striations because, if the silica gel was fluid enough to fill the grooves once generated by an abrasive particle, other depressions on the stone surface would also have been filled—and we have already seen that this does not occur (Fig. 4a).

Also, there are *smooth-bottomed troughs*, which include the above-mentioned *fern-like* and *ribbon-like* striations. According to Mansur-Franchomme (*ibid.*), this kind of linear features forms over a deposit that is fluid enough to allow an effective action of the abrasive particle but not to completely cover the groove. Our experiments show that there is no relationship between the morphology of these striations and the fluidity of the "deposits", nor is there a relation between the morphology of the striations and the presence (or absence) of the "deposits". We recorded ribbon-like striations on fresh or semi-fresh surfaces, where the only "deposit" is the groove. In the same way, we recorded fern-like striations as the result of impacts or occasional high-energy contacts. These very often appeared to be isolated and to have no relation to any other kind of trace. Obviously, a fluid surface is therefore not essential for smooth-bottomed striations to form. Rather, it is the action of the incident particle or body, and especially the intensity of the contact, that deforms the surface plastically and generates both kinds of linear features (Fig. 4b).

Finally, the *rough-bottomed troughs* have been interpreted as resulting from the removal of crystals from the surface via the action of an abrasive particle. This particle may detach from the tool edge or worked material or come from the exterior. Unlike in the above cases, where plastic deformation dominated, this type of striation is due to the brittle behaviour of tool surface.

To sum up, several variables take part in the contacts that generate striations: the physical characteristics of elements (whether these are abrasive particles or an incident body), the characteristics of the interfacial medium (which affect the contact conditions), and the energy of the dynamic contact between surfaces. The



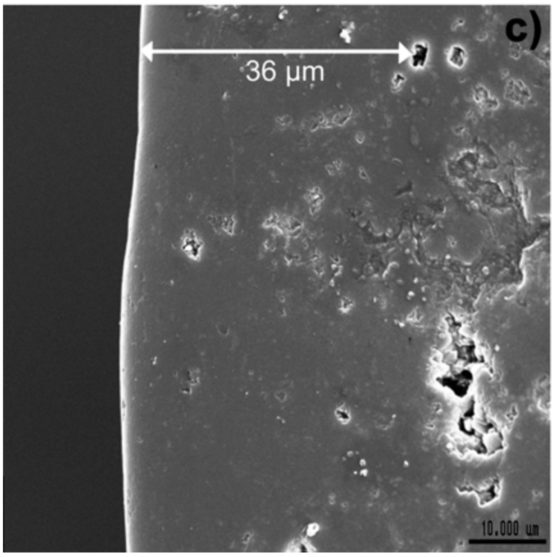


Fig. 3: Wear process on a flint surface after cutting fresh graminoid; a) fresh edge, b) after 10 minutes, and c) after 20 minutes. As in figure 2, wear begins on the highest parts of the relief and progress downwards. The edge line moves back and the asperities tend to disappear from the flint surface. No depression in-filling has been documented: the holes observed on polished areas are derived from existing ones.

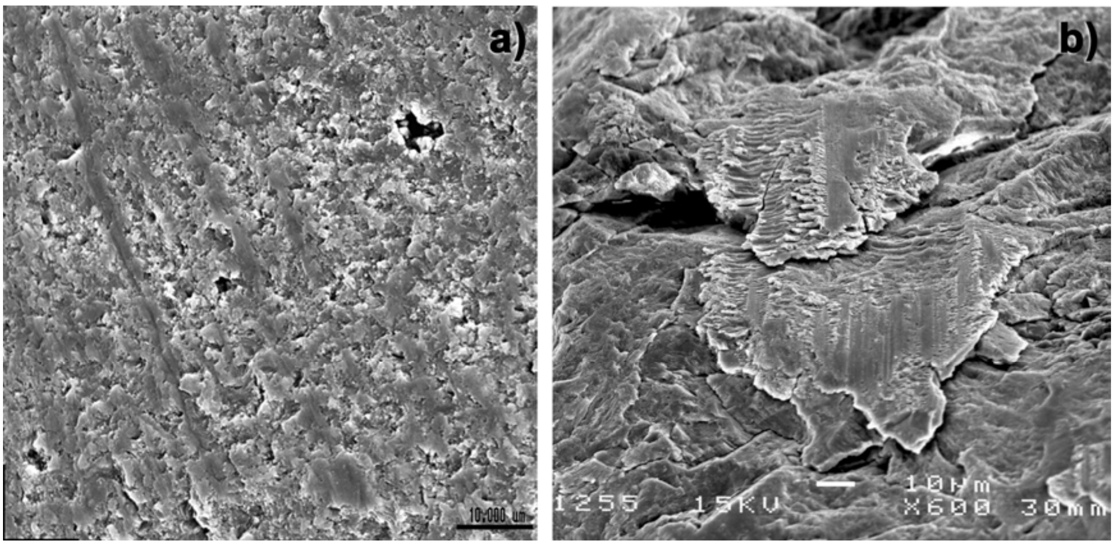


Fig. 4: a) Striations over a not-completely-polished surface of a flint tool used for cutting meat for 10'. Abrasive particles (mainly from the tool edge) removed some asperities from flint surface and caused plastic deformation to it; b) *Fern-like* striation on a flint edge caused by hammerstone impact during retouch. A strong plastic deformation accompanied by translocation of material and adhesion by compression can be seen.

different combinations of these variables promote the formation of more or less linear friction features and lead to the variability recorded in this group of traces.

Chemical composition of deformed areas

The chemical analysis of micropolished areas provides information about the origin of use-wear.
The possible inclusion of elements from the worked material has been explained in terms of an amorphous silica gel layer that, when it solidifies, traps and fossilizes these exogenous remains (Anderson 1980b; Anderson-Gerfaud 1981; Vaughan 1981; Mansur-Franchomme 1983).

Although, as we have seen, our results did not support the formation of such a deposit, we systematically applied EDX analysis on experimental polishes. In no case did chemical microanalysis detect different elements from those present in the rock composition. Our results therefore agree with those of Mansur-Franchomme (1983, p.228) and Gutiérrez (1996, pp.67-68). Even in limestone tools used to cut graminoids, where the presence of silica would be easy to ascribe, the only chemical elements detected were those that formed the rock.

On this basis we refute the transference of elements from the worked material to the tool surface and tend to interpret the identification of foreign elements on tool surfaces reported by some authors (e.g. van Gijn 1986; d'Errico 1988; Sala 1997) as the remains of worked material due to deficient cleaning. In fact, van Gijn (*ibid.*) identified Ca, K and C on experimental tools used for working fresh fish, but some of the polishes containing these elements disappeared after HCL cleaning. The author finally interpreted these polishes as residues adhered to the tool surface and noted how difficult it can sometimes be to distinguish polish from residues.

In line with these studies are valuable ones by Christensen and colleagues (Christensen *et al.* 1991, 1998; Christensen 1998, 1999), though in our opinion they concern residues more than use-wear. In our experiments we recorded similar deposits to those reported in these studies but all of these disappeared after thorough cleaning. To study true microwear and observe the underlying deformations on stone surfaces, these residues must be removed (Fig. 5).

Factors involved in microwear formation

Several factors are traditionally considered relevant in the process of microwear formation. These are presence of water, temperature, chemical composition of the worked material and physical characteristics of the raw material. It is essential to understand the role of each of these factors and to evaluate the influence on the final appearance of deformations.

Liquid presence

Authors agree that the presence or absence of water plays an important role in the development of microwear. Authors (e.g. Gysels and Cahen 1982; Keeley 1980; Anderson 1980b) also agree that in any worked material use-deformations develop more in wet state than in dry.

Analysis of experimental cases shows that the presence of water or another liquid does influence the wear process and, therefore, the final appearance of deformations. What is not so clear is whether polish would develop better on actions involving wet materials than on actions involving dry ones. An action on wet material tends to generate smoother surfaces than an action on dry material. Generally, however, actions on wet materials do not lead to more developed use-deformations. Working dry hide, bone, shell or limestone causes a much faster

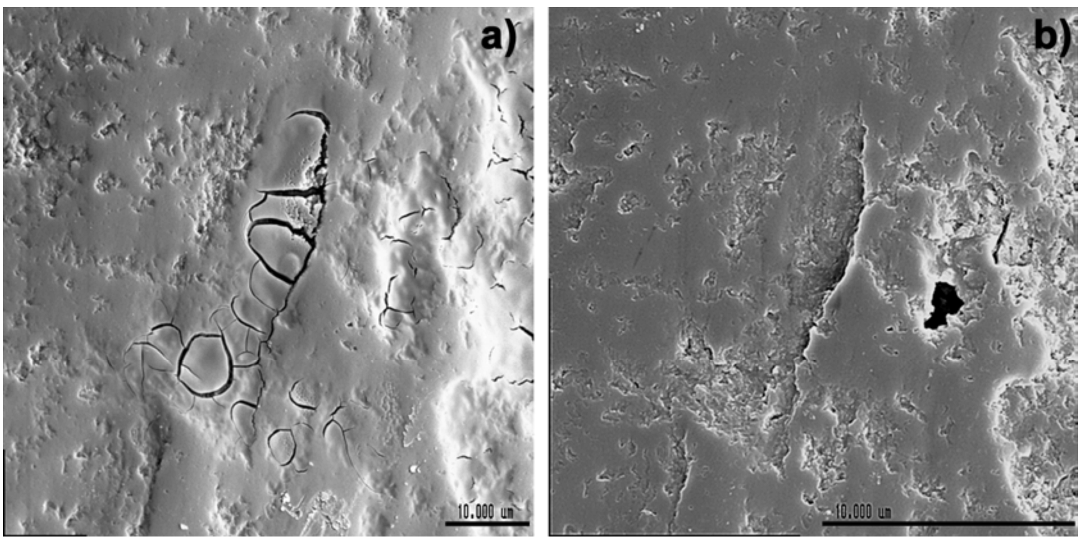


Fig. 5: a) Residues adhered to the polished surface of a flint tool used for cutting fresh graminoid for 15'; b) Plant polish underlying residues after thorough cleaning. EDX analysis showed K, Cl, Ca, S and P on image a, but only Si on image b.

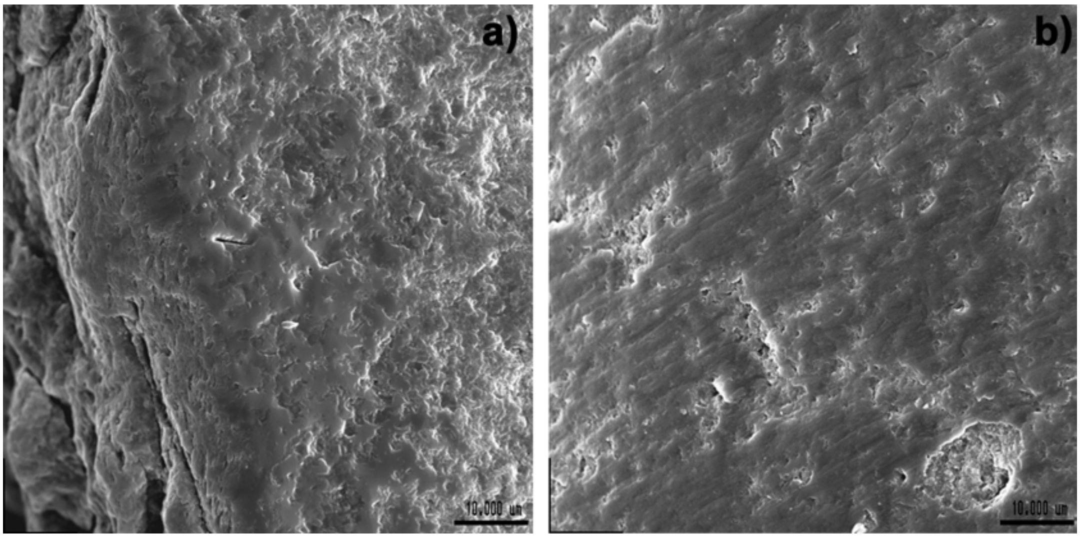


Fig. 6: Use-deformations after scraping fresh (a) and dry (b) hide for 10’ (with tools made of the same kind of flint). The different appearance can be explained by the capacity of water to modify the contact conditions: variations in the elasticity of worked material and the interfacial medium.

and more intense microwear than most actions on wet materials.

In the light of our observations, we think what really causes the presence of liquid is a generalization of the polishing processes at different heights of the microtopography of the lithic contact surface. This occurs not because of the chemical properties of the materials involved but because the liquid modifies the physical contact conditions. The presence of liquid is important because of its capacity to modify the conditions of elasticity and hardness of the worked material, thus rendering it more plastic and increasing the cohesion rate with the tool surface. Liquid also gives a cohesiveness to residues produced during work. This cohesiveness helps to create a homogeneous and plastic interfacial medium and affects the lithic contact surface more homogeneously (Fig. 6).

In wet conditions, the composition of the interfacial medium is pivotal since it can either inhibit wear by acting as a lubricant or accentuate it by increasing the amount of contact surface and increasing its rate of cohesion.

Temperature

This factor is considered important to the wear process especially by supporters of the silica gel model. According to Whitthoft (1967), heat generated by friction between tool and worked material surfaces is sufficient to melt the silica on the contact areas. However, this hypothesis is based on unproven assumptions. As several authors have noted, some of whom are supporters of the silica gel theory, it is difficult to believe that during manual work temperatures above 1,000º C, which are needed to melt silica, could be achieved. Also, in the case of polish caused by cereal working (which is the basis for the authors who propose this theory), melting would happen quickly, continuously and in a generalized way over the whole contact surface, given the speed of formation and the wide extension observed on the edge in this kind of polish. It has therefore been proposed that achieving the fusion point of silica is not necessary and that a moderate increase in temperature would be enough if the real process was silica hydrolysis (Anderson 1980b).

Even the hydrolysis hypothesis seems unlikely, however. As well as a suitable temperature, other conditions that have never been achieved need to be met. Among these is a large presence of water. The solubility conditions of silica are well known from laboratory experiments but, as Masson *et al.* noted (1981, p.46), we do not know how silica behaves at micro level during the work process, so making extrapolations is fairly risky. Even if hydrolysis conditions were reached during the work process, we would have the problem of maintaining them, so the process could extend continuously. It is difficult to imagine that during a manual work such conditions (especially humidity and temperature) could be maintained long enough for taking place silica hydrolysis. If the process were not continuous, or did not affect the whole active zone of the edge, melting would be isolated, affecting only the spots where those conditions were reached. We would then recognise different generations of deposits, and this has not been recorded in our experiments. On the other hand, we should bear in mind that, in the absence of water, polishes similar to those produced by cereals also occur and these cannot be explained by the hydrolysis hypothesis.

For all these reasons we do not believe that hydrolysis is responsible for use-wear or that temperature (at least the

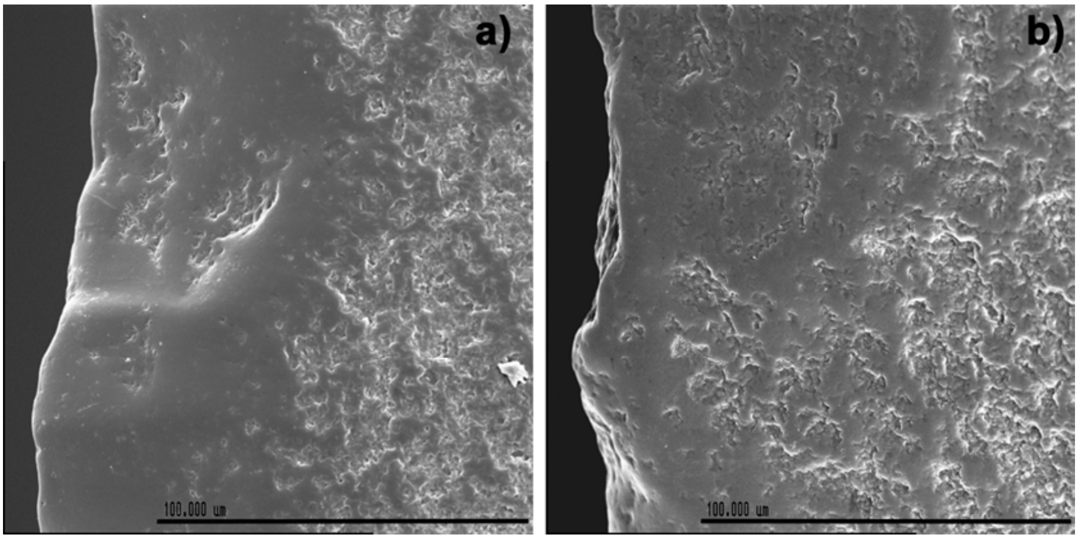


Fig. 7: Microwear after whittling hot (a) and frozen (b) reed *(Arundo donax)* for 10’ (different edges of the same tool). Note that polish do not need high temperatures. Note also that the temperature influences the appearance of the polish by modifying the physical conditions of the surfaces that are in contact and by introducing changes to the interfacial medium.

heat produced by manual working) has a key role in polish formation.

Several experiments have been conducted to evaluate the role of temperature in polish formation. Fullagar (1991) achieved some use-wear on flint edges working on a piece of ice, with no heat and no residues (in the interfacial medium there were only small flint fragments detached from the edge). Levi-Sala (1996) carried out similar experiments but in this case the worked material was soaked hide and the tools were cooled during the process. No differences were observed between use-wear obtained on cooled pieces and use-wear obtained on untreated pieces.

Our own results indicate that a high temperature is not necessary for developing polish (Fig. 7). During activities involving prehistoric lithic tools, temperature is a minor factor since the values we can achieve are too small to significantly modify the conditions of effort. However, like water content, the temperature of the worked material can modify its physical conditions and therefore the contact circumstances, which do actually influence microwear.

Grain size and microtopography of the raw material

Granulometry and the microrelief of the rocks on which tools are produced are considered to influence the dynamic, the rate of development and the final appearance of polish. Depending on the characteristics of the lithic surface we do not distinguish different processes, but different phases of a single process.

Irregular surfaces offer more resistance to displacement than smooth surfaces. The more resistance to displacement, the more pressure on the surface. On irregular surfaces, the pressure is arranged unequally and the effort is concentrated on prominent points. This means that brittle clastic phenomena (microflaking and abrasion) dominate over plastic deformation. At the same time, this dynamic provides the interfacial medium with a quantity of abrasive particles that detach from the tool surface. The interfacial medium is therefore more aggressive, the dynamic is maintained, and even the plastically deformed zones are destroyed by attrition (Fig. 8a). This process continues until the microrelief at the contact zone is regularised due to wear. At this point, the dynamics are reversed and plastic deformation begins to dominate over abrasion.

Smooth surfaces do not usually undergo this first stage of deformation because they already have a regular topography. In such conditions, the surface displaces more easily and is subjected to less pressure than irregular surfaces. At the same time, pressure is arranged homogeneously over the contact area. From the beginning, therefore, smooth surfaces bear less effort than irregular surfaces, so plastic deformation dominates over microflaking (Fig. 8b). This in turn leads to a low transference of abrasive particles from the tool surface to the interfacial medium, which helps to maintain the dynamics of plastic deformation.

Taking into account how surfaces behave in relation to effort, the microrelief of each variety of rock obviously conditions the pattern of polish, especially in its initial stages. From the beginning, the pattern generated on fine-grained flints is linked or very linked. On coarser flints, the wear process takes more time to eliminate the original relief, so at initial phases polish shows open rather than linked patterns.

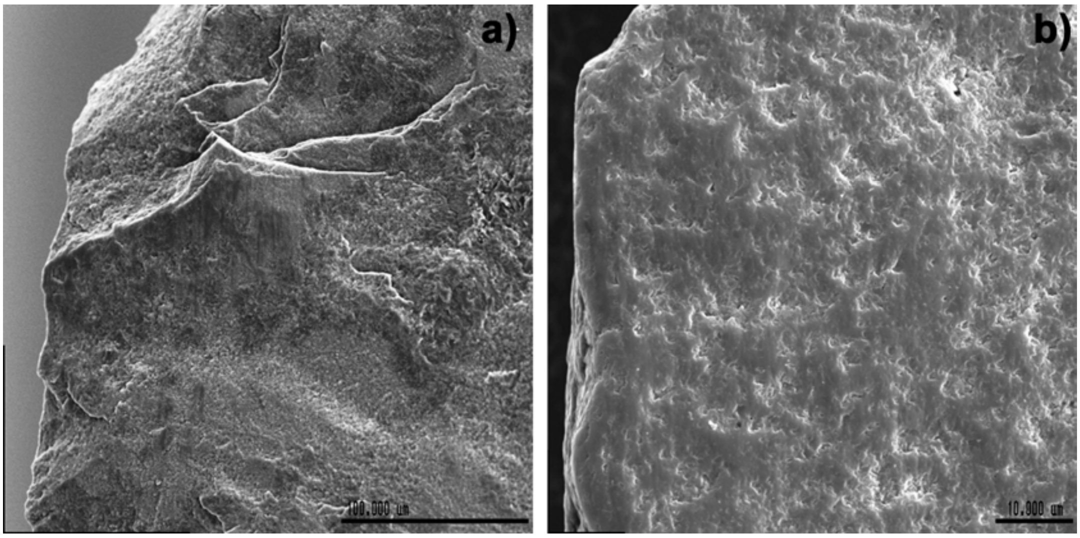


Fig. 8: Use-deformations on flint edges after cutting meat for 15'. On rough and topographically irregular surfaces (a) brittle fracture phenomena are dominant. On smooth surfaces (b) plastic deformation is dominant.

However, before the original relief is completely destroyed, the plasticity of both the worked material and the interfacial medium means that deformation affects the whole surface, especially the topographically prominent points.

It is complicated, therefore, to determine the degree of development of use-deformations and, by extension, the time of work because of the numerous variables involved. We must first take into account the characteristics of the original relief in order to assess its rate of deformation. We must also consider the incidence of the worked material and the interfacial medium during the work process. Moreover, this difficulty increases at advanced stages of wear because the development of plastic deformations decreases as the surface becomes more regular and sometimes disappear after generalized fracture episodes.

Granulometry and microtopography also affect the conservation of the residues of the worked material. Experiments have shown that these residues remain trapped mainly in depressions so, if the conditions needed to conserve these residues in archaeological materials are met, we should expect the coarsest and roughest rocks to provide the best results.

Chemical composition of worked material

The chemical composition of worked material is also thought to be an important factor. This is mainly for polishes caused by plant processing. For other materials, and with the exception of residue studies, chemical composition has hardly been considered.

The amount of silica on herbaceous plants has been considered to be the main cause of the final appearance of sickle gloss (e.g.: Anderson-Gerfaud 1981, 1986; Whitthoft 1967; Kamminga 1979; Vaughan 1981). However, at least from the chemical point of view, this hypothesis was questioned after results obtained by Meeks *et al.* (1982) and Levi-Sala (1996), who reproduced this kind of polish in experiments in which the silica came only from the surface of the flint tool. In our experiments on bipolar knapping, we obtained well-developed polishes with smooth textures that were very similar to sickle gloss via the friction of flint against limestone.

If chemical composition had a really important role in the origin of polishes, it would be difficult to explain the morphological similarities observed among deformations produced by such chemically different materials. It seems clear that, beyond chemical composition, what determines the final appearance of polishes is the size of the abrasive particles, the kind of interfacial medium and the intensity of the load applied. In our opinion, the only possible effect of the chemical composition of the worked material is that it may alter some of the conditions of the interfacial medium.

Conclusions

The evolution of microwear processes has been determined using sequential experiments and surface monitoring through SEM micrographs. The phenomena observed indicate that mechanical processes are responsible for all the use-deformations recorded. No elements were observed to support the involvement of chemical processes, so we reject the silica gel theory. If there were a chemical phenomenon directly related to utilisation, it would be on such a small scale that it would be impossible to document with the methods used in this study. Also, its role in microwear formation and the patterning of different polishes would be minimal.

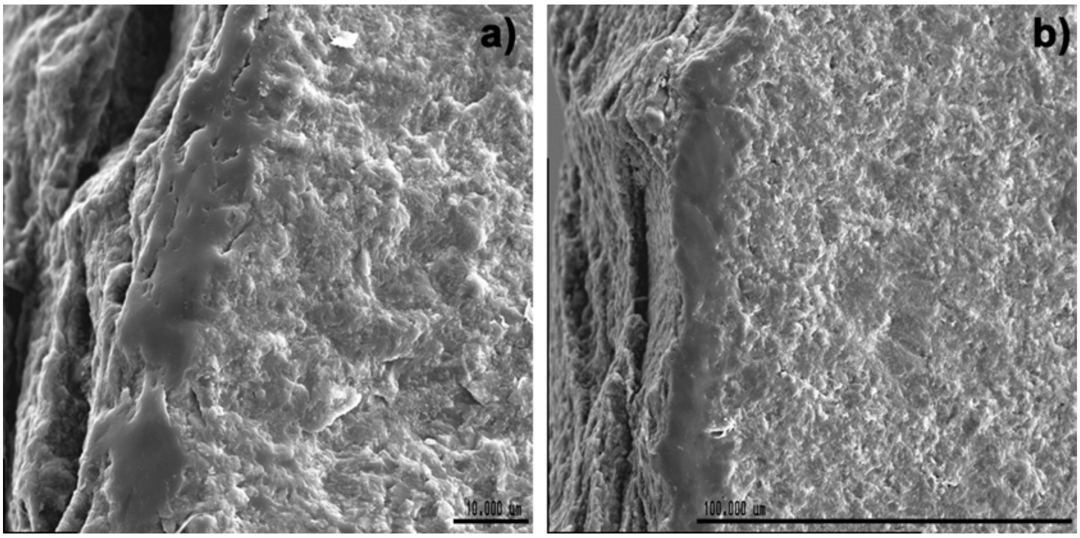


Fig. 9: Microwear on flint edges after friction on limestone (a) and after skinning for 20' (b). A specific worked material can produce very different deformations, whereas chemically diverse materials can produce very similar traces. The chemical composition is therefore much less important than previously stated.

Materials Sciences, particularly Tribology, provide a useful theoretical background to explain surface modification on stone tools subjected to load or stress (see also Knutsson 1988; Fullagar 1991; Yamada 2000). The wide variability of deformations generated on lithic surfaces when they come into dynamic contact with the worked material can be explained in terms of the type of interaction between these two bodies.

During utilisation, there is dynamic contact between the surface of the tool and the worked material. The load placed on the tool causes sliding (or rotation) over the worked material. Resistance to the relative motion of contacting bodies causes friction between the two surfaces. As a result of this friction, the lithic surface undergoes several deformations. These modifications show both brittle clastic (fracturing) and plastic (compression and translocation) behaviour. The combined effects of these phenomena during the working process lead to worn surfaces on the tool by attrition and smoothing.

The interfacial medium is the space that originates in the sliding interface between the two surfaces that are in contact with each other. Some of the particles arising from the removal of asperities are incorporated into this space, as are residues from the worked material. Other elements may also be added either intentionally or accidentally.

In conclusion, from our data, the main variables in the microwear process are: a) the tool (the characteristics and physical properties of the raw material and the morphopotential structure of the artefact); b) the worked material (physical properties such as hardness, stiffness and plasticity, and state properties such as freshness, wetness and dryness, which can modify these properties); c) the action carried out (especially the working angle and tool kinematics); d) the load (the intensity and form of application); and e) the interfacial medium.

The interrelation between these variables determines the contact surface, the range of friction and its adhesion, ploughing and deformation components. The many factors involved in the wear process explain the wide variability of the deformations recorded. They also explain why the same action can produce very different traces and why different actions sometimes lead to the same effects.

A final aspect to bear in mind is that wear is not always a linear and accumulative process. During utilisation there are alternations between episodes in which sometimes brittle fracture and sometimes plastic deformation dominates. When this happens, edge microflaking removes pre-existing plastically deformed areas, thus generating new fresh surfaces with different characteristics from the previous ones. The deformations recorded on a given tool can be very different depending on when they have been recorded and the dominant response of the tool to effort at that moment.

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In the knapper's hands: identifying handedness from lithic production and use

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Summary. *This paper starts from Semenov's pioneering work on recognising handedness from use-wear, experimentation, and biomechanics. It reviews archaeological data for manual laterality in prehistoric hominines based on these three tools. Finally, a case study of laterality in British Lower Palaeolithic handaxes, sharpened with a* coup du tranchet *or* tranchet *blow, is presented. The data are discussed in the context of language evolution and prehistoric cognition.*

Résumé. *Cet article se base sur les travaux remarquables de Semenov sur la reconnaissance de la latéralité par la tracéologie, l'expérimentation, et la biomécanique. Nous présentons une synthèse des données publiées sur la latéralité manuelle dans la préhistoire, en particulier avec la taille de la pierre et l'utilisation des outils. Une étude dans cette direction est ensuite présentée qui s'appuie sur une série de bifaces taillés au coup du tranchet du Paléolithique inférieur en Angleterre. Les résultats sont intégrés dans une discussion de l'évolution du langage et de la cognition préhistorique.*

Key words: hominid evolution, handedness, laterally, flakes, use-wear, knapping, knapping gesture.

Introduction

Handedness is a unique feature of humans. The commonly-accepted proportion of right-handers is between 70% and 90% in populations around the world (Annett 1985, 2002) . Semenov himself had a keen interest in handedness; he mentioned it several times in his 1964 volume, for example when describing the bone retouchers from Kiik-Koba and Teshik Tash: "...in working, the right hand of the Neandertaler played the predominant part, for he held the retoucher in the right hand and the flint being worked in the left" (Semenov 1964, p.173).

However, it appears that Semenov's observations about handedness in his assemblages went largely unnoticed in European and American archaeology until Toth's (1985) publication. Yet despite the interest launched by that paper, there is still little awareness of handedness. In lithic analyses it is often either overlooked or taken for granted (e.g. in assuming a right-handed use of tools). Nevertheless, a body of information about handedness does exist in the literature since Semenov's pioneering studies. The aim of this paper is to provide a brief review of this literature, with a particular focus on stone knapping and use. One method for assessing handedness from lithic production is applied to a case study from British Lower Palaeolithic archaeological material. Finally I will discuss the relevance of these results to studying the evolution of laterality in humans and, more generally, language and cognition in prehistory.

A few definitions

Frame/contents model of handedness

This paper utilises a definition of handedness which characterises it in terms of the complementary roles played by each hand when the hands are acting simultaneously. In the context of human evolution, the term handedness refers to our species-level tendency (in statistically significant proportions) to use the two hands in a consistent manner, not only individually but as a population. The definition used here is adapted from Guiard's (1987) Frame/Contents model of handedness as it applies to skilled lithic manufacture and use. In this model, one hand and/or arm performs movements which Guiard qualifies as high-frequency, being more spatially and temporally precise (i.e. being faster and having a narrower target), whereas the other hand is low-frequency, acting as a stabiliser or support. This is the frame, maintaining the spatial or temporal structure, while the other hand inserts contents into the frame, with relative precision. Most humans tend to learn the frames with the left hand and the contents with the right hand. For example, in handwriting, the left hand (frame) stabilises the paper, actively moving it around, while the right hand (contents) manipulates the pen (Guiard and Millerat 1984; Guiard and Athenes 1985). In stone knapping, most right-handed people wield the hammerstone with the right hand and support the core with the left hand. Left-handers tend to use the opposite configuration, although occasional exceptions do exist (Linda Hurcombe, personal communication). This tendency for humans to have a consistent pattern of upper limb use reflects a laterality in the controller of the upper limbs (the brain). For this reason, any archaeological evidence that bears on prehistoric handedness provides indirect information about prehistoric brain structure and function.

Bimanual action

The Frame/Contents model takes account the actions of both hands without giving priority to one hand. The traditional definition of handedness focuses on actions performed unimanually, describing one hand as dominant. But this description is not suitable for the kinds of tasks that are relevant to archaeology. For example, knapping stone involves complex coordinated movements in both hands, with some degree of precision, spatial positioning, and timing necessary for both the right and left upper limbs.

More specifically, the core hand is responsible for orienting the striking platform using three dimensions. This serves to put the intended point of hammerstone contact into the knapper's visual field and into the path of the hammerstone trajectory. With respect to knapping gestures, Takeoka (1991, pp.503-505) defines three axes of wrist movement which affect the position of the core, and thus the angle at which it receives the hammerstone blows. These are wrist abduction/adduction, forearm pronation/supination, and wrist flexion/extension. When knapping, the axis of wrist abduction/adduction (if the palm is placed flat on a table, this is a side-to-side motion of the hand) affects the direction of fracture force propagation within the core. Forearm rotation affects the angle between the platform and hammerstone trajectory: a more pronated wrist results in an obtuse angle (because the platform is tilted towards the body) while a more supinated wrist results in an acute angle (platform tilted away from the body). Wrist flexion/extension affects the horizontal position of the striking platform, bringing it closer to the knapper's body and directly affecting the flexion/extension of the elbow on the hammer-arm.

The core hand is not restricted to spatial positioning, however. It often makes a brief upward movement in anticipation of the contact moment (Bril, Biryukova and Dietrich, personal communication 2004). In contrast, the hammer-arm performs only ballistic movements during direct percussion, so no real-time feedback is available from the somatosensory, visual, or auditory modalities. This means the knapping gestures are acquired by motor learning of the spatial and temporal accuracy required to meet the target point on the core.

In other words, the moment of contact between the hammer and core results from a bimanually differentiated (Fagot and Vauclair 1991) coordination of the core hand and arm with the hammer hand and arm. This kind of bimanual action, with well-specified roles for each upper limb, characterises prehistoric activities. In fact, very few of the daily tasks of prehistoric people would have been accomplished with only one hand or arm and certainly would have required two-handed coordination (such as working wood and hide, threshing, crafting bone and shell ornaments, basket-weaving, painting, spinning, bow shooting, digging, and grinding grain). One common Palaeolithic task which might appear to be unimanual - scraping hides - also requires this coordination of both hands: one hand to hold and orient the hide, the other hand to manipulate the scraping tool. The degree of bimanual coordination for hide-scraping is likely analogous to Guiard's bimanual model for handwriting with pen and paper mentioned above.

Motor skill

The other aspect of our definition is motor skill, which results from motor learning. Learning is defined as a permanent neuronal reorganisation of motor cortex (Karni *et al.* 1998) which facilitates the execution of the motor task (Magill 1993).

In the context of prehistory, we can assume that most subsistence and cultural activities were learned (as they are in chimpanzees and other animals), which in turn suggests that archaeological artefacts are the result of skilled manufacture and/or use. Furthermore, it is important to note that the division of hand labour occurs primarily in skilled manipulations (Hinckley *et al.* 1997). This is supported not only by the standard measures of hand preference, in which lateralisation increases with task skilfulness (Healey *et al.* 1986; Steenhuis and Bryden 1989) but also by human ethnography (Marchant *et al.* 1995). Studies of wild apes also show that consistent patterns of hand use at the individual level are strongest in skilled, bimanually coordinated manipulations (Byrne and Byrne 1991; Harrison and Byrne 2000; Byrne *et al.* 2001; McGrew and Marchant 1992, 1997a, 1997b).

Keeping in mind our definition of handedness as involving both hands for specific roles, this paper will use the standard terminology of 'right-handed' and 'left-handed' to denote the hand that holds the hammer (in the case of knapping) or the tool (in the case of tool use).

Aims of this paper

Taking into account the learning required for most prehistoric subsistence and cultural activities, and the notion that both hands have equally complex but complementary roles, the main question of this paper is: What is the evidence for handedness in stone knapping, and when did the currently-observed proportion of right-handers emerge?

Indicators of handedness in extinct hominines can be found in several different fields, being either indirect (primatology; ethnology) or direct (osteology; archaeology). Here we will present only data relating to stone knapping and use. Steele (2000, 2003) has already made extensive reviews of the skeletal evidence for handedness, and a more complete review of archaeological evidence can be found in Steele and Uomini (2005).

Evidence for handedness in the Lower Palaeolithic

Here we will focus on the archaeology of the genus *Homo* in the Lower Palaeolithic. We start from Semenov's pioneering methods in reconstructing the kinematics of tool use from use-wear, experimentation, ethnographic observations, and biomechanics. Because the mechanical action of body joints is constrained by physiology, it is useful to incorporate this knowledge into the reconstruction of gestures from artefacts. One main assumption of knapping biomechanics is that the two halves of the body are more or less mirror images of each other. This means that the traces left by the gestures of right and left sides of the body can be identified from either side of a line of symmetry.

In the following paragraphs, published evidence for handedness is reviewed and the results are evaluated in terms of biomechanical validity. There are two kinds of data for handedness in the archaeological record, representing different levels of reliability. Data can reveal the hand preference of an individual, or it can testify to a sum of hand preferences over time or within a group. In addition, data can pertain to either artefacts or people, but these must not be confused. Certain categories of data give better information on one level or the other, and these are clarified in turn below.

Dental use-wear

The traces left on the body are the best way to determine handedness in individuals. Of the many behaviours that can produce lateralised traces, one is caused directly by artefacts. The characteristic striations found on Neanderthal and *Homo heidelbergensis* people's teeth can be attributed to flint and, presuming they were self-inflicted, they bear directly on the individual's hand usage over their lifetime. A valuable reference for this bimanual behaviour is ethnographic observations. Semenov subscribed to the hypothesis that Neanderthals ate meat by holding it between their teeth and cutting off pieces with a knife, because he had personally observed this practice in Russia (quote from Semenov 1964, p.104):

> "Generally pastoral or hunting people (like the nomads of Mongolia, Tibet, Abysinnia and other countries) eat such meat with a knife in one hand. Meat is normally cut into strips, and baked or cured in this form. Then each person takes a piece and, holding one end in his teeth, cuts it free with a quick movement of the knife at his mouth, repeating the operation until the whole strip has been consumed. The cutting is done upwards from below. We have seen this done among Nenetz reindeer herdsmen in the Kanin peninsula in 1928."

This practice exists in many parts of the world, and it appears that the common pattern among living people is to hold the meat with the left hand and the knife in the right hand. This is mentioned in all of the references that specify hand roles. The following eight quotes are drawn from the e-HRAF archive (HRAF 2003).

1. Koryak, Kamchatka (Jochelson 1905-08, p.575)
The women serve cooked meat in the inner tent. After it has been cut into pieces, it is placed on boards, wooden platters, or troughs. The Koryak take hold of a chunk of meat with the left hand, and, holding it with their teeth, cut off a mouthful with a knife held in the right, cutting from below upward. All Siberian natives eat meat in the same manner.

2. Copper Inuit, Canada (Pryde 1972, p.142)
Dinner, then, consisted of a barely warm piece of meat. If it was seal flippers, they still had the hair on them. Each diner had his own knife, usually just a pocket knife, and rather than cutting meat on the plate, would take the whole piece of meat into his mouth, grip it with his teeth and cut off a bite.

3. Kalahari, S. Africa (Fourie 1928, p.100)
...some of the meat for the men is also cooked. As soon as the latter is ready for eating the gei-khoib removes a piece from the pot and "tastes" (tsã-tsã) it. This is done by holding it between the teeth and fingers and cutting off and eating a morsel or two.

4. Amhara, Ethiopia (Messing 1985, p.63)
Iron knives are used at dinner time only at a feast of brindo, raw beef. In former times, and even today, men can be seen cutting off a morsel just in front of the teeth. But women rarely do so, and the meat is usually pre-cut.

5. Somali (Burton 1856, p.98)
...in the left hand they held the meat to their teeth, and cut off the slice in possession with long daggers perilously close, were their noses longer and their mouths less obtrusive.

6. Blackfoot, USA (Lancaster 1966, p.276)
The Chief and Agnes Morning Gun ate the moose meat in the old Indian fashion, holding a piece in the hand, clamping the teeth over a portion of it, and cutting the portion off close before the lips with a sharp knife. Joe, who has no teeth but is very handsome for all that, ate very fastidiously with a knife and fork.

7. Navajo, USA (Bailey 1942, pp.210-11)
Eating: Eating is done daintily and slowly. Small pieces of meat are cut from the larger one with a knife. Sometimes the meat is grasped with the teeth and the left hand and cut off close to the mouth with a knife, cutting toward the face. Sometimes the piece desired is held in the fingers and severed from the main portion with the knife moving away from the body.

8. Bakairí, Brazil (Steinen 1894, p.608)
There was, of course, no longer anything to be seen of stone axes and cutting fish teeth; axes and knives were present in abundance. But all kinds of things from the old days were still to be observed. For instance, the Bororó, when they ate, cut off pieces of meat in front of their mouths with bamboo splinters.

Three archaeological studies have examined the marks left on hominines' anterior dentition, with the assumption that they were caused by this practice of cutting meat with stone flakes. If one dislikes the idea of using the teeth as tools (e.g. Bax and Ungar 1999), there is also the interesting possibility that these marks were made by chipping flint with the teeth, an action which has been observed in 1963 in Plains Indians (Comanche, Apache, and Omaha, USA):

> "...sharpening old flint arrowheads by biting with their teeth against the edge, thus breaking off small particles" and Australian Aborigines (Hester 1973), as well as in Papua New Guinea: "A worker produces a sharp edge on a bamboo knife by using his teeth to detach a splinter from the side of the knife" (Pospisil 1963, p.279). This practice can be identified archaeologically in the form of obsidian microflakes present in human coprolites (Hester 1973) (although we have not yet found any experimental data to confirm this).

Bermúdez de Castro, Bromage and Fernández-Jalvo (1988) experimentally replicated such striations in order to determine the best way to move the hands. A prognathic mouth-guard with fake enamel Neanderthal teeth was worn by a right-hander. The experimental procedure involved holding a piece of meat between the front teeth and cutting off bite-sized pieces with flint flakes. The experimenter made striation patterns consistent with a right-handed downward motion from left to right (when viewed from the front). The authors state that "in the experimental study, the action that would produce striations consistent with a right-handed operator cutting leftwards was uncomfortable and felt less efficient" (p.410). This implies that it would be equally uncomfortable and inefficient for a left-hander to cut rightwards. The inefficiency of the right-handed leftward motion implies a constraint on simultaneous pronation at the wrist and extension of the forearm. A right-hander cutting from below (as described by Semenov) would produce the same pattern moving upwards from right to left, consistent with a right-hander cutting rightward from above, so it is not necessary to distinguish between an upward and downward cutting motion.

The striations occur on *Homo heidelbergensis* individuals from the Sima de los Huesos site, Atapuerca, Spain (19 teeth, assigned to four individuals and 10 unassigned teeth), two teeth from the La Quina 5 Neanderthal (France), one isolated tooth from Cova Negra (Spain), several anterior teeth from five individuals at Hortus (France), and single isolated teeth from Saint Brais (Switzerland), Angles-sur-l'Anglin (France), and two teeth from the buried Shanidar 2 Neanderthal (Iraq). All but two of these fossil samples show striations oriented downward to the right. Angles has horizontal marks. The teeth from Hortus VIII have inversely oriented striations, suggesting this individual was a left-hander (Bermúdez de Castro *et al.* 1988). Fox and Frayer (1997) found that among the teeth of 13 Krapina Neanderthals, six of the individuals have rightward striations, with one showing the opposite pattern. The remaining six individuals showed no predominant pattern. Further evidence comes from the two *H. heidelbergensis* anterior bottom teeth from Boxgrove, UK which were adjacent on the mandible. They also show the right-handed pattern (Pitts and Roberts 1997, p.265).

In total, these three studies sum up only 2 left-handed hominines for 19 right-handers. The number of individuals of unknown or indeterminate handedness is 7 in these studies, but we might assume that the proportion of right to left (10.5 %) is roughly similar in the indeterminate samples.

Lithic use-wear

Because lithic tools can be used by more than one person in their life history, their traceological record contains a sum of usage over time. Therefore they cannot give information about individual hand use, but only show which hand the majority of users preferred, obscuring the traces from minorities. Semenov combined biomechanics with experimentation to identify right-handed wear on about 80% of Upper Palaeolithic hand-held end-scrapers (1964, p.87). Similarly, Phillipson (1997) made reconstructions of biface grip types, taking into account different kinds of butchering gestures such as vertical chopping, scraping, cutting, digging, and scooping. Her experiments revealed biomechanical efficiency in biface use; constraints of use involve the efficient exertion of force and resistance of finger and hand muscles, for example:

> "A line of force from the working edge through the central mass of the tool to the base of the palm of the hand, for example, permits steady pressure to be applied while the fingers are partially freed to rotate the tool in subtle scooping, twisting or scraping motions. A grasp in which the handaxe is compressed between the tips of the fingers and the palm of the hand is needed to prevent loss of control when it is used for heavy cutting or sawing in a direction parallel to the utilized edge. The shock of chopping or digging motions is best absorbed by the front of the palm of the hand or the base of the fingers, although a posture with the fingers well spread and the force falling somewhat further forward is also effective." (p.174)

Drawing on these experiments, Phillipson scrutinised 54 handaxes and cleavers recovered by a 1931 L.S.B. Leakey excavation in Kenya, with a stratigraphy dated to about 1 mya. Starting from the premise that the trailing face, not the leading face, of a used edge, would show greater signs of use, Phillipson reconstructed possible grip types for each piece. Of 54 tools, 6 (11%) could be assigned to probable left-hand use, 45 to the right-hand, and 3 were indeterminate. The high proportion of right-handed bifaces in this assemblage suggests a minority of left-handers among the population of tool users.

Biomechanically-valid data from more recent sites, occupied by *H. sapiens*, confirm that lithic use-wear is a reliable means of measuring handedness. Right- and left-handed use-wear was recognised on rotated flint becs at the Belgian Mesolithic site of Meer (Cahen *et al.* 1979, 1980) and on German and Swiss Neolithic bone, antler, and stone grinding tools (Spenneman 1984). Using S.E.M., D'Errico (1988, 1992) identified right-handed engraving patterns in Azilian pebbles. This approach contains enough detailed information that precise trajectories of hand gestures can be reconstructed (Fritz *et al.* 1993).

Lithic production and knapping gesture

Handedness data from tool production can reveal both individual and population hand use patterns. Reduction strategies can interact with the manner of holding the core in direct percussion. White (1998) experimentally identified four possible bimanual configurations for manufacturing twisted ovates, two for each handedness pattern. These bifaces exist in British sites dated to between 362 kya and 334 kya, and in France from 478 kya to 242 kya. If it is the case that one biface represents one knapper, then the proportions of right-handed twisted ovates should reflect population handedness. The interpretation of handedness comes from the fact that nearly all twisted ovates have a Z- shaped profile rather than an S shape (but see Winton 2004 for alternative suggestions of twisted ovate production). An experimental study on flake production was done by Rugg and Mullane (2001), who studied the skew of the Hertzian cone of percussion. These authors were able to assign 75 % of the flakes to the correct handedness using their recognition criteria, with four left-handed knappers and four right-handers. Although these two studies are based on biomechanical assumptions, these remain to be fully validated and applied systematically to archaeological collections.

Lithic production and knapping scatters

Although there are very few high-resolution sites with *in situ* knapping scatters such as Boxgrove, they are valuable because they can reveal handedness in an individual. Of course, this assumes that one scatter is produced by one knapper. It has been shown experimentally that a knapper sitting on a seat produces a central concentration of debris which is skewed to the side of the knapping hand (Fischer 1990). When sitting directly on the ground, with the core-side leg folded and the hammer-side leg straight out, a clear triangular scatter appears (Newcomer and Sieveking 1980; Wenban-Smith 1997), in which the scatter is skewed to the core-side and ends abruptly against the hammer-side leg. A pattern consistent with a right-hander was found at Boxgrove, UK. The Boxgrove bifaces are the object of our case study for identifying handedness in *tranchet* flakes, which is described below.

Knapping and bimanual configuration

Cornford (1986) describes evidence for handedness from two kinds of sharpening flakes. The site of La Cotte de St. Brelade, France has a long stratigraphy spanning the last two interglacials (from OIS 7 at 240kya to OIS 6 at roughly 122 kya), with numerous Levallois and other artefacts, as well as a few Neanderthal remains, indicating that the knappers were intermediate between *Homo erectus* and Neanderthals. A characteristic feature of the site is resharpening, as later assemblages show the production of sharpening flakes in order to rejuvenate side-scrapers.

These scrapers possess a burin plan, which is termed an either longitudinally (LSF) or transversely (TSF) struck flake along the working edge which creates a fresh sharp margin. The hand used is constrained by the holding position when knapping; the LSFs were removed from the proximal edge (the edge gripped by the core hand) in 79% of cases, and Cornford's replication experiments showed that the knapper was unable to make LSFs when gripping the distal edge. Analysing 1590 unbroken flakes (1302 LSFs and 288 TSFs) from several layers at the site, Cornford found between 71% and 84% of right-biased flakes. In this assemblage the number of individuals is also unknown, so we must be cautious in extrapolating numbers of people from the numbers of flakes at this site.

Coup du tranchet: Materials and methods

We have adapted Cornford's (1986) methodology for our analysis of *tranchet* flakes on Lower Palaeolithic bifaces. The *coup du tranchet* on these bifaces takes the form of a removal, similar to a thinning flake, from one edge of the tip, taking part of the edge and part of the opposite face. This leaves a clean, sharp cutting edge that needs no further retouching. Pradnik knives are also made with this method (see for example Urbanowski *et al.* 2005) which produces their cutting edge, in a form similar to the La Cotte scrapers .

The resulting flakes are very distinctive when complete. Fig. 1 shows one right-handed and one left-handed flake from the Boxgrove assemblage. They can even be identified from just their proximal part. On the ventral face of the *tranchet* flake, one edge retains some of the used tip of the biface, and the other edge has a normal flake termination. When the bulb of percussion is present, the flake can be oriented to its exact position on the biface. Figs. 2 and 3 show a typical hand configuration for producing a *tranchet* flake with a soft hammer, and the resulting negative on a biface.

The interpretation of handedness comes from one assumed constraint, which matches that found by Cornford (1986): that removing a flake from the tip is much more easily done on the proximal edge, because it is necessary to hold the biface with the tip pointing towards the knapper's body. This constraint has been

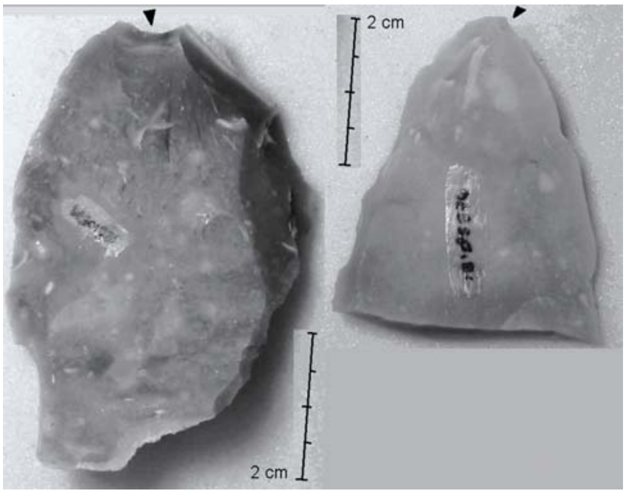

Fig. 1: Example of left-struck (# 10579) and right-struck (# 5876) tranchet flake, Boxgrove Q1B. Photo N. Uomini. Used with permission from M.B. Roberts.

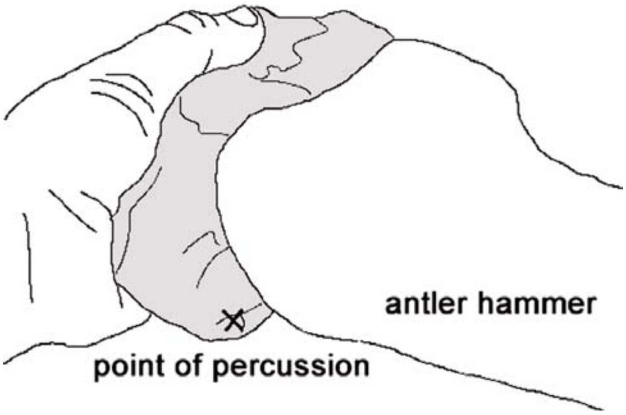

Fig. 2: Example of the hand position for tranchet removal on a biface.

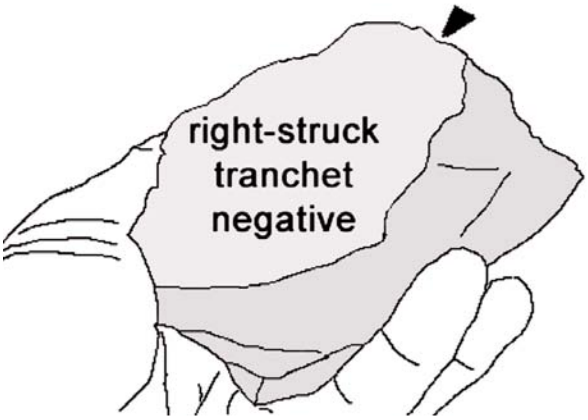

Fig. 3: Example of viewing the tranchet negative from the tip, just after tranchet removal.

identified based on personal observations, communications with other stone knappers, and experimental trials (Uomini 2005). In this case, when the knapper holds the biface in the left hand, he/she will tend to strike the *tranchet* flake from what s/he sees as the

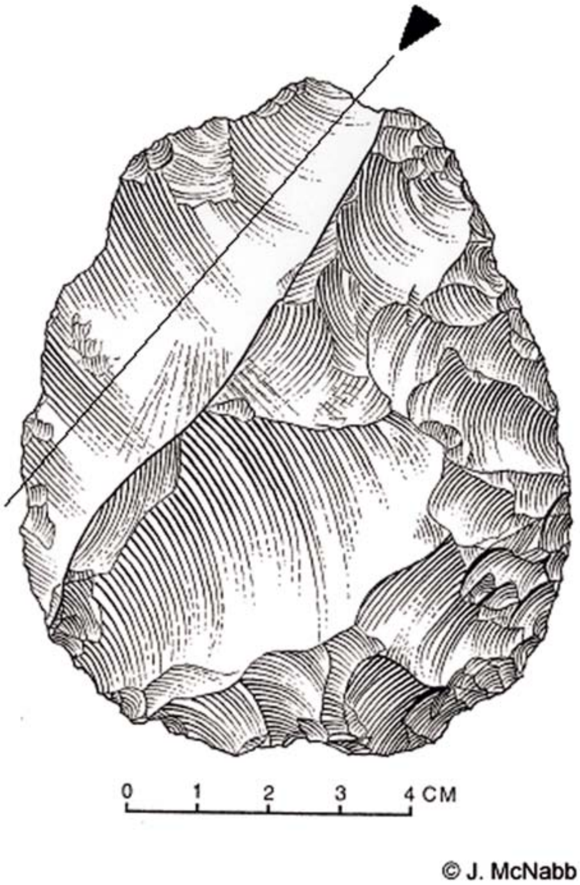

Fig. 4: Tranchet negative on the "Black Ovate", found *in situ* at Swanscombe. Image copyright J. McNabb. Used with permission from Antiquity.

right edge. The result is a negative *tranchet* scar running down the left edge of the tip of the handaxe, when viewing the handaxe with the tip up and the *tranchet* scar face up, as done in the our archaeological analyses. Fig. 4 shows a right-struck *tranchet* negative on a biface from Swanscombe (UK). Figs. 5a and 5b show a left-struck and a right-struck *tranchet* negative on two Boxgrove bifaces.

Many of the bifaces studied have two *tranchet* removals. These can consist of two identically-handed negatives, which result in an asymmetrical pattern when viewing the handaxe from the tip (such as in Fig. 6, from High Lodge), or one of each right and left, which results in a single cutting edge. Fig. 7 illustrates the different possible combinations of right and left *tranchet* blows, as seen from the tip of the handaxe with the two faces on either side of the edge.

For the analysis of these two sites, I simply counted right- and left-sided *tranchet* flakes and negatives and computed their ratio in the assemblage. Bearing in mind that this ratio represents flakes rather than people, we would require further leaps of interpretation in order to estimate the ratios of right- and left-handed knappers. In

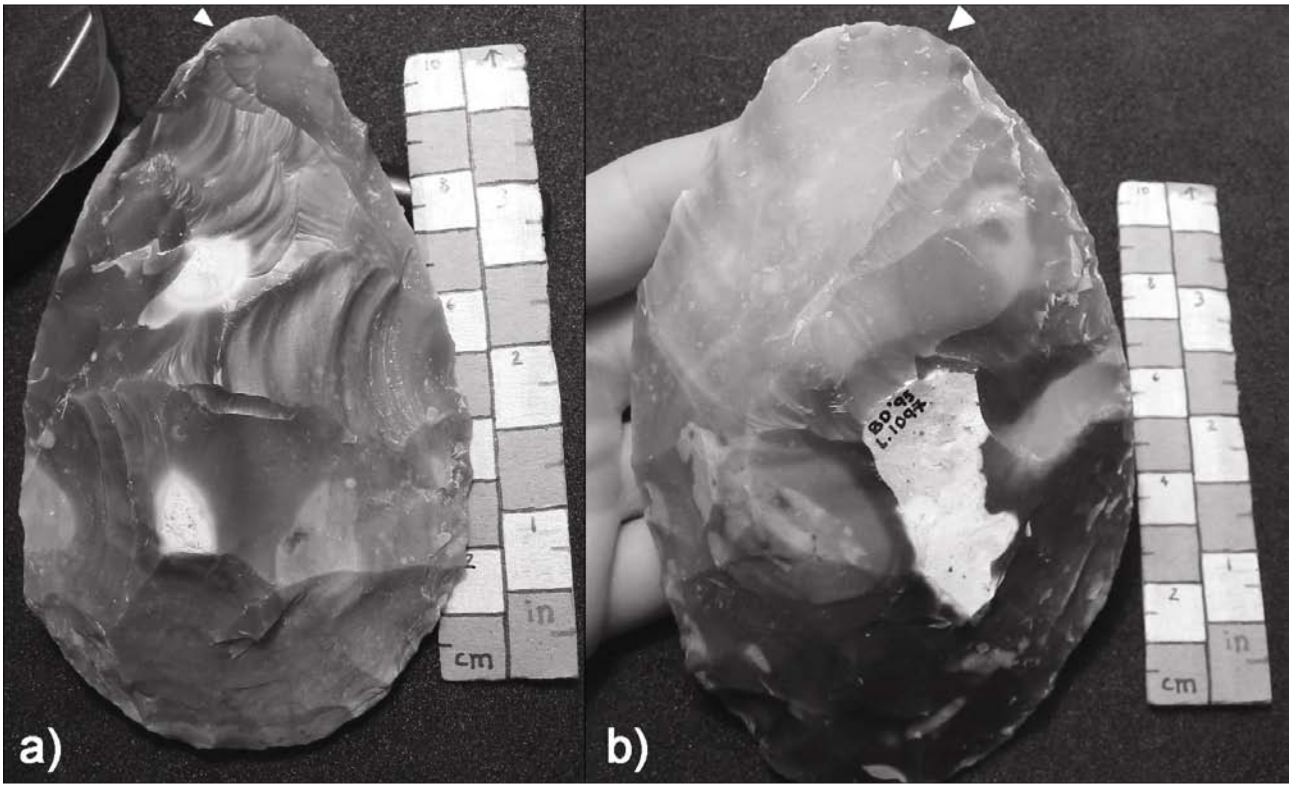

Fig. 5: a) and b) Tranchet negatives on Boxgrove biface numbers 5269 and 1097. Photo N. Uomini.
Used with permission from M.B. Roberts.

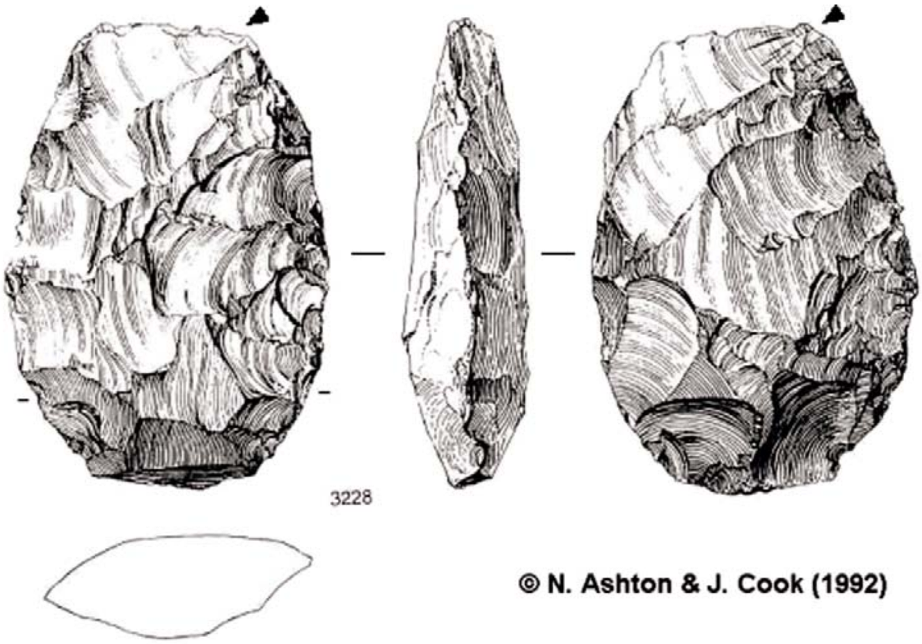

Fig. 6: Biface number 3228 from High Lodge. Image copyright N. Ashton & J. Cook 1992.
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this research I have not attempted to make such estimations, but we could envisage a future calculation, based on the appropriate kinds of experiments, taking into account the number of flakes produced by each knapper and the time span within the assemblage in order to estimate numbers of individuals.

The Boxgrove assemblage consists of artefacts from sites with different degrees of temporal and spatial resolution (Pope 2002). Given that many of the handaxes share features suggestive of individual knapping styles (M. Roberts, personal communication, and personal observation 2005), it is likely that some of the Boxgrove

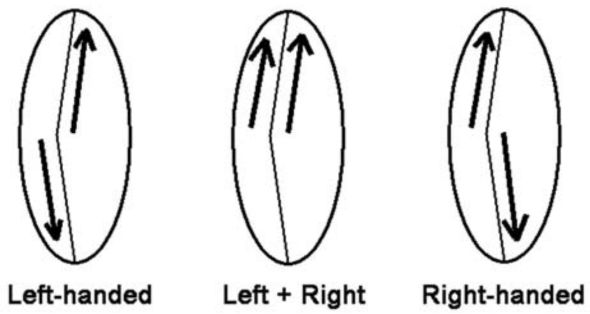

Fig. 7: Schemas of the possible combinations of sharp margins created by two tranchet blows, viewing the tip of the biface.

knappers made more than one handaxe. However, there has not yet been a formal study to estimate the number of knappers at Boxgrove. In addition, we do not know what kind of cultural constraints or mental templates existed which might have imposed asymmetrical flaking (J. Pelegrin, personal communication), or how biface use determined which edge needed resharpening. Therefore it is impossible at this point to make any statement about the number of right- and left-handed knappers at these sites.

Assemblage

Boxgrove (UK) has been described in Roberts *et al.* (1999) and some of the main results published in Roberts *et al.* (1997). The site has thousands of lithics from horizons dated to Oxygen Isotope Stages 13 to early OIS 12, including some *tranchet* flakes that were conjoined to a handaxe; a partial tibia of *Homo heidelbergensis*; two teeth from the same individual with right-handed striations mentioned above; eight *in situ* knapping scatters including the one with the right-handed outline, and an *in situ* horse butchery site with scatters containing all stages of biface debitage except for the bifaces themselves.

The object of this study was a sample of 79 flakes from site Quarry 1B which were previously identified by Dimitri De Loecker. We also include data on 43 additional flakes from Quarries 2C and 2D. We studied 50 handaxes, which come from sites Q1A (n = 9), Q2A (n = 1, with its refitted *tranchet* flakes), Q1B (n = 37), and Q2C (n = 4). Most of these bifaces have two visible *tranchet* negatives, often one heavily used.

Results

Boxgrove flakes

Among the sample of 79 *tranchet* flakes for the present study, 26 were struck from the right (attributed to right-handed knapping) and 40 struck from the left (attributed to left-handed knapping). Thirteen flakes were unable to be assigned, for various reasons such as absence of bulb or margin. Among the 66 Boxgrove flakes that I counted as *tranchet* flakes, the numbers of right and left struck flakes are not statistically different from chance according to the binomial test (two-tailed p = .109) and the chi-squared test: $\chi^2(1,\ N = 66) = 2.970,\ p = .085$. Adding to these figures the previous data from Wenban-Smith (pers. comm. 2005), the proportions are summarised in Table 1.

Data source	Quarry	Left-handed	Right-handed	Indet.	Total
Wenban-Smith	2C	12	18	0	30
Wenban-Smith	2D	8	5	0	13
Uomini (this study)	1B, 2	40	26	13	79
percentages (Uomini)		61%	39%	--	--

Table 1. Right and left biased Boxgrove tranchet flakes.

The breakdown of layer provenance for the 79 flakes from Q1B and GTP17 is presented in Table 2.

Layer	age (OIS)	Left	Right	Indet.	Total
middle unit 4	13	22	18	5	45
middle unit 4-3c	13	0	1	0	1
Q2, GTP17 unit 4b	13	2	2	1	5
upper unit 4d1	13	2	0	0	2
middle unit 4u	13	6	3	2	11
upper unit 5a	late 13	2	2	2	6
upper unit 8a	12	2	0	0	2
upper unit 8ac	12	1	0	0	1
unlabelled		3	0	3	6
TOTAL FLAKES		40	26	13	79

Table 2. Layer breakdowns for Boxgrove tranchet flakes in the present study.

Boxgrove bifaces

From the Boxgrove Q1B site, a sample of 50 handaxes was analysed for the present study. In this sample, 28 have evidence of two *tranchet* negatives. Of these, 2 have two Left scars (LL), 8 have the first Right then Left (RL) order, 12 have the LR order, and 6 have RR. Twenty-two handaxes have only one negative scar, and these occur in equal proportions (11 struck from the right and 11 from the left). The data are presented in Table 3, which also shows unit and quarry breakdowns.

Quarry	L	LL	RL	LR	RR	R	Total
1A	4	0	1	0	0	4	9
2A	1	0	0	0	0	0	1
2C	0	0	1	1	1	0	3
1B unit 4	3	1	4	7	3	3	21
1B unit 4b	3	1	2	4	2	3	15
1B unit 4u	0	0	0	0	0	1	1
TOTALS	11	2	8	12	6	11	50

Table 3. Right and left tranchet negatives on Boxgrove bifaces.

Because of the small numbers in each category, it is not possible to make a statistical evaluation of the data. However, the disparate figures compared to the flake data reinforce the need for more detailed analyses of the mode of manufacture for *tranchet* blows, in particular of the precise holding configuration and the biomechanics of the gestures required to produce a successful *tranchet* flake.

Discussion

To summarise the published archaeological data for handedness in the Lower Palaeolithic, the evidence from individuals clearly shows high proportions of right-handers. The data from tools and flakes also reveal minorities of left-handed lithic production and use. It is unclear whether these represent actual proportions of people, or simply that right-handed hominines were the ones who knapped, or if the left-handers knapped right-handed. More contemporaneous sites from other countries are urgently needed for comparison. We also need data from earlier sites and from other species of hominines in order to find changes in proportions over time. In any case, the presence of predominant right-handedness in the Lower Palaeolithic implies that modern brain structure was already in place.

Researchers in language evolution often make a link between this laterality and human language, although the exact nature of this common substrate is rarely specified. One of the longest-considered of the proposed common substrates is in left-hemisphere systems for manual and speech gestures (Hécaen and de Ajuriaguerra 1964; Zangwill 1960), an idea which was publicised by Broca (1863). Indeed, Kimura (1982) found close associations between aphasia and manual motor control defects. There is also the possibility that language areas are shared with tool-use systems (e.g. Frost 1980), as evidenced by disorders of ideomotor apraxia and conceptual apraxia (Johnson-Frey 2004). New data and theories from apraxia of speech (Ballard *et al.* 2000; Deger and Ziegler 2002) will certainly give information on speech and sequential ordering such as in knapping. Furthermore, the cerebellum is also known to play a role in symbol transmission for language, speech, and motor control (Leiner, *et al.*1993).

The role of the right hemisphere is also important, as suggested by LeDoux, Wilson and Gazzaniga (1977) for mapping spatial contexts onto perceptual and motor hand actions. Here it is useful to discuss the bimanual nature of skilled activities, for example for theories of language evolution that invoke manual-gestural communication as the precursor to speech (Hewes 1973; Kimura 1979; Armstrong *et al.* 1995; Corballis 2002, 2003). The neural substrates of such a system might possibly be found in mirror neurons (e.g. Arbib 2005). Other cortical areas that could be candidates for common substrates of language and knapping are parietal association cortex (Aboitiz and García 1997; Vandervert 1999).

In terms of conceptual common substrates, there are several possibilities. Greenfield (1991) suggests that a grammatical ability underlies both complex tool use and language, in that both require a hierarchical ordering of objects or symbols. A similar idea exists in Gibson's (2002) proposal that human linguistic and technical customs are based on the fragmentation of objects, actions, or ideas into component parts which are recombined into increasing levels of constructs. With respect to bimanual skilled actions, Guiard's frame/contents model for stone knapping can be integrated into Wray's (1992, 2002) Focussing Hypothesis of asymmetrical language functions, in which the right hemisphere manipulates the holistic or spatial elements (frames), and the left hemisphere the analytical or sequential elements (contents). Using these concepts, it is expected that a hypothesis of bimanual and linguistic behaviour evolution can be constructed which can be tested with archaeological data.

The review of literature in this paper shows that Semenov was the first and most important scientist to show the potential of combining experiments, use-wear, and ethnography to study handedness. There is a vast amount of untapped information in S.E.M., experiments on knapping and use-wear, and from courageous experimenters who try things like flaking with their teeth. It is hoped that this paper will encourage researchers to remember to study this aspect of their data and help elucidate the evolution of handedness in humans.

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Kinematics in use-wear traces: an attempt of characterization through image digitalisation

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Summary. *This paper attempts to contribute to a more accurate description of kinematics through the analysis of certain surface alteration features at a microscopic observation level. Surface alteration is the basic concept that guides this proposal. Surface alterations are registered by means of digital images showing changes in reflection light that configure a particular texture whose variation keeps a relation to a particular use (kinematics and worked material).*
Digital images are transformed into a map of pixels, each of them corresponding to a specific luminance value in a grayscale of 256 tones. The selection of groups of neighbouring pixels with similar luminance values makes up defined areas named elements of texture or texels, which refer to use-wear alterations.
Texels have linear structures, clearly related to kinematics. Also, we can translate these structures of the texel to a numerical form, through a computerized process. This allows to apply a statistic processing to the data base of all the selected texels.
The attributes that best describe kinematics are elongation and major axis angle, with independence of the worked material. This methodology was tested on obsidian experimental flake tools.

Résumé. *Dans ce nous prétendons faire des contributions pour une meilleure description de la cinématique en l'analyse tracéologique à travers la considération de certaines caractéristiques des altérations microscopique en surface. Ce concept – altération en surface– est primordial pour guider notre propos. Les altérations en surface sont enregistrées par moyen d'images digitales qui montrent des changes en la réflexion de la lumière, lesquels configurent une texture particulière qui peut être rapportée à un usage concret –cinématique et matière travaillée.*
Les images digitales sont transformées en une carte de pixels, dans laquelle chaque pixel correspond à une intensité spécifique de lumière dans un échantillon à 256 valeurs. La segmentation d'aires de l'image qui présentent des caractéristiques de luminosité similaire est l'opération pour extraire les «texels», lesquels sont liés aux altérations d'usage.
Les texels présentent structures linéales qui sont en rapport à la cinématique. Ces structures montrent certaines caractéristiques que nous pouvons traduire à un langage mathématique, moyennant un processus informatisé. Celui ci nous permettra appliquer un processus statistique aux bases de données des texels.
Les caractéristiques qui montrent la cinématique sont l'élongation et l'angle de l'axe majeur, indépendamment de la matière travaillée. Cette méthodologie a été prouvée sur une collection expérimentale d'outils en obsidienne.

Key words: kinematics, use-wear alteration, obsidian, digital images, elements of texture.

Introduction

In our discipline, there are two main aspects we are interested to infer from use-wear analysis: worked material and tool kinematics. For kinematics we mean the expression of the dynamic interaction between two material surfaces coming in contact: tool and worked material. Therefore, without kinematics use-wear could not exist. In spite of this basic fact, kinematics study has received little attention and has been left in a second place in Western literature of our discipline.

Kinematics effects on tool surface alteration are very significant since they inform us about the way human labour was performed and changed in the past, through the inference of work movement. In this sense, we look for recovering Semenov's original approach, whose main issue was to establish the way tools were used in the past to reconstruct a history of technology and the development of tools along History (Semenov 1957/1981, p.7).

The results presented here come from an exhaustive experimental work with digital images of replicated lithic tools as a first step before their application onarchaeological materials. The purpose of this paper is to contribute to a more accurate description of kinematics through the analysis of certain surface alteration features at a microscopic observation level. The same features can be seen when observing the lithic tool surface with an optical microscope.

Criteria to infer kinematics

Although there are many aspects that influence use-wear development, we basically consider two aspects that determine the formation of use alterations: properties of worked material and tool movement, that is kinematics.

Despite its well known importance, kinematics has received a minimal attention in use-wear analysis, when compared with the emphasis on the worked material effects, which have traditionally been considered more relevant. In microscopic observations, the description and analysis of striations has been the main criterion to determine the orientation and movement of the tool during use (Semenov 1957/1981, p.33, pp.37-49, Keeley 1980, pp.22-23).

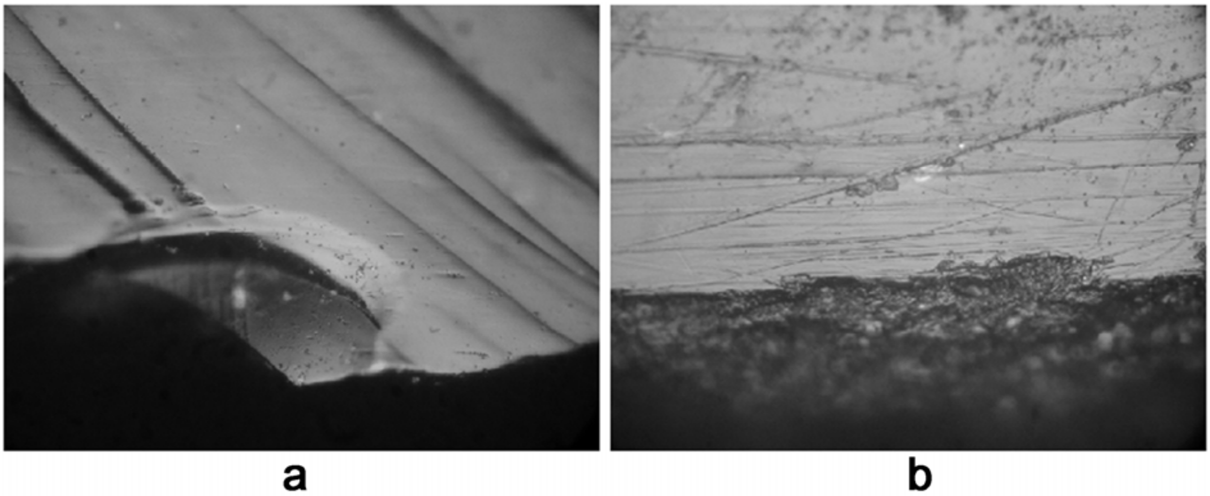

Fig. 1: Experimental used obsidian tools at 250X on: a)- Edge damage and linear structures developed on the micropolished areas with a parallel orientation to the edge, showing a longitudinal movement -the worked material is hard fresh wood. b)- Striations disposed parallel to the edge, showing a longitudinal movement also (the worked material is dry skin).

However, this fact does not mean that striations are the only one criterion to deduce movement. Also, inference of tool movement can be obtained from a global observation of use alteration. For instance, the orientation of the edge damage or the linear structures developed on micropolished areas, which sometimes can be observed (Fig. 1), are good indicators of kinematics. Usually, micropolish areas are aligned with the direction of kinematics. We say that micropolish adopts a linear structure related to the movement – transversal, longitudinal, circular,…–.

Nevertheless, the experience has taught all of us that those features which permit the inference of kinematics cannot be totally dissociated from those that permit the inference of the worked material during the observation process. In other words, the information of both aspects of use is shown juxtaposed. Consequently, we prefer to conceptualize the terms surface alteration to denote the changes on the lithic surface due to work. We do not agree with a division between micropolish and striations as two distinct phenomena; simply, we prefer to extract two distinct aspects from surface alteration: worked material and tool movement. Another reason for the choice of the concept of surface alteration is that it integrates, in a global definition, all use alterations in any lithic raw material. Surface alterations manifest themselves as a change in light reflection on the lithic surface when observed through the optical microscope. For instance, we consider that “matt surfaces” (Vaughan 1981), “plages d’abrasion” (Mansur 1988, p.41), or “attritions” (Hurcombe 1992), defined in obsidian analysis, are the same phenomenon: surface alteration.

The recognition of use: playing with images

In a conventional analysis of use wear traces through the microscope, the ability of the analyst to recognize them, depends on the accumulation of observations through time, that is his/her own experience. The analyst learns to distinguish use wear from iteration and comparison of images looked at archaeological tools against images from an experimental reference collection. By comparing many images, functional analysts learn how to distinguish among different uses based on a previous knowledge about the origin of the images (experimental control), which is a guide for the recognition of use-wear. Therefore, *image recognition* becomes the pivot of our work.

Taking into account that surface alteration of a used tool is perceived by the observer as a change in the light reflection in the image returned by the microscope, the study of images turns into the main element of the analysis.

Given that any image is no more than a map of light reflections, we argue that *image analysis* should be seen as the main procedure. The nature of the digital image is not different from any other one: a digital image and that perceived by our eyes are both representations of Reality.

The specificity of a digital image is that it should be seen as a spatial disposition of pixels, that is to say, points with an intensity value which refers to a greyscale of 256 values (Fig. 2). In this sense, input images are digital files, that is a series of numbers representing some aspects of Reality. Consequently, by using images as input we follow a strictly quantitative objective approach to use wear description.

Surface alteration features are then represented as distinct areas with particular luminance intensity, which differ from the pattern of luminance linked to a surface without use. By using image analysis, specific areas which correspond to concrete thresholds (Fig. 3), within the mentioned greyscale of 256 values, can be separated from their neighbouring zones. Thanks to this, we extract

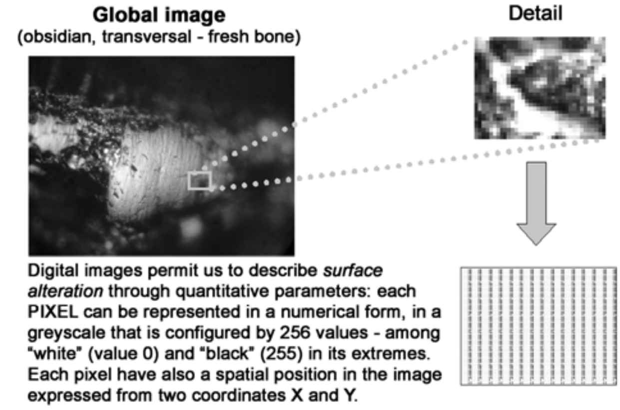

Fig. 2: The basis of the digital image language.

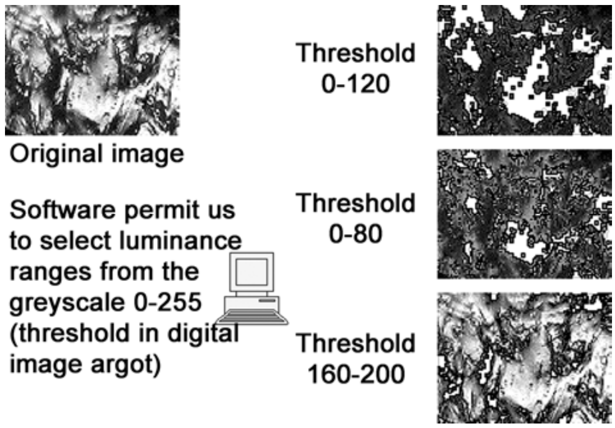

Fig. 3: The thresholding process.

quantitative information from the digital image that remits us to certain characteristics of the surface alteration.

But all methods have their own drawbacks. In the case of quantitative image analysis, it should be taken into account that the selection of relevant areas depends on the specific luminance intervals or thresholds used. The criteria for selecting a concrete luminance interval lay basically in our previous knowledge about characteristics of surface alteration. We have to look for those luminance defined areas which coincide with real alterations on the surface of the tool. Our previous experience indicates that some luminance intervals describe better some specific alteration features, whereas other intervals can be better used to reveal other features.

Consequently, we have experimented with different grey level thresholds to obtain several image segmentations. Each threshold corresponds to a different luminance band. In each case, image segmentation is used to associate pixels with the same grey level and defines areas with comparable luminance variance. We call them texture elements or *texels* (Barceló *et al.* 2001, p.71). As we can see, the elements of texture vary according to the concrete interval we were analyzing in the same image (Fig. 4).

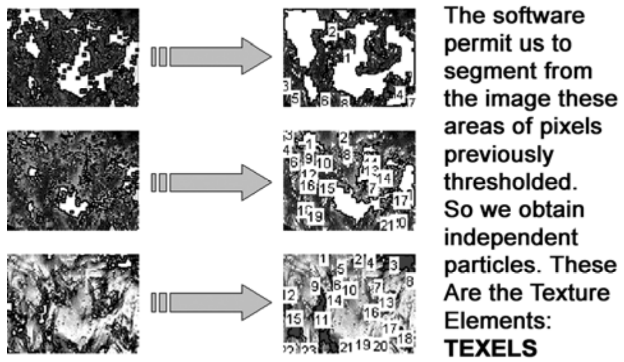

Fig. 4: The segmentation process.

By Shape:	By Composition:
- Elongation - Circularity - Quadrature - Ratio Compactness/Thinnes - Irregularity - Rectangularity, measured through two equations - Ratio Perimeter/Elongation - Feret diameter - Minimum rectangularity	- Mean, mean of luminance - SD, standard deviation of luminance - Mode, mode of luminance - Min, minimum luminance value **By magnitude:** - Area - Major axis - Major axis perpendicular to the major axis - Perimeter

Fig. 5: List of features by parameter.

Detected texels can be described on the basis of four parameters:

- Shape
- Magnitude
- Location
- Composition

Several variables are related to each parameter. The list is long (Fig. 5). For instance, the magnitude of each texel can be measured in terms of their axes and perimeters; the shape of each texel has to be studied in terms of its elongation value, circularity, quadrature, rectangularity, irregularity, thinness, and other morphological calculations which imply the use of ratios. Composition variables refer to the central tendency and dispersion of luminance values within each texel.

All those features should be studied on the basis of the hypothesis that are connected with surface alterations caused by worked material and kinematics. Based on five years of measurements and quantitative analysis we know that not all features have the same explanatory power. Some of them can be used for studying differences due to worked material effects, whereas other features reflect kinematics variations. We will focus on the latter ones.

By using specific image analysis software, all these features have been measured from all the available images for each selected texel. The purpose is to integrate in a database all texels segmented in images from tools used in the same way. It is important to insist on the fact that we have considered many images for a single tool to maximize variation within the same use-wear category.

How to describe kinematics? Our results

In the preliminary phase of our research project, we hypothesized that among the parameters that potentially could carry more information about the movement of the tool were those which take into account direction. Nowadays, we know that *Angle* and *Elongation* features are those which best describe kinematics (Fig. 6). But for arriving to these conclusions we had to do some statistical analysis.

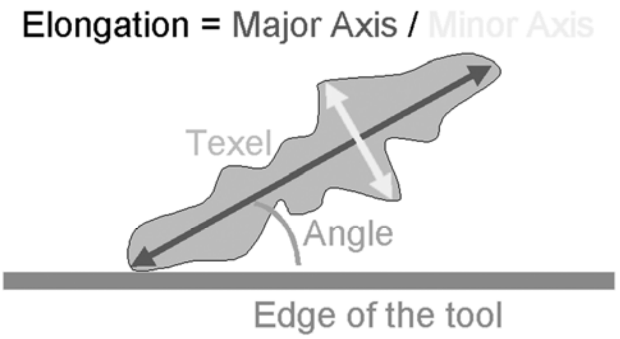

Fig. 6: Relationship between elongation and angle. Smaller values for *angle* mean the major axis of texels tend to a parallel orientation to the edge of the tool, which represents a longitudinal tool movement. Higher values for *angle* indicate a tendency to perpendicularity of the major axis of texels respect to the tool edge, so thus the tool was used in a transversal movement.

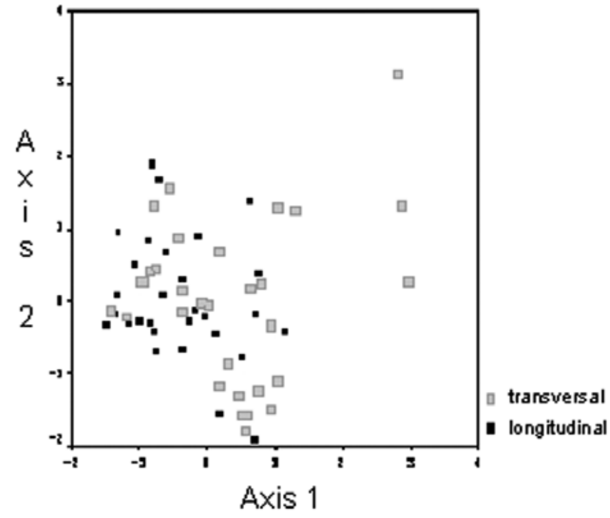

Fig. 7: First multivariate results.

We have been working on this matter –digital images studies– applied to use-wear analysis for the last eight years (Pijoan-López 2000; Barceló *et al.* 2001; Pijoan-López *et al.* 2004). Firstly, we obtained some preliminary statistical analysis of texel shape and magnitude variation on flint tools, which showed some overlapping between cutting and scrapping tools. These results suggested us that standard statistical tests were not the optimal method for our purpose (Pijoan-López *et al.* 2002). However, a multidimensional statistics provided support for our preliminary hypothesis: the elongation-angle relationship explains a 42% of total observed variance. A single variable explained by itself 23% of total variation: the angle between a texel major axis and the edge of the tool (Fig. 7).

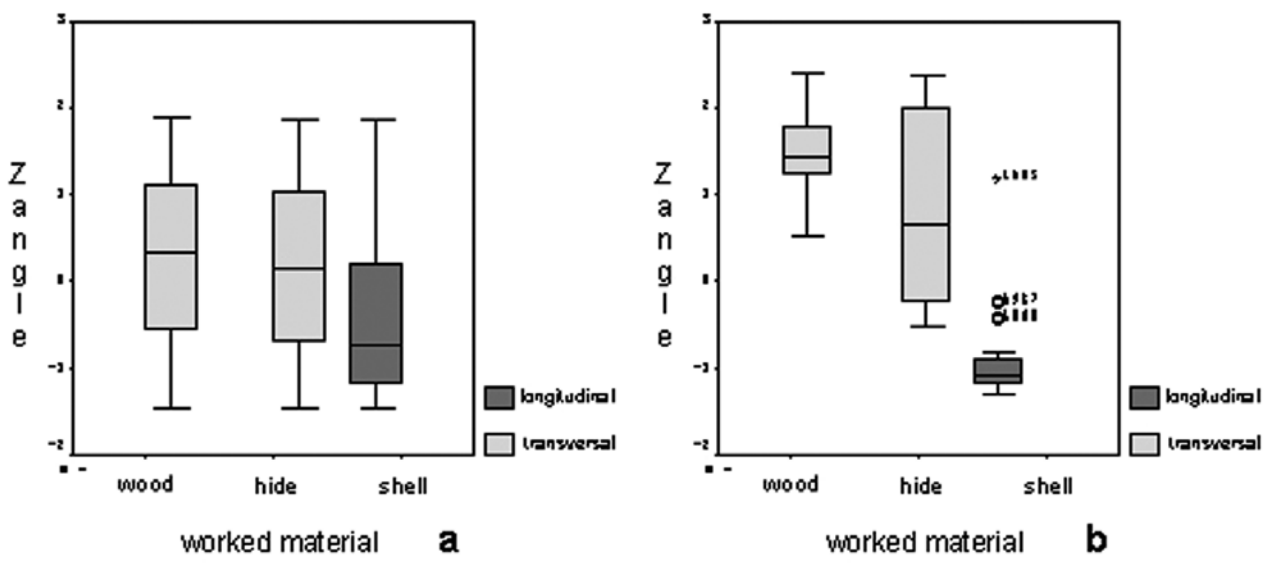

Fig. 8: Box diagrams showing the distribution of texels according to angle by movement and worked material, a)- with all the texels; b)-taking out texels with elongation values lesser than 2

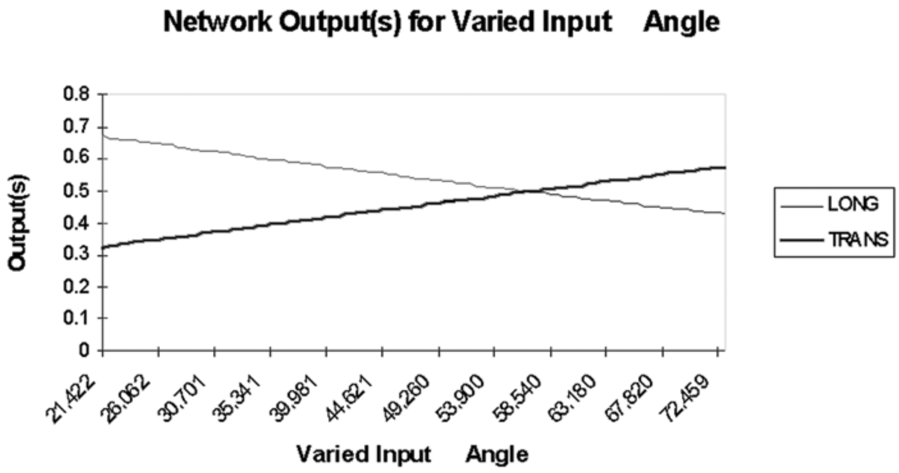

Fig. 9: Graphic for the Neural Network results.
The lines indicate the probability of texels to be correctly classified depending on the angle.

Subsequently, we extended the analysis to statistical variations and surface alterations in volcanic rock tools (Toselli *et al.* 2002). Concretely, we worked with tools made on obsidian and three varieties of basandesite rocks. All tools were used on the same materials: fresh wood (transversal motion), hide (transversal motion) and shell (longitudinal motion). Those analysis showed that not only some texel features were not necessarily related to kinematics, but even that some texels were clearly independent from kinematics variations. When we took away from the analysis non-elongated texels – those with elongation values less than 2 (normalized elongation) –, statistical differences increased notably, suggesting that only elongated texels were directly linked with movement, whereas non-elongated ones were the consequence of other causal factors (Fig. 8).

From this first approach, we also learned the chosen amplitude for the luminance interval was very important, because the information that we extracted from the image could be very different in each case. On the one hand the luminance interval 0-120 provided worse results than the interval 0-80, because it included some selected texels which were not optimal indicators of kinematics. On the other hand the interval 160-200 showed that texel values closer to black also permitted the verification of a relationship with kinematics, although the results were not as clear as those of the interval 0-80 (Figs. 3 and 4).

After these statistical applications, we also tried with Non-Linear discrimination methods. This was the origin of the Pedra Project (Barceló and Pijoan-López 2004). The idea was to implement a Neural Network for classifying surface alteration features according to longitudinal and transversal kinematics on lithic tools. Different network topologies and different learning algorithms were experimented in order to obtain the best algorithm, that is the algorithm providing the greater number of correct classifications from a test database.

A network – using 18 Inputs parameters (Shape/Location only variables) and 1 hidden layer with 24 associative units – was used to classify 650 texels extracted from images corresponding to tools used to cut and scrape. In 75 % of cases we obtained correct classification for longitudinal but only 58 % of cases were correctly classified as transversal (Fig. 9). The conclusion is that using a Non-Linear Classification Method we can discriminate longitudinal movement, but transversal movement is much more difficult to recognize.

From these results, we could gather that texels carry information about surface alterations, but not all of them carry the same information. Furthermore, some of these texels were generated by the data acquisition mechanism, or random luminance variations. These should be excluded from further analysis, because they were spurious for studying work processes. To distinguish between random, spurious and relevant texels we envisaged a research project including new variables. One of this variables was the nature of raw material, which proved to be especially important when studying luminance variation.

We then decided to study in depth the effects of movement on surface alteration in obsidian tools when working different materials (Toselli 2004). We chose obsidian due to the particular use wear development over this raw material, which allowed us to analyze a larger phenomenology of surface alteration. Furthermore, we added to the longitudinal (cutting) and transversal (scraping) movements one of perforation (boring) to explore what results could be obtained with a new variable (see Appendix for details of the experiments).

Surface alteration on obsidian has some particular characteristics related to the shiny nature and brittleness of its unaltered surface in a fresh sample, which are two physical properties that influence the characteristics of

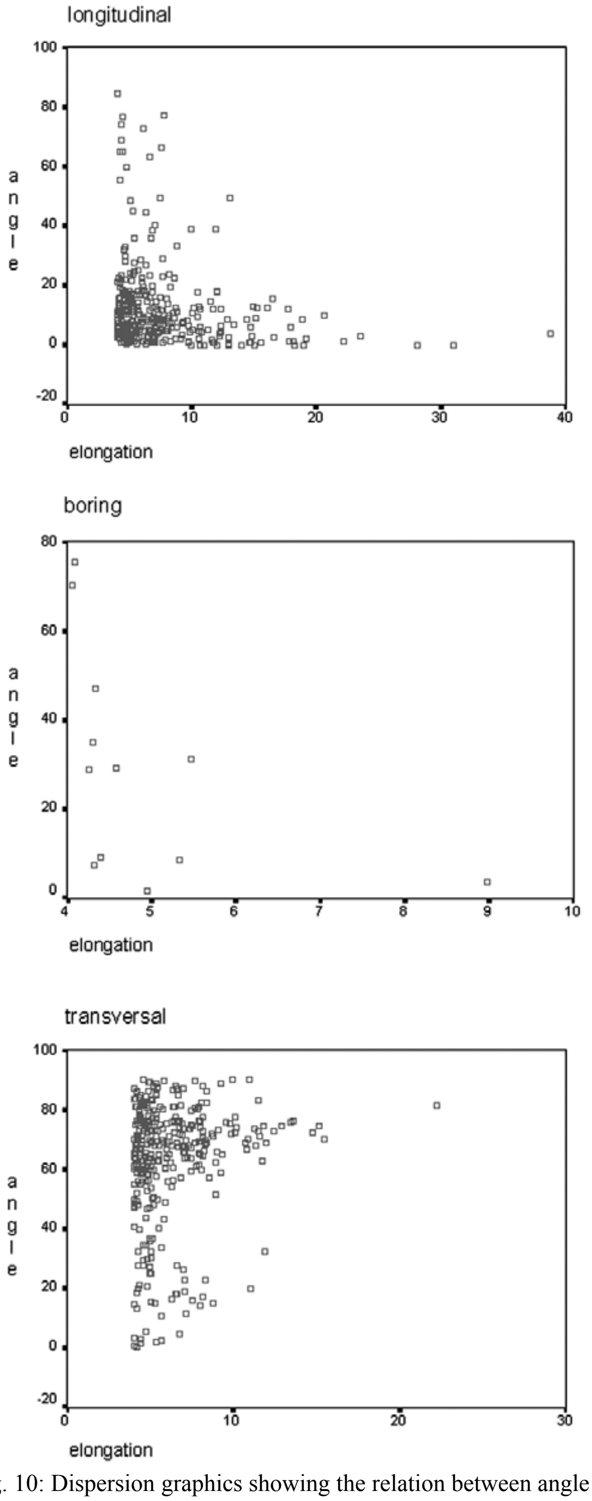

Fig. 10: Dispersion graphics showing the relation between angle and elongation for longitudinal, boring and transversal kinematics. Luminance interval 0-80.

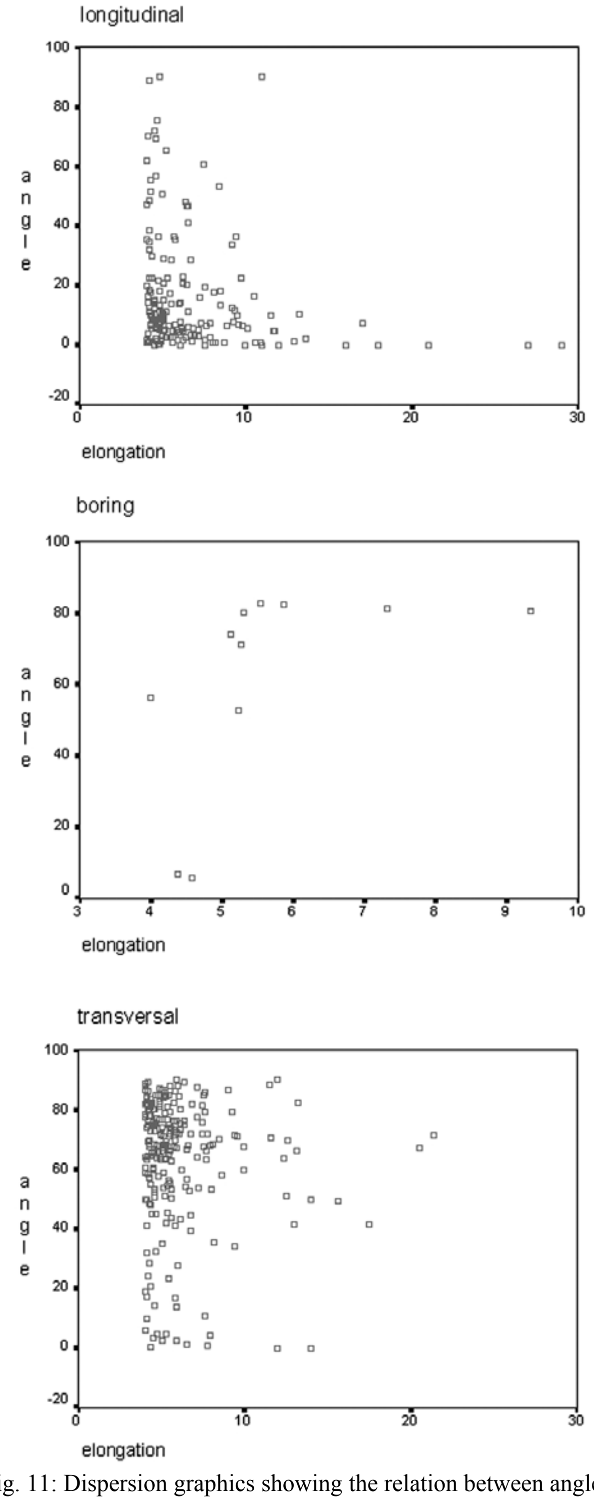

Fig. 11: Dispersion graphics showing the relation between angle and elongation for longitudinal, boring and transversal kinematics. Luminance interval 160-200.

use-wear developed on this rock. Focusing specifically on surface alteration, obsidian used surfaces have the particularity of developing alterations with a brighter or darker aspect than the original unaltered surface (unlike used flint where used surfaces acquire a brighter aspect only). Then, to have a global perception of the surface alterations we studied two intervals of luminance:

- Bright → values from 0 to 80 in the greyscale
- Dark → values from 160 to 200 in the greyscale

Figure 10 shows all texels from the 0-80 interval. Points that represent texels of transversal movement have angles that tend towards 90º and are relatively less elongated, while longitudinal movement develops texels more elongated which tend to small angles in general. As regards boring movement, texels show the shortest elongation whereas they did not display any clear tendency in angle. Figure 11 shows that all texels from the threshold 160-200 display the same tendencies.

The box diagram on the left (Fig. 12) represents the relation between angle and kinematics in the 0-80 interval, considering all texels regardless their elongation values. We can observe the tendency of texels to aggregate around the degree values corresponding to their movement. Boring movement texels keep an undetermined state between both categories.

However, if in each interval we select texels with elongation values major than 4 (Fig. 12, box diagram on the right) we obtain clearer results. Discrimination of kinematics is sharper. This means more elongated texels mainly coincide with the expected angle to each kinematics. Also, we observe that the variance of angle values is bigger in transversally used tools than in those used longitudinally. We think this result is the consequence of a major regularity in the development of longitudinal movements than in the transversal one.

Seeing the box diagram on the right of Figure 12, we can observe another particularity: after applying the filter selection, elongation > 4, the relative number of texels selected is different according to the concrete kinematics:

- In the longitudinal movement (threshold 0-80), 28% of texels (340/1210)
- In the transversal movement (threshold 0-80), 21% of texels (333/1566)
- In the boring movement, (threshold 0-80), 6% of texels (12/189)

At first sight, we can observe that the boring sample is the smallest of all. So thus, dynamics during the boring process give us texels less elongated with an orientation more variable.

Furthermore, when looking at Figures 10 and 12 for longitudinal and transversal movements, we can observe as approximately 90% of texels are aggregated according to angle, which, at the same time, is linked to the movement.

For the darker luminance interval 160-200 (Fig. 13) we obtained similar results, although the relation between

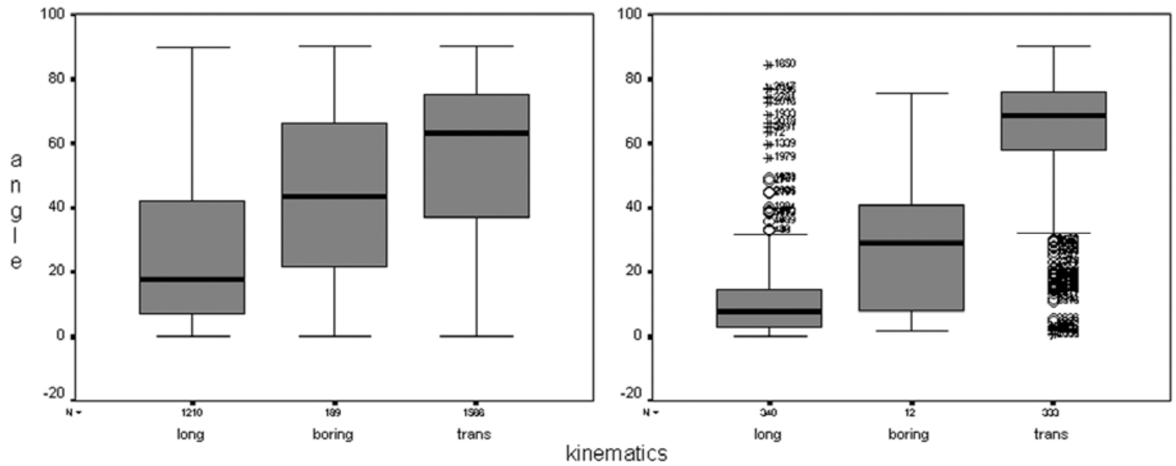

Fig. 12: Box diagrams showing the relationship between kinematics and angle, for all the texels on the left, and only texels with elongation values major than 4 without on the right. Luminance interval 0-80.

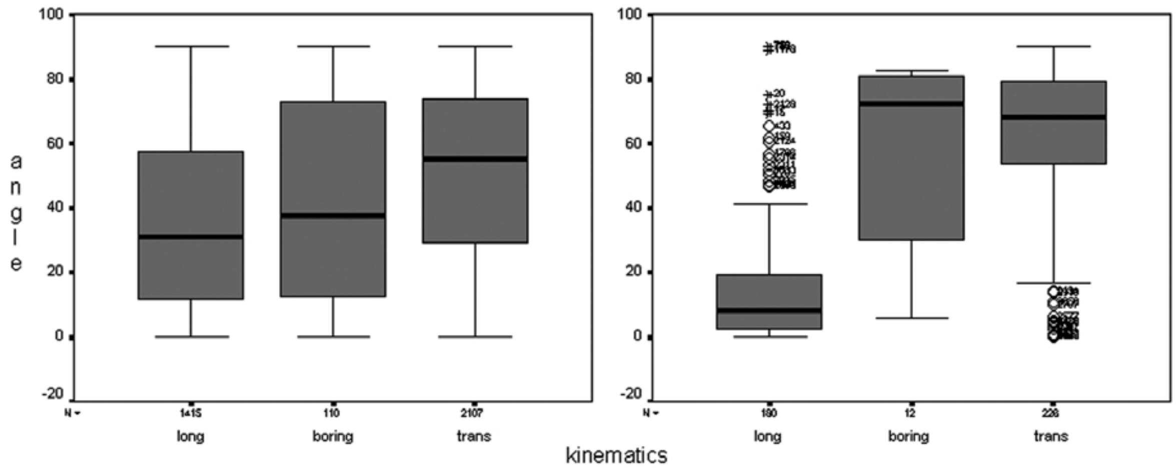

Fig. 13: Box diagrams showing the relationship between kinematics and angle, for all the texels on the left, and only texels with elongation values major than 4 without on the right. Luminance interval 160-200.

angle and kinematics is not as clear as the other luminance interval.

Conclusions

This analysis has shown that some texel features are not necessarily related to kinematics, but some texels are not related to kinematics variations. When we take away from the analysis non-elongated texels, differences increase notably, suggesting that only elongated texels are the consequence of movement.

Many conclusions can be drawn from our numeric experiments:

- The analysis of digital images is a profitable way of introducing quantification in use-wear description.
- Among the explored features, elongation and angle are the best indicators to describe kinematics.
- Not all texels are optimal indicators of kinematics. The most elongated texels are better to distinguish kinematics effects on surface alteration.
- Kinematics is only evidenced in some concrete luminance intervals within an image, which must be detected under variable criteria for each raw material, but also depending on several conditions, defined in the acquisition image processing of the set of images that we analyse.
- To find out good indicators of an aspect of use, we must select the variables and information that optimally describe it. This is a heuristic research.

Beyond these conclusions, we think the characterization of use-wear can be improved through the incorporation of quantitative data. Nevertheless, the advantages are not only of "improving" the way of analysing the archaeological record. When we are able to classify alterations by use through an experimental statistical process and a digital images set, then we may infer that use-wear characteristics are an objective fact.

We want to clearly express that our goal is not to make a software for classifying tools according to surface alteration. To create a Pattern Recognition System, we must know beforehand whether the phenomenon under study is susceptible to quantification. This paper shows that this is a correct assumption, and that some kind of automatic recognition system will be available in the next years. But this is the subject for another paper…

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Appendix

Because the experimental collection was destined to be used for the functional analysis of chipped stone tools recovered from different archaeological sites attributed to hunter-gatherer societies in the Southern Puna (Catamarca, Northwest Argentina), the experimental program was oriented to the partial replication of working processes that were probably developed by these societies.

The worked materials were:

-pieces of wood relatively hard and soft, and with a high resin content, fresh and stationed: "suncho" cane (bush that belongs to the Papaveracea family), box (*Buxus sempervirens*), oak (*Quercus ilex*), pine (*Pinus halepensis*), and poplar (*Populus sp*),
-fresh and dry skin (badger and domestic pig),
-fresh bones (pig and cow), and
-shells from marine mollusks

Worked material	Number of tool by kinematics (number of images by tool)		
	Longitudinal	Transversal	Bore
Dried soft wood	1 (8 images)	1 (7 images)	-------
Fresh soft wood	1 (6 images)	2 (5 images)	-------
Dried hard wood	1 (13 images)	1 (10 images)	-------
Fresh hard wood	1 (8 images)	1 (15 images)	1 (8 images)
Dried soft resinous wood	1 (8 images)	1 (9 images)	-------
Fresh soft resinous wood	1 (7 images)	2 (8 images)	-------
Dried skin	1 (7 images)	1 (15 images)	1 (4 images)
Fresh skin	1 (3 images)	2 (5 images)	-------
Shell	1 (9 images)	-------	-------
Fresh bone	2 (6 images)	1 (5 images)	-------

All the experiments were performed using obsidian flakes. The tools were used until the edges and points developed use-wear characteristics that allow the identification of kinematics and worked materials (from 30' to 2hs.30').

Hunter-Gatherers

Hafting traces on flint tools

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Summary. *The results of an experimental investigation concerning the formation and interpretation of macro- and microscopic hafting traces are presented. Attention is devoted to the diagnostic characteristics of hafting traces and to the variables that influence their formation. A distinction is made between dominant variables, such as the hafting arrangement and tool use, and secondary variables, such as raw material coarseness and stone tool morphology. In addition, it is examined whether hafting traces are truly patterned and whether this patterning is recurring, a condition for their interpretability. The potential of macroscopic, low power and high power analysis for interpreting hafting traces is evaluated and the kinds of interpretation attainable with each method are discussed.*
It is concluded that the designed method allows for the recognition and interpretation of hafting traces on archaeological artefacts and that an application of this method contributes to a better understanding of archaeological patterning. It is considered essential that future functional investigations systematically include hafting traces and hopefully the designed method will be useful for analysts that try to do so.

Resumè. *Les résultats sont issus d'une recherche expérimentale concernant la formation et l'interprétation des traces macro- et microscopiques d'emmanchement. On a examiné les caractéristiques diagnostiques des traces d'emmanchement et les variables influençant leur formation. Une distinction est faite entre les variables dominantes, comme le type d'emmanchement et l'utilisation, et les variables secondaires, comme la granulosité de la matière première et la morphologie de la pièce lithique. En plus, comme c'est une condition pour leur interprétation, la question sur la régularité et la récurrence de la formation des traces d'emmanchement est développée. On a évalué le potentiel d'une approche macroscopique, 'low power' et 'high power' pour interpréter les traces d'emmanchement ainsi que le niveau d'interprétation atteignable par méthode. On peut donc conclure que la méthode qui est développée pendant cette recherche permet la reconnaissance et l'interprétation des traces d'emmanchement sur des pièces archéologiques et que l'application de cette méthode contribue à la compréhension des données archéologiques. Il est essentiel que des recherches fonctionnelles futures incluent les traces d'emmanchement de façon systématique. Espérons que la méthode proposée peut aider à le faire.*

Key words: hafting traces, use-wear analysis, microscopy, analytical method.

Introduction

Microscopic functional research is mainly centred on use-wear traces visible on working edges (active tool parts). Non-active parts are largely neglected, although these parts may also carry traces worthwhile exploring. Technological traces, resulting from production, and prehension or hafting traces can be observed. While the issue of hafting is considered important by most researchers (e.g. Keeley 1982) and is frequently referred to, doubts reign concerning the possibility to interpret hafted tools based on lithics, and hafts are thought to be situated somewhere beyond the limits of archaeological inference. It is generally assumed that the only window towards it is formed by the rare occasions on which a hafted tool is recovered thanks to ideal burial conditions (e.g. lakes). Although experimental hafted tools were sometimes produced within the framework of use-wear experiments, the resulting hafting traces were hardly ever investigated (e.g. Kamminga 1982). Only a number of analysts attempted to characterise hafting traces (e.g. Odell and Odell-Vereecken 1980; Odell 1980, 1981; Plisson 1982; Moss and Newcomer 1982) but also the hafting conference organised by Stordeur in 1984 formed an important hallmark as it stimulated a search for potential hafting traces (Stordeur 1987). In spite of that, investigations remained limited and rather unsystematic in nature and often lacked a sound experimental basis. The prevailing attitude is one of resignation and attempts towards hafting interpretations are sometimes looked upon with a certain reticence. There is no need to emphasise that the first attempts to interpret use-wear traces had a similar effect. Yet, the principle on which use-wear research is based is simple: a friction between two mediums results in traces on both mediums. Logically, the friction within a hafting arrangement is equally real and can result in traces. The frequent observation of traces away from the active edge (e.g. Keeley 1980; Vaughan 1985) and the interpretation of experimental hafting traces as traces of use in blind tests (Unrath *et al.* 1986) confirm that this assumption is not mere speculation. Thus, the problem is not situated on the level of their formation, but on the level of their interpretation. It is difficult to interpret hafting traces if one does not know what to look for and what the importance of a particular observation is. A sound reference was thus lacking and observation simply does not equal interpretation.

It is clear that in order to resolve this issue, a more systematic search for hafting trace patterns was highly desirable for a more conclusive assessment of the interpretability of hafting traces. Therefore, a large-scale experimental program centred on the formation, identification and possible interpretation of hafting traces was performed (Rots 2002a). It was examined whether

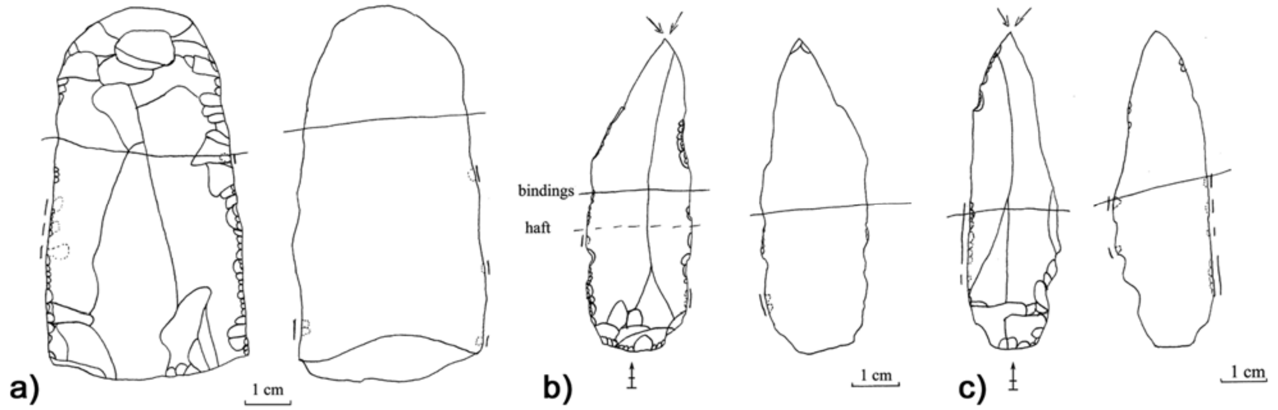

Fig. 1: Drawings of experimental stone tools used in a haft to (a) adze wood and (b-c) groove antler. Hafting arrangements include (a) a juxtaposed wooden haft with leather bindings, (b) a male split antler haft with lime tree bark bindings and (c) a male antler haft. Dotted lines represent the macroscopic traces that formed during hafted use.

hafted tools could be identified and whether the exact hafting arrangement could be interpreted. In addition, it was examined whether the results were applicable to archaeological case studies (Rots 2002a, 2002b, 2005).

Methodology

The results presented here rely on an extensive experimental program that consists of about 400 experimental tools. The experiments were performed in controlled conditions and different variables were tested individually. Different worked materials (earth, hide, wood, bone, antler, etc.), and actions (adzing, grooving, scraping, drilling, etc.) were considered, as well as different hafting materials (wood, bone, antler, etc.) and arrangements (male: stone tool inserted into a hole in the haft, male split: stone tool inserted and fixed into a cleft of the haft, juxtaposed: stone tool placed and fixed next to the handle). Several blind tests were performed during this research (Rots *et al.* 2006). In addition, the experimental results were confronted with the trace patterns that were observed on a series of ethnoarchaeological stone scrapers used while hafted to process hides in Southern Ethiopia (Rots and Williamson 2004). The potential of an application to archaeological assemblages was examined based on an analysis of small selections of material from different sites in Belgium and France and for periods ranging from the Upper Palaeolithic up to the Early Neolithic. Sites examined include *Maisières-Canal* (Perigordian, Belgium; Rots 2002b), *Verberie* (Magdalenian, France; Rots 2005) and *Vaux-et-Borset* (Early Neolithic, Group of Blicquy, Belgium; Rots 2002a).

In this article, attention is only devoted to the direct evidence of hafting, meaning the macro- and microscopic traces that can be observed on stone tools. There are also indirect indications of hafting, such as specific fractures, the exact distribution and characteristics of use-wear traces, morphological characteristics, etc. While the validity of each of these indirect lines of evidence was examined, these results are not included here. We refer to Rots (2002a, 2002b) and to Beyries and Rots (this volume) for more details.

The potential and reliability of different approaches with regard to the analysis of hafting traces is evaluated and compared. Particular attention is devoted to the distinction between hand-held and hafted tools and the interpretation of the hafting arrangement. Approaches include a macroscopic analysis, a low power microscopic analysis with the aid of a Wild binocular microscope (magnifications ranging from 6-100x) and a high power microscopic analysis with the aid of an Olympus metallurgical microscope (magnifications ranging from 50-500x).

Are hafting traces formed?

In order to examine whether hafting traces are indeed produced, it is sufficient to run a short test. When a tool is analysed before and after it was used in a haft and both analyses are compared and their results differ, the matter is already proven. For this test, a macroscopic analysis is sufficient. A set of tools was drawn and analysed before and after hafting and use. A comparison between both allowed the identification of a set of wear traces, part of which is macroscopically visible (Fig. 1). The marked areas and dotted lines indicate the traces, in particular scarring, that were formed during hafted use. Apart from the macroscopic traces, such as scarring and gloss, also microscopic traces form. These primarily consist of polish and scarring, but striations occur as well. Bright spots, defined as well-developed localised polish spots, also form and under specific well-defined conditions, these spots are an important indicator of hafting (Rots 2002c). Based on this small test, there remains no doubt that hafting traces form.

The main characteristics of hafting traces can be summarised as follows. The types of wear traces that occur correspond to what is generally observed for most

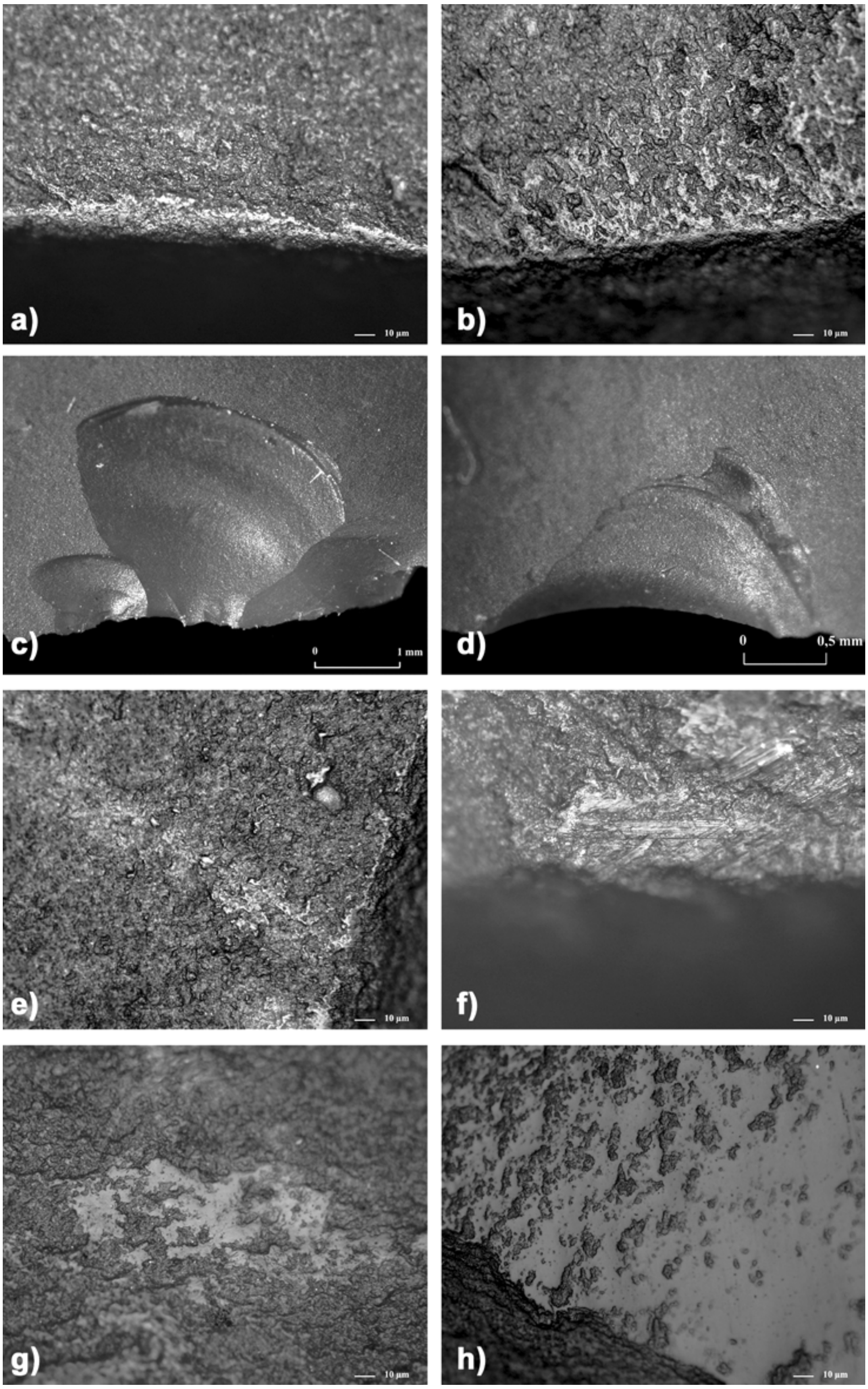

Fig. 2: Example of hafting wear: a) polish from a contact with an antler haft; b) polish from a contact with a leather wrapping and indirectly with a wooden haft; c) scars from a contact with an antler haft; d) scar from a contact with leather bindings; e) striation caused by flint particle; f) striations from a contact with an antler haft; g and h) bright spots from a contact with flint particle(s).

other trace causes and thus consist of polish, scarring, striations, rounding and smoothing (Fig. 2). The trace differences between the causes rest upon the exact wear characteristics, the individual importance of a particular wear type and the associations between the different types of wear (Fig. 3). In general, it can be stated that hafting traces are always limited to the tool part opposite the used edge and that the boundary between both is marked. Polish and scarring are relatively abundant while rounding and striations are relatively rare. Important for recognising and interpreting hafting traces is the exact pattern of the wear traces over the hafted part and the

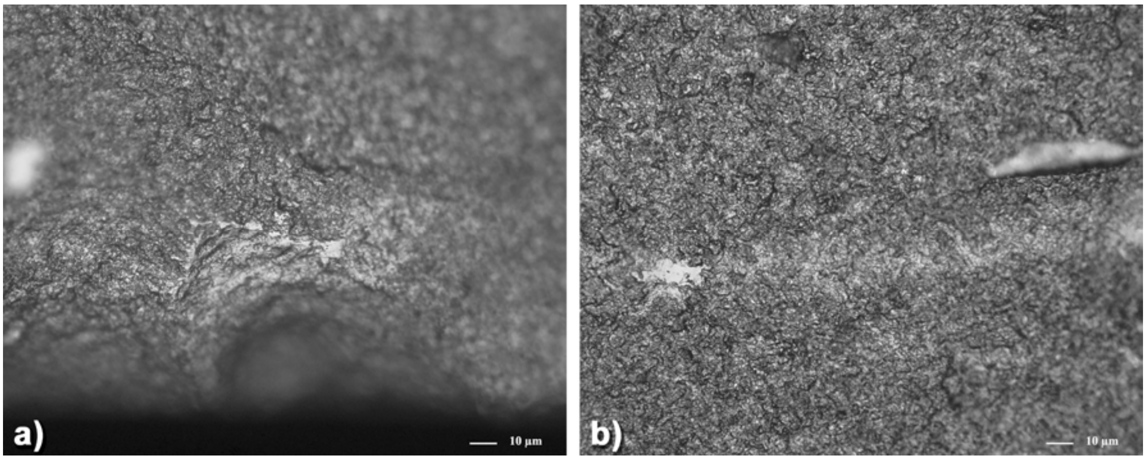

Fig. 3: Associations between traces: a) between a bright spot and scarring; b) between a bright spot and a striation.

specific associations between the trace types. Clear-cut direct associations between scars and bright spots or striations and between bright spots and striations are indicative of hafting under *strict* conditions (Fig. 3; Rots 2002c). One should be *extremely* careful not to confuse post-depositional bright spots with hafting bright spots (Rots 2002c). A general rule that can be applied in this light is to ignore *all* bright spots for hafting if the tool is altered. Further details concerning the characteristics of hafting traces are included below.

At which stage are hafting traces formed?

Aside from the observation that hafting traces form, it is important to identify their exact moment of formation. Three theoretical possibilities exist: during hafting, during hafted use or during de-hafting. Obviously, the impact of hafting and de-hafting cannot be separated, as one does not occur without the other if the tool is to be analysed. Only two moments of trace formation remain: during the hafting process or during hafted use. The latter was investigated in the previous paragraph and consequently, I now focus on whether a part of the hafting traces may be produced earlier, during the hafting process itself. Again, a rather straightforward experiment can be undertaken. The tool can be drawn and analysed after production and again after hafting (and de-hafting) in order to obtain clear-cut comparative data. Obviously, all visible production wear needs to be recorded in detail in order to prevent confusion.

This experiment demonstrates that several traces are already produced during the hafting process itself. I observed the formation of macroscopic scarring and microscopic evidence. Scarring is no doubt the most dominant trace that is formed, in particular when the arrangement is male. Polish is overall very limited, only in the case of a direct male hafting in antler is polish more extensive even though it remains difficult to interpret. This indicates that the dominant moment of polish production is during hafted use. Other traces are rare. Bright spots are in this experiment only notable on male-hafted tools.

It is clear that the most important moment of hafting trace formation is during hafted use. This implies that it is a necessity in most cases for use to have occurred before a tool becomes identifiable as once-hafted.

Can hafting wear be distinguished from other wear?

In the past, technological (i.e. production and retouch) wear was particularly assumed to cause potential confusion with hafting traces. Apart from those, also friction during transport (i.e. prehistoric), sheath wear, trampling, post-depositional processes, and (post-) excavation friction (i.e. friction with metal tools during excavation and flint-on-flint friction during subsequent transport and storage) may potentially cause confusing wear. Rather extensive research has already been undertaken concerning several of these external factors. Especially the influence of trampling, post-depositional processes and chemical actions have received a lot of attention in microwear research in view of an insight into their impact on the reliability of microscopic (use-wear) interpretations (e.g. Mansur-Franchomme 1986; Plisson and Mauger 1988). While the possibility to distinguish hafting traces from traces caused by one of the aforementioned external factors was examined (Rots *et al*. 2001; Rots 2002a, 2002c, 2003) and while their impact on the interpretability of hafting traces was evaluated (Rots *et al*. 2001, In press, Rots 2002a), only limited attention is devoted to production, use and prehension wear in this overview.

External factors: production wear
With production wear, I refer to wear that results from knapping and retouch as well as from anvil contact. It is clear that an investigation of production wear is important if traces on a tool's surface are to be adequately interpreted.

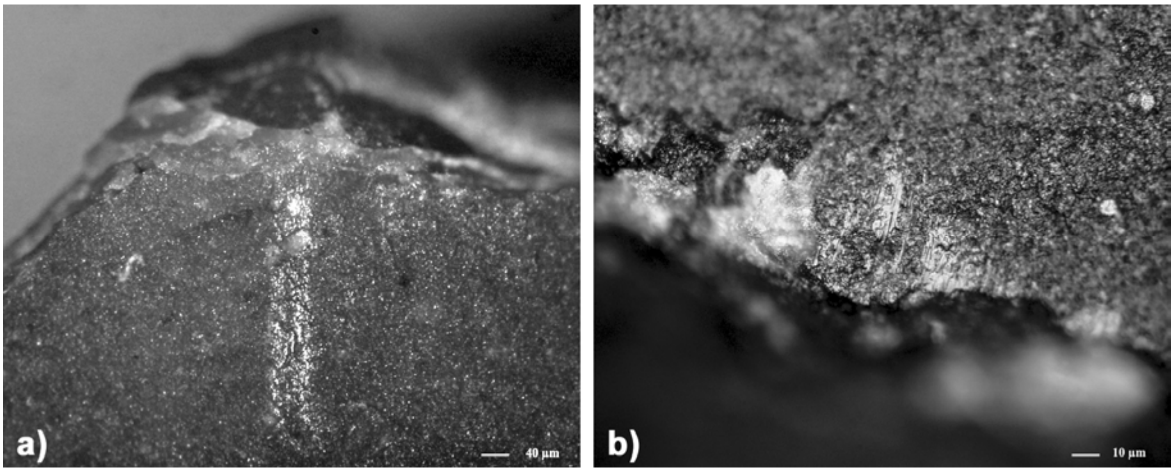

Fig. 4: Production wear: a. knapping striation from the impact of an antler hammer on the butt, b. retouch striation from the contact with a stone hammer on the ventral edge.

Based on my experiments, I argue that production wear does not pose a major interpretative problem with regard to hafting wear. In all cases, production wear is associated with a specific technological feature: knapping traces with the butt, retouch and anvil traces with retouched edges, etc. Production wear is also limited to those areas and thus shows an organised pattern. All production wear – apart from occasional intense anvil wear – is very limited in nature and shows a distinct, most often stone-on-stone, morphology (Fig. 4). The morphology depends on the hammer that is used (Fig. 4). Excluding anvil wear, polish is restricted to a few minute spots and scarring to a few dispersed scars. Striations differ in frequency; they form the most characteristic feature of production wear (Fig. 4). Further, I can remark that production traces have a high visibility under low power, in particular in the case of hard stone contact. This is evidently linked with the high pressure that is exerted. Considering the advantages of low power on the level of the relationship between trace and tool morphology, a low power analysis seems to provide a useful tool to distinguish production wear.

Use-wear

Use-wear traces are characterised by a clear impact on the edge and a particular distribution over the edge that corresponds to the action that was performed. The traces are also limited to the used part of the artefact and show a clear directional character. In comparison to hafting traces, the kinds of associations that occur between traces differ. For instance, in the case of use, an association between polish and a distinct rounding is frequent (e.g. hide-working), while this is not the case for hafting wear. On the other hand, hafting causes a distinct association between bright spots or striations and scarring in contrast to use-wear. Lastly, the individual importance of each trace with regard to the other differs. Rounding and striations, for instance, are far more important in the case of use than in the case of hafting.

Prehension wear

The importance of understanding prehension wear, which is defined as wear that results from hand-held use, is evident as it is necessary in order to be able to isolate and understand hafting wear. Maybe one should first pose the question whether prehension wear is actually formed. For answering this question, a similar experiment was performed to the one outlined above for determining whether hafting traces form and the results clearly indicate that prehension traces can indeed form during hand-held use (Rots 2004).

An experiment that allows an easy evaluation of whether prehension and hafting wear can be accurately distinguished is one in which all variables are constant apart from the prehensile mode. In practice, hafted tools can be divided in two groups: wrapped tools (i.e. a stone tool with a leather pad or leather bindings) and hafted tools *strictu sensu* (i.e. a stone tool mounted in/on a true handle). Each tool set should thus include a minimum of three tools: one hand-held, one wrapped and one hafted *s.s*. We aimed at identical experimental conditions within one tool set as much as possible. For this particular experiment, most tools were used for approximately one hour in a grooving motion on hard animal matter (bone and antler). More details concerning this experiment as well as a trait list that allows the distinction between hand-held and hafted tools can be consulted in Rots (2002a, 2004).

Based on this experiment, prehension wear traces proved to be characterised by an occurrence all-over the stone tool without any clear boundaries. Mainly polish forms, next to scarring and also some rounding. The formation of striations and bright spots is limited. Important is that the polish morphology always corresponds to the worked material (apart perhaps from some minor spots that can be linked to the flesh of the hand). The "dirtier" the worked material, the more prehension polish forms. Schist or antler working result in the detachment of many

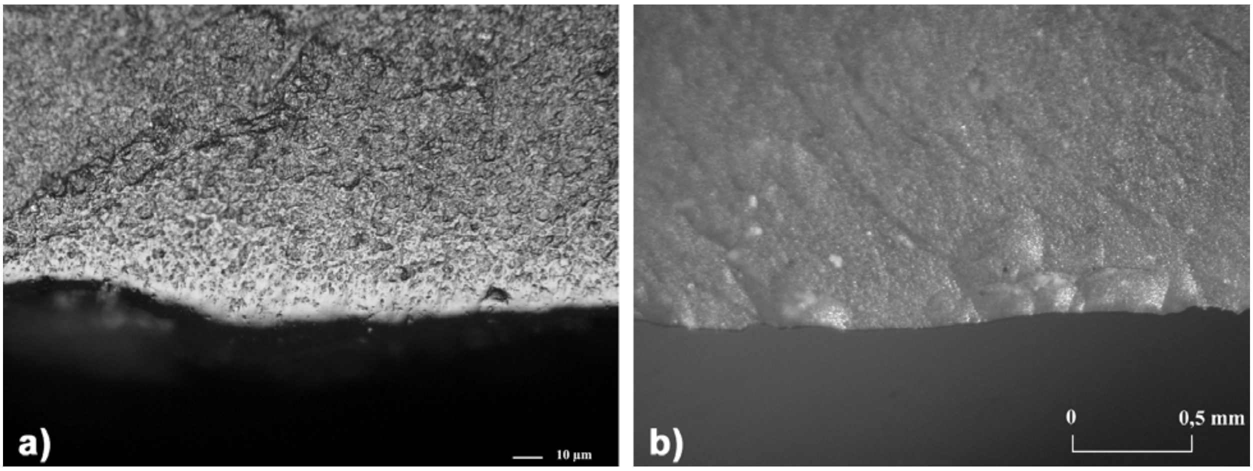

Fig. 5: Prehension wear: a) prehension polish on a stone tool used to work antler; b) scars from the contact with the hand during use.

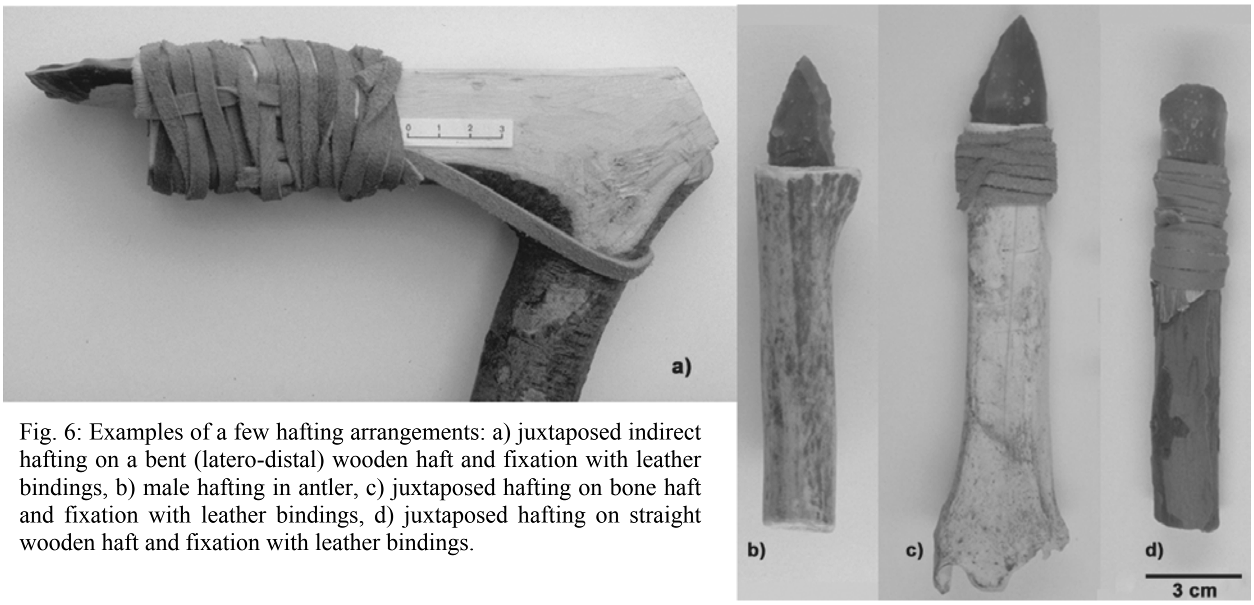

Fig. 6: Examples of a few hafting arrangements: a) juxtaposed indirect hafting on a bent (latero-distal) wooden haft and fixation with leather bindings, b) male hafting in antler, c) juxtaposed hafting on bone haft and fixation with leather bindings, d) juxtaposed hafting on straight wooden haft and fixation with leather bindings.

small particles that gradually cover the hands during use and that are responsible for the formation of prehension polish (Fig. 5). Other tool uses, such as hide worked without abrasives or wood working result in far less particles and consequently the prehension polish formation remains limited, while the impact from the flesh of the hand increases. The scars that are formed as a result of the contact with the hand are mainly small and feather-terminated (Fig. 5).

Which variables determine the formation process of hafting traces?

Now that it is demonstrated that hafting traces form, some during hafting, but most during subsequent use, and that hafting traces can be distinguished from other traces that are potentially present on a stone tool, their internal variability can be examined in detail. In doing this, a distinction is needed between dominant variables that have an important determining impact on the formation of hafting traces and secondary variables that cause minor variations on an existing pattern. Based on our experimental program, it was possible to identify tool use (action and worked material), the hafting material and the hafting arrangement (Fig. 6) as determining factors in the hafting trace formation process. Variables such as raw material coarseness, the stone tool morphology, etc. proved to have a more limited impact on the formation of hafting traces.

Dominant variables

What the impact of tool use concerns, attention is devoted to the worked material and action separately as each has a particular and diagnostic impact on the formation of hafting traces. More details concerning the relevant experimental reference can be found in Rots (2002a) and Rots and Vermeersch (2004).

Worked material

In order to examine the exact impact of the worked material on the formation of hafting traces, a set of tools was examined for which all variables remained constant

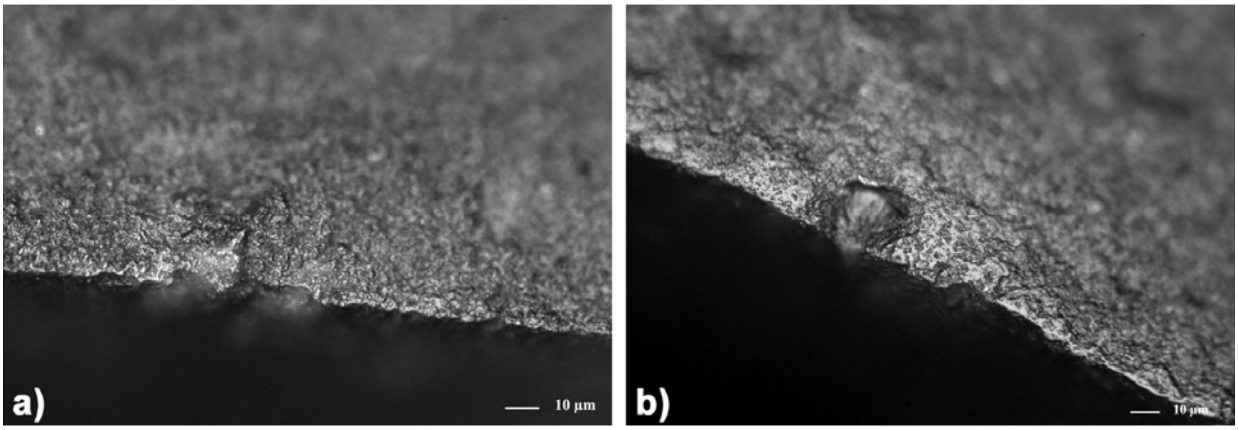

Fig. 7: Impact of the worked material on the intensity of hafting traces: comparison of hafting wood polish between (a) earth hoeing and (b) wood adzing.

apart from the worked material. So within the tool set, the hafting arrangement and hafting material remained identical, as well as the tool user and the use duration.

The worked material appeared to determine the *intensity* of hafting traces: the more resistant the worked material, the more intense the resulting hafting traces. If one compares for example the hoeing of earth and the adzing of wood (both actions are comparable) for tools that are fixed with leather bindings on a juxtaposed wooden haft (Fig. 6a), the intensity of the resulting hafting traces is significantly lower in the case of earth hoeing than in the case of wood adzing due to the more limited pressure on the hafted edges during use even though the use duration is the same (Fig. 7).

Action

A similar experiment in which the action is now kept constant allows the identification of the kind of impact that action has on the hafting trace pattern. The specific action that is undertaken during use determines the *distribution* of the hafting traces (Fig. 8). In the case of adzing and chopping motions (Fig. 8a), the traces occur over the whole hafted part in more or less similar amounts. In the case of scraping and grooving motions, distinct trace concentrations are visible in the area around the haft boundary and the most proximal extremity of the hafted stone tool (Fig. 8b). In the case of drilling and perforating motions, traces concentrate in two other areas: polish concentrates in the centre of the artefact (i.e. the ridges), while scarring concentrates on the edges (Fig. 8c).

Hafting material

The hafting material concerns all materials used in hafting: the haft, as well as other means of fixation like bindings and/or glue should be considered. The haft material used in the experiments concerns various wood species, antler and bone, while the material used to fix the

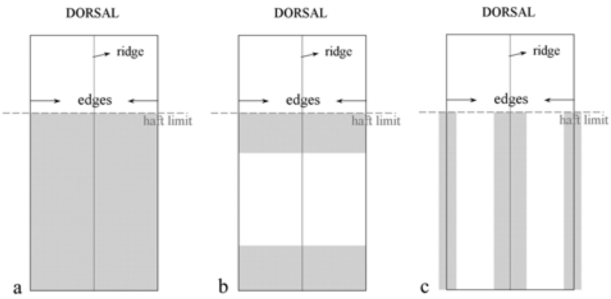

Fig. 8: Impact of the action on the distribution pattern of hafting traces: a) adzing and chopping motions; b) scraping and grooving motions; c) perforating and drilling motions.

stone tools in their haft concerns animal (leather (applied wet and dry), intestines, tendons) and vegetal bindings (lime tree mainly) and resin (Fig. 6).

The interpretation of the hafting material proved to rely on the same principles as in the case of use-wear interpretations. However, attention should be devoted to traces resulting from a “double” contact, as in the case of wrappings. For instance, when a stone tool is first wrapped in leather and then mounted against a wooden handle, the resulting wear traces will be reminiscent of both contact materials. The polish morphology will be similar to what is generally expected of a leather polish, but the distribution will be influenced by the indirect wood contact meaning that the most prominent areas are dominantly affected. The end result is a somewhat mixed polish that is in itself quite typical for indirect contacts (Fig. 2b).

A distinction between wood and antler hafts is not always straightforward given that the wood used for hafting is dry and relatively hard. When the hafting polish is poorly developed, distinctions are very difficult (Fig. 9). Only in the case of well-developed hafting polishes are distinctions truly possible (compare Fig. 2a and 7b).

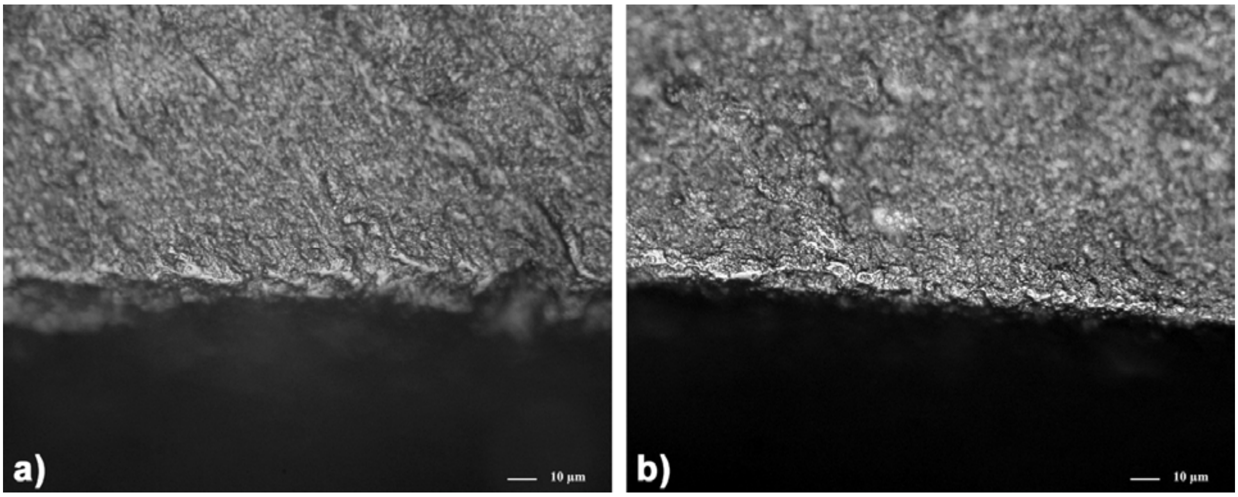

Fig. 9: Distinction between (a) wood and (b) antler hafts: poorly developed polishes.

Hafting arrangement
Many variations are possible in the way in which stone tools are hafted (Fig. 6). Hafts can be male (with a hole or cleft) or juxtaposed; straight, curved or bent, long or short, etc. The position of the stone tool with regard to the handle can differ: it can be terminal or lateral, etc. In addition, the stone tool can be fixed under pressure (e.g. in a hole); the arrangement can require the use of bindings (e.g. split handles) or the use of resin. Lastly, a wrapping of the stone tool before hafting can prevent direct contact between the stone tool and the haft and/or bindings. All these factors and variations need to be taken into account when examining hafting trace patterns.

Trace characteristics were determined for each hafting arrangement; some of these are included here. For more details, reference is made to Rots (2002a).

What the trace distribution concerns, it is clear that a male hafting will result in similar traces over the dorsal and ventral tool surface, while an opposition can be noted between the edges and the centre of the stone tool in the case of male split arrangements. A haft polish will be located on the ridges and in the centre of the tool, while traces caused by the contact with bindings will be observable on the edges. The latter will mainly consist of very typical scars (Fig. 2d) and polish. When a stone tool is mounted in a juxtaposed arrangement, different traces occur on the dorsal in comparison to the ventral face as one face is in contact with the haft while the other face is in contact with the bindings (if the contact is direct).

Also the kind of *fixation* used has a particular impact. A fixation with resin for instance, results in a zone void of traces or with occasional resin friction spots (Rots 2002c). A fixation with bindings (in the case of direct contact) results in the formation of very typical and easy to recognise scars, which we termed "binding scars" (Fig. 2d). They are characterised by a curved or bent initiation, and they are sliced in morphology or they start off sliced and continue into a scalar morphology. Their size and abundance differs depending on the exact tool use, the other components of the hafting arrangement and the difference in width between the stone tool and its haft.

Secondary variables
Secondary variables only cause minor variations on the hafting trace pattern. The raw material coarseness has a similar impact to the one for use-wear traces: traces form slower on coarser-grained tools.

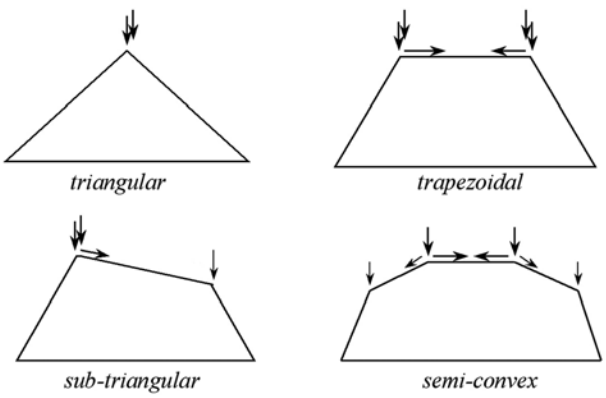

Fig. 10: Impact of the transversal cross-section of stone tools on the distribution of hafting traces.

The tool morphology influences the exact location and distribution of hafting traces and determines the risk of fractures. The transversal cross-section of a stone tool can be triangular, sub-triangular, trapezoidal or semi-circular (Fig. 10) and it determines the kind of contact between the stone tool and the hafting material. This is particularly important for harder hafting materials. In the case of a triangular cross-section, contact with the hafting material is concentrated on the ridge with limited intrusion into the inner surface, especially when the contact material is hard. Given the limited contact area between stone tool and haft, there is a higher risk of fractures in the haft (Fig.

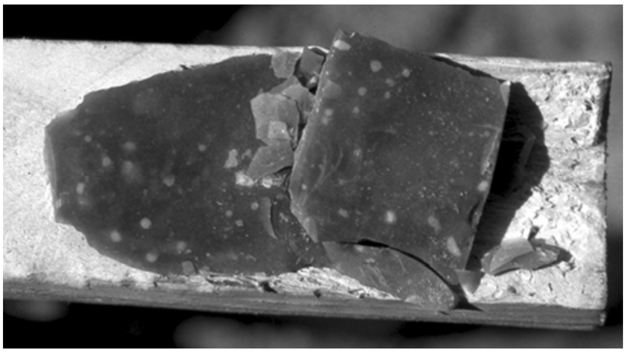

Fig. 11: Complex fracture in the haft of a stone tool hafted on a juxtaposed wooden haft, fixed with leather bindings and used for adzing wood.

11). The other types of cross-sections allow more contact between the hafting material and the inner surface of the stone tool: in the case of a trapezoidal cross-section, this concerns mainly the area between both ridges; in the case of a semi-convex cross-section, contact is more dispersed. The longitudinal convexity of a stone tool partially determines the risk of fractures and it may determine the need for additional adaptations in the case of hafting, such as the removal of the bulb of percussion. In archaeological contexts, one can frequently observe the systematic removal of the bulb of percussion when the longitudinal convexity is too important (e.g. Rots 2005). Lastly, it is important to be aware of the potential impact of the morphology of the butt and bulb of percussion. It is clear that protrusions have a higher chance of showing better-developed hafting wear.

Another secondary variable is the presence and coarseness of retouch. Retouch influences the distribution of hafting wear and the visibility of hafting scars. Similar to use-wear formation, the more retouch there is, the less hafting scarring forms and the coarser the retouch, the less hafting scarring forms and the less visible the scars are.
A last factor that needs to be taken into account is the amount that the stone tool protrudes from its haft. The more the stone tool protrudes, the higher the chances that diagnostic scarring forms. When the edges do not protrude from the haft, the scarring intensity reduces significantly.

Is the hafting trace pattern recurring?

A final point that needs to be made is whether hafting traces always form in a similar manner when the experimental conditions are identical. This is an obvious requirement for their recognition and adequate identification. An elaborate experiment was therefore performed in which variables remained constant within a particular tool set consisting of about five stone tools. A total of 18 different tool sets was produced and all sets differed from one another what the dominant variables concerns (Rots 2002a). The experiment allows the confirmation that the formation of hafting traces is indeed recurring, which means that the condition for their potential identification is fulfilled.

The only differences in the wear traces and their pattern that occurred within one tool set were a result of the exact morphology of the individual piece. After all, it is impossible to produce 5 identical stone tools, so some variation is unavoidable. The important fact remains that the trace characteristics and general distribution correspond to what is expected for the tool use and hafting material and arrangement in question.

What kind of analytical approach provides the most reliable results?

The experimental investigation in combination with the blind test results (Rots *et al*. 2006) allows the evaluation of the potential contribution of each of the three considered approaches. A macroscopic analysis proved to be an acceptable procedure for gaining a first general impression of the potential presence of hafted tools in an assemblage. However, no reliable results should be expected, but it helps guiding a more elaborate microscopic investigation. A microscopic low power approach is a valid means to examine hafting and reliable results can be obtained. A low power approach proved particularly successful what interpretations of the hafting arrangements concerns. Also a microscopic high power approach proved to allow reliable interpretations of hafting. The particular advantage of this approach is that it allows more exact hafting material interpretations than a low power analysis does, just like for use-wear determinations. The most reliable and elaborate result, however, is only obtained when the three approaches are combined: in an integrated approach the disadvantages of one approach are compensated by the advantages of another approach.

Discussion

Based on this summary of the results of the elaborate study devoted to the understanding of hafting traces, I can make the valid and reliable statement that hafting traces can indeed be identified and interpreted. This implies that this knowledge can now serve as a basis for an application to archaeological assemblages, contributing to a better understanding of archaeological stone tools and their life cycle (Rots 2003, 2005; Rots and Van Peer 2006).

It is clear that when the analysis of hafting traces is included in a larger analytical framework in which other wear traces are also examined, a more complete image can be obtained of the archaeological stone tools and thus the assemblages and sites in question. In addition, the proposed analytical procedure strongly reduces the risk of interpretative errors that are the result of a focus on one trace cause (such as use-wear for instance) given that all known traces are now taken into account.

Acknowledgements

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Subsistence strategies at Zengpiyan, South China

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Summary. *This paper reports the outcome of a research project on the functions of pebble tools and subsistence strategies in Zengpiyan Cave, South China by archaeological experiment, use-wear and starch residue analysis. Based on manufacturing experiment, it is argued that the labour input for manufacturing pebble tools is quite low. The preliminary result of use-wear analysis identifies butchering and chopping to be two functions of the pebble tools. Floatation and starch residue analysis suggest that tuber plants, particularly taro, were important food ingredients, while zooarcheological data suggest an extensive exploitation of wild animals and freshwater shells. The results of a multi-disciplinary study indicate that the Zengpiyan inhabitants from 12000 to 7000 years ago were affluent hunters and gatherers subsisting on various floral and faunal resources.*

Résumé. *Cet article rend compte d'une recherche sur la fonction d'outils sur galets et des stratégies de subsistance dans la grotte de Zengpiyan, dans le sud de la Chine, conduite à partir de l'expérimentation et des analyses de traces d'usure et des résidus. Sur la base d'expériences de manufacture, il est argumenté que l'investissement pour la fabrication de tels outils est assez faible. Les premiers résultats de l'analyse des traces d'usage montrent que la boucherie et le hachage étaient leurs deux fonctions. Les analyses de résidus suggèrent que les tubercules, et particulièrement le taro, étaient des ingrédients alimentaires importants, tandis que les données zooarchéologiques laissent entrevoir une exploitation intensive des animaux sauvages et des coquillages d'eau douce. Les résultats de l'étude multidisciplinaire indiquent que les habitants de Zengpiyan d'il y a 12000 à 7000 ans étaient des chasseurs collecteurs opulents vivant de ressources animales et végétales variées.*

Key words: pebble tools, use-wear, starch residue analysis, subsistence strategies, South China.

Introduction

The peopling of the landmass from the Yangzi River Valley to Southeast Asia can be traced back to the Pleistocene period, or more than one million years ago. The dominating prehistoric tool industry in this area is the chopper-chopping tool tradition, or the Hoabinhian industry, which persisted from the early Pleistocene to the middle Holocene (Bellwood 1992; Higham 2002). However, studies on manufacturing techniques and functions of this tool industry are extremely limited, hindering our understanding of the regional and local prehistoric cultural developments, including the subsistence strategies and social changes.

In order to tackle the above issues, an archaeological project focusing on South China has been carried out from 1999 to the present by the author and several archaeologists of the Institute of Archaeology, the Chinese Academy of Social Sciences, and of local institutes in Guangxi, South China. One open site at a river terrace and three caves in northern Guangxi, near the present Guilin City have been excavated (Fig. 1), including the Zengpiyan Cave.

Located in a limestone area, the Zengpiyan Cave comprises a major hall and a small tunnel, with an underground stream running beneath the floor. The cave was found and dug in the 1970s by local archaeologists, yielding large quantities of animal bones, shells, ceramics, stone and organic tools, as well as burials dated from the Final Pleistocene, or approximately 12,000 years ago, to the middle Holocene of about 7,000 years ago (The Institute of Archaeology CASS, 2003). But the stratification was not clearly distinguished at that time. Consequently, the chronology and cultural developments at Zengpiyan remain unclear.

The above problems needed to be addressed. From 2001 to 2003, the South China Team of the Institute of Archaeology, Chinese Academy of Social Sciences (CASS), local archaeologists, and the author worked together to conduct a multi-disciplinary project at Zengpiyan. About 10 square meters were meticulously dug in the field season in 2001. Every shovel of dug soil was subjected to floatation. Stone and organic tools, pottery, animal and shell remains, as well as pollen and phytolith from both natural and cultural layers were studied. Residue and use-wear of the stone tools have so far been analysed. The objectives of this project are to obtain more data for our understanding of the past environment, climates, human subsistence strategies and cultural developments. This paper focuses on the preliminary results of the residue and use-wear analysis.

Methods and Results

Residue analysis

Eighty pebble tools found in Zengpiyan were subject to the colleting procedure of residue analysis based on van der Meer's protocol with adjustments (van der Meer 1998), as follows:

1) Each sample tool was packed and sealed in a new and clean plastic bag as soon as unearthed.
2) After several days, hold the plastic bag and shake off the dry soil attached onto the pebble tools. Use clean brush and distilled water to carefully wash the sampling spots (i.e. the edge and the proximal end) of the tools. Pipette residue liquids and transfer each sample into a labelled beaker.

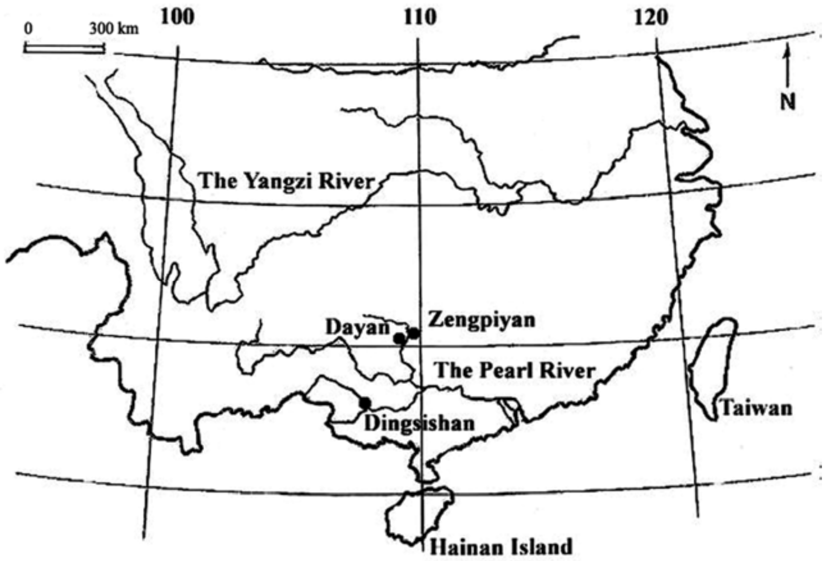

Fig. 1: The Zengpiyan Cave in South China (drawn by Tracey L-D Lu).

3) Add 15 ml of 5% sodium bicarbonate into each beaker. Samples were vigorously stirred, and left standing for 8 hours. Decant supernatant.
4) Wash samples by ultra-pure water. Samples stood for 8 hours. Decant supernatant.
5) Centrifuge at 2000 rpm for 5 minutes. Decant supernatant.
6) Add heavy liquid (bromide zinc) at gravity of 2.35-2.4 in order to retrieve both starch and phytolith. Stir samples. Centrifuge at 2000 rpm for 15 minutes.
7) Pipette residues from the top phase of the heavy liquid into new, labelled tubes. Repeat steps 6) and 7) to maximize the harvesting of starch and phytolith.
8) Add sufficient water to reduce the gravity (calculating the amount of water required). Centrifuge at 2000 rpm for 10 minutes. Decant supernatant.
9) Rinse samples. Mounting residues on glass slides and examine under Nikon Eclipse E600 at 400-600 magnifications.

A total of 208 samples were collected and processed from different parts of the Zengpiyan stone tools. As it has been reported that starch grains also exist in soil (Fullagar, Loy and Cox 1998), samples were collected from both the working edge and the proximal end of each specimen in order to detect the possible contamination. For example, if a pebble "chopper" has two working edges, three samples are collected: two from each working edge and one from the proximal edge. The presence of starch residues in all three samples is considered as a result of soil contamination. Only the presence of residue on working edges, but not on proximal ends (i.e. Table 1), is considered as "residue possibly resulted from usage".

The quantity of residue grains is another criterion for us to decide whether they were residue possibly result from usage, or from soil or other contaminations. If there are only a few grains of starch and/or phytolith, they might have resulted from soil or wind contamination. Only when tens to hundreds of starch/phytolith grains are present, then they will be identified as residues resulted from usage.

Residues were found in 27 samples out of 208. Of which, three samples contain a few grains of both phytolith and starch, 15 samples have phytolith only, four samples yield only a few grains of starch, some of them belonging to the Grass family, and another five samples contain large amount of starch. Of these 27 samples, 22 were collected from both working edges and proximal ends of the same specimens, so they are considered as results of soil or other contamination. Another five samples collected from working edges only contain large quantities of starch grains, so they are likely the remains of tool usage (Table 1). These items are dated from 12,000 to 7,000 BP (Table 1).

Based on current starch references collected by the author, the majority of starch is identified as of taro (*Colocasia* sp.) (Fig. 2), but it is not clear whether it is a wild or domesticated species at this stage. Given the small quantity of starch grains of the grass family, they may result from soil contamination. The quantity of phytolith grains is also quite limited (i.e. fewer than five fan-shaped phytolith are present on each item), and may also result from soil or other contamination too.

Manufacturing and Use-wear analysis

Semenov (1964: 12) pointed out, 40 years ago, that there were two categories of wear: "(1) traces of wear and use, (2) traces of manufacture." This approach of studying both the function and the manufacturing process seems to have developed into the notion of *Chaîn Opératoire* by Andre Leroi-Gourhan in 1966, which is to study the

Cultural phase and date (uncalibrated)	Artefact N.	Artefact Name	Sampling spots	Residues
I (12,000-11,000 BP)	DT6(28)2	Stone point	Distal end	Taro starch and phytolith
			Proximal end	No residues found
II (11,000-10,000 BP)	DT4(28)3	Bone implement	Working edge (distal end)	Taro starch and phytolith
			Proximal edge	No residues
III (10,00-9000 BP)	DT6(24)3	Perforated shell knife	Distal edge	A few starch grains of the grass family
			Left-side edge	Taro starch
			Right-side edge	No residue
			Proximal edge	No residue
IV (9000-8000 BP)	DT3(4):1	Long stone flake (no proximal end)	Left-side edge	Phytolith, some are fan-shaped
			Right-side edge	Taro starch
V (8000-7000 BP)	BT2(5):1	Stone chopper	Distal (working) edge	Taro starch and phytolith residue
			Proximal end	No residue

Tab. 1: Starch residues found on Zengpiyan implements.

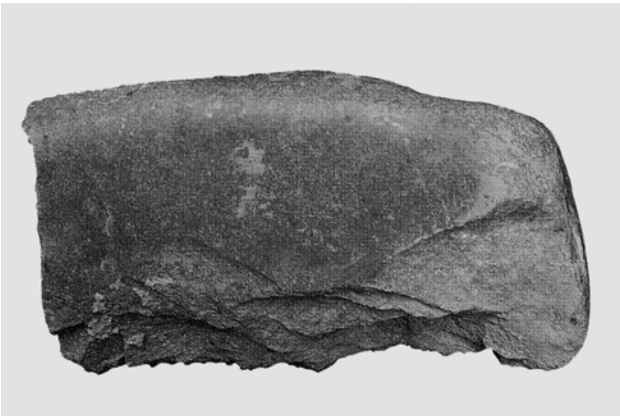

Fig. 2: A sandstone chopper found in Zengpiyan. Scale: 1:1.2.

process from obtaining raw materials to discard the used tools (Grace 1997). Apart from studying the choices and techniques of making stone tools, it is also important to investigate the raw materials available to prehistoric peoples. Thus the objectives and methods of the Zengpiyan project on pebble tools are as follows:

1) To identify raw materials (minerals and rocks) of the pebble tools found in Zengpiyan. A local geologist was invited to carry out the task by observing both hand specimen and microscopic specimen.
2) To locate these raw materials in the vicinity of the cave with the help of the geologist.
3) To investigate the labour input of procuring raw materials, as well as the catchment area of the prehistoric Zengpiyan inhabitants by an experiment of collecting pebbles in the river and transporting them to the site.
4) To examine the efficiency and labour input of manufacturing pebble tools by producing replicas. The working edges of these replicas were verbally and visually recorded under Olympus Stereo SZH at 30-60 magnifications before being used.
5) To study the functions of the pebble tools by using replicas for various foraging activities. As both the replicas and unearthed pebble tools are too big to be observed under a metallographic microscope, the lower power method was used. Used replicas were observed under Olympus Stereo SZH at 30-60 magnifications, and compared with the use-wear pattern of the unearthed artefacts.

According to our survey, the most commonly found rocks in the Li River, which is only two km east to Zengpiyan, are sandstone, granite, shale, quartzite, mudstone, limestone, and quartz (Lu 2003). Mineral analysis suggests that the pebble tools found in Zengpiyan were made from similar rocks (*ibid.*). As there are no other resources of pebbles within the vicinity of Zengpiyan, it is most likely that the pebbles were from the Li River (Lu 2003).

However, not all pebbles in the river were selected. By analyzing the rocks of the Zengpiyan pebble tool assemblage, it is clear that the prehistoric Zengpiyan residents chose mainly sandstone to make choppers and chopping tools, granite to make stone hammers, and shale to make ground axes and adzes. It seems that certain rocks were selected as raw materials for certain types of tools, and this pattern remained very stable over the period from 12,000 to 7,000 years ago, when Zengpiyan was occupied.

The Zengpiyan lithic assemblages mainly consist of single-edged chopper/chopping tools, points, flakes with or without retouch, some with use-wear traces, and a few

Cultural phase and date (uncalibrated)	Types of pebble tools	Quantity of each type	% within the stone assemblage	Quality and types of ground tools	Quantity of each type	% within the stone assemblage
I (12,000-11,000 BP)	Hammer	54	84.38%	Nil		
	“Chisel”	10	15.62%			
	Subtotal:	**64**	**100%**			
	Chopper	158	55.05%			
	Flake(cutter)	40	13.94%			
	Point	10	3.48%			
	Perforated disc	1	0.35%			
	Uncompleted	78	27.18%			
	Subtotal:	**287**	**100%**			
	Pebbles	239				
	Debitage	2196				
II (11,000-10,000 BP)	Hammer	9	100%			
	“Chisel”	0				
	Subtotal:	**9**				
	Chopper	44	47.31%			
	Flake(cutter)	5	5.38%			
	Point	0				
	Perforated disc	1	1.08%			
	Uncompleted	43	46.23%			
	Subtotal:	**93**	**100%**			
	Pebbles	66				
	Debitage	351				
III (10,00-9000 BP)	Hammer	9	81.82%			
	“Chisel”	2	18.18%			
	Subtotal:	**11**	**100%**			
	Chopper	18	62.07%			
	Flake(cutter)	1	3.45%			
	Point	0				
	Perforated disc	1	3.45%			
	Flaked adze	1	3.45%			
	Uncompleted	8	27.58%			
	Subtotal:	**29**	**100%**			
	Pebbles	74				
	Debitage	223				
IV (9000-8000 BP)	Hammer	2				
	Subtotal:	**2**				
	Chopper	4	66.67%			
	Uncompleted	2	33.33%			
	Subtotal:	**6**	**100%**			
	Pebbles	14				
	Debitage	26				
V (8000-7000 BP)	Hammer	7				
	Subtotal:	**7**	100%			
	Chopper	3	60%	Ground adze	1	100%
	Uncompleted	2	40%			
	Subtotal:	**5**	**100%**			
	Pebbles	5				
	Debitage	13				

Tab. 2: The Zengpiyan lithic assemblage.

perforated discs, with noticeable variations in terms of their quantities in different periods (Table 2). There are also granite pebbles with no flaked scars but bearing dense small “holes” in the centre, which, based on our experiment, are most likely hammers used for tool manufacture (Table 2). Pebble “sticks” of about 15-10 cm

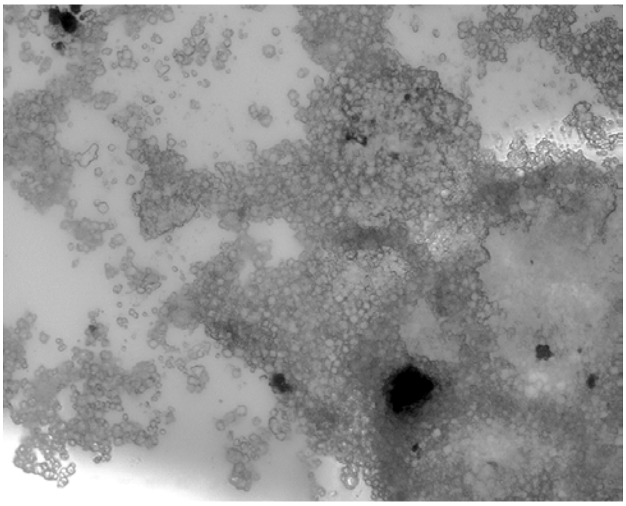

Fig. 3. Taro starch residue found on a pebble chopper. Scale: approximately 900:1.

in length have also been found, which are probably "chisels" for slicing bone as raw materials for tools according to our observation and experiment.

In addition, untouched pebbles of different sizes have also been discovered (Table 2). Some of them are large enough for making tools or used as "chisels", but others are very small, measuring from 6-2.2 cm in length and 1.5-0.8 cm in width. As the rocks of these pebbles are the same as those of the tools and pebbles found in the Li River, it is inferred that they were brought in by the Zengpiyan residents from the river. However, it is not clear why the small pebbles were also brought into the cave, as they are too small to be used to make tools or for "chisels".

Regarding the manufacturing technique, the Zengpiyan pebble tools have deep and large scars along the edges, without any traces of trimming and/or retouch (Fig. 3). Manufacturing experiments suggest that direct percussion by hard hammer was the major technique for making the tools, seconded by pecking.

The manufacturing experiment also manifests that making pebble tools is very efficient. Based on our test and trial, a person can collect more than 70 pebbles within 6-8 minutes at the river bank in dry season, and at least 80% of which can be used for making tools. It took about one hour (or 53-55 minutes) for a young man to carry 10 kg of pebbles, or between 14 to 23 pebbles suitable for making tools (depending on the size and the weight of each pebble) from the river to the Zengpiyan Cave. A sandstone chopper can be produced in 12-16 minutes, a sandstone scraper in 19 minutes, and a sandstone point in only 9 minutes. Therefore, it is estimated that the average labour input for making a pebble chopper or point is about 20 to 10 minutes, including the time spent on collecting pebbles, transportation, and production.

A total of 10 chopper replicas and six point replicas were made, and were used for crushing nuts, butchering, cutting trees and bamboo, scraping hard wood and bamboo, slicing wild yam, digging bamboo roots, and harvesting grasses. The wear traces were observed under Olympus Stereo SZH at 30-60 magnifications, recorded by words (Table 3) and microphotos, and used as references for the use-wear analysis of the Zengpiyan tools.

The quantities of pebble tools found in different cultural phases in Zengpiyan vary significantly (Table 2), mainly due to the discovery of a spot for tool manufacture in the early period. Consequently, the quantities of tools selectable for use-wear observation also vary significantly at different phases. All completed pebble tools were observed by a magnifier at 20 magnifications to identify the presence of use-wear traces. Those with

Function	Replica used	Types of use-wear
Scraping hardwood	Sandstone flake	Rounded working edge. The shapes of minerals become unclear after use, forming small "platforms".
Scraping bamboo	Sandstone flake	Similar to scraping hardwood.
Chopping hardwood	Sandstone chopper	Many minor "flakings" occurred at the working edge, which was rounded after use. Some striations vertical to the working edges were observed.
Chopping bamboo	Sandstone chopper	Fewer "flakings". The mineral grains were rounded.
Butchering (chopping animal bones)	Sandstone chopper	Rounded working edge with shattered mineral grains. Bright polish.
Slicing animal meat	Sandstone flake	Bright and "oily" polish.
Digging bamboo roots	Sandstone point	The 'point' was rounded with bright polish and striations vertical to the working point, apparently caused by interacting with sand in the soil.
Cutting grass (green foxtail, *Setaria viridis*)	Shale flake	Very bright polish along the working edge.
Slicing wild yam	Sandstone flake	Use-wear traces not observable.
Crushing coconut	Sandstone point	Many small "holes" at the working point with shattered mineral grains.
Crushing ginkgo nuts	Sandstone chopper	The working point was rounded with polish.

Tab. 3: Use-wear caused by different functions (all replicas were used for 45 minutes for each function).

Cultural phase and date	Artefact N.	Artefact	Use-wear traces	Inferred last function*
I (12,000-11,000 BP)	DT6(31)a	Sandstone flake	Rounded edge with shattered mineral grains	Chopping animal bones
II (11,000-10,000 BP)	DT4(28):026	Sandstone flake	Rounded edge with shattered mineral grains and bright polish.	Chopping animal bones
	DT4(28):027	Sandstone flake	Rounded edge with shattered mineral grains and bright polish.	Chopping animal bones
	DT46(27):01	Sandstone flake	Rounded edge with shattered mineral grains, bright polish and "flaking".	Chopping animal bones, possibly also used for chopping bamboo/wood before?

* Usually the traces observable are those caused by the last usage of the tool.

Tab. 4: Use-wear traces identified on some unearth artifacts.

possible wear traces were selected for microscopic observation. Thus 86 artefacts have been microscopically observed, including 56 specimens dated to cultural phase I, nine specimens dated to phase II, 10 specimens dated to phase III, eight specimens dated to phase IV and three specimens dated to phase V. Traces of usage have been observed on 15 specimens of phase I, accounting for only 7.2% of the 208 completed tools. Three specimens, or 6% of the completed tools of phase II, bear some use-wear traces. Four pieces, or 19.04% of the completed tools of phase III, have use-wear traces. The two pieces of phase IV with wear-traces account for 33.33% of the total completed tools of this period, but no traces of usage have been identified on tools dated to phase V. However, only four specimens dated to phases I and II bear diagnostic use-wear traces related to subsistence strategies (Table 4). The use-wear traces and possible usages of the other 11 specimens cannot be certain at the moment.

Apparently, the result of use-wear analysis is not very satisfactory, mainly due to two reasons. First, the microscope is a very old one, and the objective lens is dim, making observation very difficult. Second, it is extremely hard to observe the use-wear pattern of sandstone and granite, not only because the grains of these rocks are much larger comparing to chert and flint, but also, and mainly, because they consist of different types of minerals at different scales of hardness and of different structures. For example, quartz is much harder than feldspar, mica and calcite; yet all of them are constituent minerals of the sandstone and/or granite we studied. As a result, the degree of wore-out and damaged patterns caused by tool-use vary significantly at one working edge. Further, different minerals show different degrees of brightness under microscope. Altogether these make the diagnosis of use-wear patterns, such as the brightness, different types of polish, minor flaking, featherings and "rounding" etc. extremely difficult. Our study is further hindered by the lack of references on sandstone use-wear analysis. Therefore, only two functions can be identified at this stage (Table 4).

Discussion

This project is the first multi-disciplinary study to integrate residue and use-wear analysis, as well as floatation, to examine archaeological data in China. The result of starch residue analysis is in consistency with that of floatation, which retrieved many charred tubers from deposits dated from 12,000 to 7,000 years ago in Zengpiyan, although the species of the floated tubers cannot be identified (Zhao 2003). Apparently, tuber plants were important food ingredients for the prehistoric Zengpiyan residents.

Our observation and manufacturing experiment indicate that the prehistoric tool makers at Zengpiyan purposely selected raw materials based on the hardness and structures of the pebbles. Sandstone is relatively softer and easier to strike compared to granite, thus it was selected as raw material for tools. Granite is harder, thus it is more suitable to use it for hammers. This pattern of selecting raw materials remained almost unchanged at Zengpiyan from 12,000 to 7,000 years ago, although the quantities of pebble tools found in different phases vary. This stability may indicate cultural continuity in this area, particularly in terms of raw material selection.

It has also been noticed that very few pieces of the Zengpiyan tools had been rejuvenated. Given the abundance of raw materials and the easiness of making these tools, apparently it was not worthwhile to retouch the wore-out edges of the tools.

On the other hand, as discussed above, the majority of pebble tools found in Zengpiyan, especially those found in the early deposits dated to 12,000-11,000 years ago, bear no obvious use-wear traces. We have also found hundreds of debitage at the same spot (Table 2). It is thus inferred that the prehistoric Zengpiyan residents made their tools in the cave, they then probably used the tools in spots outside the cave for various activities, and left or even discarded the used tools at those spots, instead of taking them back to the cave. Of course, a few tools bear traces of use-wear (Table 4), indicating that some activities like butchering and probably chopping also took place in the cave. Again, given the easiness of making pebble tools, there was little incentive for the hunters and gatherers to carry the heavy tools back to their camp.

The butchering and possibly chopping functions of pebble tools identified by use-wear analysis, however, are in consistency with other research outputs. Large amount of animal bones of 37 mammals including large and small deer, boar, small carnivore and rodents, 20 species of birds, 1 species each of fish and turtle , and 47 species of freshwater shells have been found in Zengpiyan (Yuan 2003: 344), indicating that hunting and shellfish gathering were important subsistence strategies. Butchering must be part of hunting and consuming behaviour taking place at the camp, or in the cave.

Briefly, the integrated result suggests that the prehistoric culture in Zengpiyan was quite stable from 12,000 to 8,000 years ago; that the major subsistence strategies of the Zengpiyan residents during this period was mainly hunting wild animals, and collecting tubers, wild vegetables and freshwater shells (The Institute of Archaeology CASS 2003). It was at around 7,000 years ago that there were noticeable cultural changes, including the occurrence of ground stone tools and pottery with exotic motifs. This cultural change might have related to cultural contact with the adjacent areas at that time.

There are, of course, remaining problems. For example, other functions of the stone tools cannot be clearly identified. On the other hand, processing tuber plants did not leave any traces on stone tools, hindering our attempt to investigate whether tuber plants were collected or cultivated at Zengpiyan. Much more work is required to be done to further investigate the subsistence strategies and social/cultural changes in South China.

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Use-wear analysis of retouched lithic tools from the Abric Romaní Middle Palaeolithic site (Barcelona, Spain)

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Summary. *The Abric Romaní is one of the most important Upper Pleistocene sequences in the Iberian Peninsula. Its dates between 40 and 70 Ka BP by U/Th and AMS dates place the Middle to Upper Palaeolithic transition at 36 Ka BP. All archaeological levels show the same knapping method and tool types, even though dates and pollen analyses show they are chronologically and environmentally differentiated. Microwear analysis has been performed on retouched artefacts from the whole sequence. Flint is the main raw material used for these objects and denticulates and notches are the main tool types; in the lower levels, these artefacts represent over 90% of the retouched tools. In the upper levels, the percentage of side-scrapers may be as high as 20% of the total. Discoid method was used for knapping sequences and blanks detached from these cores were selected for retouching. Blanks and retouched artefacts (denticulates, notches and side-scrapers) show an ergonomic handle morphology; they are characterized by thin edges (retouched or not) opposite to a thicker one, coinciding with a natural back or a débordant flake. In this technical, chronological, and environmental context, micro-wear analysis examines how denticulate edges were used, and determines if they were a tool type linked to woodworking as it is normally believed. Denticulates from the Abric Romaní were used for butchery activities and to work fresh and dry hides. None of the objects show use-wear associated with woodworking. From this evidence, denticulates must be considered polyvalent tools since their edges were used for longitudinal and transversal motions and processed materials of different densities. Moreover, discoid technology was suitable for meeting human needs, since it was produced in the Abric Romaní for millennia in different environmental contexts. We do not think this technology may be considered "expedient" or ad hoc; it was perfectly organised and tools show an ergonomic design deliberately devised to participate in subsistence activities and the tanning process.*

Résumé. *L'Abric Romaní constitue une des séquences plus importantes du Pléistocène Supérieur de la Péninsule Ibérique. Il est daté entre 40 et 70 Ka BP par le méthode d'U/Th et les datations par AMS situent la transition du Paléolithique Moyen au Supérieur sur 36 Ka BP. Tous les niveaux archéologiques montrent les mêmes méthodes de débitage et types d'outils, même quand les datations et les analyses de pollen indiquent que ils sont différentiés du point de vue environnemental. Nous avons étudié la tracéologie des objets retouchés de toute le séquence. Le silex est le matériel plus utilisé pour débiter ces objets et des denticulés et des encoches sont le type d'artefact plus représenté ; dans les niveaux inférieures, ces objets représentent sur le 90% des outils retouchés. Dans les niveaux supérieures, le tant pour cent des racloires peu arrivé au 20% du total. Le méthode discoide va être développé par des séquences de débitage et les éclats débités de ces nucleus vont être sélectionnés pour le retouche. Les éclats et les outils retouches (denticulés, encoches et racloires) montrent des morphologies ergonomiques ; ils sont caractérisés par des tranchants fins (retouches ou non) opposés a des tranchants épaisses, que concordent avec un dors naturel ou un éclat débordant. Dans ce contexte technique, chronologique et environnemental, l'analyse tracéologique examine comme les tranchants denticulés vont être utilisés, et détermine si ils sont des outils retouches liés á des travails sur bois, comme á été interprété traditionnellement. Les denticulés de l'Abric Romaní vont être utilisés par des activités de boucherie et pour le travail de la peau fresque et sèche. Aucune des outils préservent déformations par utilisation lié au travail sur bois. Dans ce sens, les denticulés doivent être considérés comme des outils versatiles, donc ces tranchants vont être utilisés par des activités longitudinaux et transversaux et ils vont servir pour travailler des matérielles de différent densité. En plus, la technologie discoide va être appliqué pour solutionner les besoins humaines, donc va être produite à l'Abric Romaní pendant des miliaires d'années dans des différents contextes environnementales. Nous ne pensons pas que ce technologie doive être considéré comme « expéditive » ou ad hoc ; elle errait organisé parfaitement et des outils montrent un dessin ergonomique confectionné de forme délibéré pour participer dans des activités de subsistance et processus de tannage.*

Key words: ***Middle Palaeolithic, retouched lithic artefact, Abric Romaní, denticulates, notches, micro-wear analysis.***

Introduction

Denticulates are the retouched lithic objects which are best represented in the archaeological record, as they appear in the first Plio-Pleistocene assemblages and last at least up to the macrolithic industries of the early Holocene. Moreover, these objects make up one of the classic Mousterian facies which Bordes used to subdivide the technological variability of the Middle Palaeolithic (Bordes 1981). Consequently, the geographical and temporal spread of denticulates in the archaeological record and their manufacture by successive hominid species oblige us to consider their technical feature, the saw edge, as a morphology capable of satisfying functional demands in distinct ways. At the Abric Romaní site, denticulates appear as the dominant tool type for over 10,000 years (54-43 ka BP), with minimal percentage variations between the different levels of the sequence: on level Ja these objects make up 90% of retouched items, while the lowest percentage is on level E, with 80% of denticulates. This morphological similarity between retouched objects is repeated in other features of the archaeological record from the Abric Romaní, such as methods of exploiting cores, the spatial organisation of settlements or the capture and processing of game.

This homogeneity in the behaviour and technology of these communities persisted in spite of considerable variations in climatic conditions throughout the Abric Romaní's sequence, with periods of steppe landscapes and others in which thermophile and mesothermophile arboreal species predominated (Burjachs and Julià 1994). The morphology of the shelter itself also changed, recreating a cave setting from level I, due to the fusion of the cornice with the fill material (Vallverdú 2001). The only archaeological differences to be recorded in the sequence excavated are in the intensity of occupation. The amount and diversity of technical sequences carried out in the different levels, as well as the density of the record, disturbances or superimposition of occupational events over a single point in the shelter indicate that occupations succeeded one another with differences in the temporal impact or numerical composition of such groups (Vaquero 1999a; Vaquero *et al.* 2001b). Up to now, the research carried out at the site makes it possible to venture that groups of Neanderthals faced changing historical and environmental situations with social strategies of population dispersion and concentration, or with a network of camps of varying durations and functions. However, lithic production did not vary in the same way, displaying a limited margin of variability throughout the sequence excavated (Vaquero 1999b). This paper presents the results of the functional analysis carried out at the site, one of the goals of which was to ascertain whether the function of the objects remained constant throughout the sequence in accordance with the organisation of lithic production, or whether it varied, displaying technical changes (Martínez 2005).

Functional analyses conducted upon Middle Palaeolithic samples coincide in pointing to the versatility of the lithic objects, which were used in both longitudinal and transversal actions to work on a wide range of materials. However, despite this general versatility and range of functions which characterised the objects of the Middle Palaeolithic, denticulates, and in particular notches, have had attributed to them a tendency towards specialisation in transversal work on wood (Boëda *et al.* 1990). Therefore, according to these initial traceological analyses, these two types of object would have their own functional nature, irrespective of the flexibility in use displayed by flakes and side-scrapers (Beyries 1987).

Nevertheless, to date no analysis has been carried out on large samples of denticulates (Beyries 1987; Anderson-Gerfaud 1990; Roebroeks *et al*. 1997; Lemorini 2000; Rodríguez *et al*. 2002). Our work focused on a functional study of all the retouched objects, largely denticulates, recovered in the sequence excavated at the Abric Romaní, from level B to level M. The archaeological research done on this site provides us with extensive information about the environmental and chronological context of the levels excavated (Carbonell *et al*. 1996; Vaquero *et al*. 2001b; Martínez *et al*. 2005). All this information enables traceological analysis to go beyond a description of the actions and materials worked on, to suggest interpretations of the function and nature of lithic production and how it fitted into the social organisation of the human groups and into their strategies for exploiting their environment.

Denticulates

Denticulates are taken to mean retouched objects with deep extractions which break the continuity of the natural edge of the flakes, so creating a toothed shape rather like a saw. Notches, for their part, refer to objects with a single deep extraction, shaped with a single blow, Clactonian notches, or by means of successive superimposed retouching. However, beyond such typological definitions, in order to be able to interpret the function of denticulates and notches it is necessary to describe in detail the technical features of the object. This study considers the general morphology of the object, the position of the retouched edge and its relation to the other sides of the object. It then describes the technical features of the retouched edge: the depth of the extractions, the angle of the edge and the length of edge retouched and its relation to the total length of the side on which the retouching is located. All this should make it possible to ascertain any relationships between actions and materials worked on and the morphology of the object and the technical features of the edge.

The first step in interpreting the function of the retouched objects from the site was to characterise: 1) modes of use: the way in which the objects were used, in terms of different actions of cutting, scraping, perforating and so on, and 2) technical criteria of use: the technical features of the edges used in the different actions and upon the different materials. Once these technical aspects have been clarified, it is possible to discern possible functional patterns if a relationship exists between uses and the morphology of the objects or the edges used. In accordance with the functional patterns, we will have specialized or versatile objects, depending on the degree of relationship between modes of use and technical criteria of use.

Furthermore, on the basis of these results of the traceological analysis (the description of the modes and technical criteria of use) interpretations can be made concerning the productive capacity of the hominid communities. As human groups' ability to satisfy their needs was based on lithic objects, the organisation and function of lithic production had to be able to meet these demands. Also, the social organisation of groups of hunters was linked to a particular productive capacity. Therefore, through the nature of the functionality of the lithic objects (specialized or versatile), the productive development attained by these groups can be interpreted (Risch 2002).

Traceological analysis method

The apparatus used for observation in this traceological analysis was the scanning electron microscope (SEM). This device, largely for reasons of cost and complexity of use, is not normally used to analyse archaeological samples, and its use has been limited to experimental or methodological work. Our research contradicts some opinions which consider that deformations by use in archaeological objects cannot be interpreted by SEM (Yamada 1993; Levi-Sala 1996). In fact, this apparatus offers some significant advantages over optical devices, including a greater depth of field, the possibility of working at greater magnification and having a chemical analysis probe which makes it possible to describe the elemental composition of deformations. These advantages, together with the poor development of the deformations by use and a high incidence of phenomena of disturbance among the Lower and Middle Palaeolithic assemblages, lead us to believe that the use of this apparatus provides more critical information than methods using a combination of a binocular magnifier and metallographic microscope (Lemorini 2000).

The objects to be analysed were first subject to a cleaning treatment using an ultrasound bath, consisting of submerging the objects in neutral soap, in H_2O_2 to remove any organic residue and in HCL to remove concretions. Concerning observation conditions, a working distance of 10-15mm was maintained between the detector and the piece inside the chamber, with a current of 15 Kv. Exploration was to a depth between 500 and 1000x, and the images obtained, some of which are included within this paper, were taken at the same depth.

In interpreting the action and the material worked with the archaeological objects, we took the type of deformation (fragile, abrasive or plastic) into account. The first type corresponds to chipping, the second to rough surfaces and the third to polished and compacted surfaces (smooth surfaces contrasting with the natural grainy surface of flint). The traceological interpretation also took into account the distribution of the deformations over the edge, the relation between them and their morphological features (Martínez 2005).

The site

The Abric Romaní is located 50 km north-east of Barcelona, in the locality of Capellades. It is one of the caves and rock-shelters which form part of the Cinglera del Capelló, a 60m high quaternary travertine structure overlooking the right bank of the river Anoia, a tributary of the Llobregat river. The tectonic movements which raised up the pre-coastal chain, of Alpine orogenesis, and the distensional movements during the Miocene generated a series of transversal faults in the mountain range. One of these faults forms the Estret de Capellades, a valley with a maximum width of 4 km through which the river Anoia runs to cross the pre-coastal mountain chain. These faults also caused the major hydrological emergences in the area, which formed the travertine platform where the site is located. (Fig.1)

The Abric Romaní is 280m a.s.l. It faces north-east, it is 25m long and covers an area of some 300 m^2. The shelter forms two small cavities separated by a wide convex feature. The sedimentation in the shelter consists of a succession of travertine platforms, formed during periods of humidity, by packages of detritic sediments generated by the chemical erosion of the walls and ceiling and by the detachment of blocks and sheets during dry periods. At two points in the sequence, in the upper part topping the fill and on level E, these carbonate sediments are interrupted by clayey deposits originated by the wind, indicating an interruption in the process of sedimentation of carbonate materials in the shelter (Vallverdú 2001).

Archaeological sounds have recorded a stratigraphic sequence 14m thick, with 27 archaeological levels. To date work has gone as far as level O, at a depth of about 8m. The series of U/Th datings frame the stratigraphic sequence between 43 ky BP for the top platform of level

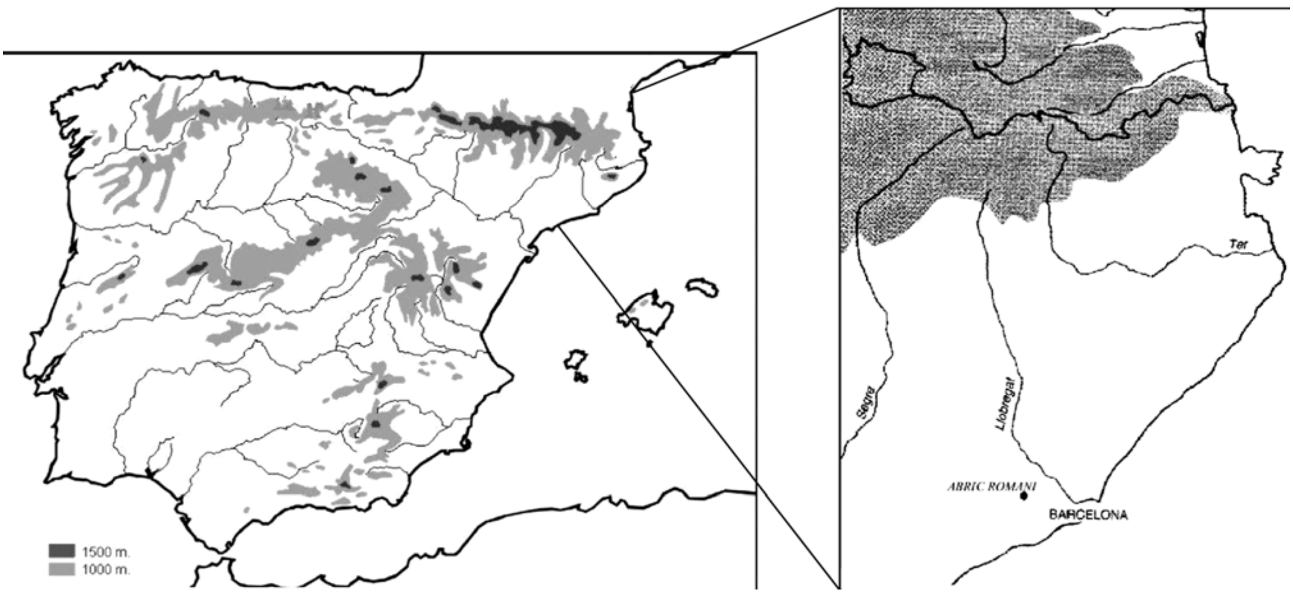

Fig. 1: Map of location of the Abric Romaní.

A, which tops the carbonate sedimentation in the shelter, and 70 ky BP (Bischoff *et al*. 1988). All the archaeological levels belong to the Middle Palaeolithic with the exception of the first, level A, which is attributed to the Aurignacian and it has been dated to 36 ky BP by C14 (Bischoff *et al*. 1994). Pollen analysis, in turn, has identified considerable fluctuations in climate conditions and landscape throughout the sequence, with cold, dry phases dominated by steppe landscape with *Artemisia* and *Poaceae*, such as that between 49.5 and 46.2 ky BP, alternating with others where the surroundings were populated by mesothermophile and thermophile species, such as between 46.2 and 40.8 ky BP, in the upper part of the sequence (Burjachs and Julià 1994, 1996).

The site was discovered in 1909 and throughout the 20th century successive archaeological interventions took place. Since 1983, the current team directing research has been working continuously on the site, with the principal goal of interpreting the ecosocial behaviour of hominid communities on a synchronic level (Carbonell *et al*. 1996). To this end, the whole surface of the different archaeological levels was excavated with the aim of recovering all the archaeological assemblage and structures of the levels. This approach to excavation is possible because the archaeological levels on the site correspond to fine sandy strata separated from one another by travertine platforms, so avoiding vertical movement of material. Moreover, the rapid growth of these travertine platforms reduces the time lapse included in each archaeological level, and the said platforms allow uncommon archaeological evidence to be preserved, such as rubefaction due to the thermal impact of hearths or the preservation of positive and negative traces of wooden objects (Carbonell and Castro-Curel 1992).

From the study of the archaeological assemblage, clear well-structured behaviours in the organisation of exploitation of resources were deduced (Vaquero *et al.* 2001b). For example, analysis of the lithic industry on the site was oriented to three areas of study: 1) the selection and management of raw materials, 2) the morphotechnical structure of the record and 3) the spatial and temporal dimensions of the knapping sequences, i.e. reconstruction of the *chaînes opératoires*. Analysis of these three factors shows a recurring pattern, with a minimum margin of variability. Thus, flint is the preferred raw material, though on some of the levels, particularly towards the bottom of the sequence excavated, quartz and limestone reach significant proportions of nearly 30%. There are rich outcrops of these last two raw materials in the immediate surroundings of the site, in the Estret de Capellades area itself, located in the Palaeozoic and Triassic formations of the pre-coastal mountain chain. Flint on the other hand, though it can be collected in large amounts in the Palaeogene formations situated on the border between the central depression and the pre-coastal chain, lies at distances greater than 10 km. Therefore, the differences in the respective percentages of raw materials on each of the archaeological levels seem to indicate adaptation of the selection to technical needs and not just exploitation of the diversity existing in the immediately surrounding area (Vaquero 1997).

In the same way, in the knapping sequences, technical patterns were identified which are repeated throughout the sequence. The cores are exploited in accordance with hierarchical discoid-type centripetal biface knapping methods, with the top face exploited by preference with a flat angle, while the bottom displays marginal semi-abrupt extractions. These types of core raise the question of links between them and the Levallois cores, because except the latero-distal preparatory extractions of levallois cores (Boëda 1993), there are not other technical differentiating criteria between them (Vaquero 1999b).

These knapping processes are dominated by spatial and temporal fragmentation of the sequences, both within the shelter and between the shelter and the outside. This feature is observed basically in flint cores, as there are very few cases where the whole process of exploitation was carried out inside the site, and they habitually arrived at an advanced stage of their reduction and were finally finished off in the shelter. Only on those levels with a major anthropic impact have almost complete sequences of exploitation been observed; in fact, on level Ja, large rough blocks of flint were brought in. As these were not exploited, we interpreted them to be a reserve of material. Management of flint on the site is characteristic of the Middle Palaeolithic, when the sequences of the *chaîne opératoire* which are present on the site, depend on the distance from sources of raw materials, so that artefacts made of distant raw materials (flint) came into the shelter after a large amount of work had been done on them (Roth and Dibble 1998). This behaviour is probably due to an individual supply strategy in the collection of lithic resources (Kuhn 1992).

Due to the excellent sedimentary conditions on the site for studying the spatial distribution of the record, the fieldwork strategy was oriented towards extensive excavation of the whole surface area of the shelter, nearly 300 m^2. The aim is to determine the implementation and spatial organisation of the camps on the basis of the distribution of the archaeological record and the relationships among it. This line of research relies on systematic collection of the finds and the use of analytical tools like refittings.

The spatial organisation of camps is structured around hearths and the activities pursued around them, principally knapping sequences and the final consumption of prey. As occupations got longer, and following the ethnographic models which explain the dispersion of remains and the consequent spatial organisation which comes about, a rise in the complexity of this basic archaeological structure was observed (Binford 1980; O'Connell 1987; Stevenson 1991). Thus, first of all an increase in accumulations around hearths in different spots in the shelter was observed; these spots were not related to each other, which could indicate that they are diachronic accumulations. In other cases, accumulations with several focuses of heat were recorded, implying the repeated re-use of a single hearth, with an increase and diversification in the record built up. Another spatial model is that made up of accumulations around hearths which are related by the exchange of objects with more dispersed accumulations on the outside of the shelter, with a record consisting largely of bone remains. Finally, on the levels with the greatest anthropic impact, a duality was observed between a fully-exploited central space, indicating the simultaneous existence of the different hearth accumulations, and an outside part without any evidence of having been the site of *in situ* activities and with a record which would have been carried there from the main areas of occupation during cleaning activities. As the most complex spatial structures are connected with a greater number of knapping sequences, a wider range of raw materials and more complete lithic production processes inside, we related the spatial variability of the camps to the duration of the occupations, which means that these groups organised their exploitation of the territory through a hierarchical network of camps (Vaquero 1999a; Vaquero and Pastó 2001; Vaquero *et al.* 2001a; Vaquero *et al.* 2004). It is probable that these differences in the intensity of occupation of the camps reflect practices of concentration and dispersion of the groups, and different residential mobility strategies during a single year cycle.

The sample

For the functional analysis, all the retouched flint objects recovered on the site since excavations resumed in 1983 were selected. The analysis excluded the few examples of other raw materials (mainly quartz and limestone) and those which were highly altered. The retouched objects from the upper levels (B-G), largely excavated during previous fieldworks at the site, were grouped together (Assemblage II) so that they would be minimally represented. The remaining retouched objects were distributed by their respective levels. With the exceptions of levels K and L, the sample represented over 50% of all the retouched objects recovered in each of the archaeological units, with a total of 211 objects analysed, making up 60.2% of the total recovered at the site.

In general, the retouch sequences are of little importance on the site, with the exception of level H, in comparison with the exploitation sequences, which form the bulk of the site's lithic record. Thus, retouched objects make up a maximum of 5.3% on level H and just 2.7% on level L, among the lithic artefacts.

The morphotechnical features of the materials selected for retouch are those of products of the (discoid) centripetal bifacial knapping sequences which are typical of the site. A preference for large flakes - over 1250 mm^2 in area - was observed and also a preference for thick objects, particularly for the smallest retouched objects. This increase in the thickness of the retouched pieces in comparison with the rest of the flakes from the site is not due to greater intensity of retouching with successive series reducing the width of the objects (Vaquero 1997). Therefore, there is a deliberate selection of large flakes and thick ones probably connected with a functional need or with some requirement in terms of holding the artefacts. In terms of morphological features, these flakes stand out in that they have asymmetrical cross sections, where the retouched edge is opposite to a backed edge. This morphology allows the object to be comfortably held in the hand. This ergonomic shape is important in naturally backed objects (No. 32) and *débordant* flakes (No. 30) (Lemorini *et al*. 2003).

As regards the retouched edge, 74.7% of the objects are denticulates, 11.2% are notches and only 7.2% are side-scrapers. While the latter are best represented on level E, where they come to nearly 20.4% of the total, they are hardly significant on the other levels. Retouching is limited to one side of the object, generally the left-hand side, there being only 28 with more than one edge retouched. The average length of edge shaped is 25 mm, and the shaping does not generally take up the whole length of the side, indicating a low rate of retouching. The denticulate edges form varying contours, with convex, concave, straight and twisting edges similarly represented. With these contours, especially the twisting and concave ones, it is difficult for the whole length of the edge to be used at once. The angle of the retouched edges is medium by preference, between 45 and 75º, in 82.4% of the artefacts.

Finally, direct and indirect refittings indicated that the retouched pieces reached the site already finished or were worked on from large flakes brought in, isolated from their production sequences. On the other hand, very few cases were identified of the resharping of a flake resulting from the knapping sequences carried out inside. From these observations it may be deduced that these objects played an important part in the mobility strategies of the hominid groups.

Results

Out of the total of 211 artefacts analysed, only 35 of them were identified as having deformations by use, making up 15.6% of the sample. In general, the bulk of the material was affected by the chemical alteration causing the white patina which covers many of the objects. Like other researchers, we have seen how polish is affected by alkaline environments such as those formed during the sedimentation in the shelter (Plisson and Mauger 1988). In our case, we submerged experimental objects for a week in a solution 10% of NaOH and observed how polish suffered a chemical attack which partly removed the experimental deformation. This may be one of the reasons explaining a low rate of identification, though it should not be forgotten that in general traceological

SAMPLE OF RETOUCHED TOOLS								
	LEVELS							
	C-II	N-E	N-I	N-Ja	N-Jb	N-K	N-L	TOTAL
Fa	20	43	4	101	20	9	14	211
Fr	*9.4%*	*20.3%*	*1.8%*	*47.8%*	*9.4%*	*4.2%*	*6.6%*	*100%*
Total tools level *% sample*	37 *(54%)*	76 *(56.5%)*	6 *(66.6%)*	138 *(73.1%)*	34 *(58.8%)*	28 *(32.1%)*	31 *(45.1%)*	350 *(60.2%)*

USE-WEAR ANALYSIS RESULTS	C-II	N-E	N-I	N-Ja	N-Jb	N-K	N-L	TOTAL
USE-WEAR	8*(40%)*	14*(32.5%)*	0	9*(8.9%)*	2*(10%)*	1*(12.5%)*	1*(7.1%)*	35*(16.5%)*
INDET	*2(10%)*	*5(11.6%)*	0	*7(6.9%)*	1*(5%)*	1*(12.5%)*	*3(21.4%)*	*19(9 %)*
PDSM	*4(20%)*	*8(18.6%)*	4*(100%)*	46*(45.5%)*	5*(25%)*	2*(25%)*	*4(28.5%)*	*73(34.5 %)*
UNDEFORMED	*6(30%)*	16*(37.2%)*	0	39*(38.6%)*	12*(60%)*	5*(55.5%)*	*6(42.8%)*	84*(40.7%)*
TOTAL	20*(100%)*	43*(100%)*	4*(100%)*	101*(100%)*	20*(100%)*	9*(100%)*	14*(100%)*	211*(100%)*
RETOUCH WEAR	4*(20%)*	5*(11.6%)*	0	8*(7.9%)*	1*(5%)*	2*(25%)*	1*(7.1%)*	21*(10%)*

Fig. 2: 1) sample analysed 2) results of the use-wear analysis.

analyses conducted on assemblages from this period obtain rather low rates of identification (Fig. 2).

In all artefacts displaying deformations by use, such deformations were only found on one of the sides of the piece, reinforcing the idea of the existence of a model whereby the active part is differentiated from the passive part, with the latter being used to hold the object (Lemorini 2000). Only one object was identified as having been used in different actions: in one denticulate from level Ja, the proximal part of the retouched side had been used in a transversal action over fresh skin, while the distal part had been used in a lengthwise butchering task. It seems, therefore, that this object could be used for two different activities.

The denticulate edges were used in preference for lengthwise actions to cut soft animal materials, though crosswise actions of scraping fresh skin with a negative movement (backwards) and in bone scraping actions to remove all muscle material from the bones were also well-represented. Indeterminate polishes which might correspond to the task of whittling fresh wood was observed in just two objects, but due to the lack of development of the polish and its concentration at a single point on the edge we cannot confirm this use. Our results therefore contradict the widespread opinion that considers denticulates as tools specialized in working with wood.

Although the results do not make it possible to suggest functional differences between levels, higher rates of identification were obtained in the upper part of the sequence, Assemblage II and level E. The objects from these levels were the least affected by the white patina which covers most of the lithic record from the site. This factor may have played a part in this higher rate of deformations by use. Otherwise, this higher rate must be attributed to an increase in the intensity of use of tools in the top of the sequence. This increase would coincide with a more demanding technical organisation of production as identified in the technological analysis (Vaquero 1999b) and with a wider spectrum of animals being consumed on the top levels (Vaquero *et al*. 2001b).

Butchering Actions

In 23 artefacts the deformations identified run parallel to the edge, and their distribution and features correspond to working with soft animal material. The experimental deformations generated during butchering were differentiated according to the specific action performed; thus, 1) there were the actions of flaying, when the animal was skinned, 2) actions of carving up and defleshing, when the animal is cut up, eviscerated and muscle material removed, and 3) actions of cutting muscular matter. While all these actions generated deformations which overlapped each other, there exist some characteristic traits which make it possible to differentiate them. For example, in skinning actions, the deformation is abrasive, causing considerable wear on the crystalline surface and rounding off of the edge, but without developing polishes.

In general, the archaeological deformations are not well-developed and are located at specific points on the edge, which would indicate low intensity of work. Among the denticulates, the actions of carving up and defleshing are the best-represented, within 20 pieces. These deformations are characterised by the development of compacting of relief and the formation of flattened polished strips, sometimes accompanied by striations, which we connected with rubbing on hard parts of animals, such as bone. On the other hand, the actions of flaying - the first stage in processing animal carcasses - were only visible on three objects. It therefore appears that denticulates were used mainly in the most demanding stages of the processing of carcasses where tougher edges with semi-abrupt angles were required.

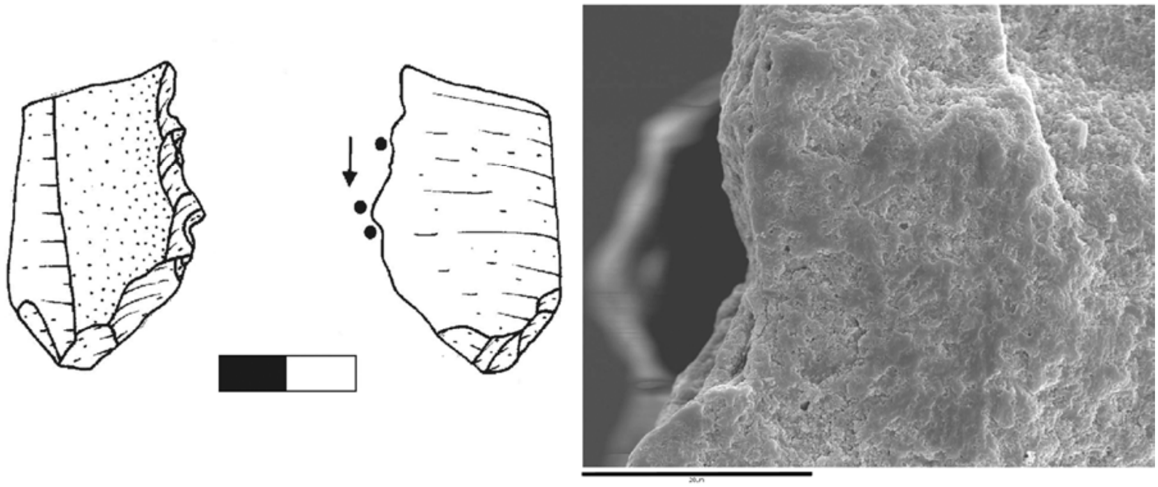

Fig. 3: Denticulate tool from level E with longitudinal butchery use-wears.

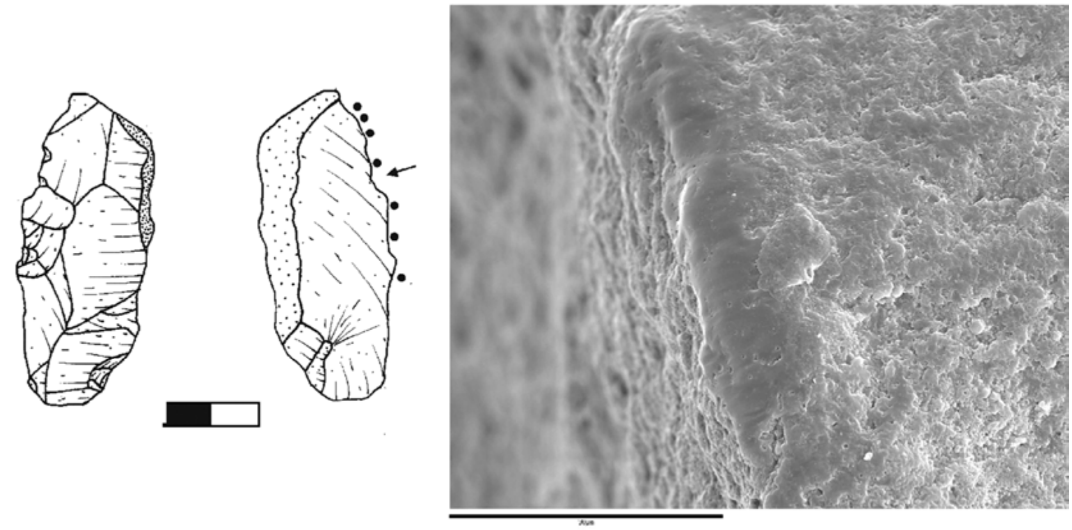

Fig. 4: Denticulate tool from level E with transversal fresh hide-scraping use-wears.

Finally, on four artefacts polished spots were identified, which we related to crosswise actions on hard material. As these spots are dispersed over the length of the edge we linked them to occasional rubbing on bone in scraping actions to remove the fat material adhering to the cortical surface of the bone. This action may be a practice aimed at cleaning the bone before breaking it to get at the marrow. The breaking of bones is a systematic practice in the processing of carcasses within the site, for which reason a low percentage of the bones found there could be identified taxonomically and anatomically (Fig. 3).

Actions of Scraping Fresh Skin

In eight of the objects analysed, a continuous polish was identified, crosswise to the edge. We interpreted this as the result of working with fresh skin. The position of the polished area, just over the edge and affecting both faces of the dihedron, would seem to indicate a backward action with a medium to high angle of attack for scraping the skin. Only in one object could abrasive deformation be observed accompanied by chipping reflected on the ventral face, which could be linked to the scraping of fresh skin with a forward motion. In all these tools, unlike those used for butchering tasks, the deformations are well-developed and continuous along the edge used. This indicated to us intensive, prolonged work in cleaning skins.

The available ethnographic information shows an enormous variety of techniques and actions in the process of treating and tanning skins. In general, the first stage consists of cleaning off the remains of fat adhering to the skin and removing the epidermis, to avoid this rotting. The skin is then left to dry and next the hypodermis is removed and the dry skin softened (Beyries 1999). In the case of the Abric Romaní, we only have evidence of the first of these stages, the cleaning off of the epidermis. Some communities, like the Ona from Tierra del Fuego, limited the treatment of skins to this action, so it may be the handling of skins at the Abric Romaní was similar to this ethnographic practice (Jardón 2000) (Fig. 4).

Actions upon Vegetable Materials

Denticulates have generally been considered as tools specialized in working with wood. The functional analyses carried out by Beyries (1987) and Anderson-Gerfaud (1990) and the ethnographic references by Hayden (1979) concerning Australian aborigines appear to confirm this. However, in preliminary analyses with samples from the Abric Romaní, I misunderstood polishes from hideworking, related them wrongly to woodworking (Martínez *et al*. 2003).

At present, of the denticulates and notches analysed, we only identified indeterminate polishes which could be linked to woodworking, in two of them. This is a poorly developed polish and limited to specific points on the edge, for which reason its connection with woodworking could not be confirmed. Among the possible explanations for the absence of vegetable deformations in this Middle Palaeolithic assemblage, we see no reason to believe that the sample of actions and materials worked on does not correctly reflect the activities going on at the site. The white patina coating most of the pieces analysed completely covers 27.4% of them, and there can be no doubt that this affected the preservation of the polishes. Our experimental tests with alkaline solutions showed that under these conditions the crystalline texture, and consequently the polishes, were affected. Perhaps for this reason, most of the deformations by use were identified among the objects without patina, when they only make up 28% of the total sample. However, in our tests we did not observe that the polishing was affected in different ways depending on the material worked on. In contrast to other opinions (Plisson and Mauger 1988), we think that the variety of flint, its composition and its properties are what finally determine the degree of alteration suffered by lithic objects and their deformations by use.

A specialisation of the site in activities which did not include working on vegetable matter does not appear probable. Levels succeeded one another on the site with a variable intensity of occupation, which rules out settlements of different importance in strategies for exploiting the territory always carrying out the same activities. Therefore, we currently lack a likely explanation for the absence of deformations by wood in the sample analysed. In any case, several authors have recently warned that the presence of wood in Middle Palaeolithic assemblages may have been overestimated, due to alterations which have incorrectly been interpreted as polishes from wood (Lemorini, 2000; Caspar *et al*. 2003). Likewise, analysis of the lithic assemblages from the Grotte Breuil (Italy) (Lemorini 2000) and the Salt site (Alicante, Spain) (Rodríguez *et al*. 2002) have also obtained low values for actions upon vegetable materials. This means that the different actions interpreted in Middle Palaeolithic assemblages are drawing level with each other in percentage terms, so giving more importance to all those actions related to butchering activities and the treatment of skins, which were not previously well-represented.

Discussion

The retouched artefacts from the Abric Romaní can be described as versatile, as they were used for different actions (lengthwise and crosswise, forwards and backwards) and on different materials (butchering, fresh skin, dry hide? and wood?). Moreover, they show little technical adaptation to the actions carried out, as the same types of edges were used in all these actions.

We have not identified clear deformations to these objects which could be connected with their hafted use. In all of them, only one side was identified as being used, generally opposite an abrupt angle which could easily be held in the hand. As C. Lemorini (2000) has stated, Middle Palaeolithic objects appear to have a morphological design in which an active part for use and a passive part for holding are distinguished.

The denticulate edge appears, therefore, to offer greater versatility than the flakes produced using centripetal bifacial knapping methods. The semi-abrupt angle of the edge and the denticulate shape makes the objects tougher for more demanding jobs, such as scraping fresh skin or for the more demanding parts of the processing of animal carcasses. However, as no technical adaptation of the denticulate edge to the different actions for which it was used has been observed, its morphology does not seem to have been dictated by technical requirements or efficiency in the actions carried out. We therefore interpreted that the shape of the denticulate edge responds more to strategic than tactical needs and, in this light, efficiency would appear to be secondary to the availability of versatile tools.

In this light, if the form of the denticulates does not conform to any functional specialisation and continued to predominate for over 10,000 years at the Abric Romaní, despite differences between levels in intensity of occupation and climate conditions, this persistence must be attributed to cultural factors. Exploitation of the regions' natural resources by the communities settled at the Abric Romaní does not seem to have been based on lithic technological efficiency, as the changing circumstances were only met with a minimum of technological variability as identified on the site. The archaeological studies conducted appear to show that changes were met with social changes like variations in the length of occupations, in the composition of groups and perhaps in the function of camps (Vaquero *et al.* 2004; Henry *et al.* 2004).

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Typology, technology and use-wear: the necessary integration. An example from the Aurignacian site of San Cassiano (Arezzo, central Italy)

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Summary. *The authors face the typological, technological and functional study of the Aurignacian industry of San Cassiano, in the municipality of Caprese Michelangelo (Arezzo). The material comes from a surface collection carried out in a rather limited area (approximately 40X50 m), situated to the margins of an ancient lake basin. This lithic complex is characterized for the abundance of elements on flake assimilables to that particular subtype of burin known in literature as Burin des Vachons, to which is currently attributed the function of core for the production of bladelets.With regard to such production, other elements like the carenated end scrapers and prismatic cores play a decidedly subordinate role in San Cassiano. Traceological investigation, integrated with techno-typological analysis, has however lay stress on the complexity of the problem, bringing to light that Burins des Vachons were further used as instruments once exploited as cores. The traces, developed above all on the biseau, indicate the prevailing working of a hard material, carried out through a movement perpendicular to the active margin of the tool in an action similar to that one of planning.*

Résumé. *Les Auteurs exposent l'étude typologique, technologique et fonctionnelle de l'industrie aurignacienne de San Cassiano (Caprese Michelangelo – Arezzo). Le matériel lithique vient d'une récolte de surface réalisée dans une zone assez délimitée (40x50m) sur le bord d'un ancien bassin lacustre. Ce complexe est caractérisé par la fréquence d'outils sur éclat très proches des burins demi carénés décrits en littérature comme Burins des Vachons, dont la fonction de nucléus à lamelles est aujourd'hui presque universellement reconnue. A propos de cette production, à San Cassiano les éléments comme les grattoirs carénés et les nucléus prismatiques jouent un rôle décidemment subordonné. L'analyse des traces, intégrée aux analyses technologique et typologique, a cependant démontré la complexité du problème, en mettant en évidence que ces Burins des Vachons, après leur exploitation comme nucléus, étaient ultérieurement utilisés comme des véritables outils. Les traces, développées surtout sur le biseau, indiquent un travail sur matière dure exécuté par un mouvement perpendiculaire au bord actif de l'outil, avec une fonction de rabotage.*

Key words: Upper Palaeolithic, burins, *burins des Vachons*, cores on flake.

This project represents the continuation and development of a previous paper presented at the round table: "*Burins: formes, fonctionnements, functions*", held in Aix-en-Provence in March 2003 (Arrighi *et al.* 2003), and focuses on the Aurignacian material from San Cassiano in eastern Tuscany, province of Arezzo (Central Italy) (Fig. 1).

It is an open site which was located in an area near a lake basin which silted up only towards the end of 1800, at 560m a.s.l.. An explorative trench, opened in 1998, following a number of surface findings by the Archaeological Group of Sansepolcro, showed that the prehistoric material was contained inside a layer of about 10-15 cm. This layer rested upon a sequence of sterile lacustrine silts and had, unfortunately, been greatly eroded and disturbed by agricultural work. The localization of the lithic assemblage in a limited area and the absence of patinated and pseudo-retouched pieces indicate the primary position of the artefacts found. The fauna component was not preserved.
The lithic assemblage (Fig. 2) is composed of 171 tools (*sensu* Laplace), among which there is a high percentage (36.3%) of *burins des Vachons*, 16 cores, and a few dozens of blanks. The raw material consists mainly in high quality flint (88.9%) of far-away origins (most probably from the Umbria / Marche regions); to a lesser extent local flint of a much inferior quality (11%) was used. The debitage products, the dimensions of which are concentrated principally between 26 and 33 mm, are formed predominantly of flakes (approximately 63%). Among the blades, which constitute the remaining 37%, two components are present, blades and bladelets,

Fig. 1: Localization of the Aurignacian sites of San Cassiano and Caruso.

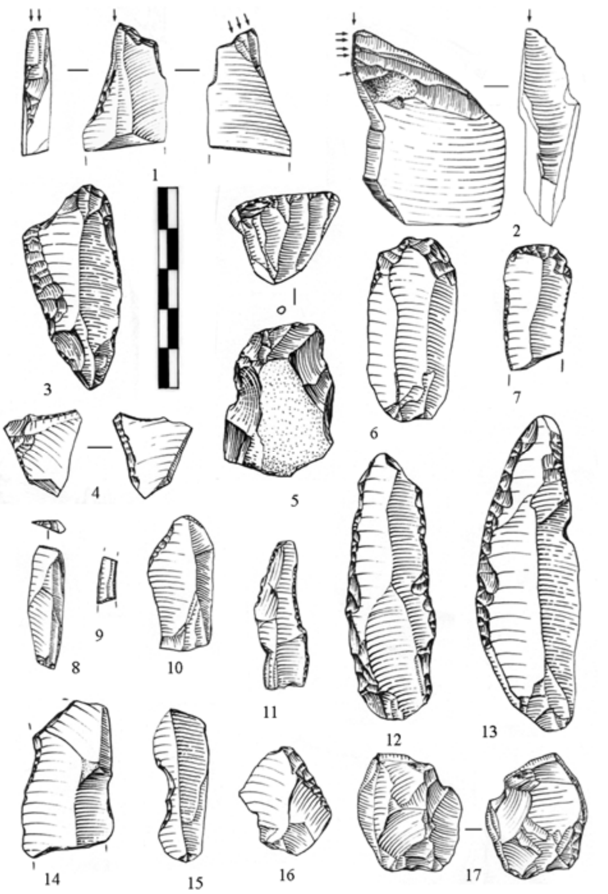

Fig. 2: San Cassiano. Ns. 1- 2 burins, ns. 3, 5 – 7 end scrapers, n. 4 bec, n. 8 truncation, n. 9 marginally retouched backed tool , ns. 10 – 13, 16 side – scrapers, n. 14 indifferentiated abrupt tool, n. 15 denticulate, n. 17 scaled piece (1:1) (drawnings by A. Moroni Lanfredini).

deriving from independent operative chains .These different productions are identified in the core typology which includes flake, blade and bladelet elements.

Recent research, carried out at the site over the past two years, has led to the recovery of new material; thus we present now an updated version, compared to previously published papers (Moroni Lanfredini and Ronchitelli 2000, 2001), of the industry structure.

The cultural attribution to the Aurignacian is confirmed by the typological structure of the industry, analysed according to the Laplace typology (Laplace 1964):

- high index for burins (*burins des Vachons* included);
- medium index for end-scrapers;
- low index for differentiated abrupt retouched tools, mainly represented by truncations, with only two marginally retouched backed tools and lack of deeply retouched backed tools;
- high index for the substratum, with numerically equivalent side scrapers, denticulates and undifferentiated abrupt retouched tools; the side scrapers on blades have a low index and deep retouch, never stepped; there are also a few deeply retouched notches on blade but an absence of *étranglées* blades;
- very low index for scaled pieces.

Burins	***80***	***46,8***	Bc1	1	0,6
B1	36	21,0	PD1	1	0,6
B2	17	9,9	Δm	1	0,6
B3	14	8,2	***Substratum***	***59***	***34,5***
B4	3	1,7	L1	4	2,3
B5	4	2,3	L2	2	1,2
B6	4	2,3	R1	7	4,1
B7	2	1,2	R2	7	4,1
End scrapers	***22***	***12,9***	L/R1	2	1,2
G1	2	1,2	L/R2	1	0,6
G2	2	1,2	A1	10	5,8
G3	3	1,7	A2	6	3,5
G2-4	2	1,2	D1p	13	7,6
G7	4	2,3	D2m	1	0,6
G8	2	1,2	D2p	5	2,9
G9	7	4,1	D8	1	0,6
Diff.abrupt retouched tools	***8***	***4,7***	***Scaled pieces***	***2***	***1,2***
T2	1	0,6	E1	2	1,2
T3	4	2,3	**Total**	**171**	

What is immediately striking about this assemblage is the quantity of core-like pieces on flakes similar to pieces identified in literature as *burins des Vachons*, the characteristics of which have been summarised, from the typological point of view, as follows: "simple burin with a polygonal mixed *biseau* with prevalent plan removals which tend to invade most of the ventral face" (Perpère 1972; Moroni Lanfredini and Ronchitelli 2001, p.329). These artefacts, together with bladelet carinated end scrapers, are today almost universally seen as serving the function of cores for the production of bladelets typical of the Aurignacian.

	Burins des Vachons	Other burins
B1	33	3
B2	13	4
B3	10	4
B4	3	
B5	1	3
B6	1	3
B7	1	1
Total	**62**	**18**

The high percentage of *burins des Vachons* has encouraged us to carry out a more in depth analysis to verify their function as both cores and tools.

Therefore, we carried out a technological study, which was tightly integrated with the traceological one, obtaining, as we will see, definite proof that these objects were also used as tools. This entails a brief premise regarding terminology, in that the definition of the different surfaces varies according to the object's function in the course of the history of its exploitation (Fig. 3: a, b, c).

In the initial stage, the *burin des Vachons*, in the role of a core, has a striking platform and a debitage surface. In the final stage, in the role of a tool (typologically burin), the

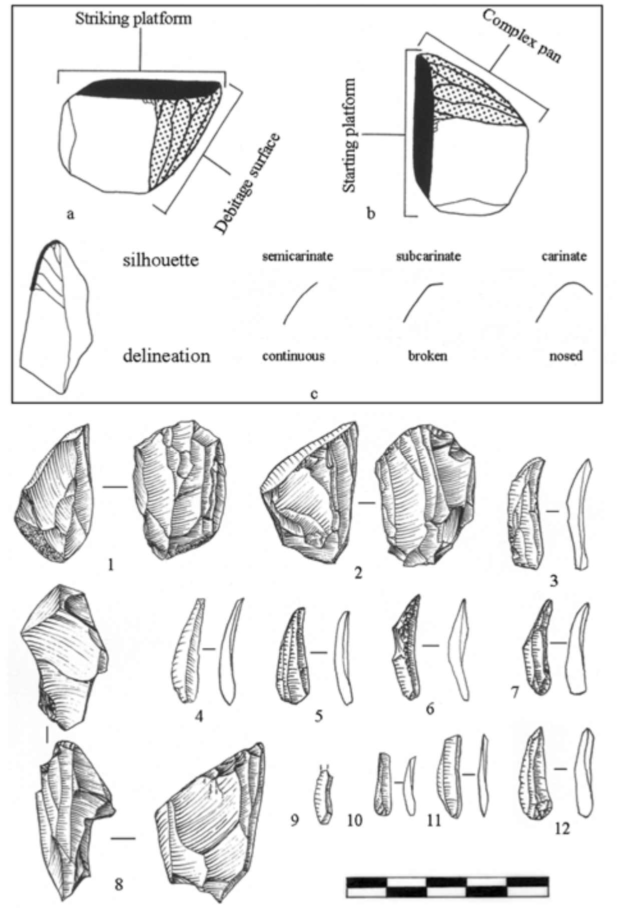

Fig. 3: San Cassiano. Terminological scheme of the "burins des Vachons" as cores (a) and as tools (b, c) (above); n. 1 prismatic core, n. 2 *nucléus caréné*, n. 8 "burin des Vachons", ns. 3, 4 – 7, 9 – 12 bladelets (1:1) (drawnings by A. Moroni Lanfredini).

striking platform becomes the starting platform, and the debitage surface corresponds to the complex pan.

As cores (Fig. 3, n. 8), these pieces are specialised in the production of bladelets, beginning from carinated flakes, the scarcely elaborate debitage, which is shown by the frequency of cortex portions (about 30%) and by the presence of flat or natural butts. The raw material normally has an outside origin (Umbria-Marche) and the cores from which these flakes have been removed have not been found. Nevertheless, among blanks, some pieces (at least 8) have been found to have characters compatible with those registered on *Vachons* supports: a notable thickness (index of carenage comprised between 1.9 and 2.6), flat butt, presence of cortex on the dorsal face (in 2 cases we are dealing with flakes with dorsal surface covered in cortex). Being cores the *burins des Vachons* have a striking platform, which is usually single, not prepared or formed by a single removal. The specimens of San Cassiano show a number of features which indicate, in most cases (no. 48), a terminal stage of reduction:

- overall presence of hinged removals, even short and stepped;
- loss of distal-proximal convexity (*carenage*);
- very small size.

On these pieces it is also possible to occasionally note, as a final touch, an abrasion of the overhang which involves the entire perimeter of the debitage surface: although this might have been the result of a functional regularization due to the piece being used as a tool rather than in preparation to obtain more bladelets.

The finding of crested burin spalls and the presence of residual crests on the pieces demonstrates that this operation took place during the various phases of core management.

Bladelet production of San Cassiano was also obtained, albeit minimally, from other categories of artefacts, such as carinate end scrapers and prismatic cores (Fig. 3, nos.1, 2).

There are eight carinated end scrapers (2 G8, 3 G9 (G8) e 3 G9) which can be traced to a primary function of core and classifiable as *nucléus carénés* (Bon 2002); these systematically present convergent sides and a trapezoidal or triangular transverse section. Another frequent characteristic is that of the removal, on one or both sides, in a position next to the bladelet debitage surface (*front lamellaire*), of a flake, generally *laminaire*, destined to create or restore the properties necessary for the removal of the bladelets (*éclat de cintrage*) (Bon 2002, p.47). The presence of a distal crest (*crête distale*) is less systematic. In just two elements an abrasion of the overhang was found. As for the burins, the abandonment of the core - like end scrapers is mainly due to the formation of hinged removals.

The *burins des Vachons* and carinated end scrapers can be traced conceptually to autonomous operative schemes which foresee the use of morphologically different blanks and an alternative use of the volumetric structure. It should, however, be stressed that the presence on numerous burins of a removal similar to that indicated as *éclat de cintrage* on carinated end scrapers, testifies the adoption of technical solutions common to the two procedures (Le Brun-Ricalens and Brou 2003, p.74).

Prismatic cores (10 pieces) indicate an advanced level of exploitation. Debitage is strictly unipolar and the striking platform is generally formed by a single removal. Bladelet debitage surface appears distally tapered and is drawn, contrary to what can be observed in the end scrapers, on the largest dimension of the core volume. It should be highlighted that the limit between burins, *nucléus carénés* and prismatic cores is not always clearly distinguishable.

As previously observed by other authors (Bon 2002), to the three operative schemes described a completely homogeneous bladelet production corresponds, without being able to determine the category of origin of each bladelet. The actual production of bladelets (from 62 *burins des Vachons*, 8 carinated end-scrapers and 10 prismatic cores) does not correspond with the actual quantity of bladelets found. The minimum number of pieces produced is estimated at around 270, but the bladelets recovered at San Cassiano are only 34, 8 of which retouched (1 PD1, 1 frg. of marginally retouched backed tool, 1 L1, 3 D1, 1 T3, 1 A1). These pieces (Fig. 3, nos. 3-7 and 9-12) share relatively homogeneous characteristics with flat, often oblique butt, length comprised between 13 and 31 mm, width between 3 and 10 mm and thickness between 1 e 5 mm. The majority have a right hand sided morphology accompanied by the characteristic dorsal-ventral dextro-rotatory torsion (Le Brun-Ricalens and Brou 2003); there are only rare examples (no.6) with parallel edges, among which we find 3 crested pieces.

Traceological analysis was carried out based primarily on the evaluation of microwear. For this purpose a metallographic microscope (Leica DMR XP), with magnifications from 50x to 100x was used. The specimen that underwent analysis consists of 112 pieces (58 *burins des Vachons*, 22 end-scrapers, 1 prismatic core, 31 bladelets).

As far as the burins were concerned, 16 examples were without traces, 18 with dubious or illegible traces, and 24 with clearly identifiable polishes.

The microwear localization (Fig. 4) indicates that the use was made by means of the *biseau*, shaped like a nose end-scraper, and the action consisted in a movement perpendicular to the active edge of the tool; the object, leaning on the starting platform, where the more developed use-wear traces are localised, was probably used *en coupe positive* (Rigaud 1977), as shown by the presence of less extended polishes on the complex pan (i.e. on the back).

Other microwear also identified on the potentially active edges of the piece (different from the *biseau*) can be referred to the same action. Principally:

- use-wear on the edges of the starting platform, at times localised on protrusions which inevitably came into contact with the material being worked when the tool was used;
- use-wear probably connected with handling, at times overlapping a localised retouch.

Based on the characteristics of the same microwear we can hypothesize that most of the burins were used for working hard materials, with an action similar to planing (Fig. 4) with the exception of two pieces. The latter have an active end with a straight shape (more similar to a frontal end scraper than to a nose end scraper) and would seem to have been used for working soft material.

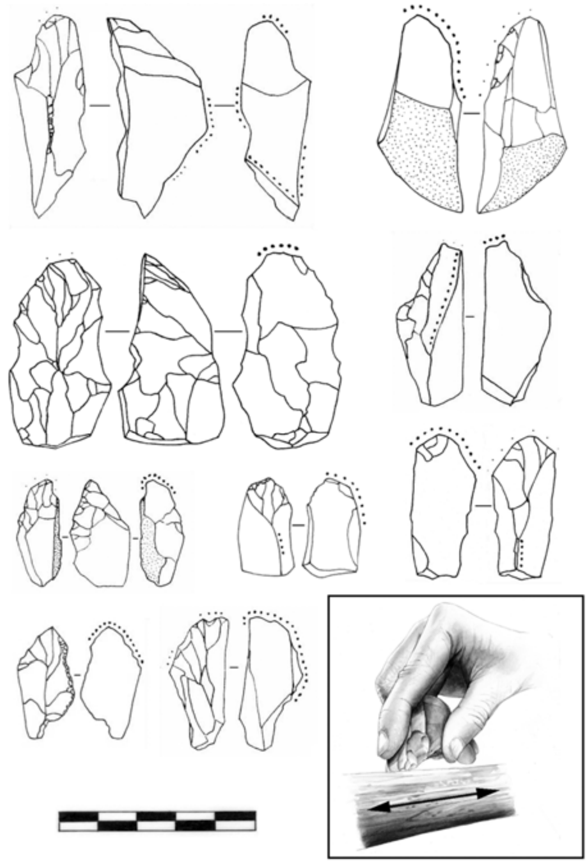

Fig. 4: San Cassiano. Use - wear traces localization on "burins des Vachons" and hypothesis about their working (1:1) (drawings by A. Moroni Lanfredini and S. Ricci).

Of the 22 traceologically analysed end scrapers, only 7 had easily identifiable polishes (on the others the traces were absent or illegible) and only one of these belongs to the category of the *nucléus carénés*; in all cases the use-wear traces were found on the front of the tool and were most intense on the ventral face; their typology would indicate their use on soft materials, unlike those from the Cave of Geissenklòsterle, where the traceological analysis conducted on a carinated end scraper with bladelet removals would indicate its use on hard materials (Hahn and Owen 1984, p.37).

In the number of products from San Cassiano which were traceologically examined, we find a prismatic core where polishes were identified analogous to those found on the end scrapers.

Among the bladelets, it is important to stress the scarcity of retouched pieces (no. 7) or with use-wear traces (no. 8) along the lateral edges, and the absence of a strict correlation between these two properties; the light entity of the polishes has, in addition, prohibited the recognition of the type of material with which these pieces came into contact.

Thanks to Prof. A. Palma di Cesnola it has been possible to analyse, traceologically, a sample of selected pieces from the Aurignacian industry of Caruso (Palma di Cesnola 1989) in the Gargano (Puglia), the only other Italian complex where a similar quantity of *burins des Vachons* to that found at San Cassiano has been discovered. Once again, unfortunately, the findings were made in an extremely eroded level, which filled a doline. The investigation was performed on 8 burins, 15 end scrapers, 5 of which carinated elements which can, with all probability, be traced back to a primary function of core, and 4 curved and twisted bladelets. Of the burins, 5 presented polishes corresponding with the *biseau*, more evident on the starting platform; for only one sample was it possible to identify the kind of material worked (wood or bone). Among the end scrapers, well developed traces, caused by contact with soft material, were identified on the front, and along the edges of 2 G2 and 1 G6; a single carinated end scraper (G8) had polishes not clearly identifiable in correspondence with the nose. Among the bladelets, 2 showed light polishes along the lateral edges. As far as the bladelets are concerned, analogous traces to those found at Caruso and at San Cassiano were recognised on 9 examples (of a sample of 12) coming from layer 24 (Aurignacian) of Grotta Paglicci in Gargano (Palma di Cesnola 2005). In any case, none of the examples studied seem to present fractures brought about by an impact comparable to that which can be created by a projectile, even though polishes visible on the bladelets of Paglicci are compatible with those obtained during experimentation on analogous bladelets handled laterally on a *viburnum* spear and thrown against an animal carcass (Borgia in print in this volume).

The question regarding the Aurignacian bladelets remains problematic partly due to a lack of investigations of a functional nature.

A recent study carried out by O'Farrell (2004) on 42 retouched bladelets from Cave of Hyènes in Brassempouy (France) highlighted the occasional presence (6 examples) of probable impact fractures which, according to the author, would have been caused by the contact between the handled bladelets at the moment of impact. This data could support the widespread opinion (Bon 2002, p.184) which tends to attribute to the Aurignacian bladelets a function linked to the manufacture of hunting weapons, whilst the blades would have been destined for domestic use. A destination as *armatures* would be further confirmed by the analysis of the macro wear carried out on materials from the Cave of Fumane in Veneto. In this latter case, the authors underline, however, the multi-functional character of the bladelets examined, among which both elements with impact chipping compatible with the function of a projectile point, and examples used to engrave and cut would be present (Lemorini and Rossetti 1998-1999).

From this point of view our study does not provide any significant breakthroughs because of the limited number of bladelets found; a factor which, as we have seen, is in contrast with the abundance of cores and the presence of debitage products, such as crested elements, which would indicate manufacture was carried out on the site.

Loss of bladelets, because of the conditions in which they were found, does not seem to fully agree with the difference registered between the effective quantity of pieces collected and the minimum number of products calculated on the cores. We are inclined to assume that the bladelets were moved elsewhere, probably in the form of composite tools.

Summarising, we can say that the Aurignacian people at San Cassiano aimed to obtain at least three sorts of products: flakes, blades and bladelets, each with precise characteristics. The last two of these were most certainly derived from operative chains independent one from the other; the bladelet debitage indicating that work was based on 3 different operative schemes, the one occupying the most privileged position being that linked to the exploitation of the *burins des Vachons*, whilst the carinated end scrapers and prismatic cores played a much less important role.

If, based on the above, we look for a link between the different uses of the *burins des Vachons* found at San Cassiano, like cores and tools, we could suggest the existence on site of a complex process which, starting from the bladelet production and with the use of the relative cores as tools, ends with the manufacture of tools for specific usage. This hypothesis would justify, in part, the scarce characterization of the rest of the industry.

A last problem remains: the chronological attribution within the Aurignacian of this complex, itself diagnosable exclusively on the basis of the techno-typological study of the industry. Substantial new elements have not been found on this subject. We only highlight that the attribution to the Classic Aurignacian (comparable with the ancient Aurignacian of the French authors) already proposed (Moroni Lanfredini and Ronchitelli 2000, 2001) on the basis of the very close cultural and typological similarities of our industry with that of the already cited complex of Caruso, is confirmed, by the technological point of view, by the presence of operative sequences specialised in bladelet production (*burins des Vachons*); proof of a largely independent production modality of blades on one hand, and of bladelets on the other, whereas, in the archaic phase, (with marginal backed tools), a sequential blade and bladelet debitage starting from the same core seems to predominate (Bon 2002).

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Functional analysis of the backed tools coming from the Gravettian layers 23 and 22 of Paglicci Cave (Foggia, Italy)

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Summary. *In the present work the backed tools coming from the layers of the ancient Gravettian of Paglicci cave have been analyzed with the aim of understanding the modalities of use of these particular instruments connected to the hunting activity.*
With this purpose several methodologies of analysis have been employed together, always from a functional point of view.
The assessment of the techno-typological and typometrical characteristics has allowed us to define the level of standardization of the tools and to create copies for the experimental phase, necessary in every functional study since it allows the interpretation of the archaeological data. The microscopic (both at low and high power magnification) observation of tools, in accordance to the methodologies of use-wear analysis, has been therefore carried out with the aim of associating to the use some types of macro- (fractures) and micro-traces (polishes and striae).

Résumé. *Dans le présent étudie les éléments à dos provenants des couches du Gravettien ancien de Grotta Paglicci ont été analysés avec l'objectif de comprendre les modalités de utilisation de ces particuliers outils liés à l'activité de la chasse. Dans ce but ont été associées, toujours dans un optique fonctionnelle, divers méthodologies d'analyse.*
L'évaluation des caractéristiques techno-typologiques et typometriques a permis de définir le niveau de standardisation des outils pris en considération et de créer des copies pour la phase expérimentale, nécessaire dans chaque étudie fonctionnel puisque permet l'interprétation du donné archéologique. L'observation des outils au microscope selon les méthodologies de recherche tracéologique à basse et haute résolution a été donc effectuée avec le but d'associer à emploie quelques types de macro (fractures) et microtraces (polie et striae).

Key words: Grotta Paglicci, Ancient Gravettian, backed tools, throwing weapons.

Introduction

At the time when the Gravettian culture began to spread, lithic points show a radical change in dimension and morphology, which indicates an interest in and research into the characteristics of penetration and fixing. Scholars unanimously agree that these pieces were specifically designed to function as projectile points. They also agree that the Gravettian population developed this technological innovation in connection with hunting and that it was linked to the invention of a weapon, probably a spearthrower, which enabled them to hunt from a distance: an advancement of fundamental importance for the cultural evolution of mankind.

The exact make up of the lithic tool within the complex system which comprised, in addition to the stone tool, elements which are missing, such as the spear, the bindings, and the throwing weapon and also the methods adopted for hunting, has yet to be established.

In this study the backed tools found in the ancient Gravettian layers (23 and 22) of Grotta Paglicci, and identifiable as elements of throwing weapons used for hunting, have been analyzed from a functional point of view.

The two objectives of the research are: to understand in which terms backed tools were used and, in particular, whether these specific tools had ever been used.

The archaeological context

Situated at the base of a rich series of the Upper Palaeolithic deposits uncovered at Grotta Paglicci (Fig. 1-1), layers 23 and 22 have been dated between 28.100±400 BP (layer 23 A) and 26.800±300 BP (layer 22B). The study of fauna and coals has enabled us to associate these levels with a cold dry period corresponding with the start of the 2nd Pleniglacial, in the lowest part of the Isotopic 2 Stadium, and to identify a climatic change during this period, compatible with the Interstadium of Kesselt (Palma di Cesnola 2005).

Among the large mammals, aurochs (*Bos Primigenius*) and horses (*Equus ferus)* are the most prolific, in addition to steinbocks (*Capra ibex*) (Boscato 1994).

Typological analysis of the lithic manufacture has led to these assemblages to be culturally attributed to the oldest phase of the Italian Gravettian, which is known as the period 'of backed points' or 'indifferentiated' (Laplace 1966; Palma di Cesnola 2005).

In the lithic assemblages, whole and fragmented backed tools make up 80% (Level 22E) of the entire produce.

Methodology

The backed tools are part of a complex system, the one of throwing weapons, which comprises various elements (spear, glues, bindings, system of propulsion). For the effective functioning of the various elements of this system, stone tools need to be fashioned in accordance with the other components and therefore need necessarily to have specific characteristics as regards morphology, dimension and weight.

The analysis of these characteristics has not been carried out in order to create a precise description of the different morphologies and their attribution to a series of types, but rather in order to identify the operative chain which begins with the purposes of production and ends with the manufacture of the supports and how they are changed. This was done on the basis that information regarding the use of prehistoric tools can be obtained primarily from the method of manufacture rather than from the traces of their use (Montoya 2002).

For the study of the backed elements at Paglicci we have tried to employ, whilst maintaining the aim of evaluating their use, different methods of analysis.

When assessing the techno-typological and typo-metrical characteristics, we started by looking for the recurrent elements which might indicate a standardization of the utensils, in order to find the real reasons which led the Gravettian artisans to design and manufacture such tools. Data regarding backed points morphology has allowed the production of replicas to be used during experimental stage under controlled parametres, a necessary phase of every functional study providing information which can in turn be used in the interpretation of the archaeological data.
Microscopic observation of the tools was carried out in accordance with the method of traceological investigation, at high and low magnification, so as to associate the use to a number of identified types of macro- (fractures) and micro-wears (polishes and striations).

As far as the analysis of the fractures caused by impact on the points is concerned, a classification scheme was created on the basis of the terminology proposed by different authors of the principal functional studies on projectile points (Ho Ho Committee 1979; Fischer *et al.* 1984; Perpère 2000; Plisson and Geneste 1989). The scheme is based on the position of the two principal types of complementary fractures, *cone* and *bending* (Fig.1-3, a and b), which forms at the moment of impact and tend to have a specific position: *cone* fractures usually affect the part of the tool directed towards the impact whereas *bending* fractures regard the part of the tool turned towards the base.

Whilst for *cone* fractures no sub groups were identified, *bending* fractures were divided into 4 sub-groups on the basis of their endings (step, feather, hinge, snap, Fig. 1-3, no 2). Among these sub-groups some have been identified as highly diagnostic of their projectile function: e.g. the *bending* fractures with snap ending, and especially the *spin-off* fractures, in which tiny splinters are removed starting from a *bending* fracture for the inflection produced by the impact.

Other elements considered as diagnostic of the impact caused are *enlèvements burinants* on the point, and *fissurations,* indicative of the application of a powerful force.

Instruments used for microscopic observation and microphotography

Macrowear analysis was carried out using an Optech LFZ binocular stereomicroscope whilst for the observation of the microwears Leica DM RXP and Leica DM LM metallographic microscopes were used, both equipped with 10x eyepieces and CF Plan Acromet lenses from 10X to 40X.

Before proceeding with examination, lithic tools were cleaned with pure acetone so as to completely remove any residue.

For the photos we used a Canon AET-1 reflex camera with Konus T2 adaptor, a digital Nikon Coolpix 5000 camera inserted in the metallographic microscope using a specially designed adaptor.

The experimental phase

Evaluation of a projectile point functional specialization, which has been attributed to categories of tools such as the backed points, but also to Geometrics and in some cases to backed blades, is based on experimental works and traceological analysis (in particular: Frison 1974; Moss and Newcomer 1982; Fischer *et al.* 1984; Odell and Cowan 1986; Plisson and Geneste 1989; Dockall 1997), and primarily on a number of valuable archaeological findings throughout Europe (Odell 1978; Nuzhnyi 1988). The most significant example is the bone point armed with backed elements found at the Upper Palaeolithic site of Talitskij, in the north-eastern part of the Russian planes (Nuzhnyi 1988) (Fig. 1-2), but there are also various fragments of points found in animal bones (Aquilas-Wauters 1956; Stapert 1977).

Based on these findings, the direction experiments can take regarding this type of tool is precise. The problem lies in the fact that in the use of the weapon to be thrown there are a number of difficult to control variables: type of hafting, propulsion method, ballistics of the shot, and hit target.

Of all this, the backed tool is the only archaeological data in our possession with which to reconstruct an extremely complex operative chain.

When planning the experimental phase of the functional study of the backed points of Paglicci it was therefore necessary, given that we possessed just the one known data, to have extremely precise objectives: i.e. the identification of traces due to impact created on these tools, and to work out from these traces where the points would have been positioned on the spear, made of wood or bone, on which they would have been hafted.

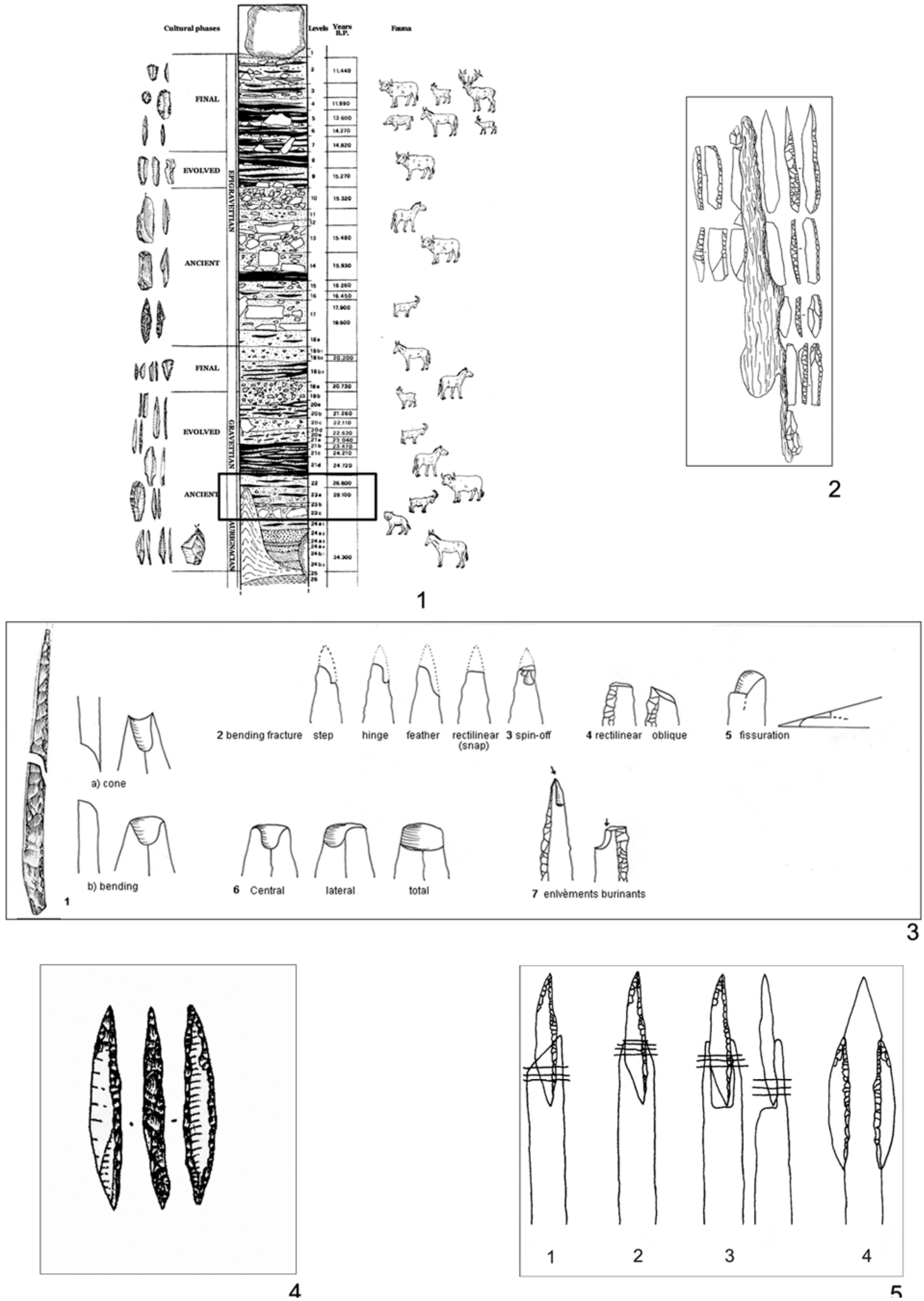

Fig. 1: 1) Stratigraphy of Upper Paleolithic in Paglicci Cave; 2) Talitskij bone point (Nuzhnyi 1989); 3) Scheme for the classification of fractures; 4) Morphology of bipoint reproduced in the experimentation; 5) Different experimented positions of hafting.

In order to reproduce the backed points, the techno-typological characteristics of the intact pieces from layers 23 and 22 were analyzed: these tools would appear to derive from a few principal morphotypes, one of which is the most frequently observed. The bi-points of small dimensions (average length between 21 and 44 mm) with total rectilinear abrupt retouch opposite to a non-retouched, more or less convex, shearing edge. The traversal section is triangular and the profile is almost always perfectly rectilinear (Fig. 1-4).

Approximately 70 backed points were created, using raw materials as close as possible to the archaeological material. These were used in various phases of the experiments. Part (no. 35) of the points were hafted in different positions (Fig. 1-5) in *viburnum* haft (Length 80 cm, diameter 0.8 cm) and shot with a bow towards an animal target and to the ground, the latter to simulate an error on the part of the hunter. In this experiment the variable of bow/spearthrower was not considered and only the bow was used. On this latter point, current debate, from a traceological point of view, has come to a standstill: no experiment conducted with flint points has been able so far, to distinguish the type of traces according to whether a bow or spearthrower was used (Cattelain 1997).

Following the impact, the backed points which had been hafted in a lateral position (Fig. 1-5, no. 4) did not sustain any macroscopic damage, the others broke, in 70% of the cases above halfway of their length from the base. As a consequence, according to this method of hafting, the base fragments (always functionally orientated) are longer than the apexal fragments. It was also possible to note that the point of fracture remains, in general, above the binding. In 4 cases the points literally disintegrated.

The type of the fractures, as can be seen in the table below (Tab.1), largely repeats the alternating scheme proposed *cone/bending* (Fig. 1-3, no.3), in which the *cone* fractures involve the distal part of the apexal fragments and the *bending* fractures involve the proximal part of the base fragments. On the tips it is possible to note many cases of *enlévèment burinants* and the *bending* fractures, frequently of step type (50%), present *spin-off*. It should be noted however, and this data is of extreme importance, that in some pieces (13%) the typical position of the *cone/bending* fractures is inverted.

As far as the macrotraces on the lateral margins of the experimental tools are concerned, despite the fact that many authors (and in particular Odell 1981) have noted how, following impact, microfractures are created obliquely to the longitudinal axis, on the points used in this experiment (as on the points of the Gravettian of Paglicci) these microfractures have an orientation and a disposition of a chaotic nature, and therefore it has been impossible to establish a regular relationship between these and the impact itself.

A separate consideration should be made as regards the microtraces on the experimental pieces; it is particularly interesting to note the differences between the points hafted in an apexal position and those in a lateral position.

On the latter (Fig. 2-1) one frequently notes, albeit light, shining linear traces, definite linear polishes (or linear features) (Fischer et al. 1984, Plisson and Geneste 1989, Moss 1983), positioned perpendicularly to the margin on the extremities of the pieces, probably caused by the abrasion which occurred at the moment of the insertion of the handle.

Also present, on the lateral margins, are extremely light longitudinal polishes or linear features, which are caused by the contact with the animal target (Fig. 3-3).

It is significantly interesting to note how analogous traces have been observed on the Aurignacian bladelets from layer 24 at Grotta Paglicci, which were examined in order to establish a comparison with the Gravettian material (Fig. 2-2, 4-5).

In contrast, on the hafted points in a proximal position (Fig.2-3), the traces are almost absent and only on the distal portions of some of the pieces thrown towards the ground, this was caused by the less firm hafting of these pieces, used in the very first phase of experimentation. The polishes and linear features were caused in this case by the movement which the point underwent at the moment of impact and are no longer present on the perfectly fixed pieces thrown after an animal target.

Another portion of the points produced for experimentation were in part hafted and hurled against a wall with a 90° angle (no.16), in part broken by hand or

Type of fracture %	None (intact)	Cone	Bending	Enlèvement burinant	Spin-off
Apex dist	28,5	14,2	-	57,1	-
prox	-	83,3	16,6	-	-
Base dist		17,6	70,5	11,7	22,7
prox	90,9			9,1	

Tab. 1: Type of fractures on the experimental pieces.

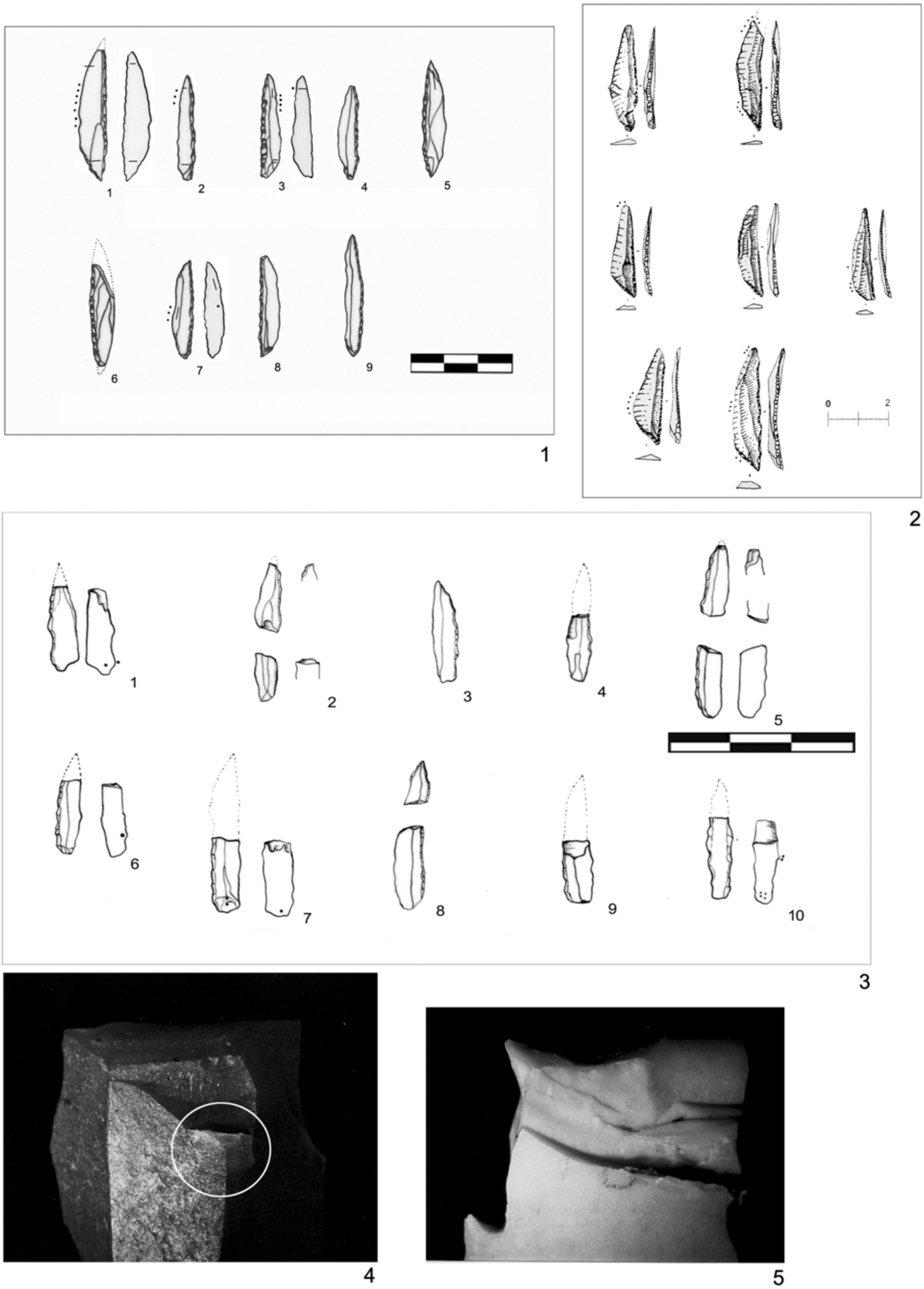

Fig. 2: 1) Laterally hafted experimental point; 2) Microwear on a sample of Aurignacian bladelets coming from layer 24 of Paglicci Cave; 3) Experimental points throwed to the ground; 4- Bending step and fissuration on a experimental point (20X); 5) Enlèvement burinant (or lateral spin-off) on a bending step fracture (20X).

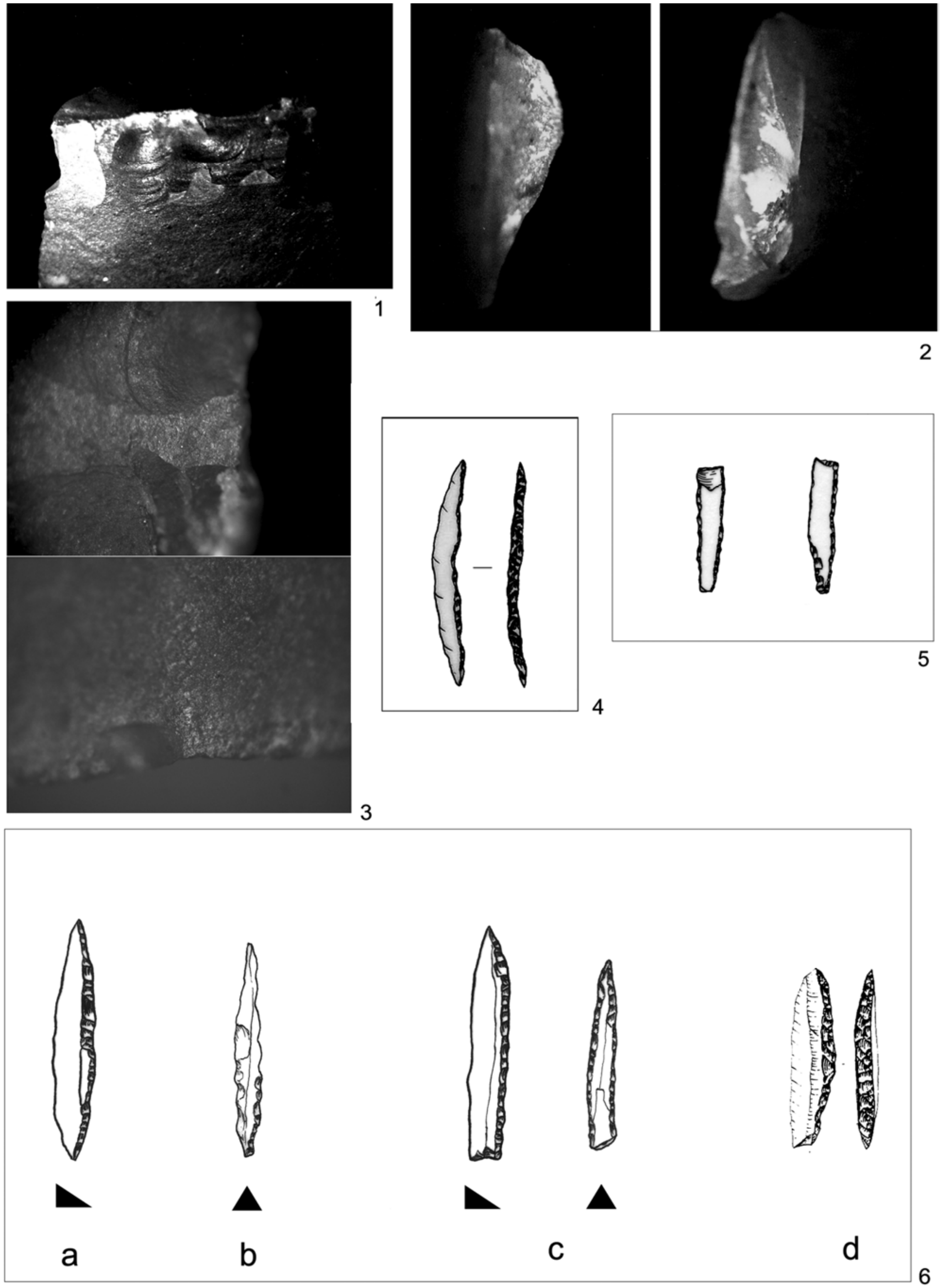

Fig. 3: 1) *Enlèvement burinant* and spin off on a bending fracture (20X); 2) Fractures on a experimental point broken with the aid of a percussion (20X); 3) Light polish and linear features on experimental points laterally hafted (100X); 4) Backed point with concave profile and edges (layer 22 D); 5) Backed blade with a apexal truncation; 6) Morphologies of backed points of the layers 23 and 22.

with the aid of a percussion (no.18) so as to obtain a greater variety of fracture types.

This additional experimental phase produced positive results in that, if the fractures present on the hurled pieces reveal precisely the percentages cited in table 4 as far as the position of the *cone* and *bending* is concerned, the points broken by hand leave no traces of anything which can be diagnosed as resulting from impact: the fractures are almost always rectilinear (or snap), and the percussion point is often recognisable (Fig.3-2).

Analysis of the archaeological material

The Gravettian layers 23 and 22, divided in 3 and 6 levels respectively, have provided an enormous quantity of lithic material, including 1191 backed tools.

The intact pieces of backed points and backed points and truncation (no. 80) have allowed for typometric, typological and morphological evaluations.

The typometric analysis of the pieces brings to light a certain dimensional variation in the length of the pieces, which ranges from 16mm to 72mm, whilst the width and thickness of the pieces appear to be more homogeneous. These dimensional aspects are strictly tied to the diameter of the spear destined for the insertion of the point and the preparation of a furrow suitable for fixing it, therefore it is hardly surprising that they be calibrated. The thickness which, unlike the length, cannot be modified by retouching, indicates the desire to obtain, starting with the debitage, supports with specific characteristics.

In the table below and those that follow, the values listed refer exclusively to level 22 F, the series in which most finds were made (338 pieces), and not to the average of the values of all the levels.

Layer 22 F	Length	Width	Thickness
average (mm)	34.4	5.1	3.1
min	16	3	1
max	72	9	7
Mode	27	5	3
Standard dev.	11.6	1.7	1.2

Tab. 2: Dimensions of intact backed points from level 22 F (no. 27 pieces).

The weight of the backed points, measured exclusively on intact pieces, tends to be between 0.5 gr. and 1 gr.

We are, therefore, dealing with extremely light tools and, despite their weight being of fundamental importance in a ballistic system, in this specific case we do not think that minimal differences such as those observed could influence substantially the functioning of the throwing weapon.

An extremely important data concerns the profile of the supports, because it is closely linked with the hafting of the points and the shooting ballistics.

The attempt to obtain supports as rectilinear as possible is evident and in the cases in which the profile is concave, sinuous or twisted, these features are never very accentuated (and at times corrected by the retouch) and the pieces axis remains in any case rectilinear. It should be underlined however that in the most recent levels (22 D-A) we find pieces with a profile and edges decidedly concave (Fig. 3-4), a characteristic which makes it hard to explain the hafting, at least that in a proximal position, of these tools.

From a typological point of view (Palma di Cesnola 2005), according to the Laplace typological list (1964) almost all of these tools fall in to the category of the total backed points (PD4), with a narrow index which exceeds 95%; the other secondary types (no.3 PD1, no.17 PD2, no.6 PD3, no.7 PD5) are sporadically present and it is likely that the typological differences between these tools do not correspond with specific requirements of a functional nature.

There are also 12 backed points and truncation (DT 7-8), the typological difference of which, linked to a morphological variation, cannot have no significance at a functional level.

In the majority of cases, the points are formed by a rectilinear edge, treated by the abrupt retouch, and by a convex shearing edge.

These characteristics provide the tools with a transversal section almost always in the form of a right angled triangle, less often that of an equilateral triangle: in the latter case determined by the presence of a bilateral back or by the use of a support which is itself extremely narrow.

In the points where bilateral sharply angled retouch is not present, the edge opposite to the back has, in 95% of the cases, been modified by a secondary retouch which, depending on its position, has the function of creating the necessary convergence to create the point, or both the points in the recurrent case of the bi-points (simple direct retouch or abrupt, sometimes also inverted), to narrow the apexes, or, more often, the bases (inverted flat retouch), to correct the profile of the support (direct or inverse flat retouch) and, finally, to calibrate the width of the piece (simple retouch or flat in medial position).

Independently of the typological classification, various recurrent morphologies have been identified, representing very analogous percentages in all the fractures (Fig. 3-6):

a) The most frequent form (71.6%) is the point which presents tapering at both extremities, which can be typologically traced to a bi-point (Fig. 3-6). Within this group it is possible to recognise a standardization of the forms despite a notable variety in dimension. The transversal section takes the form of a right angled triangle. In 20% of the cases both distal and proximal parts of the bi-points are perfectly pointed; whilst in the other tools there is a marked difference between apex and base, with the base resulting slightly more pointed (40%), flatter (16%), somewhat angled (8%), or with the retouch failing to arrive right at the very tip (16%).

b) A different morphology of bi-point (7.4%) presents a transversal section with equilateral or isosceles triangle (sometimes trapezoidal isosceles) in that the retouch is bilateral or the supports used have a trapezoidal form (Fig. 3-6). Consequently, these points haven't a shearing edge. The dimensions are largely standardized, with a length which varies from 28 to 35 mm and a width of 3-4 mm.

c) In contraposition to these morphologies pointed at both extremities are the points which have a truncated base (14.7%), generally perfectly rectilinear. This characteristic, which appears highly distinctive, involves, however, elements with or without a shearing edge, and therefore with a transversal section both in the form of a right angled triangle and that of an equilateral triangle. The maximum length of these pieces is concentrated between 27 and 35 mm whilst the thickness is of 5-6 mm for those examples with shearing edge and 3-4 mm for the others.

d) In layer 22 there are also 3 examples of points with a length and width superior to the average and above all characterized by a convex back (Fig. 4). These backed tools, with distinctive morphological features which would exclude them from the main group of points, and present microwears caused by contact with dry skin. In order to be able to make typometric and morphological evaluations, as well as traceological ones, on the fragments of backed tools and to be able to draw comparisons with the experimental material, it was necessary to divide these elements in three main categories, in relation to their presumed functional orientation: point fragments, base fragments and median fragments.

This division is based on the fact that in the intact examples, even the bi-points, it is often possible to identify a more sharpened apex, very standardized, with straight converging edges, in comparison with a more varied base which can be truncated by the retouch, pointed, angled etc. As we have seen, however, a high percentage of bi-points (20%) have both perfectly pointed apex and base, and it is for this precise reason that a non classifiable category was created among the fragments

It was possible to make this subdivision because of the large number of disposable pieces (no. 1111), which has allowed statistical evaluations to be made.

Excluding, then, the non classifiable (no. 246), the group is formed principally by median fragments (no. 342) followed by apex fragments (no. 325), which are much more numerous than the base fragments (no. 198). From a typometric point of view one notes that the base fragments, in line with the data relative to the experimentation, have a greater length, and the width is also greater compared to that of the apex fragments, probably because it represents a larger portion of the tool.

The median fragments are particularly interesting in that they seem to possess very standardized dimensions. The fragmentation of the tools at both extremities could be caused by various factors: an accident during manufacture (during the preparation of the replica points fragments were produced in this way on more than one occasion), post-depositional fragmentation, or during the use of the points or, finally, so as to obtain elements with these precise morphological characteristics (lateral elements of an arrow or a javelin).

Most probably all of these possibilities should be taken into consideration. The typometric data has brought to light how every level of these utensils has, in groups, identical dimensions and a perfectly rectangular form. The possibility that some of the median fragments could be functional elements in their own right, seems to be confirmed by the fact that some of these (7%) have a width (10-11mm) which has not been found in any intact backed point and in 15% of the cases a flat direct lateral retouch, which is extremely rare in the intact examples. In addition, there is an entire tool which has the typical dimensions of median fragments and both proximal and distal truncation and one finds backed blades with distal truncation (Fig. 3-5) which could have been positioned laterally in the spear as final elements of a series.

The type of the fractures present on the fragments of backed tools is described in the tables below (Level 22F).

Comparing this data with that derived from the experiments two important differences emerge. Above all it should be noted that roughly a third of the fractures are of a rectilinear nature - a type of fracture which in the experimental material was seen exclusively on the points broken by hand and not on those thrown. In addition, whilst in the proximal fragments, as in the experimental material, the *cone* fractures in a proximal position are prevalent, in the base fragments a similar prevalence of *cone* fractures can be seen, but in a position which, following the division made, would be considered to be distal. *Enlévements burinants* and *spin-off* are found only very rarely.

Type of fracture %	None (intact)	Cone	Bending	Rectilinear	Spin-off	Enlèvem. burinants
Dist	98,3	-	-	-	-	1,6
prox	-	44,1	17,5	29,1	-	-

Tab. 3: Type of fractures present on fragments of apex.

Type of fracture %	None (intact)	Cone	Bending	Rectilinear	Spin-off	Enlèvem. burinants
Dist	-	38,4	33,3	30,7	2,5	-
Prox	100	-	-	-	-	-

Tab: 4: Type of fractures present on fragments of base.

Differences with the experimental data can also be noted as far as the median fragments are concerned. If a median fragment is the result of the fragmentation of a point following impact, it should be possible to identify a *bending* (distal) fracture compared to a *cone* fracture (proximal).

And yet in our case, despite of this possibility, one finds other combinations, such as the association *cone-cone* and *bending-bending*, which are not easily compatible with impact, which could be of post-depositional origin or caused by intentional fracturing, (as would be demonstrated by the propagation axis, which in 20% of the pieces does not coincide: from one part ventral/dorsal and the other dorsal/ventral or lateral).

For the analysis of the microwears a sample of 106 tools has been chosen. These represent both entire pieces as well as fragments.

The position of even the lightest traces has been noted, in order to establish an eventual recurrence in the position of these, given that the said tools rarely show developed polishes from which it is possible to find the origin of the material with which they have come in contact.

Among all the points examined (no.34) 14 (41%) have light polishes and/or linear features both parallel and oblique to the edge (Fig. 4-2).

A recurrent position of the traces has not been found, rather they are positioned both on the apexal and median or base section of the piece.

The backed fragments presenting traces of use account for 14 of 61 pieces examined (22.9%) (Fig 4-1,4) and are mostly base fragments (no. 11).

Finally, 11 median fragments were examined and on 4 of these (36.3%) polishes or spots on the shearing edge were found (Fig. 4-3), in equal measure on the front and back face.

Conclusions

The initial aims of this study were to understand what part the backed tools found in layers 23 and 22 played in the system of throwing weapon and whether these same tools had been used or not.

The first question to ask concerns the lithic elements on the arrow or javelin. Based on the characteristics of the median fragments of Paglicci, and using the Talitskij finding for comparison (Fig. 1-2), it would seem to indicate, at least for this category of tools, a lateral hafting in the spear. The purpose of inserting lateral elements would be to increase the damaging power of the arrow, and consequently to provoke a greater hemorrhage in the animal which would speed up its death.

The position of the backed points is more difficult to understand given the various morphologies. As far as the bi- points, with shearing edge opposite the back (which have been tested in the experimentation) are concerned, it has not been possible to explain the functional motivation of the double point, unless this tool was not also inserted laterally in the spear. The lateral position would seem to be most likely given the examples with concave profile in the higher levels (which in a proximal position would deviate the trajectory of the launch) and the variation in dimension presented by this category of tools.

The narrowest type of bi-point, with bilateral back and without shearing edges cannot be considered as being definitely compatible with a lateral position. These narrow tools (with isosceles or equilateral triangle section) are more likely to have had a proximal position, especially so when points with truncated bases are involved (Fig. 4-6).

We can not however exclude that a part of the tools might have been interchangeable, or hafted in various ways, and it is just as possible that there may have been different ways of arming a javelin or an arrow.

On the other hand, the possibility that multiple hunting methods might have coexisted, associated with arms even only partially different, is evident if faunal remains of the ancient Gravettian layers of Grotta Paglicci are taken in to consideration. As well as the large mammals which the populations of the era preferred to hunt, such as aurochs, horse, steinbock, and chamois, one finds various species of bird (*Anatidae, Gruiformes, Galliformes*), on

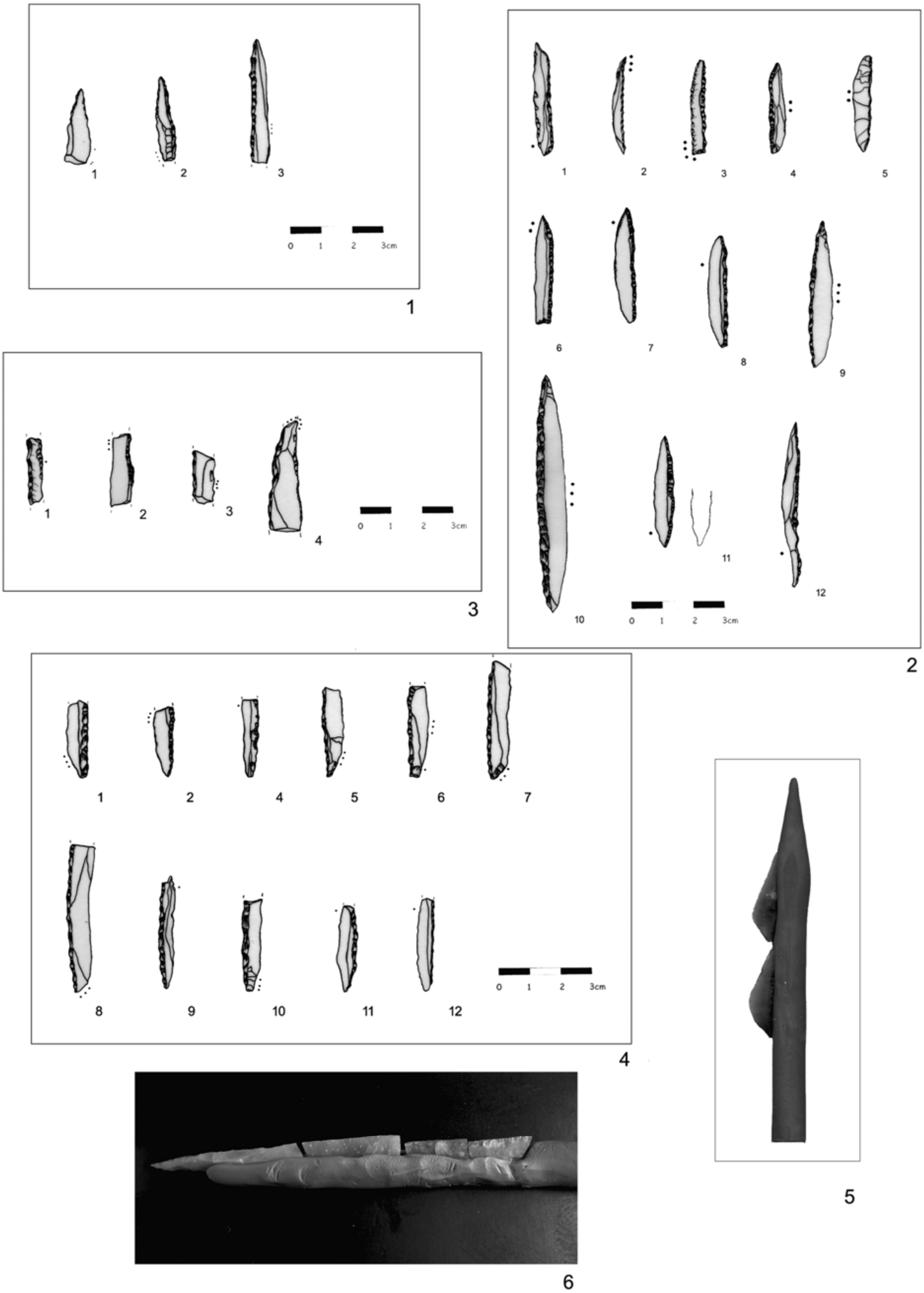

Fig. 4: 1) Microwears on apexal fragments; 2) Microwears on entire backed points; 3) Microwears on median fragments; 4) Microwears on basal fragments; 5) Reconstruction of hafting of Aurignacian bladelets; 6) Reconstruction of hafting of a backed point (type B Δ) and median fragments.

which signs of slaughtering have been found (Tagliacozzo and Gala 2005), which would indicate almost certainly a specific type of hunting.

It still needs to be ascertained whether the backed tools of Paglicci, which we have identified as elements of a throwing weapon have been used or not. The characteristics which should be considered in this identification are numerous.

The fragmentary character of these tools is generally extremely high, and could be explained by the particular fragility of the backed points compared to other categories of tools as well as, naturally, their use. The analysis of the macrotraces has brought to light, in the greatest number of cases, an elevated contrast between the archaeological and the experimental data and above all a variation in the data within the series. The predominance, in general, of *cone* type fractures would support the observation that there are more apex fragments present than base fragments. This last data is extremely important because it conflicts with that noted in two functional studies of points de la Gravette which have been used both in the plan of this research and in order to create comparisons (Perpère 2000, Derndarsky 2003). At both the considered sites (Abri Pataud in France and Stillfried in Austria) distal fragments were without doubt dominant (59% and 69%) and these statistics are considered to be compatible with the use, in general, of the tools.

It is believed, in fact, that whilst the distal part of the points can be easily dispersed following impact, the proximal part is retrieved along with the spear and is therefore taken back to base with the rest of the hunters' equipment. The information which derives from the typological study of the ancient Gravettian layers of Grotta della Cala (Boscato et al 1999; Borgia and Wierer 2005) demonstrates the same occurrence: distal fragments are almost double than proximal ones.

With the site of Abri Pataud it is also possible to establish a comparison as far as fracture type is concerned, which, contrary to that which occurs at Paglicci, in the large majority of cases reflects the typical scheme: the *bending* fractures concern the distal part of the bases and the *cone* fractures concern the proximal part of the apexes. This data is used to demonstrate that in general the material has endured impact.

In conclusion, we can affirm that only a part of the analysed backed tools of Paglicci present associated and highly diagnostic macrotraces and micropolishes which would indicate their having been used. The variation of the data in our possession leads us to think that in the same deposit the greater part of the elements had never been used and that the high grade of fragmentation of these instruments has post-depository causes. It cannot ruled out that all of these tools were actually part of a kind of arsenal, containing elements recently constructed and others which had already been employed but which were, once repaired, still valid for further use, a practice which was most certainly carried out (Derdarsky 2003; Kelterborn 2000).

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Bilancino, a specialized site for “latent technology”: an integrated approach

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Summary. *The application of an integrated methodology - connecting the archaeological record with morphological analysis, reconstruction of the operational-functional sequence, wear traces and analysis of the residues, ethnographical comparison and archaeological experimentation - to the study of latent technologies (i.e. related to the treatment of highly perishable raw materials) has allowed us to obtain different data which led to a coherent interpretative framework for the understanding of a Gravettian camp site. At Bilancino site different technological processes could be reported, all related to vegetal fibre (Typha) exploitation: while manufacture and use of specialized tools is documented for the treatment of vegetable fibres (Noailles burins), the further phases of fibres processing in order to obtain other products are to be inferred only as a working hypothesis (possible dyeing of these products with hematite dust). Nevertheless independently from the worked raw material the Bilancino grindstones, which still has no analytical and archaeometric comparisons in coeval European sites, testifies the adoption of an innovative technique -the grinding activity - in the Italian Gravettian, stressing both the importance of vegetal resources exploitation in Palaeolithic economies and the importance of the technological innovation within the development and the diffusion of the Gravettian culture in Europe.*

Archaeological evidence (B. A. & A. R.)

Unlike all technologies related to the exploitation of durable raw materials, like for instance flint, bone or antler, which can be reconstructed through direct evidence, latent technologies related to the treatment of highly perishable raw materials, both of vegetable and animal origin, require an integrated research methodology. Such methodology, connecting the archaeological record with morphological analysis, reconstruction of the operational-functional sequence, wear traces and analysis of the residues, ethnographical comparison and archaeological experimentation, allow us to obtain different data which can be integrated in a coherent interpretative framework.

The great improvement of both technical and methodological analysis available today, enable us therefore to study a site such as that of Bilancino with great potential for the enhancement of the technical and therefore economic knowledge related to the Gravettian culture. The exceptional conditions of the preservation of the paleosurface (over 120 square meters with various areas of lithic workshop and a structured hearth), the accuracy of the recording during the excavation and the following data-processing phase (Aranguren et alii 2002), all led to the creation of a complex database, in which the progressive in-depth consultation allows us to always obtain new information on life at the site and on the activities that were performed.

The interdisciplinary studies carried out so far on the Bilancino site (Fig. 1), on the basis of typological, technological and functional analysis of the lithic industry, raw material procurement, paleoenvironmental data and ethnographic comparisons have allowed us to propose a functional interpretation of the site as a seasonal camp linked to acquisition and processing of vegetal fibres, whose most ancient evidences are related to the Eastern European Gravettian (Pavlov) (Brezinová 1999; Soffer *et al.* 1998, 1999, 2000; Soffer 2004), most probably to the processing of the Typha fibres (Aranguren and Revedin 2001a).

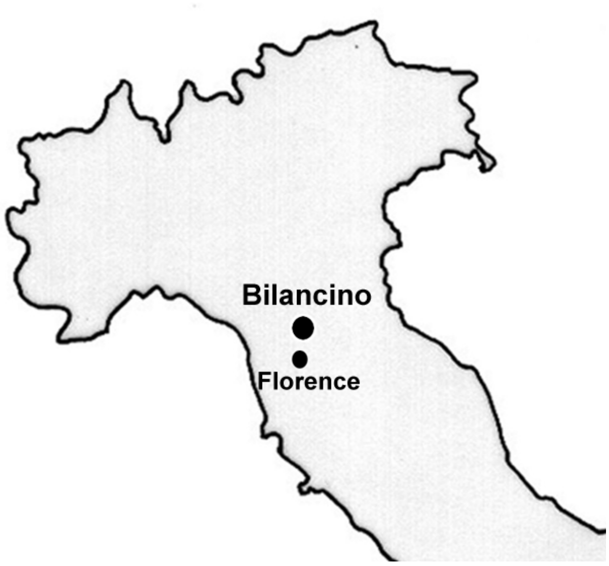

Fig. 1. Localization of the Bilancino site.

The lithic industry is composed of around 15,000 artefacts. Among the instruments, around 1500, the burins predominate and compose over 70% of the tools; among these the majority (80%) is constituted by Noailles burins (about 900, including the multiple burins). The high typological standardization of the lithic industry suggests that at the site a specific activity was carried out with highly specialized tools suitable for fine precision work on soft materials.

The operational and functional sequence of the Noailles burins has been reconstructed thanks to the recovery on the paleosurface of numerous elements which demonstrate the various phases related to the production, use, reshaping, re-use, etc. until the tools were discarded: burins in the earlier phase of production or Protonoailles, burin spalls, double and triple burins, obsolete burins, rejuvenated burins, burin rejects, etc. (Aranguren *et al.* in press). Evidently during their utilization these tools little by little deteriorated and the renovation was a necessary task; the exotic flint (of best quality) was highly exploited as shown by the high percentage of multiple burins (85%) and burin rejects (100%) obtained with this specific raw material: probably the locally available raw material was less resistant than the exotic flint (Aranguren *et al.* 2004b).

The sedimentological and archeobotanical data (related to the pollens and charcoal analyses) suggest that Bilancino site was a summer camp located in a damp environment, as pointed out by the hydromorphic conditions both of the soil and of the alluvial-colluvial deposits and strengthened by the presence of abundant hygrophylous plant pollens, particularly of the Typha, a spontaneous grass which develops in fresh water ponds of around 1 m of depth, whose pollen dispersion is extremely limited and seems to correspond to the area of the settlement (Aranguren *et al.* 2003).

The ethnographic parallel established with the nineteenth-century processing techniques of the spontaneous vegetations of the damp zones of Bagnacavallo (Ravenna), points out to the summer as the suitable season for the Typha plants harvest and the use of an utensil -the arfinden- morphologically analogous to the Noailles burin, used for the activities of Typha fibres separation starting from the dried leaves of this plant (Aranguren *et al*. 2004a).

The preliminary study of the wear-traces allowed to recognize the location of the active functional edge: a series of striations and polishing traces are concentrated on the edge of the burin (the biseau) and on the areas close to the truncation.

It has been thus reproduced an experimental replica of Noailles burin; the artefact was used as "the arfinden" to separate the fibres of Typha leaves: later around an hour of activity the experimental sample was interested by a series of analogous striations, even if less consistent, to those recognized on the archaeological material, thus confirming the formulated hypothesis.

Use-wear analysis has also allowed to identify on some burins the presence of organic residues entirely located on the active edge of the tool and close to the truncation. The morphology and the chemical analyses performed on the residues point out to the presence of carbon and chlorine; these data led us to suppose that these residues were part of organic materials of vegetal origin (Aranguren *et al.* 2008).

In conclusion, to the various indirect evidences is linked the direct test offered by the recovery on the burins of organic residues of probable vegetal origin. This allows us to corroborate the hypothesis that at the Bilancino site people employed a specific technology for the processing of vegetal raw materials.

Description of non flaked tools

The same protocol of analysis of lithic industry was applied to other artefacts typologies recovered in the site and the work is still in progress; in this paper we will focus on the utilized pebbles, here considered as important markers of technological innovation: the typology of this artefacts, spread and diversified only from the Gravettian, is an element which can offer new important data on the activities carried out on site.

The first artefact we have already analyzed (Aranguren and Revedin 1997) is a pale grey limestone "*alberese*" pebble with clear wear traces on both surfaces; on one of them an engraved motive is also present.

This artefact typology is spread in a vast geographical area and for a long chronological span and was a subject of in-depth analysis and experimentations from S. de Beaune (1989, 1997) who recognized as the most reliable functional hypothesis the use of these pebbles as mallets in association to lithic tools.

The reconstruction of the operational chain suggests a meaningful correlation among the tool and the graphic composition which could assume the value of identification mark of the tool. For this pebble it is still to define its specific use among the operational chain of the knapping area in which was recovered.

The second artefact is a rounded sandstone pebble (cm 19 x 9.5 x 4.5) found in a different area of the excavation, with red colour traces. The analysis performed on these traces allowed to recognize the presence of iron oxide; its limited presence on one of the flat surfaces could suggest a possible use as grindstone for hematite, since on the Bilancino paleosurface were found some crystalline hematite fragments (a micaceous variety), whose origin is far from the site (more than 90 km) and points out to their deliberate introduction to the site (Aranguren *et al*. 2006).

The macrocrystalline hematite if finely ground produces a highly colouring red-blood dust. It has been therefore investigated the relationship among the employment of this dust and the principal activity hypothesized for the site of Bilancino, that is the processing of marshy grasses.

Fig. 2. Experimental production of the flour by grinding peeled and dried *Typha* rhizomes.

The hypothesis of the employment of this dust as vegetal fibres dye has been also tested using ethnographic parallels and experimental archaeology.

The first step of the experimentation has been the grinding of a crystalline hematite fragment; since the hematite is a non water-soluble pigment and communicates colour for overlap and not for penetration, the hematite dust has been mixed with an organic substance used as adhesive (e.g. white of egg). It has been positively tested also the solubility of the hematite dust in the urine, whose use is commonly documented in the dying processes used before the advent of the synthetic dyes. In both cases the obtained mixture sticked well enough both to the fibres of Typha and to woven vegetal artefacts (twines and mats) (Fig. 2).

The ethnographic comparison has allowed to individualize others techniques used by the pre-

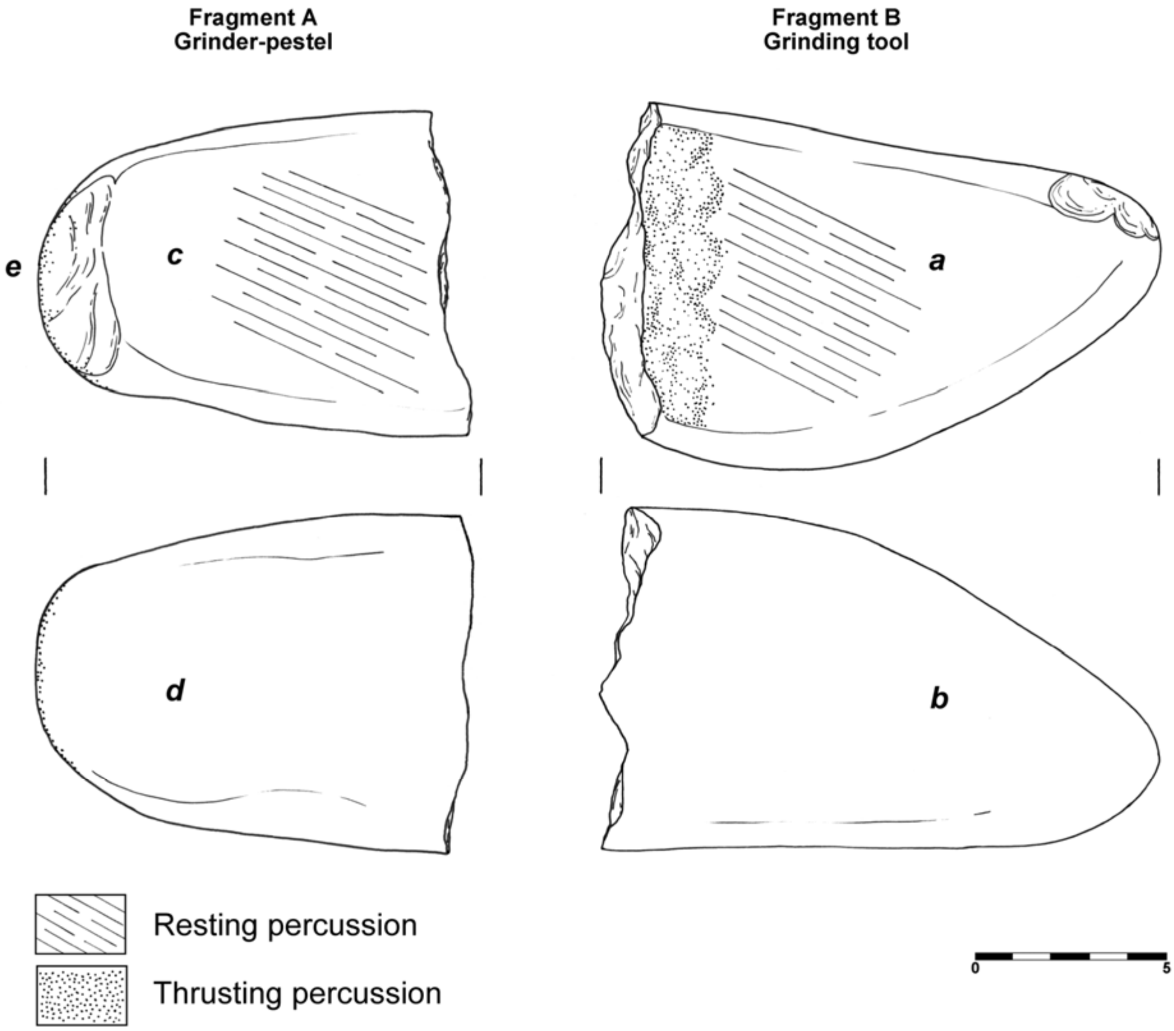

Fig. 3. The grinding tool: drawing and description of the active areas.

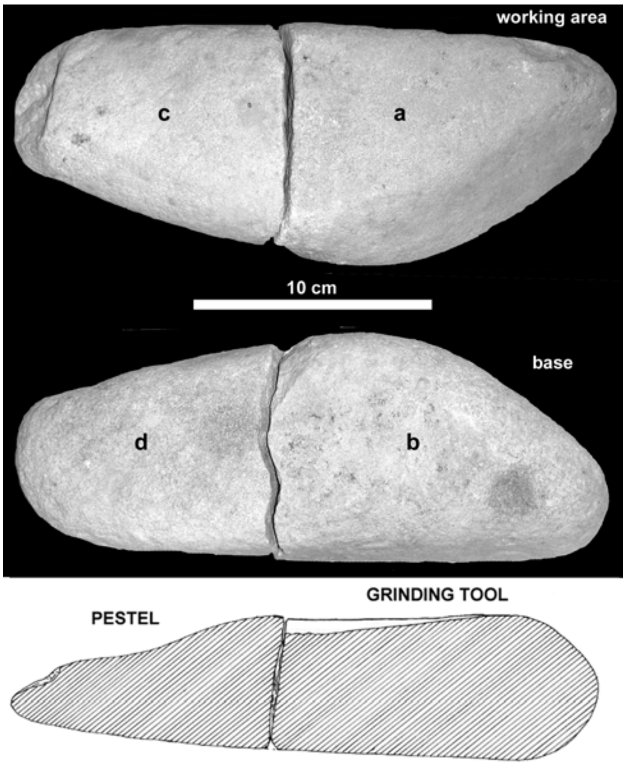

Fig. 4. Photos of the grinding tool surfaces and the drawing of the tool section, where the strongly weathered portion is evident (on the right).

Columbian population Chihuahua (Kasha, 1948), realized by the stable imbuing of the vegetable fibres with iron oxides, which will be submitted to experimentation.

The third artefact is a quartz-feldspar-micaceous sandstone pebble fragment coming from the nearby geological unit of "Macigno" (cm 13.6 x 9.7x 6.2) with one flat surface and the opposite one with concave morphology, recovered in the left area of the paleosurface close to an unstructured hearth; due to its morphology and to the raw material it has been easily identified as a grindstone (Fig. 3).

The recovery of another fragment of pebble of the same raw material located on the paleosurface at a distance of m 1.15 from the first one has allowed, through refitting, to reconstruct the operational sequence which produced the artefact: the whole pebble (originally cm 25 x 9.7x 6.2) was broken with a blow on the edge adjacent to the flat surface; the smallest fragment has been used as grinder-pestle; the other one has been used producing on the originally convex surface a concavity of the maximum depth of around mm 0.8 in the point adjacent to the fracture; the grindstone posses therefore an asymmetrical wear trace (Fig. 4).

The oldest known grindstones are the three granite elements reported by Leroi Gourhan (Leroi Gourhan 1964; 1965) in the Chatelperronian layers of the Grotte du Renne at Arcy-sur-Cure, for whom the Author suggests a probable utilization for soft raw material processing, such as dry meat.

In the following periods grindstones are sporadically attested since the Aurignacian, but it is from the Gravettian that these artefacts become more frequent and more clearly identifiable, although these evidences are flat slab stones identified as grindstones only by the absence of wear traces rather than for their morphology (De Beaune 2000). This type of grindstones has been neglected during old excavations if not when they are displaying traces of dyes and only recent and more accurate investigations have allowed to individualize a certain number of these artefacts at the Grotte de la Vache and Isturiz (De Beaune and Boisson 1996). Only from the Epipaleolithic and the Mesolithic the presence of grindstones with a decidedly concave surface is reported.

Out of Europe some grindstone fragments are reported at Cuddie Springs site in Australia whose very ancient dating, around 28.000 years b.p. (Fullagar, Field 1997) however results controversial.

Dealing with grindstones morphology some elements with asymmetrical wear traces which reveal an axial movement of back-and-forth and opened on one side as that of Bilancino, were recovered in some Levant sites dated to the Natufian culture (12.000-10.500 b.p.: Wright 1991) and were classified as Trough Quern type A.7 (Wright 1992, fig.4, 7). Their intentionally asymmetrical forms with side opening answers to the purpose of facilitating the recovery of the grinded dust in an underlying container (De Baune 2000).

Besides the morphology, a very meaningful character of this category of artefacts is obviously given by the raw material they were made with. The abrasive qualities of every type of rock depends on the nature, the dimensions and the cohesion of its granules in relationship to the performed activity: granules of greater dimensions allow a best abrasion, but if the rock has little cohesion the grindstone will not be suitable for an alimentary use because of the great number of detached granules mixed with the worked materials. On the opposite if the cement is too hard the grindstone quickly loses its abrasive proprieties and should be frequently rejuvenated. It is therefore evident that raw material choice, besides the availability of different rock types, is due to the artefact function and the processed materials (Shoumacker 1993).

Use wear analysis

The wear traces analysis has been carried out on the surfaces of both fragments (A and B) - which composed the whole original piece – appears to be particularly meaningful regarding the functional management of the tools referred to their chronological and cultural attribution. Their significance is not only to be related to their antiquity but as well as to the technical and functional meaning which undergone.

The study of functioning (kinematics) and their function (processing systems) had been carried out by following the protocol including a true multidisciplinary connections between wear traces, experimental reconstruction and residues analyses on the active surfaces of both the used fragments.

At this stage we prefer to maintain the neutral denomination of the fragments A and B, since their final functional definition will derive from the analytical process herein described (Fig. 4).

The two fragments present different wear patterns visible both with the naked eye and under the microscope.

Conventional orientation cannot be applied to such a kind of tool so we described the two fragments as separate pieces. No support of technological preparation are evident on the natural stone. Therefore the orientation and the description of both tools are based on the morphological and functional characteristics derived by the data coming from the integrated approach applied to traceology and experimental analyses finalized to the reconstruction of the technical behaviour.

At a morphological level we can distinguish the following features:

- **Surfaces:** they are more or less extended, with a regular profile and variable inclination (flat, leaning, concave or convex), according to the natural shape of the original stone as well as to the modified shapes they acquire after technological operations or due to their use;
- **Margins:** the edges which outline the general shape of the original stone;
- **Extremities:** they represents the portions of the margins –generally pointed or convex - and proximally or distally located (toward the user).

Due to the different morphological features a functional meaning we decide to apply the terminology recently published (De Beaune 2000; Hamon 2004; Adams *et al.* in press).

- **Working surfaces:** the surface in contact with the worked material showing use-wear traces. By definition all the morphological features (surfaces, margins and extremities) can be considered totally or partially as working surfaces;
- **Passive element:** the tool that - from the kinematics point of view - stay still during the action of transforming the worked material;
- **Active element:** the tool that - from the kinematics point of view – is moving during the action of transforming the worked material.

The active and passive elements can be used independently (e.g. *polishing stones* for treating the skin or *abraders* to smooth an object) or they can be used as associate tools (e.g. quern and handstone; mortar and pestle).

The recognition and description of use wear traces had been carried out by means of Low Power Approach (using a Leika MZ6, 10 to 40 X) and adopting a terminology already applied in recent studies (Dubreuil 2004; Hamon 2004; Lunardi 2007; in press; Adams *et al.* in press). According to Hamon (2004) the topographic definitions like distal, proximal or mesial had been named considering their localization towards the operator.

Fragment A

Fragment A presents a sub-triangular shape, a rectangular section (thickness mm 56) with the short side (Length mm 90) – the fracture line – and the long sides (Length mm 150 and mm 135) composing the margins of the tool. It weights 994 gr. Face ***a*** has an area of about 37.5 cm^2 while the opposite face ***b*** has an area of about 63 cm^2.

All the surfaces of element A underwent microscopic observation with Low Power Approach at different magnifications (10 to 40 x). The aim was to recognize the possible working areas.

Face ***a*** slopes toward the short side: this morphology is even more evident when combining the two portions of the tool (A + B) along the fracture line, where it is notable a step of about 1 cm between the two faces (A and B, Fig. 8). Close to the fracture line it is evident a sort of pecked strip, extended for about 2 cm towards the inner working surface.

The grains of surface ***b*** are well defined and do not show mechanic alterations (Fig. 5), while the grains of surface ***a*** appear abraded and levelled as consequence of the resting percussion which they underwent (Fig. 6). Therefore face ***a*** corresponds to the only working surface of fragment A.

Grains surface alteration is comparable with the morphologies of that of the Neolithic cereals grinding tools, but differs for the absence of “homogeneous zones” (sensu Dubreuil 2004; Adams *et al.* in press). In this tool the grinding task has been carried out with one single hand and so with less strength as well as to the different softness of the worked material (the *Tyha* rhizomes). Nonetheless such abrasive action produced a loss of raw material out of the active surface, creating a step recognisable by combining the two fragments (Fig. 4).

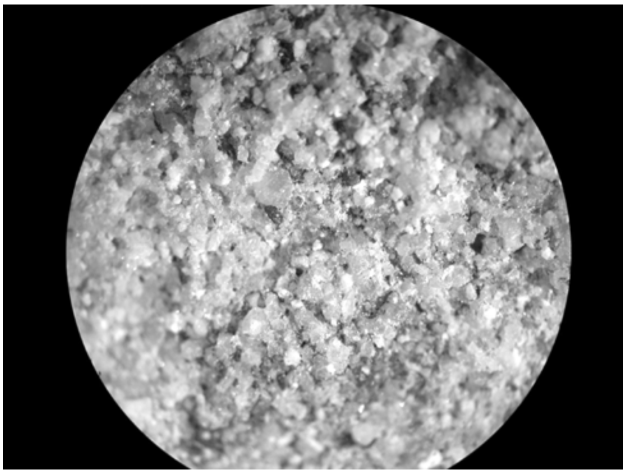

Fig. 5. Unused area, grains not weathered, 20 x.

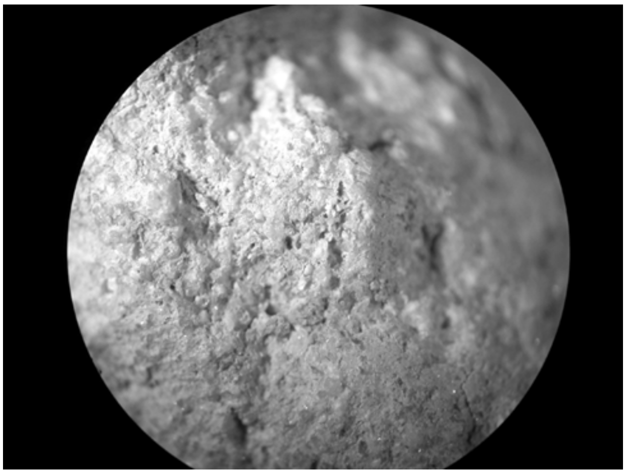

Fig. 6. Rounded and weathered grains of the used area on the grinding tool, 40 x.

It is possible to observe striations oblique to the longitudinal axe of the tool. These traces are related to the use of the tool A in diffuse resting percussion connected with a kinematics slightly oblique to the principal axe of the tool. On the basis of the traces we consider the element A as the passive one; furthermore the reduced working surface, together with experimental and ethnographic considerations suggests that it was hold on the bare hand or leaning on a box, as suggested by the experimental reconstruction.

Regarding to the "pecked zone", its formation can be related to an action carried out in thrusting percussion with an active element to facilitate the processing of the worked material. In fact the grains of this area show a frosted appearance on their top, characteristic of the passive basis , which corresponds to the area where the mechanic action was stronger and prolonged.

Fragment B
Fragment B presents a subtrapezoidal shape, with a rectangular section (thickness 47 mm) with a general

Fig. 7. Used area of the grinder-pestel where the levelled top of the grains is evident, 10 x.

shape similar to element A (Length 88 x 110 x 114 mm) from which it differs because of the less convergence of the long sides, linked by a wide convex surface. Fragment B weights 676 gr and represents about ⅔ of the volume of fragment A.

Fragment B was still covered in part by the sediment therefore the microscopic observation had been more difficult. Nonetheless it is possible to distinguish three different working areas, corresponding to the upper (surface c) and lower (surface d) face and to the convex edge (surface e).

On both the faces it is possible to observe grains levelled on top, abraded by an action of diffuse resting percussion, even though the alteration is less developed compared to the working area *a* on fragment A. Comparing the development degree of the traces on the two faces, the one with a flat and regular profile (surface ***c***), interested by a wide scar at its very edge, was surely the preferential utilised area with respect to opposite surface d (Fig. 7).

The extremity of fragment B (surface ***e***) is interested by percussion impacts, which occur because of the kinematics in thrusting percussion and produced the wide scar on surface ***c****; the movement is directed to the "pecked zone" of surface a (fragment A).*

It is possible to suggest an associated use in resting and thrusting percussion connected with two technical actions, produced simultaneously during the same processing system.

The use wear traces analyses on the surfaces and edges of fragments A and B allowed the reconstruction of two different kinematics strictly related to both the active elements: grinding tool or passive element (tool A) and pestle-grinder for the active one (tool B). We are facing two tools strictly related by the action, that is two different technical actions but synchronous: grinding

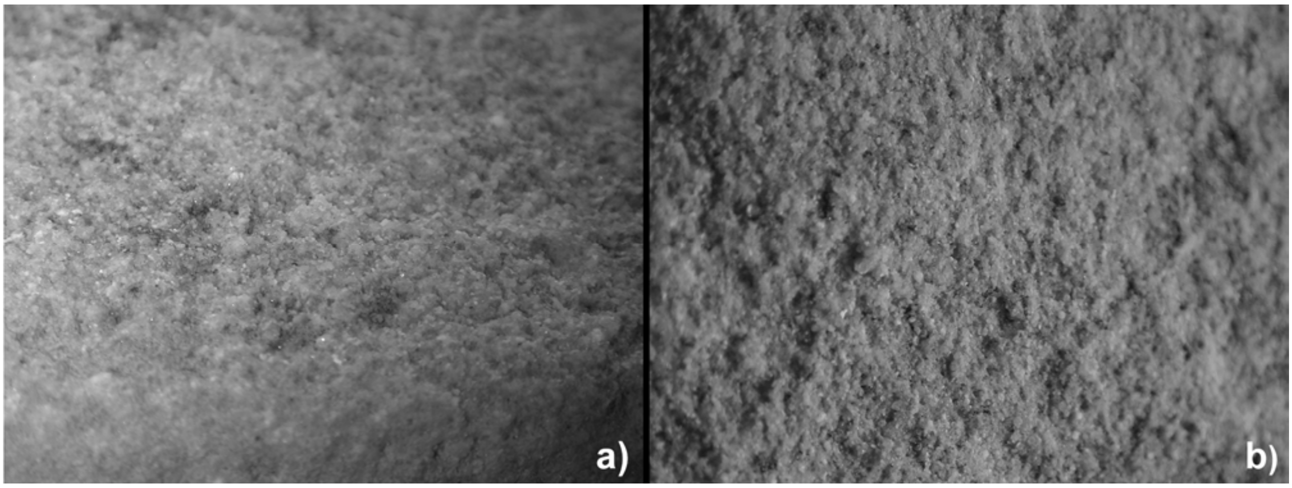

Fig. 8. **a** Unused area with sharp profile grains, 10 x; **b** enlargement of the observed area, 20x.

		Functional elements	
		Fragment A	**Fragment B**
Kinematics (functioning)	Passive/active	Passive	Active
	Working surfaces	1 (surface a)	3 (surfaces c and d; extremity e)
	PercussionType	Resting	Resting and Thrusting
	Working surfaces morphology	Flat, sloping	Slightly convex, convex large extremity
Processing systems (function)	Wear traces	Levelled and abraded grains; striations; pecked zone with percussion impacts	Levelled grains (c and d); percussion impacts (e)
	Localization Wear traces	Concentrated on the distal central zone	More visible on the surfaces c and e
	Processed substance charateristics	Solid, average soft, stringy	
	Aim of processing system	Coarse grinding	Effortless pestling
Tool type		**Grinding tool**	**Grinder-pestle**

and pestling. These functional characteristics are summarised in the table, which aims to explain the intrinsic complexity of a tool the recognition of which involves behavioural consequences derived from the exploitation of material resources and technical skills that will become common only 15.000/20.000 years later.

Final remarks

The Bilancino grindstone made out of local quartz-feldspar-micaceous sandstone is characterized by strongly abrasive granules embedded in a calcite matrix which does not constitute therefore a very resistant cement. As aforementioned this kind of grindstone is not exactly suitable for alimentary use due to the easy detachment of the granules during the utilization, but on the other hand it is more efficient and the prolonged use creates more easily a deep concavity in the used surface.

The use of grindstones for alimentary or technical purpose (mineral substances or vegetal and animal fibres processing) can be recognized both by the presence of wear traces, which allow to reconstruct the gesture and to hypothesize the worked material, and by archaeological experimentation, but above all because of possible residues sampling on the active surface of the tool.

At Cuddie Springs site, Australia, the study of 25 grindstone fragments - based on morphology, wear traces and analysis of residues related to vegetal remains rich in starches or silica - allowed to argue that, starting from about 28.000 years ago, an economy based on plants with alimentary purpose processing is attested, as it is documented by ethnographical work in the same area (Fullagar, Field 1997). In this sense it is interesting to note the specific reference to *Typha* treatment with the aid of pestles; the same plant we have suggested was processed in the Bilancino site by the activities performed with Noailles burins.

The same plant is also considered among those processed by Natufian grindstones (Wright 1991, tav. 7).

Ethnographical comparisons point out that the use of *Typha,* in its different varieties, is well known with different purposes all over the world particularly in the extra-European countries from China to Australia and North America, where this plant is still used.

Based on the analyses of Bilancino remains we can assume that this plant was possibly grounded to get a flour: in this last way the product maintains better nourishing qualities and the obtained paste is similar to cereals flour, both for taste and for nourishing qualities (proteins: 6%; fat: 0,29%; carbohydrates: 17% of which 15,4% of starch; ashes: 2,54%). Moreover almost all the plant portions can be utilized (buds, spikes, pollen, but above all the raw rhizomes, cooked or better peeled and/or sun dried). The study of wear traces, the experimentation, and the analysis of residues recovered on the surface of the grindstone and pestle offer definitive data on the use of this artefact for Typha rhizomes processing during the Gravettian.

The multidisciplinary research methodology applied to the study of Bilancino allowed to propose other possible different activities documented by the archaeological record. The reconstruction of the operational sequences, the use-wear analysis, the ethnographic comparison, the experimental archaeology and of the analysis of the residues converges to strongly support the exploitation of *Typha* plants as the main economic activity carried out in this specialized seasonal camp. It is also important to stress the other exploitations which point out to this plant as a multifunction economic resource: besides the leaves used for the fibres weaving, the stem is used as building material, the blooms offer a material similar to wool, employed as well as starting element for the fire, and also as insulator and for stuffing.

At Bilancino site different technological processes could be reported, all related to the *Typha* exploitation: while manufacture and use of a specialized tools is documented for the treatment of vegetable fibres (Noailles burins, Aranguren *et al*. 2007), the further phases of the fibres processing in order to obtain other products are to be inferred only as a working hypothesis (possible dyeing of these products with hematite dust).

Nevertheless independently from the worked raw material the Bilancino grindstone, which still has no analytical and archaeometric comparisons in coeval European sites, testifies the adoption of an innovative technique -the grinding activity - in the Italian Gravettian, stressing both the importance of vegetal resources exploitation in Palaeolithic economies and the importance of the technological innovation within the development and the diffusion of the Gravettian culture in Europe.

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The complexity of an Epigravettian site viewed from use-wear traces. Insights for settlement dynamics in the Italian eastern Alps

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Summary. *The author presents the results of a functional analysis on flint tools recovered at Val Lastari, a recent Epigravettian open-air site which played a strategic role in flint provisioning and toolmaking.*
From this data it has been inferred that the settlement reveals a more articulated economic profile related to different activities, in particular acquisition and treatment of animal resource.
Correlation with the surrounding territory and inferences with the Epigravettian settlement system in northern Italy are also discussed.

Résumé. *On présent ici les résultats de l'analyse fonctionnelle de l'industrie lithique de Val Lastari, site épigravettien de plein air lié à l'approvvisionnement de matière première et à la production lithique.*
Sur la base des données obtenues, le rôle fonctionel de l'occupation du site parait plus articulé et orienté en particulier à l'acquisition et à l'exploitation de ressources animales.
Une correlation avec le territoire autour du site et ses inférences avec le système d'occupation épigravettien dans le Nord de l'Italie sont aussi pris en examen.

Key words Late Glacial, recent Epigravettian, northern Italy, lithic industry, use-wear traces, site function.

Introduction

The study here discussed concerns the Epigravettian site of Val Lastari, on the eastern Prealps in North-Eastern Italy. The site, lying at 1060 m a.s.l., is one of the mid-altitude open camps which were seasonally occupied by hunter-gatherer groups during the Late glacial temperate stages, when the first notable human settlement on the Alpine upland after the last Glacial Maximum took place (Broglio 1992).

Field research was carried out from 1990 to 1996 and supplied abundant flint artefacts mostly scattered on a paleoliving floor (Broglio *et al.*, 1992; Angelucci and Peresani 1995). Excavations brought to light evidence of repeated human occupations and revealed the existence of flint workshops, a flint cache and waste pits. Field data, pedo-sedimentological and spatial analyses have demonstrated that various post-depositional processes acted in reducing the archaeological record and affected the original spatial distribution of the lithic artefacts, at least in the upper part of the sequence.

Geoarchaeological data (Angelucci and Peresani, 2000) indicate that soil profile developed from a loess like sediment cover (unit 3) resting on slope deposits (unit 4). Two phases of soil formation occurred during the Late-glacial; the latest one can likely be related to the paleoliving floor. Radiocarbon dates (11,213-11,806 Cal. BC; Broglio *et al*. 1992) as well as the typological features of the retouched lithic tool set confirm that the site was occupied during the second half of the Late-glacial Interstadial and the Younger Dryas.

Toolmaking concerned almost exclusively local flint collected at site surroundings in the valley bottom, on karstic surfaces and from slope-waste deposits. In addition to the most abundant flint (Biancone Cretaceous limestone), a small percentage is represented by the green-yellowish type (Scaglia Variegata), red (Scaglia Rossa) and undeterminable flint (Montoya 2004). Biancone flint is very compact, fine textured and light to dark grey in colour. The flint cache recovered in the site, attests storage of lithic raw material.

A recent technological study (Montoya and Peresani 2006; Montoya 2004) allowed to recognize 4 different production sequences, aimed to obtain two morphometric categories of bladelets, straight blades and finally laminar flakes. Bladelets were then shaped into baked pieces, while straight blades could be used as blanks for backed knives. Some laminar flakes were retouched, while others could have been used without retouching. Among the retouched tools, end-scrapers, backed knives and retouched blades are well represented, while backed points, backed and backed truncated bladelets are the most representative types among the microliths.

The research carried out focuses on site-function and on its role in a settlement system that includes residential sites at the foot of the Prealps and different highland sites and middle altitude sites (Broglio and Lanzinger 1990, 1996), often close to lithic raw material sources. For these latter field data suggest seasonal multi-occupations aimed to flint-knapping and tool-making. Nevertheless the loss of faunal remains probably causes an under-representation of other activities that could have been carried out on-site or off-site. So, it seems to be necessary to point out other aspects in the economic role of this site and its relationship with settlement system and territory exploitation.

In order to answer these questions, a wider perspective has been adopted through the application of use-wear analysis on the lithic assemblage.

tools	*pieces analyzed*	*with use-wear traces*
backed points	111	47
backed bladelets	67	36
backed and truncated bladelets	36	21
not-determinable backed pieces	111	65
total	*325*	*169*
scrapers	92	46
backed blades	44	12
retouched blades	59	8
truncated blades	23	6
truncated and retouched bladelets	33	3
retouched flakes	19	3
burins	10	3
not-determinable tools	2	-
façonnage accidents	11	-
total	293	82
débitage products	108	19
TOTAL	**726**	**269**

Fig. 1: Val Lastari. Composition of the lithic sample analysed.

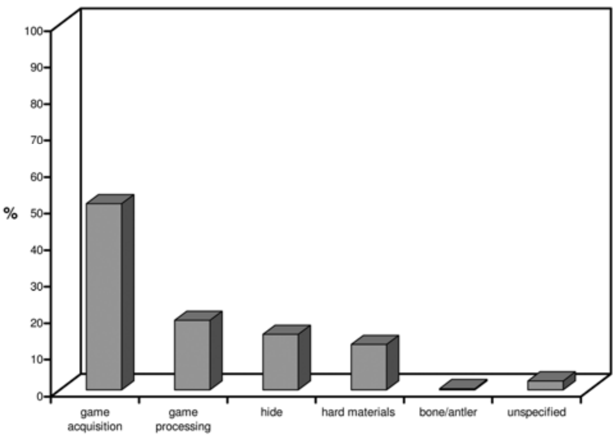

Fig. 2: Val Lastari. Distribution of activities individuated on lithic artefacts by use-wear traces.

Methods

After a first experimental phase, when the lithic raw material exploited at the site was tested in order to interpret the results of utilization and the use-wear formation on the surface, the functional analysis of the lithic industry was carried out.

The analysis on the archaeological pieces was made through optic microscopic approaches as the method defined by Semenov (1964) and Keeley (1980), at both low and high power approach, so it was possible to interpret the macroscopic and microscopic traces. The interpretation of the traces observed on the archaeological pieces is supported by the analogy with the experimental results.

Results

A sample of 726 pieces was investigated. The pieces were chosen among retouched tools and *débitage* products from US 3 and US 3A-F.

State of preservation of the collection
The pieces observed are often interested by the presence of surface alteration, in particular very common is the soil sheen. In some cases (at least 256 pieces) the soil sheen gets a medium or a high level: on those pieces the interpretation of microtraces results more difficult.

Fortunately the edges of pieces are not often modified by mechanical alteration (only 15 cases), so the interpretation of macrotraces was possible. If pieces result to be well-preserved at low power approach, the analysis of microtraces was sometimes very delicate, given that the soil sheen on this kind of surfaces could be interpreted as a generic weak polish or even as a tender animal materials polish (such as meat or tendons). For this reason the analysis on the surfaces and the interpretation were very prudent and this could cause an under-representation of some traces.

A few pieces are interested by bright spots (8 cases) or white patina (12 cases).

A total of 269 pieces showed macrotraces or microtraces due to utilization (37% ca). The utilization rate is in fact vary variable in relation to different typological groups: in the case of scrapers and backed tools the rate of utilization overtakes the 50%, while other typologies have not displayed many traces.

Retouched tools

End-scrapers
End-scrapers were obtained from laminar blanks or flakes. On 92 scrapers 46 show use-wear traces; their functional areas always coincide with the retouched front. They were used on transversal motion and are strictly related to hide processing, so we can affirm that, as in other context of the Upper Palaeolithic, the correspondence between type and function is very strict (Plisson and Vaughan 2002).

Different stages of hide working were individuated. The best represented, anyway, is dry hide processing, which causes very heavy roundings on the functional edge and a typical polish (Fig. 3, 3; Fig. 4, 1). Other pieces have shown evidence of fresh or humid skin treatment. In some cases the presence of transversal striations was interpreted as the result of using additives, that might have a mineral nature (Fig. 3, 4; Fig. 4, 2). Some ochre found into the paleoliving floor suggests that this substance could be used in the treatment of hide as fine abrasive, as already noticed in other Palaeolithic and Mesolithic contexts in Europe (Audouin and Plisson 1982; Moss 1983; Philibert 1994). We can certainly affirm that the additives utilized had an abrasive nature, given the heavy rounding and the high frequency of striations.

In a few cases particular polish detected (very bright and with domed aspect), associated to a heavy rounding which is typical of dry skin, allow to think of an additive containing a siliceous substance (Fig. 4, 3). By working experimentally a dry hide surface treated with ash we could obtain similar macro and micro-evidences on this kind of flint (Biancone; Fig. 4, 4).

Backed blades

Backed blades of Val Lastari are made on long and regular blanks, obtained from the blade production sequence. They present a retouched, convex edge and an opposed rectilinear non-retouched edge, which is generally the functional area of the tool (Fig. 3, 1). A few exceptions to this scheme are present: in 2 backed blades the retouch is partial and the functional area corresponds to the non-retouched part on the same edge. Furthermore in another case the retouch is present on both sides of the blank, forming a sharpen functional point (Fig. 3, 2).

Forty-four backed blades have been examined; 12 of them present traces of utilization. They were used in longitudinal motion, on tender animal tissues (3 cases), on tender (5 cases) or semi-tender material (2 cases), while 2 blades were probably used in butchery activities. Four of the functional areas are interested by micropolish from tender animal materials. Surfaces of these blades are often altered and this could explain the lack of microtraces, even if another reason could be a very brief utilization of these tools.

Retouched blades

Some blades with retouch on the edges were studied (59 in total). In comparison with the backed tools the retouch does not form a real backed edge but it is discontinuous and irregular (Fig. 3, 5-7). In some cases the retouch seem to be a result of utilization. Just 8 of them show use-wear traces, with 14 functional areas in total. Some blades were used for cutting actions on tender materials (6 functional areas; Fig 3, 5); one of this pieces present a micropolish that is interpreted as meat trace. Another retouched blade was used to cut harder materials. Other blades were used on transversal actions on semi-hard materials (2 functional areas) or hard materials (3 functional areas; Fig. 3, 6). Finally, a couple of blades were used for boring unspecified materials (Fig. 3, 7).

The presence of more functional areas on the same piece and the variability observed in the movement and also in worked materials suggest a quite versatile conception of these tools.

Truncated blades

A sample of 23 truncated blades was studied. The analyse revealed a certain variability in the utilization of these tools, which could correspond to the typo-morphometrical variability already observed (Ziggiotti 1999-2000; Peresani *et al.*, 2002). In fact, the functional literature gives a very varied picture of the functionality of this typology which has been already discussed (Ziggiotti and Peresani 2000-2001).

At Val Lastari 6 truncated blades (showing sometimes more than a functional area on the same piece) were used for different actions, such as longitudinal (2 cases) or transversal motion (4 cases; Fig. 3, 9 and 10). A couple of pieces were used for engraving hard or semi-hard materials (Fig. 3, 10). The lack of diagnostic micropolish is a limit in the interpretation of worked materials. The fact that the functional part of the piece corresponds in some cases the truncated edge while in other the lateral edge, suggest that the transversal retouch of truncation is a technical solution chosen to answer to different needs, that could be related to a specific hafting system but also to a particular functional task (such as boring or piercing).

Retouched and truncated bladelets

Thirty-three retouched and truncated bladelets were studied. Just 3 of them present traces of utilization: 1 piece was used to scrape hard material, while another one was used for cutting tender material (Fig. 3, 8); finally another bladelet presents an impact fracture and could be used as hunting weapon.

Retouched flakes

Nineteen retouched flakes were studied, and 3 of them have displayed traces of utilization to scrape tender animal materials, maybe skin or hide, but it was not possible to determinate the state of the worked material. The functional area corresponds to the retouched edge and their functional role seem to be very close to that one of scrapers.

Burins

The identification of burins was quite difficult. In fact, some pieces of Val Lastari traditionally ascribed to this category could be cores for bladelets production. As suggested by Montoya (2004), just the burins on which the burin spall seems to be finalized to obtain a functional area were considered. So, a sample of 10 pieces was examined.

The tools were used with transversal motion on bone (1 piece; Fig. 3, 11) or more generally on hard material (1 piece), then for boring hard material (1 piece) or cutting tender material (1 piece), probably skin.

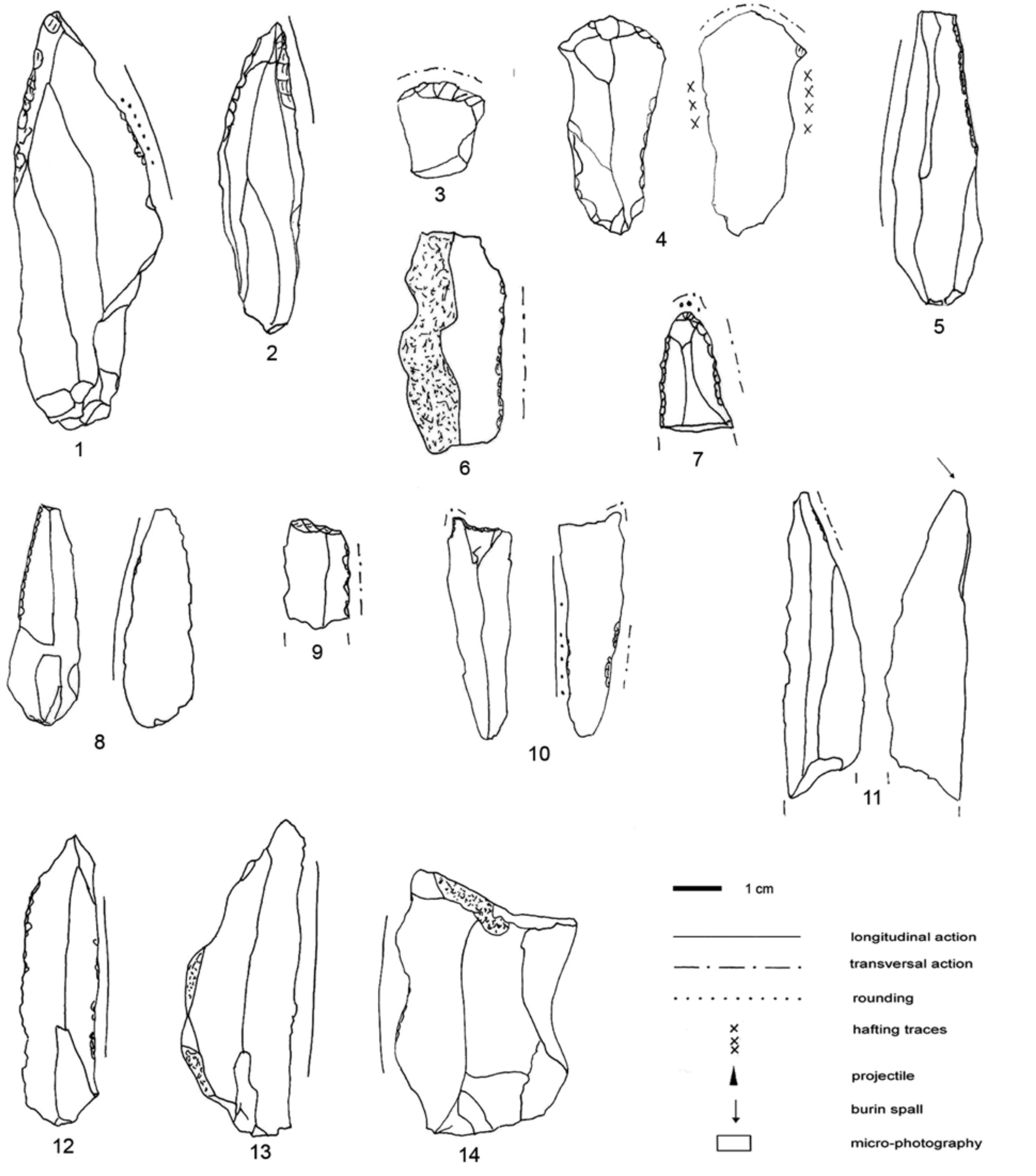

Fig. 3: Val Lastari. Lithic artefacts presenting with use-wear traces: 1, 2) backed blades; 3, 4) scrapers; 5-7) retouched blades; 8) retouched bladelet; 9, 10) truncated blades; 11) burin; 12, 13) not-retouched blades; 14) not-retouched flake.

Others
Some other non specified tools (2 pieces) and some *façonnage* accidents (11 cases) were studied. They did not present any trace of utilization.

Backed tools
In this category we include all the backed pieces which present at Val Lastari different types, as backed bladelets, backed and truncated bladelets, backed points; other fragment cannot be specified from a typological point of view. Two different bladelets sequence of production furnished the blanks to obtain backed pieces. The integration with a technological approach revealed that the production of blanks, then retouched to shape microliths, was made at the site.

The results were detected through a study that considered impact features such as fractures or other morphologies

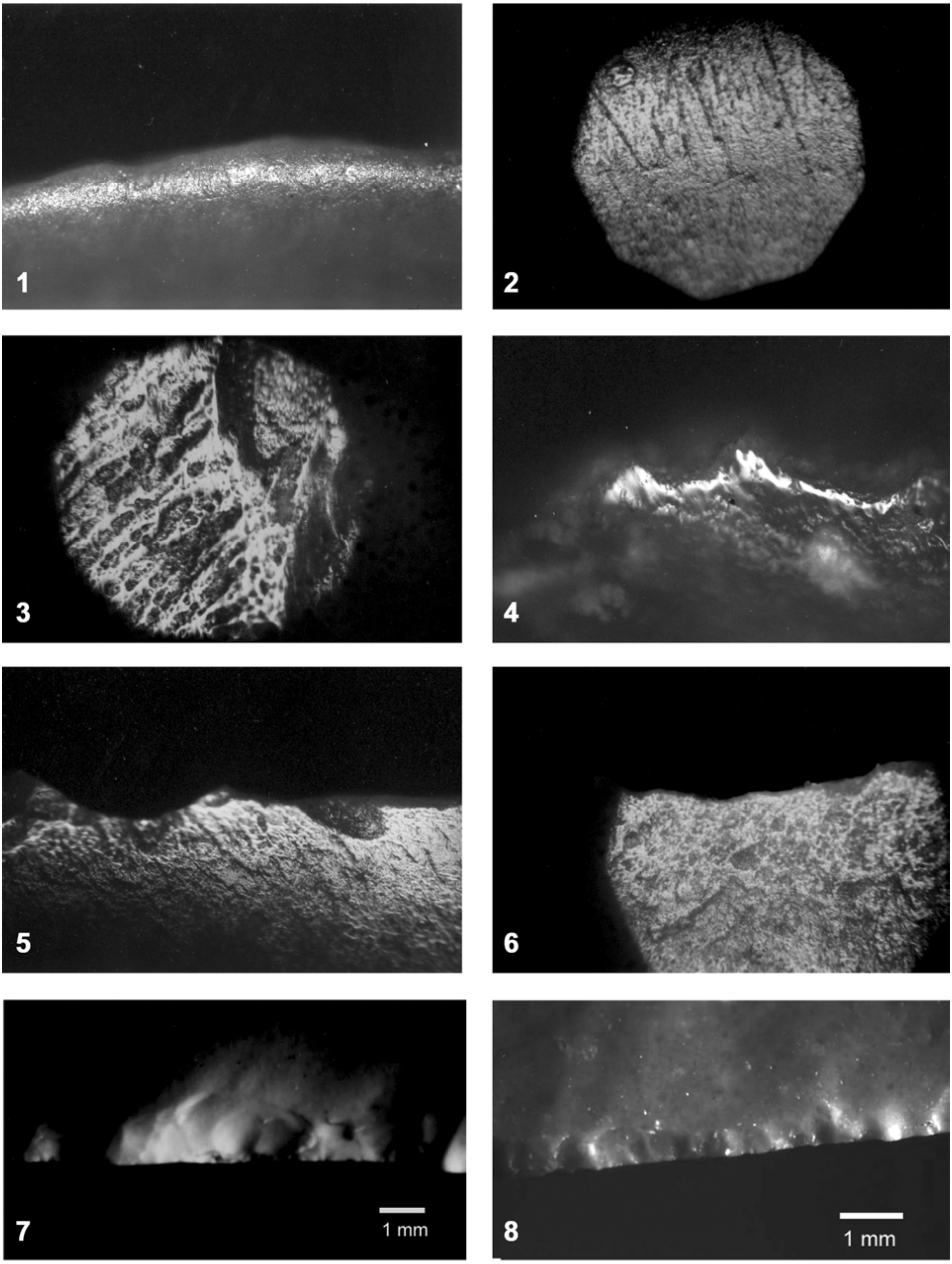

Fig. 4: Val Lastari. Use-wear traces on lithic tools: 1) rounding and micropolish from hide working on the front of the scraper VL 90 (magnification: 200X; Fig. 3, 3); 2) rounding, micropolish and striations from hide working with abrasive additive on the front of the scraper VL 33 (magnification: 200X; Fig. 3, 4); 3) micropolish from hide working with siliceous additive on the front of the scraper VL 36 (magnification: 200X); 4) experimental micropolish from hide working after adding some ash (magnification: 200X); 5, 6) micropolish on not-retouched blades from cutting tender animal materials (such as meat or tendons; magnification: 5: 100X, 6: 200X); 7, 8) scarring on *débitage* products from a transverse motion on hard materials.

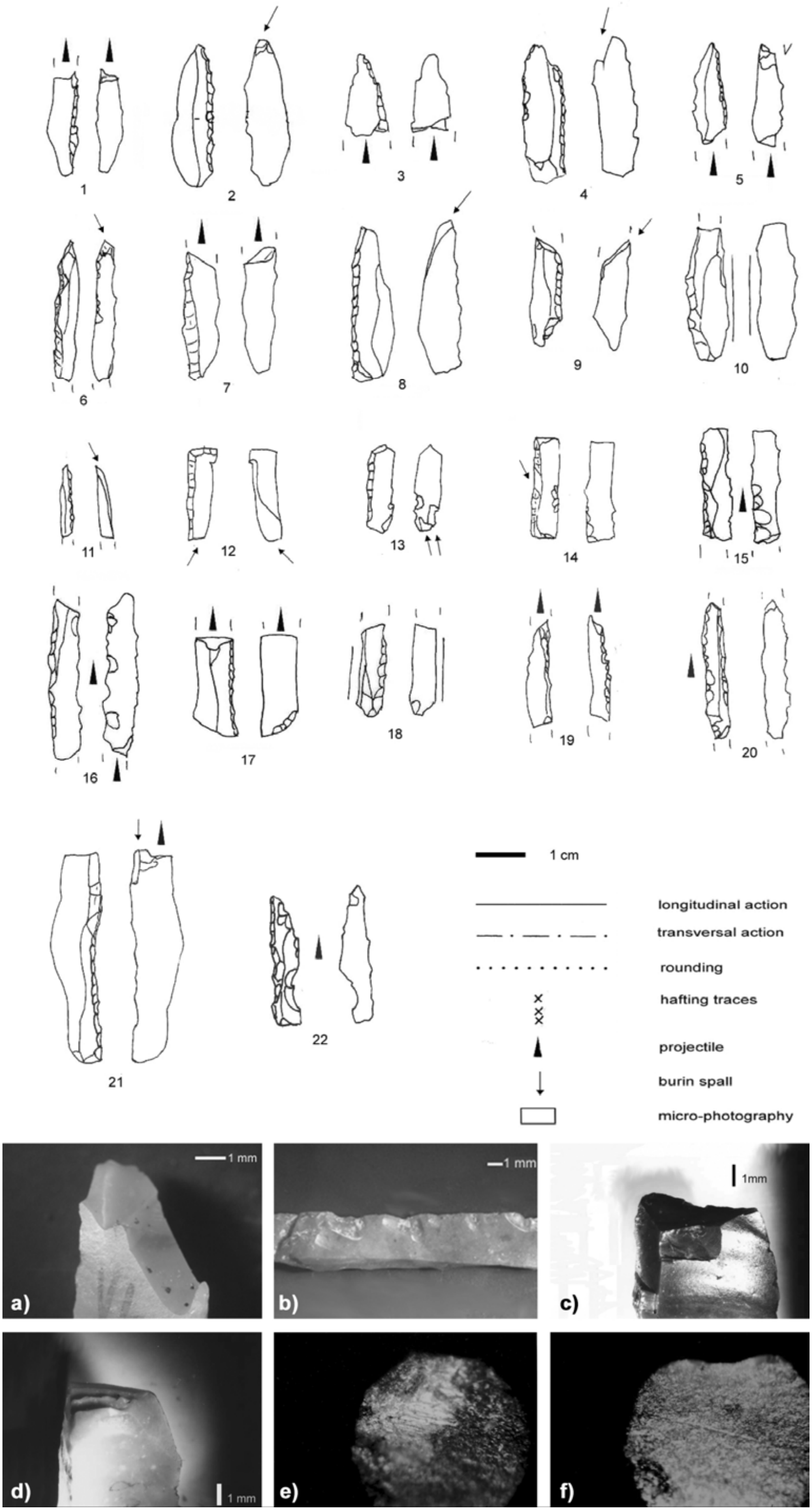

Fig. 5: Val Lastari. Backed pieces showing impact traces (1-9, 11-17, 19-22) or longitudinal action traces (10, 18). Burin fracture on backed fragment (a), edge scarring (b), fracture and burin spall (c), step fracture (d); microlinear impact traces (e, magnification: 200X; f, magnification: 100X).

(burin spalls, fissures, microlinear impact traces, lateral scarring on the edge; Fig. 5) in relation to the fragmentation rate of pieces and their morphometric analysis. On 325 pieces analyzed, 149 presented impact features and were interpreted as hunting weapons: so the category of backed pieces is clearly related to hunting activities and game acquisition.

In a few cases (20 pieces) some backed bladelets were probably used for diversified activities, in particular for cutting tender materials (Fig. 5, 10 and 18), but the absence of diagnostic micropolish does not allow to go forward in the interpretation. In fact the utilization of backed pieces in diversified activities, beside their main function as hunting weapons, was noticed in many contexts of the Upper Palaeolithic (Symens 1988; Guiuorova and Schtchelinski 1994; Moss 1983; Plisson 1985; Philibert 1994).

The presence of other fragments related to the fabrication of backed pieces can be imagined as related to repairing or maintaining hunting weapons. Those fragments do not present traces of utilization.

Débitage

A sample of 108 pieces chosen among the knapping products were chosen for the functional analysis. This sample includes some laminar blanks (98 specimens) and also some laminar flakes (10 specimens) coming from different phases of production.

Among the analysed pieces, 19 present some use-wear traces.

As regards non-retouched blades presenting traces of utilization, the most interesting result of this analysis consists in the analogy observed between this category and the one of backed blades. In fact non-retouched blades were generally used for cutting activities on tender animal materials like flesh or tendons (4 cases; Fig. 3, 13) or for butchery activities (3 cases; Fig. 3, 12). Some examples of diagnostic meat or tendons polish are also present (Fig. 4, 5 and 6). As highlighted by the technological study (Montoya and Peresani 2006), these two categories show a clear typo-metrical similarity and present a sharp edge very efficient for cutting. Nevertheless non-retouched blades can present functional areas on both edges, while on backed blades the functional areas are generally opposed to the retouched side. This may be the consequence of a hafting system of backed blades, while non-retouched blades seem to be more versatile in the functioning of their edges.

Other blades are interested by scarring due to a transverse motion on medium-hard material, maybe of vegetal nature, while others (8) seem to be connected to the treatment of harder materials (such as bone or antler?; Fig. 4, 7 and 8).

Among the non-retouched flakes, just 2 present some traces and were used for sawing semi-hard materials (Fig. 3, 14) or for scraping hard materials.

From materials to activities

Functional analysis on the lithic industry of Val Lastari has displayed evidence of a complex economic role.

The choice of settlement does not answer just the need of provisioning and exploiting raw material: game acquisition, in fact, was one of the main activities carried out from the Epigravettian groups that occupied the site of Val Lastari. As said earlier, backed microliths of the site (backed points, backed and backed-truncated bladelets) were strictly related to hunting activities and to the acquisition of faunal resources.

On the other hand, even faunal resource processing is well represented, especially hide working that concerns, in particular, the group of scrapers. Retouched or non-retouched blades used in butchery activities or for cutting tender animal tissues, can also be ascribed to the processing of animal resources. From a techno-economic point of view the functional convergence observed between backed blades and not-retouched blades seems so interesting and suggests that their functional role was very similar. These data fit well with a technological study, which demonstrated that both backed blades and non-retouched blades are the principal aim of the same technique sequence (Montoya 2004).

Processing harder materials is attested by some macrotraces detected on the edge of blades or flakes. These traces could concern animal materials as bone, antler or some kind of wood. Despite this, the observation of diagnostic micropolishes is very rare. In fact in the Epigravettian sites of North-East Italy bone and antler tools were recovered only in the contexts where a good preservation of these materials was possible, as sheltered sites (such as Dalmeri shelter; Dalmeri *et al*. 2002a) or burial contexts (Villabruna shelter; Aimar *et al*. 1992). Nevertheless, the absence of bone and antler tools in so many open sites in the region, the archaeological deposits of which are seriously altered by some post-depositional processes, makes very hard to evaluate the role and the distribution of a hard animal material industry. For this reason use-wear analysis, by individuating some traces on lithic industry related to this kind of production could clarify the presence and the economic meaning of this production. Unfortunately, results of functional analysis in Val Lastari do not clarify the picture enough. Diagnostic polish of antler or bone working are so rare, even if some macrotraces due to hard materials working could be related to this kind of activities. Despite this, even the lack of this archaeological evidence could open some perspectives of research: is the scarce representation of bone and antler working a consequence of a documentary deficit or rather a consequence of a specific cultural habit? Some elements such as a total absence of organic remains in the archaeological deposit, and the alteration of tools surfaces, lead to think of a documentary deficit rather than a cultural feature. On the other hand, the scarcity of representation of bone-antler working could be interpreted as a result of some dynamics in the Epigravettian technical systems, such as a variable incidence of bone and antler tools and so an irregular presence of tools attesting their manufacturing, or also a not-intense use of lithic tools during manufacturing, so that they could not display clear evidence of bone and antler working. Another possibility is that this is the result of settlement dynamics, as the production of bone and antler tools in other sites, as attested by the awls on elk bone found in the Pradis Cave, which lies at 650 m a.s.l. on the Prealps of Friuli, in the North-East Italy. This tool was manufactured in another site, at the foot of the Prealps, as the elk faunal remains in the Epigravettian sites have been found only in the valley bottom sites (Soman shelter, Tagliente shelter; Gurioli 2004.). This could contribute to interpret the site as related to game acquisition and carcass treatment, while other activities as transforming hard animal materials could be done in other typologies of sites (such as valley bottom sites or sheltered sites?).

Settlement system inferences

One of the aims of a functional approach is understanding the duration and rhythm of the site occupation. In this case, some results of use-wear analysis are significant. First of all, the representation of a complete "life-cycle" of hunting weapons (that were produced on local flint, used and finally discarded within the site) seem to be significant. Furthermore, the representation of different stages of hide working seem to be an important feature.

Considering also other evidence coming from the field data, like the presence of structures and of the paleoliving floor, it seems that the camp was not exclusively interested by ephemeral settlement but it rather represents a repeatedly occupied place aimed to accomplish multipurpose tasks.

Despite this, the nature of the archaeological record does not allow, for the time being, to go further in the interpretation, because repeated human occupations cannot be distinguished in the stratigraphic sequence.

Functional analysis can also suggest some inferences on the relationship between the site and surrounding territory. Towards this aim the case of hunting weapons is particularly significant. As demonstrated by both technological and functional studies, hunting weapons were produced in the site, used off-site and re-introduced into the site after utilization. This re-introduction could be carried out through dynamics as transport of game in the camp or hunting weapons recovering. This allows us to imagine a hunting territory in surroundings, where specialized camps (maybe subordinated camps with very short occupations) were present. Some other elements could support the relationship with other sites in the surroundings: a techno-economical approach has demonstrated, in fact, off-site circulation of laminar blanks, maybe in an unexplored area, possibly in other different sites (Broglio *et al*., 1992; Montoya and Peresani 2006).

Conclusions and perspectives

Results of the functional analysis at Val Lastari demonstrate the existence of a logistic integrated system in the mountain area of North-East Italy.

In a synchronic approach, the perspective of research is offered by the investigation of differences or complementary elements between open contexts such as Val Lastari and other sheltered camps. Lying on middle or high mountains, these sites offer a very different logistic solution and preservation of the archaeological record. The comparison with the results of functional studies could provide a clearer idea of differences or convergences, between the two settlement models, in order to understand whether from a functional point of view they offer complementary solutions and how this interrelation could be carried out.

At the same time attention should be paid to other kind of so-called "minor" sites, generally lying in the open and characterised by a poor archaeological record, usually consisting of a few thousands of artefacts (as in the case, for instance, around the Marcèsina plain or at Laghetto delle Regole; Dalmeri *et al*. 2002b). These sites might be the result of settlement dynamics, interpretable as secondary and short-occupation camps complementary to the nearby sites with more consistent archaeological records produced from a longer or more intense occupation.

In a diachronic perspective, an interesting issue is represented by the relationship with other middle and high mountain camps of the final part of the recent Epigravettian, occupied during the Younger Dryas and the Preboreal period. Lithic industries seem to suggest a more specialized function that anticipate the shift in socio-economic organization that occurred during the Early Sauvetterian in the same region. The hypothesis, based on a typological approach to lithic industries, need to be further proved through an integrated techno-functional approach.

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The relationship between coastal and inland settlements in Mesolithic South-East Norway. An experimental approach

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Summary. *Experimental archaeology has been under-utilized in Mesolithic research in South-East Norway. This paper shows how an experimental approach to lithic assemblages from this region can recognise alternative raw material procurement strategies previously overlooked. The result of a lithic reduction analysis of several inland and coastal sites suggests that non-flint raw material was explored not merely due to necessity, serving as a deficient replacement for flint, but reflect a preferential, socially motivated selection.*

Résumé. *Dans la recherche sur la période mésolithique dans le sud est de la Norvège, l'archéologie expérimentale a été peu utilisée. Cet article démontre comment une approche expérimentale aux assemblages lithiques de cette région peut démontrer des stratégies alternatives d'obtention de matière première, auparavant négligées. Le résultat d'une analyse de réduction lithique de plusieurs sites intérieurs et littoraux suggère que l'utilisation d'une matière première autre que le silex n'était pas simplement motivée par une nécessité de remplacer le silex par une matière moins performante que celui-ci, mais que l'utilisation de ces matières alternatives reflète une sélection préférentielle et de motivation sociale.*

Key words: Mesolithic Norway, experimental approach, non-flint raw material, lithic replication, coast-inland relationship.

Introduction

There is an ongoing debate concerning the relationship between coastal and inland settlements in Mesolithic South-East Norway (Bang-Andersen 1996; Indrelid 1973b; Boaz 1999). A question central to the debate is whether coastal groups moved into the inland on a seasonal basis, or if distinct communities explored different ecological and geographical zones. In this contribution to the "Prehistoric Technology: 40 years later. Functional Studies and the Russian Legacy" I intend to investigate this particular question using an experimental approach.

First, I will give a brief introduction to the history of research in South-East Norway. This background information is crucial to understand how the interaction between the coast and the inland during the Mesolithic (10 000-5 000 B.P) has been viewed in this region. From this, I will present my own experimental research on the subject. The case study for this paper will be axe production in flint and non-flint raw material. Based on the results from a technological analysis of six archaeological sites, I hope it will be evident why I find it of such great importance to include experimental archaeology and lithic reduction analysis to the investigation of our assemblages.

History of Research in South-East Norway

In general, artefacts made of non-flint raw materials are neglected in the Mesolithic research of South-East Norway. There are two apparent reasons for this. First, Norwegian archaeologists still depend on a rigid lithic classification system based on typology, which only include flint assemblages. Many non-flint artefacts do not fit into these categories and are, naturally, being left out. Second, experimental lithic replication and lithic reduction analysis have been heavily under-utilised in Norwegian archaeology. The lack of technological understanding and skill is acute, and most archaeologists have never knapped non-flint raw materials. Due to this poorly developed technological knowledge, most of the non-flint assemblages are looked upon as crude and undesirable raw materials for tool production, and regarded as having been explored due to necessity and merely considered as an inferior substitute for flint. Thus the potential for both lithic debitage in general, and non-flint raw materials, for providing valuable information about economic and social organization in the Mesolithic are widely ignored.

The South-East Mesolithic in Norway: Coast-Inland Interaction

There is no indigenous flint in Norway. Flint is only available in the form of pebbles and nodules found along the coast as drift flint which was brought in by ice during the Glacial Periods. This led to the assumption that the prehistoric people settled close to the available flint sources and that the Mesolithic was mainly a coastal phenomenon (Nummedal, 1924; Shetelig, 1922, 1925; Gjessing, 1945). However, from the 1960s several hundred sites have been discovered and excavated in the inland of Norway, where an abundance of local, non-flint raw materials like quartzite and quartz among many others have been utilised in addition to coastal flint (Hagen, 1963; Johansen 1973; Indrelid 1973a; Bjørgo, 1992; Boaz 1998). The Mesolithic in South-East Norway is thus no longer only a coastal phenomenon. The fact that flint was brought to the inland in the form of nodules, prepared cores or blanks is well established through the presence of flint at such sites, but is this a sign of a coastal population bringing their high quality flint on hunting expeditions to the inland, or could it be a resident inland population trading flint occasionally with the coast?

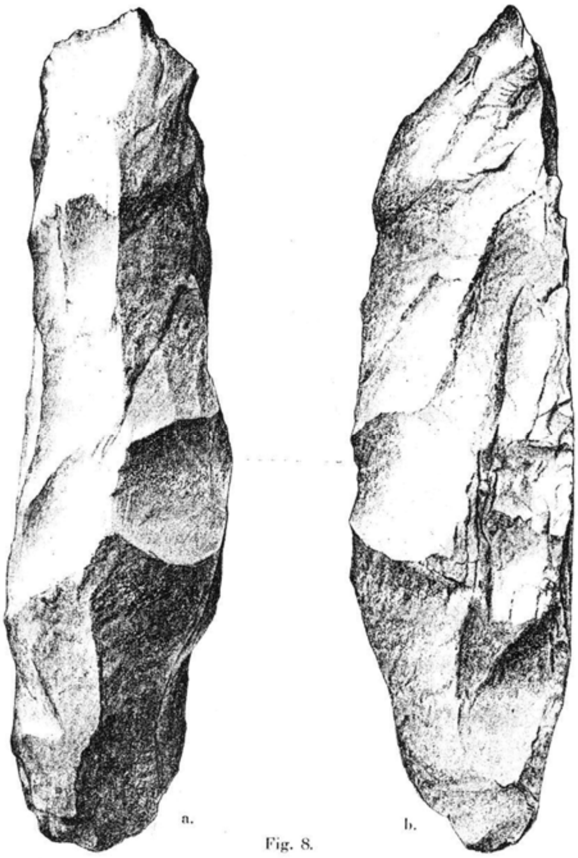

Fig. 1: A typical Nöstvet axe.

So far, the use of an experimental approach to resolve this question remains unexplored due to aforementioned lack of interest in lithic reduction analysis. Archaeologists would rather focus on discussions of an ecological or chronological nature, lamenting over the character of the archaeological material which they claim can give little insight into other aspects of the Mesolithic societies. In the following I will demonstrate that results from experimental archaeology can provide us with new and useful information about social organization and human choices in the Stone Age.

Research Question

The research question I will address in this paper is: Can a technological analysis of non-flint raw materials and debitage from lithic reduction, based on experimental results, give a new perspective to the coast-inland debate? I have carried out experiments on several local Norwegian raw materials replicating different artefact groups and technologies. Here, I will limit myself to present and discuss one particular artefact group, that is axes in flint and non-flint raw materials.

The Nöstvet Axe

The late Mesolithic phase (ca 7500-5800 B.P) in South-East Norway is often termed the "Nöstvet Phase" after the great number of axes, made of non-flint raw materials like basalt, diabas, hornfels, sandstone and others (Brøgger 1905). These axes are only found by the coast. The Nöstvet axes come in many sizes and shapes, but a common diagnostic trait is that removals are detached from one flat side which gives the axe a triangular cross section. The edge of the axe is often grounded. Figure 1 is an illustration of a typical Nöstvet axe.

During the last century of archaeological research, a certain amount of facts about Mesolithic axes have evolved. As these facts are only based on typological information and distribution patterns, I would rather present them as preliminary prejudices. They are: Firstly, there is an assumption that there are no axes in the upper inland irrespective of raw material (Boaz 1998). This is based on the fact that very few axes have been found at inland sites. Secondly, flint would be the ideal raw material for axe production, but due to its scarcity, the prehistoric people used basalt, diabas and others to replace flint. And thirdly, these non-flint raw materials were chosen especially because they had the same fracture dynamics as flint.

Experimental Archaeology

To test these facts I carried out several experiments at Historical Archaeological Research Centre (HAF) in Lejre, Denmark in 2004. The first thing I did was to replicate a core axe in flint to create a reference collection for the archaeological assemblages. Next I was determined to replicate Nöstvet axe production in different raw material types. I wanted to get a general knowledge of the technological attributes and the quality of basalt, diabas, hornfels and sandstone. Fortunately, there exists a refit from a Nöstvet axe production from one of the sites that I am analysing (Olstad 1995). The axe itself is missing from the refit, but the axe has been produced from a big flake and worked from one flat side into a triangular shape (See Figure 2). This would be the method of production that I would mainly attempt to replicate.

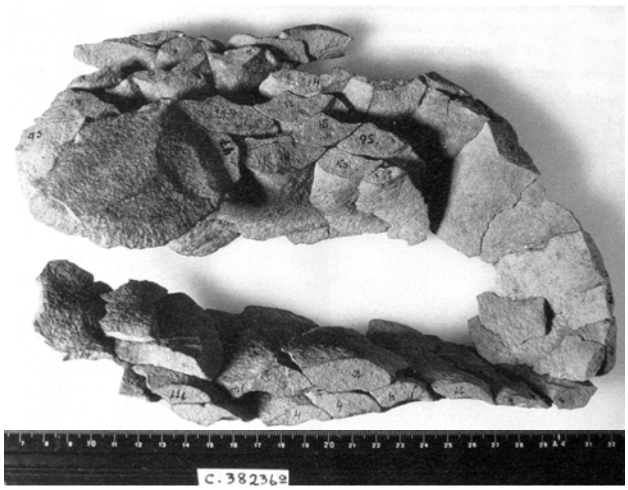

Fig. 2: Refitted debitage from Nöstvet axe production.

Fig. 3: Core axe production and debitage.

Core Axe Production in flint – Methodology and Results

The core axe production in flint was designed to get an impression of both how much debitage the production would accumulate and the characteristics of these flakes. To get an understanding of this process, a step by step photographic strategy was used. The core was photographed after every sixth flaking attempt. In addition each flake got a number in succession and all the debitage were kept for refitting and further analysis (See Fig. 3).

This particular core axe production consisted of 110 flakes, and of these, 51 were analysed. Categories that were included in the analysis were for example: size, form, termination, bulb type, platform type and angle. With this experiment the most interesting result was the diagnostic character of almost all of the flakes. 40 of the 51 analyzed flakes had a diagnostic angle (65-50 degrees) and many had a winged shape as well, which both are common traits in bifacially produced axe flakes (See Figure 4).

Nöstvet Axe Production – What a (end) shock!

I will now sum up the results from the Nöstvet axe experiments. Clearly, I had little idea about what I was up against here. A large amount of knapping force was needed to produce flakes in basalt and diabas. In addition, I picked out many cores that I thought would work well

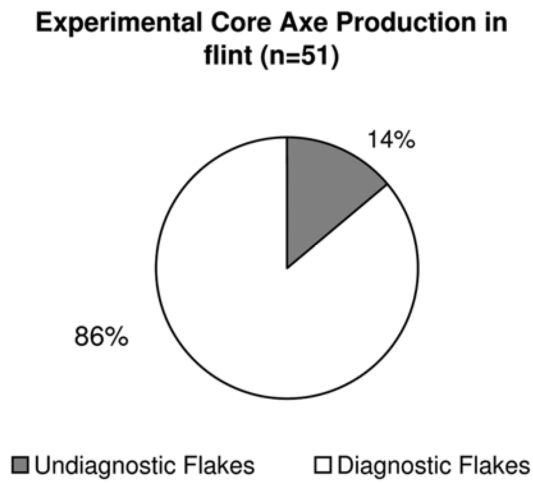

Fig. 4: Results from core axe experiment.

Fig. 5: Nöstvet axe production in diabas.

based on my knowledge of axe production in flint, but they did not work at all. It seems to be the case that these cores must be carefully picked out and satisfy certain demands concerning shape and thickness prior to production. They ought to be triangular and very thin. Figure 5 shows knapper, Harm Paulsen,[1] struggling with a diabas core which is too thick for axe production.

Another point I realised was that all of these raw materials are exposed to end shock. To work these non-flint raw materials one has to master a difficult balance between force applied and the resistance of the raw material (See Figure 6). When it comes to comparing these raw materials to flint there are some interesting interpretations. In my opinion, hornfels and sandstone are the two types that are most similar to flint. They can be knapped rather effortlessly. However, diabas and basalt are completely different. These materials are solid and robust, and are nothing like flint. I do not believe that these raw materials were chosen because they had the same fracture dynamics as flint, or as a deficient replacement. I believe they were worked because they

[1] Harm Paulsen, Landesmuseum Schleswig, Germany

Fig. 6: End shock in a varity of raw materials.

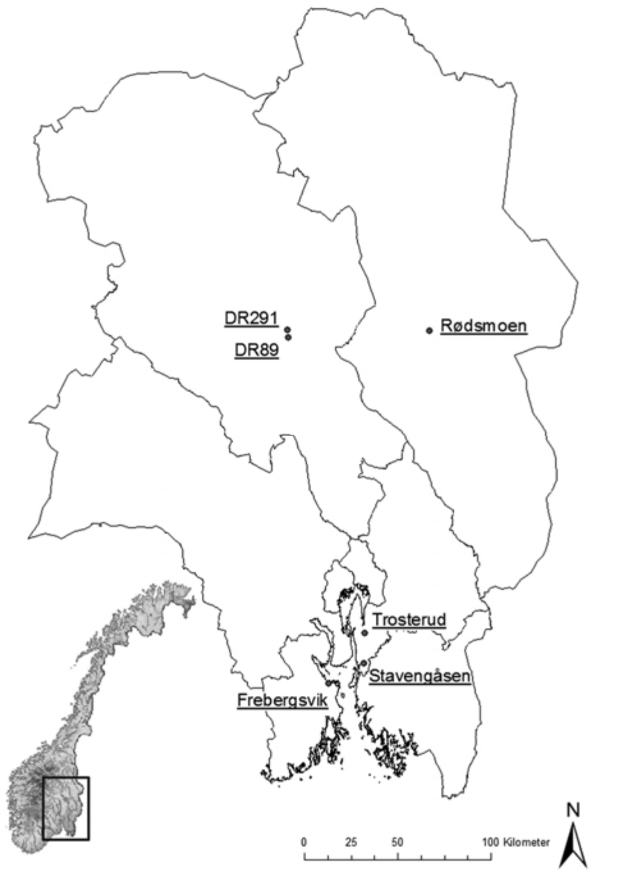

Fig. 7: Sites in the South-East region of Norway.

were better than flint, stronger and more durable. I am convinced that a Nöstvet axe would last longer than a flint axe if they were used at the same task. The fact that Nöstvet axes are to be found by the coast, where flint is most abundant, supports this view.

Study Area and the Archaeological Assemblages

With the results from the experiments in mind, and the reference collection at hand, I have carried out a reduction analysis of six sites in the South-East region of Norway (See Figure 7). To address the question concerning coast-inland interaction in the Mesolithic I have analysed three coastal sites and three inland sites.

Are there really no axes inland? I have analysed a great part of the debitage from all of the sites and searched for diagnostic axe flakes. One inland site stands out. Rodsmoen has an assemblage of over 30% diagnostic axe flakes in flint (See Figure 8). This is a lot more than any of the other sites that only have a few percentages. To me this is a clear indication that there has been axe production or at least bifacial core reduction at the site. At another site in the inland, Dokkfloy, I discovered a typical end shock part of a preform to a Nöstvet axe (See Figure 9). In addition several diagnostic axe flakes could be found. This seems to be enough evidence to suggest that prehistoric people produced at least one axe at this site as well.

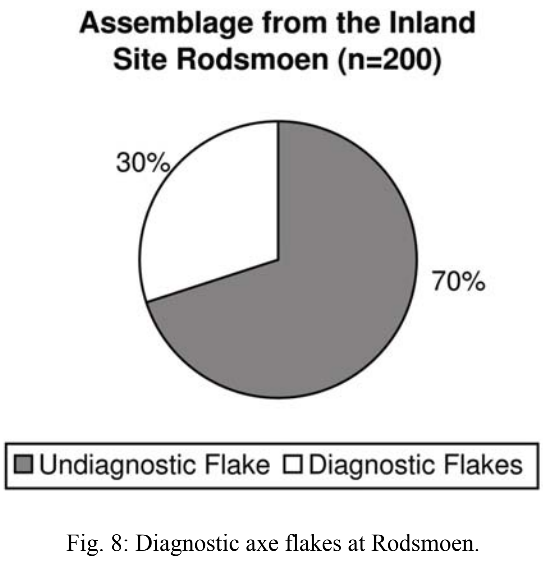

Fig. 8: Diagnostic axe flakes at Rodsmoen.

What about the Nöstvet axe? Were the non-flint raw materials for these axes chosen as deficient replacements

Fig. 9: End shock part of preform to Nöstvet axe.

Fig. 10: Diabas and basalt Nöstvet axes.

for flint because they had similar technological characteristics? All of the three coastal sites I have analysed contain Nöstvet axes, respectively 5, 22 and 33. Looking at the coastal assemblages as a whole they are flint-abundant, and only a few percentages of the sites consists of non-flint raw materials. Knowing this, and looking more closely at the axes, it becomes clear that the raw materials preferred were the solid and robust basalt and diabas, not the flint-like sandstone and hornfels (See Figure 10). From the experiments I learned that basalt and diabas did not have the same technological characteristics as flint. Thus it is very likely that the choice to use these raw materials at the sites was a preferential, socially motivated selection. Prehistoric people knew that these raw materials were stronger and more durable than flint, which is why they chose to use them.

Discussion: Coast-Inland Interaction

From the results we can see that possible core axe production in flint was recognised at one inland site. Why is this important? It might seem strange that there are flint axes in the inland and non-flint axes by the coast. As we know that flint can only be found by the coast one should think it would be the other way round. I believe we are witnessing a brilliant strategy. Prehistoric people brought with them flint axes to the inland when they utilised this ecological zone. At the stage when the axe broke or could not be used anymore, it was transformed into other tool types, such as knives and projectiles. This would not be the case if they brought a basalt axe with them, as this raw material could not be made into sharp blades or projectiles when the axe broke.

All of the three inland sites I have analysed have some flint. Quartz, and abundant raw material in the inland, would be an equivalent to flint as it is just as sharp. However, this raw material has not been utilised in any degree at any of the sites. In my opinion, this is a good indicator that the people who stayed at these sites originated from the coast, still clinging to a flint-tradition. The end shock piece of a Nöstevt axe preform also hints at a coastal tradition, as these axes are found in abundance by the coast.

Conclusion

In this paper I have demonstrated that an experimental approach combined with a lithic reduction analysis can give new insights into a research area that has come to a standstill. From looking at the debitage from the inland sites, which was previously ignored, I was able to recognise axe production. In addition to this, working with the unfamiliar Nöstvet axe materials, made me realise that these types have indeed been misinterpreted by archaeologists with little knowledge of their actual technological qualities. Thus I fear that much archaeological information will be lost in south-eastern Mesolithic research in the future if these new analytical methods are not incorporated into the existing ones.

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I wish to thank the Historical-Archaeological Research Centre, Lejre, Denmark; Farina Sternke; Harm Paulsen; Elin Hansen; Marianne Bugge Kraemer and Antonie Lysholm Kraemer for the translation.

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The functional significance of Sauveterrian microlithic assemblages: broadening the focus of investigation

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Summary. *Microlithization is one of the most intriguing trends in the evolution of lithic industries. In Europe, studies of this phenomenon have particularly focused on the Sauveterrian, a major facies of the Mesolithic. In a recent synthesis of use-wear data, it has been suggested that the Sauveterrian flint industries reflect a minimal technical system produced by groups with simple social structures.*

This view is in sharp contrast with the general perception of the Natufian, a period marking the transition to agriculture in the Near East characterized by increased sedentarization and extensive production and utilization of microlithic tools. Yet, Natufian and Sauveterrian flint tools are very similar and appear to have been involved in a similar range of tasks.

A reduction in tool size and assemblage diversity seems to have been initiated at the end of the Upper Palaeolithic. Functional studies suggest that during this period some categories of flint tools were replaced by less elaborated macro-tools, as seems to have been the case in the Natufian. The Natufian illustrates the dichotomy between micro and macro-tools, each category involving distinct raw materials and concepts. These observations stress the necessity to reassess the functional significance of Sauveterrian assemblages.

Résumé. *La microlithisation est l'une des tendances évolutives les plus étonnantes des industries lithiques. En Europe occidentale, le Mésolithique de type Sauveterrien constitue un exemple particulièrement typique de ce phénomène. Les outillages de silex sauveterriens ont récemment été interprétés comme les produits de systèmes techniques simples, reflétant une organisation sociale relativement peu complexe.*

Cette hypothèse contraste avec la perception que nous avons du Natoufien, une période durant laquelle s'amorce au Proche-Orient un processus de sédentarisation des populations. L'industrie de silex associée à ces groupes est essentiellement de nature microlithique. Elle comprend des types d'outils fortement semblables à ceux attribués au Sauveterrien, objets qui semblent en outre avoir été utilisés dans les mêmes registres techniques.

On observe à la fin du Paléolithique une diminution de la taille des outils de silex et une moindre diversité de types. Un macro-outillage semble s'y substituer, comme l'indiquent certaines analyses tracéologiques. Le Natoufien constitue un exemple particulièrement frappant de cette dichotomie entre formes micro- et macro-lithiques, chaque catégorie impliquant des matériaux et des concepts distincts. Les nombreuses similarités fonctionnelles documentées entre les assemblages Natoufiens et Sauveterriens soulignent la nécessité de reconsidérer la signification fonctionnellle de ces derniers assemblages.

Key words: macro-tools, Mesolithic, microliths, Natufian, Sauveterrian, tool function, site function, use-wear analysis.

Introduction

One of the strengths of Semenov's functional and technological approach to past material culture is that he considered the entire technical system without limiting his analysis to a narrow range of tool types or raw materials.

In Western archaeology, use-wear analysis initially developed as a ramification of typological studies. For a long time, the focus was on flint industries and beautiful artefacts (Maigrot and Plisson in press). It seems fair to say that in these developments, little interest was paid to the theoretical implications of the use-wear method. As a result, the potential of the approach originally developed by Semenov was rarely fully exploited. In this paper, an effort is made to consider use-wear data in a broader perspective, while discussing some aspects of human adaptation during the late Pleistocene and early Holocene. More particularly, we explore the significance of the increase of microlithic tools in the assemblages made by the last hunters-gatherers of south-western Europe.

Microlithization has raised much attention in archaeology, as it represents one of the most important and interesting patterns in the evolution of material culture. However, because microliths developed in a great variety of ecological, geographical, cultural, and chronological contexts, it has proven difficult to explain this multifaceted phenomenon using a single explanatory model (Elston and Kuhn 2002). In Western Europe, microlithization has generally been approached focusing on the Sauveterrian, a Mesolithic facies.

Based on use-wear analyses, it has recently been suggested that the Sauveterrian flint industries reflect groups with minimal technical systems and simple social structures (Philibert 2002). The aim of the present paper is to reassess functional interpretations of the Sauveterrian by comparing this industry with Palaeolithic and Epi-Palaeolithic assemblages from Northern Europe and the Near East. Moreover, we would like to broaden the scope of the discussion by considering all categories of lithic tools, including microliths and ad hoc implements.

The onset of post-glacial climatic conditions during the Epi-Palaeolithic induced important changes in the landscapes. The current consensus view is that the human diet during the late glacial period consisted of a low diversity of resources. Consequently, a broader range of resources became available to prehistoric populations. As pointed out by Semenov (1961, 2005), developments of abrading and grinding technology might have been especially critical in these new environments. Therefore, examining grinding and abrading implements may be particularly informative for determining subsistence strategies during the Epi-Palaeolithic.

Abrading and grinding tools include, among others, abraders, polishers, shaft straighteners, mortars, pestles, grinding slabs, handstones, as well as used pebbles and blocks. Most commonly, these implements were made of limestone, sandstone, basalt, and granite, raw materials that are quite distinct from those used for cutting tools. Because most grinding and abrading implements tend to be larger and heavier than flint tools, the term "macro-tool" is generally used to refer to them. In the Near East, a significant increase in the proportion of macro-tools and a florescence of microliths are observed during the Epi-Palaeolithic.

Studies of the emergence of macro-tool technology are still few. To the contrary, the microlithization of flint tools has been for long a major focus of archaeological research. Yet, despite the accumulated knowledge on this last issue, the significance of the trend towards tool size reduction remains a tricky question to address.

Why microliths? Two insightful case-studies

With the warming conditions of the post-glacial, a general trend towards tool size reduction, accompanied by an apparent decline in knapping abilities, is observed in European and Near Eastern sites. The nature of the relationship between these cultural patterns and climatic change remains obscure. Schild's (1976, 1979, 1984) study of the Final Palaeolithic in the Polish plains provided insightful observations regarding this problem. Climatic fluctuations seem to have been more pronounced in this area than in Western Europe. According to Schild, late glacial periods, characterized by reindeer hunting in open landscapes, were associated with Upper Palaeolithic-like industries. During the more forested interstadial phases, territories were smaller and the industry Azilian-like, as indicated by the presence of short scrapers and backed points. Subsistence was probably based on the exploitation of more sedentary species. This case study suggests rapid reorganization of group mobility, hunting strategies, and material culture in response to changes in resource availability. Such cultural flexibility might have permitted adaptation to small-scale environmental changes and fostered the colonization of new territories.

Since the general trend towards microlithization began at the end of the Palaeolithic, examining assemblages from this period may improve our grasp of this phenomenon. In this perspective, a comparison of Magdalenian and Azilian assemblages in regions differing markedly in raw material abundance has yielded interesting results. Technological and use-wear analyses demonstrated that the scarcity of raw materials affected considerably flint tool management, use, and discard during the Magdalenian, but not during the Azilian (Plisson 1985). These results suggest that this new concept of the flint toolkit, based on the production of fewer tool types, tools of smaller size, and on a simplification of the manufacturing techniques, contributed to reduce dependency on raw material availability. This proposition is in agreement with the hypothesis of changes in mobility patterns at the end of the Palaeolithic, as argued for Poland (Schild 1976, 1979, 1984), and, more recently, Northern France (Valentin 2005b).

It has been suggested that in a few Azilian sites faunal and/or chronological data demonstrate that the technical changes observed in the Epi-Palaeolithic *preceded* environmental changes. However, none of the assemblages associated with reindeer used to support this claim are derived from secure stratigraphic contexts. Moreover, the oldest reliable dates obtained for the Azilian come from regions in which reforestation occurred particularly early, for instance the Swiss piedmont (Leesch *et al.* 2004). Because they are in continuity with regional traditions and observed over a wide geographic scale, the modifications in lithic toolkits at the Pleistocene-Holocene boundary cannot be reduced to local phenomena. This supports the hypothesis that these modifications were mediated by global environmental changes affecting subsistence and mobility strategies.

It seems to us that the available data sustain the view that microlithism was one of the many strategies used by prehistoric groups for managing risk (Elston and Kuhn 2002). In the particular context of the end of the Upper Palaeolithic, microlithism appears to be a response to dramatic changes in mobility patterns induced by the replacement of Pleistocene fauna by less gregarious and non-migrant species, and to the development of more forested landscapes.

This assumption is examined further in the remainder of this paper while investigating Sauveterrian adaptation. An emphasis is placed here on the use-wear approach. However, departing from a strictly materialist standpoint, we will consider the evolution of the symbolic dimensions of stone implements, along with transformations of the production and subsistence systems.

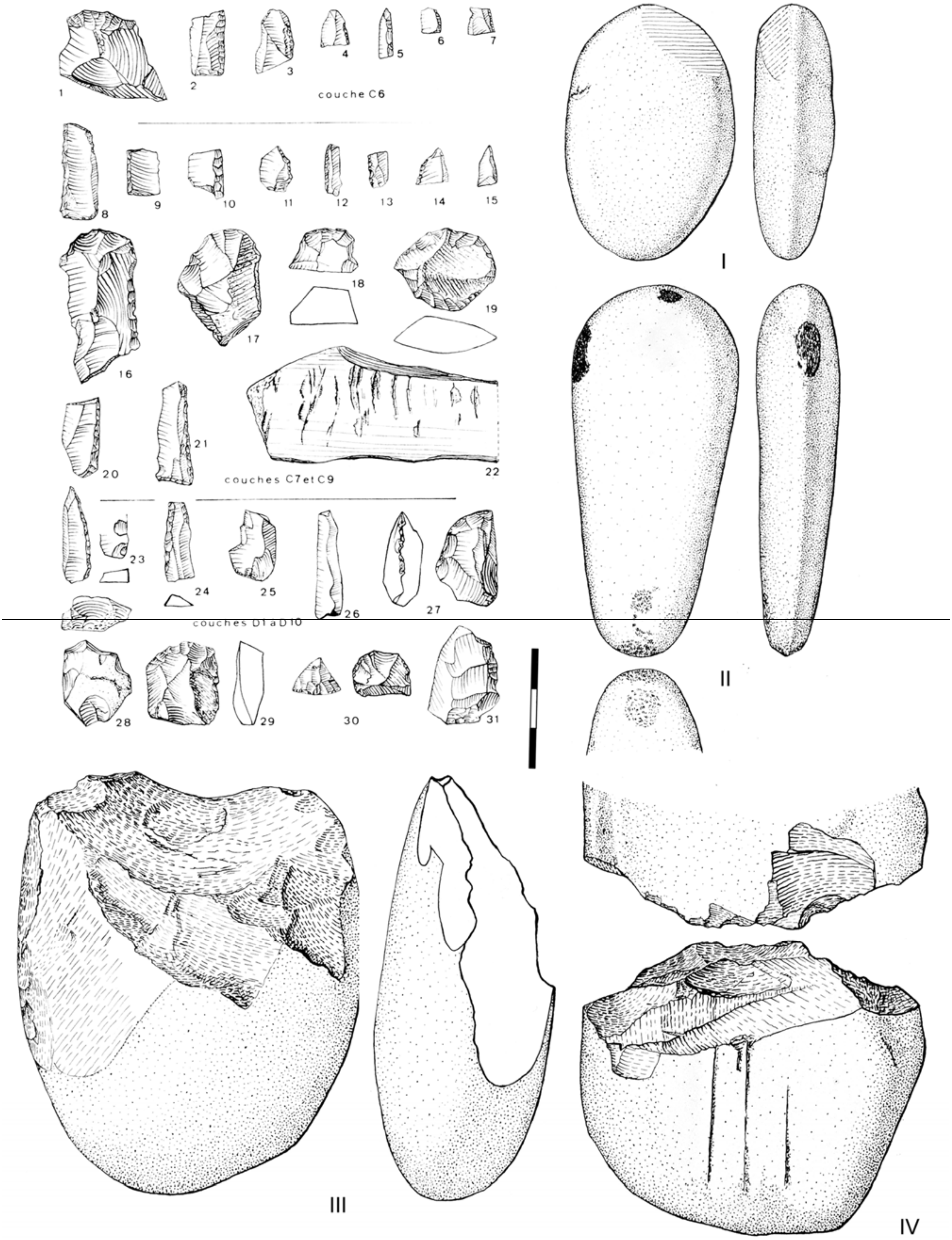


Fig. 1: Azilian micro-tools and macro-tools from La Tourasse cave, France. Objects drawn at the same scale. Drawings: M. Orliac.

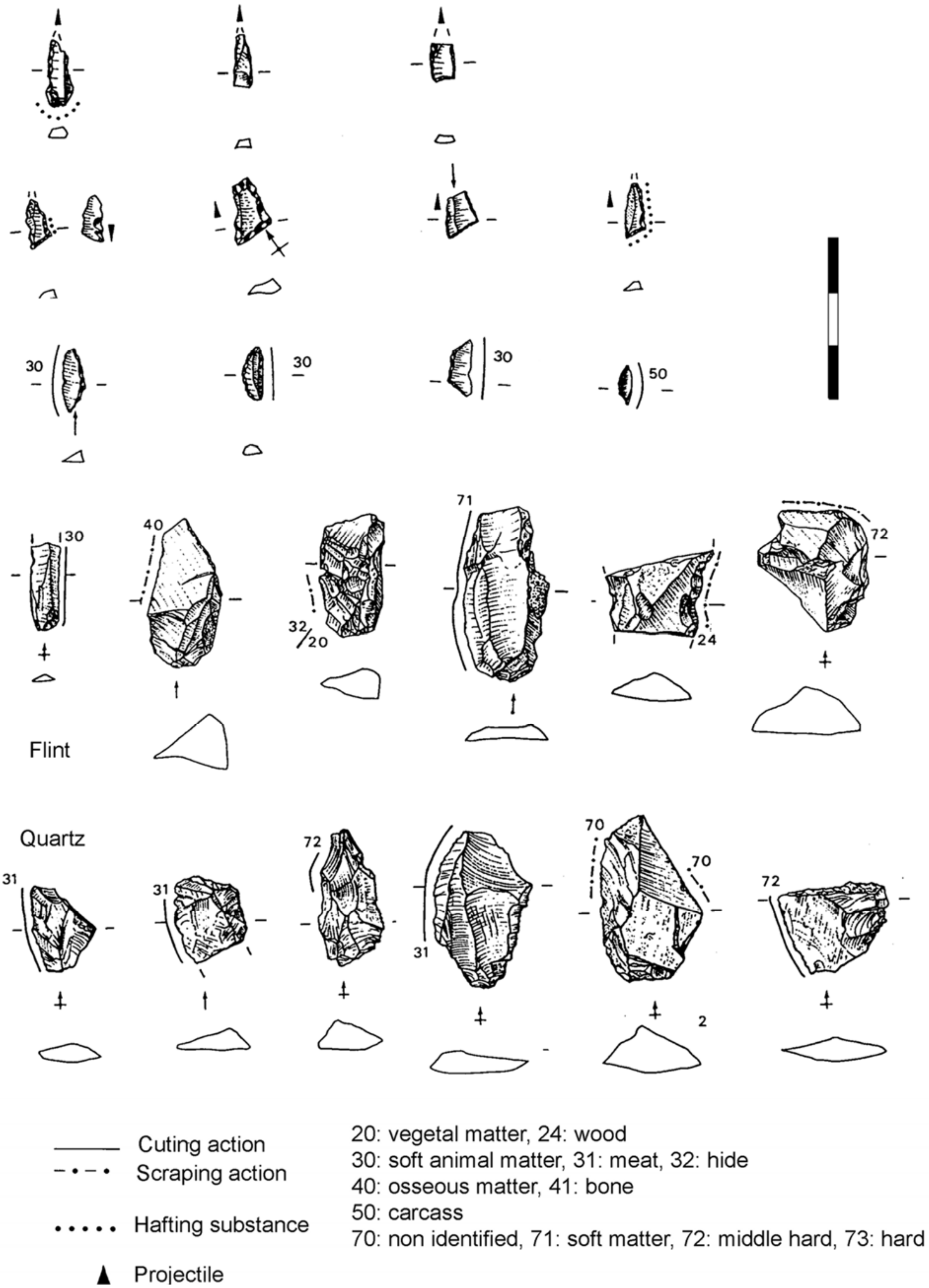


Fig. 2: Sauveterrian flint and hyaline quartz tools showing use-wear, from Vionnaz, rockshelter, Switzerland (Pignat and Plisson, 2000). Drawings: H. Lienhard.

A use-wear perspective on the Sauveterrian flint industry

The Sauveterrian emerged around 10,000 BP in south-eastern France and Northern Italy, and then progressively spread to other regions of Western Europe where it replaced the Azilian tradition. This industry is characterized by highly standardized geometrical microliths, produced using different knapping and retouch methods (Guilbert, 2003), and a gradual simplification of the methods of microlith blank production. The Sauveterrian toolkit also includes small irregular flakes and few retouched artefacts (Fig. 2), mostly scrapers.

Even though functional studies of Sauveterrian flint assemblages are fewer than those for the Upper Palaeolithic, use-wear data (approximately 5000 artefacts) are now available for a dozen sites (Lemorini 1990, 1994; Martinet 1991; Rodriguez Rodriguez 1993; Philibert, 1999, 2002; Pignat and Plisson 2000; Khedhaier 2003; Juan Gibaja in press). Despite variation in artefact surface preservation and sampling methods, these studies yielded similar results. In the Sauveterrian, patterns in the use and discard of flint tools can be characterized as follow:

- a very low proportion of artefacts were used;
- a limited range of activities is documented. These activities are mostly related to the procurement and processing of soft animal matters, such as meat and hide, and involved microliths, flakes, blades, and scrapers;
- woodworking is poorly represented in the use-wear sample, and is mostly associated with unretouched flakes;
- a relative scarcity of traces associated with bone working is noted.

In the following section, these patterns are compared with earlier, contemporaneous, and succeeding industries in Europe and the Near East.

The Sauveterrian in a wider perspective

On one hand, there are striking contrasts in the use and discard of Sauveterrian flint tools compared with the Upper Palaeolithic and Neolithic. In general, Upper Palaeolithic assemblages differ from Sauveterrian ones in showing more diverse toolkits and higher percentages of utilized and recycled implements. In addition, tools were probably involved in a wider range of activities. Neolithic toolkits contrast with those of the Sauveterrian in presenting evidence for new activities, processed material, and tool categories (some of which had a very long use-life).

On the other hand, several similarities are observed in flint tool management between the Sauveterrian and several industries from the end of the Palaeolithic and the Epi-Palaeolithic:

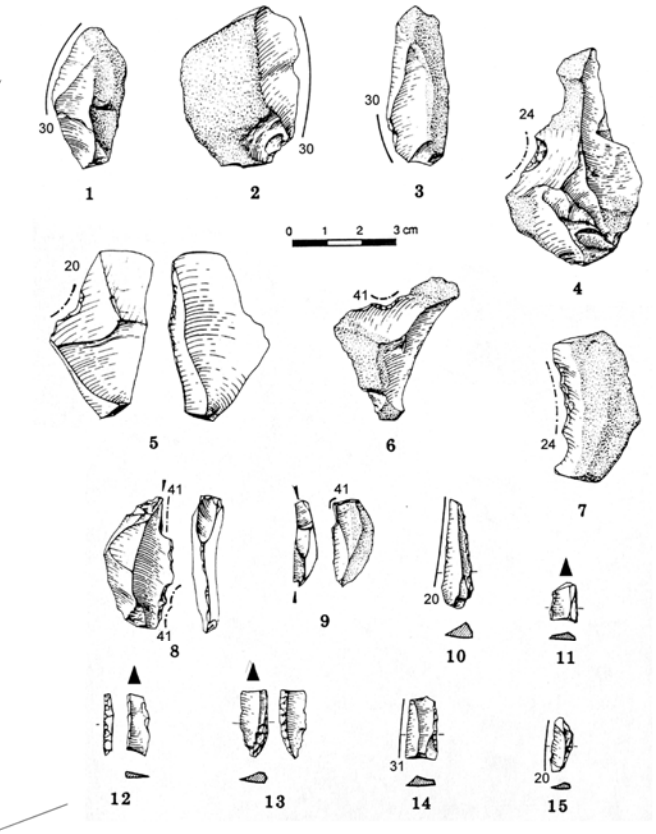
- Very similar patterns in tool use and discard are found between the Final Palaeolithic industries (Azilian and Federmesser) and the Sauveterrian. Indeed, all these industries present evidence of a narrow range of processed materials and low proportions of utilized artefacts (Célérier and Moss 1983; Moss 1983; Plisson 1985; Ibañez Estévez and González Urquijo 1996; Caspar and De Bie 1996; De Bie and Caspar 2000). These similarities are noted despite differences in methods of blade production (more elaborated in the Azilian and Federmesser), and projectile point size and morphology.
- The Sauveterrian also shows many typological and functional similarities with the Natufian, an industry associated with the emergence of sedentary societies in the Near East. With respect to assemblage composition and production techniques, these contemporaneous industries present the same basic structure: an expedient toolkit manufactured on irregular flakes and rough blades, some of which were retouched, and the presence of notches and denticulates (Fig. 3). In addition, assemblages from both periods contain very similar proportions of elaborated geometric microliths. However, contrary to what is observed in the Sauveterrian, burins appear to be more common than scrapers in the Natufian. A use-wear study of 500 flint implements from Hayonim Terrace (Israel) shows patterns of artefact use and discard similar to those described for the Sauveterrian (Valla *et al.* 1989; Valla *et al.* 1991): the edges are mostly unretouched and use-wear indicates light work and short use-life for the most abundant tools; in general, geometric microliths and retouched bladelets were hafted projectiles. Two distinctions can be made between the Natufian and the Sauveterrian, based on use-wear and typological data: the scarcity of hideworking flint tools in the Natufian; the use, at least in some Natufian assemblages, of burin sides and small notches for light boneworking and woodshaping, possibly for making points or shafts. Tiny bone points that could have been produced with these burins and notches were also found at Hayonim.

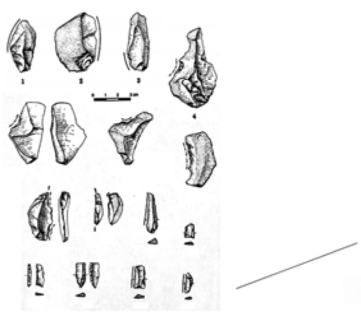
Overall, in spite of the few differences mentioned above, Natufian and Sauveterrian toolkits show a common core set of features in tool management. These similarities are particularly striking, as these industries were produced by groups with very different social organizations: semi-sedentary groups occupying permanent houses in the Levant and mobile hunters-gatherers living in forests and mountains in Europe. In this case, dramatic differences in adaptations are not reflected in the flint toolkits.

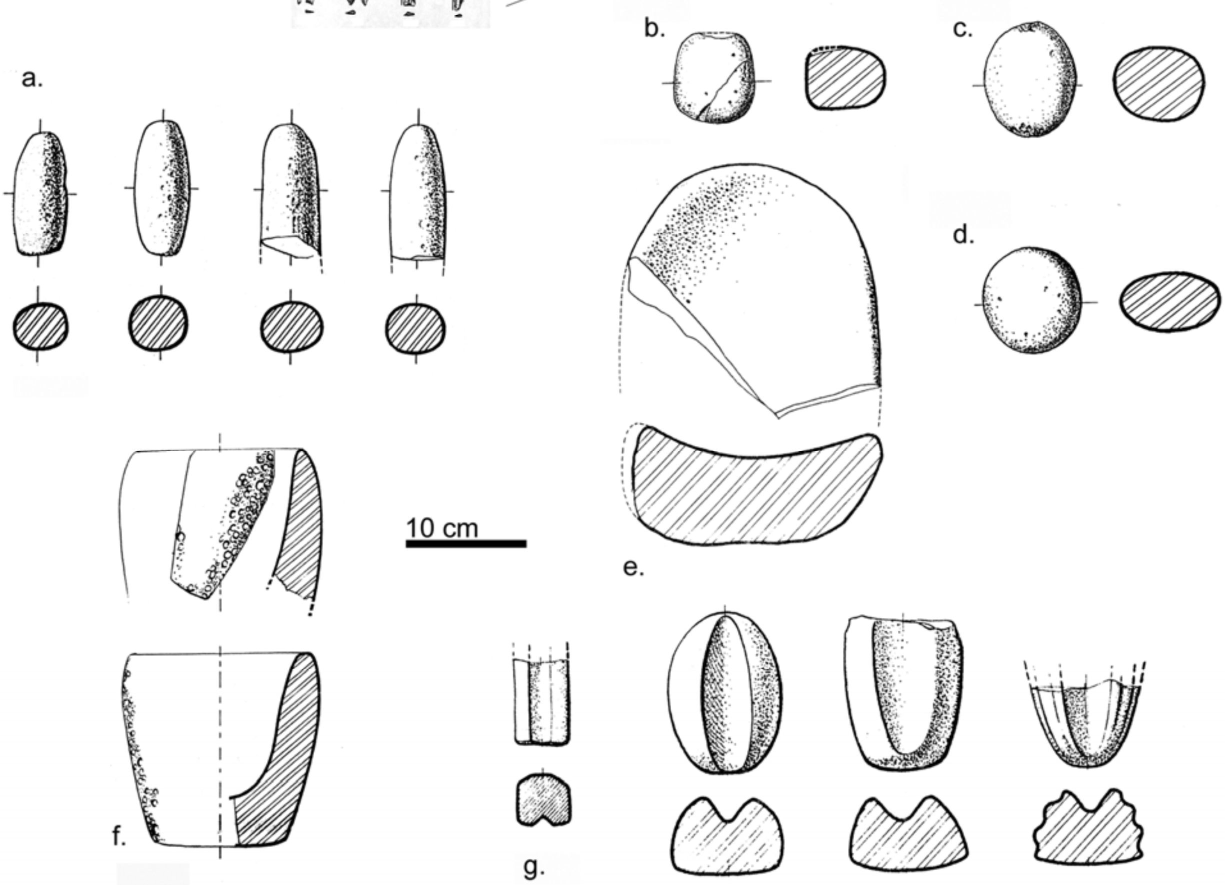
Broadening the focus: A look at the macro-tools

Two important cultural changes have been attributed to the end of the Natufian: the emergence of plant domestication (e.g., Moore *et al*. 2000; Belfer-Cohen and

Fig. 3: Natufian micro-tools and macro-tools from Hayonim Terrace (1–15) and Mallaha (a–g). Flint artifacts enlarged with respect to macro-tools. 1-3: cortical flakes used for cutting flesh; 4, 5 and 6: notches used in plant, wood, and bone scraping; 7: denticulate used to scrape wood; 8-9: burins used to scrape and groove bone; 10 & 15: microliths used to cut plants; 14: microlith used to cut meat; 11-13: microliths used as projectile barbs (from Valla, et al., 1991). a: pestles; b-d: handstones; e: grinding-slab; f: mortar; g: shaft straighteners (drawings from D. Ladiray).







Bar-Yosef 2000; Bar-Yosef and Belfer-Cohen 2002; Bird 2005), and a shift from a semi-sedentary to a more nomadic adaptation (e.g., Goring-Morris and Belfer-Cohen 1997; Belfer-Cohen and Bar-Yosef 2000; Bar-Yosef 2001; Valla *et al*. 2001; Bar-Yosef and Belfer-Cohen 2002; Munro 2004). With the exception of a reduction in microlith size (Valla and Plisson, 2005), these changes occurred in a context of relative stability of the flint tool assemblages (e.g., Valla *et al*. 2001).

While flint toolkits were apparently relatively stable during the Natufian, other classes of objects seem to document changes in the technical system. More particularly, a significant increase in the abundance of grinding implements is observed (Bar-Yosef 1980, 1981; Wright 1992, 1994). This increase is striking when compared with previous periods. A functional study of these tools showed that some specimens were used to process plants, more specifically, legumes and cereals (Dubreuil 2002, 2004). The use-wear study also suggested that changes in grinding implement morphology during the Natufian are probably related to intensification of plant processing. This conclusion appears in line with other changes observed in subsistence and settlement patterns during the end of the Natufian.

An additional finding of the use-wear analysis of Natufian macro-tools is that some of the artefacts commonly classified as grinding implements were actually used in activities unrelated to plant-food processing (Dubreuil 2002, 2004). For instance, hide-currying implements, rare in the flint assemblages of Hayonim Terrace, are documented in the macro-tool sample. Furthermore, some macro-tools may have been used for woodworking. Also, stone implements seem to have been involved in bone abrasion activities, as suggested by bone tool studies (Stordeur 1991), and residue analysis of shaft straighteners (Christensen and Valla 1999). Based on these data, it can be suggested that non-flint implements replaced flint tools, at least in certain activities, in Natufian assemblages. It is suspected that this shift also occurred in Mesolithic industries of Europe, as mentioned by Rozoy (1978).

In sum, along with the development of a flint industry based on small flakes and bladelets, and a trend toward microlith size reduction, flourished a macro-tool technology differing in raw materials and concepts (Fig. 3). Use-wear data indicate that at least some of the Epipalaeolthic macro-tools were associated with the exploitation of vegetal resources. In contrast, flint tools appear to be designed specifically for the procurement and processing of game. The transformation of plants by grinding and pounding constitutes a mean for maximizing caloric returns (O'Dea *et al.,* 1980; Stahl 1989; Wright 1992). Therefore, the emergence of macro-tool technology may have been particularly important in a context of increased sedentarity and faunal resource overexploitation (Stiner *et al*. 1999, 2000; Monroe 1999).

While the emergence of macro-tools during the Epi-Palaeolithic may stemmed from resource intensification, the trend toward microlithization seems to be linked to the optimization of resource procurement through mobile strategies. Flannery (1986) proposed that mobility, a strategy long used for coping with resource variation, was no longer possible in the context of the Late Pleistocene to Holocene transition in the Near East, due to increased demographic pressure. It is suggested that the role of the flint technology became less central in the subsistence system during that episode.

Social representations: The symbolic dimensions of microliths

The study of the Sauveterrian raises the issue of the evolution of the role and symbolic dimension of flint industries during the early Holocene. At the beginning of the Epi-Palaeolithic, microlithism can be explained as a strategy used to cope with variation in raw material availability in relation with new patterns of mobility resulting from smaller territories and more diverse resources. However, the study of the Natufian suggests that, just prior to the decline of microliths, flint technology was not a vector of major innovations. This may be related to the specialization of flint implements for game procurement and processing, in continuity with the Kebarian. The similarities noted between the Natufian and Sauveterrian toolkits leave us with the impression that the flint tool repertoire was strongly associated with high residential mobility, and possibly, an egalitarian ideology. The technological changes observed during the neolithization process are most conspicuous in non-flint implements. Macro-tools, which represent a significant proportion of non-portable implements, are, at least for some of them, partly related to the exploitation of vegetal resources. This macro-tool versus micro-tool dichotomy was possibly reinforced by a sexual division of production activities, as suggested by ethnography (Testart 1986) and the study of Natufian human remains (*e.g.* Peterson 2002; Bocquentin 2003). It has been proposed that the sexual division of labour played a significant role during the rise of plant domestication (Rohrlicht-Leavitt 1975; Forest 1993, in preparation). Despite the probably growing significance of macro-tools in subsistence activities, the efforts devoted to the production of microliths during the Natufian seems to indicate that these tools were in response symbolically overinvested (Valla and Plisson 2005).

Back to the Sauveterrian

The development of macro-tools in many microlithic industries is not surprising, given that these often lack—or show a very low proportion—of heavy-duty tools. Because microliths, bladelets, and most flakes have thin, small, and fragile edges, these implements were not designed for the transformation of large volumes of raw material. The Mesolithic dugout canoes of Noyen-sur-Seine and Nandy (Bonnin 2000), for instance, were certainly not manufactured with these tools! Therefore, it is almost tautological to argue that the Sauveterrian microliths were involved in a narrow range of activities. As a result, it is difficult to accept the proposition that the limited range of activities seen in the Sauveterrian reflects a concomitantly simple technical system (Philibert 2002). Moreover, models that attempt to establish a direct link between the complexity of a technical system and the complexity of the social network that produced this technical system are likely to run into many difficulties (Maigrot and Plisson in press).

To better understand the Sauveterrian, it is critical to broaden the scope of analysis by including macro-tools. In the Natufian, these implements are characterized by high archaeological visibility, possibly because sites of this period were occupied intensively. Although poorly documented, similar tools exist in more expedient forms in Palaeolithic (de Beaune 2000) and Mesolithic (Rozoy 1978) contexts. For instance, J.E. González Urquijo and J.J. Ibáñez (2002) showed that in the late Magdalenian and Azilian sites of the Spanish Basque country, pebbles were not only used as flintknapping hammers and mineral crushers, but also for hide rubbing and for pounding organic matters. Evidence of hide rubbing with ad-hoc implement has been found in south-western France as well (Lenôtre *et al*. 2003). Used pebbles were also reported for the Azilian levels of the La Tourasse cave in France (Orliac and Orliac 1972) (Fig.1). The Federmesser site of Rekem (Belgium) contains a number of imported macro-tools showing evidence of use, ranging from hammerstones and other heavy-duty tools, to spokeshaves and grinders (De Bie and Caspar 2000).

Macro-tools have been largely overlooked in the study of the Sauveterrian. This is possibly the result of the low visibility of these tools in sites produced by highly mobile groups. However, the scarcity of macro-tools in Sauveterrian assemblages may be also due to biases in recovery methods. Indeed, these implements were generally ignored by archaeologists in past excavations. Another important source of bias comes from our incomplete knowledge of Sauveterrian settlement patterns. For instance, certain types of sites, such as those found in specific biotopes or those peripheral to zones of high occupation density, are probably overrepresented in the archaeological record (Guilbert 2001) and particularly in the functional studies. In addition, the sexual division of labour may have mediated spatial distribution of tool types, as suggested by the specialization of flint implements for game procurement and processing activities. Comparing contemporaneous assemblages and sampling all types of habitats may allow us to overcome biases induced by the differential spatial distribution of tool types and to detect patterns in flint versus non-flint tools.

For Semenov, use-wear analysis was not limited to the study of a selected range of artefacts or raw materials. Rather, it was for him a method aimed at unravelling the structure of a coherent system. In this framework, use-wear analyses may yield very valuable information on early Holocene adaptations.

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5.3. Food Producers

Stone axes as cultural markers: technological, functional and symbolic changes in bifacial tools during the transition from hunter-gatherers to sedentary agriculturalists in the southern Levant

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Summary. *Dramatic socioeconomic changes marking the origin of agriculture are reflected in the stone tools made and used by early farmers. Tools designed for wood-working, harvesting, and craft production were among the "Neolithic Novelties," and technological innovations of these farmers, and their tools also seem to have had new social and symbolic value. Our ongoing ethnoarchaeological, experimental, and microwear studies suggest that changes in bifacial tool production and use reflect the restructuring of economies, architecture and social organization during the late Epi-Palaeolithic, Neolithic and Chalcolithic periods in the southern Levant, as foraging societies adopted food production and moved to the threshold of urbanism. During the early Epi-Palaeolithic societies lived in small seasonal camps and manufactured microliths, but no large bifacial tools. In contrast, Neolithic and Chalcolithic groups settled in larger, more permanent farming villages and produced new types of blades and bifaces (e.g, arrowheads, sickle blades, axes, adzes, and chisels). We know how the arrowheads and sickles were used, but the functions of bifaces were not clear. We learned that flaked and ground flint bifacial tools were used for felling trees, chopping wood, and for carpentry and woodworking. However, the ground stone celts did not seem to have been utilized. Bifacial axes and adzes changed from early Neolithic tranchet forms to flaked and polished late Neolithic and Chalcolithic types, but all the larger bifacial tools were used for chopping and splitting wood while the smaller chisels seem to have been used for lighter wood-working or carpentry. A few bifaces were used for boring holes in wood, hides, and bone and for scraping hides and whittling bone. None of the bifacial tools on our sample were used as cultivating or mining tools (e.g., hoes or picks). New types of bifacial tools helped Levantine societies master the new crafts, economies, and symbolic systems that emerged during the transition to farming.*

Résumé. *D'importants changements socio-économiques marquant l'origine de l'agriculture sont reflétés par les outils lithiques fabriqués et utilisés par les premiers fermiers. Parmi les « nouveautés néolithiques »se trouvent des outils conçus pour le travail du bois, la moisson et la production artisanale; les innovations technologiques de ces agriculteurs et leurs outils semblent également avoir eu de nouvelles valeurs sociales et symboliques. Les études ethno- archéologiques, expérimentales et de tracéologique en cours suggèrent que les changements dans la production et l'utilisation des outils bifaciaux reflètent la restructuration des économies, de l'architecture et de l'organisation sociale pendant les périodes de l'épipaléolithique tardif, du néolithique et du chalcolithique dans le Sud-Levant, au moment où les sociétés fourragères ont adopté la production de la nourriture et atteint le seuil de l'urbanisme. Pendant les débuts de l'épipaléolithique, les sociétés habitaient des camps saisonniers et manufacturaient des microlithes, mais pas de grands outils bifaciaux. Au contraire, les groupes du néolithiques et du chalcolithiques se sont installés dans des villages à la fois plus grands et plus permanents et ont produit de nouveaux types de lames et de bifaces (par exemple des pointes de flèche, des lames de faucilles, des haches, des herminettes et burins). Nous savons aujourd'hui comment les pointes de flèche et les faucilles étaient utilisées, mais les fonctions des bifaces ne sont pas claires. Nous avons appris que les outils bifaciaux en silex débité en lames ou polis étaient utilisés pour abattre des arbres, couper du bois et en matière de charpenterie et de travail du bois. Toutefois, les outils en pierre polis ne semblent pas avoir été utilisés. Haches bifaciales et herminettes se sont transformées, passant des tranchets du début du néolithique aux types laminés et polis du néolithiques tardif et du chalcolithiques, mais tous les outils bifaciaux de grande taille étaient utilisés pour couper et fendre du bois, alors que les burins, plus petits, semblent avoir été utilisés pour de travaux en bois plus légers ou pour la charpenterie. Quelques bifaces ont été utilisés pour perforer bois, peau et os et pour racler les peaux et redimensionner les os. Aucun des outils bifaciaux de notre échantillon ne fut utilisé comme outils du culture ou minier (à l'instar des houes ou des pioches). Des nouveaux types d'outils bifaciaux ont aidé les sociétés levantines à maîtriser les nouvelles techniques artisanales, les nouveautés économiques ainsi que celles des systèmes symboliques qui ont émergé pendant la période de transition vers l'agriculture.*

Key words: stone axes, origins of farming, southern Levant.

Sergei Semenov may be best know for his experimental and traceological studies of Palaeolithic tools, but he and his students also investigated the technological and economic innovations that occurred during the transition to food production (Semenov 1965, 1974; Korobkova 1993; Skakun 1992, 1993, 1994; also see references in Anderson *et al.* 2005). Other microwear analysts have also studied the "Neolithic Novelties" and technological changes that occurred when this new agricultural way of life emerged (Coqueugniot 1983; Keeley 1983a; Anderson 1992, 1994; van Gijn 1994; González *et al.* 1994; Juel Jensen 1994; Ibáñez *et al.* 1998), but the emphasis has been on studies of harvesting implements or tools used in craft production. The bifacial tools of the Neolithic and Chalcolithic periods have not received as much attention.

The changes that are associated with the origin of farming at the end of the Pleistocene were reflected in the new types of tools that were needed for agricultural tasks, but the social and symbolic value of these tools also may have changed. Bifacial axes, adzes and chisels were vital components of these new toolkits. During the Late Epi-Palaeolithic and Neolithic in the Levant, mobility was reduced. Short-term camps were replaced by larger, more permanent settlements with new types of houses and equipment. During the Neolithic and Chalcolithic, forests were cleared for croplands and grazing areas. New agricultural lifeways emerged, based on intensive exploitation of the landscape and contravention of the balance between humans and their environment. Standardized bifacial tools were produced and used for agricultural and craft activities. Some of these bifacial tools continued to be used throughout the Chalcolithic period, when the use of metals began, social complexity increased, and the first steps towards urbanization were taken (Barkai 2005).

We suggest that changes in the production and use of lithic artefacts, and particularly bifacial tools, reflect the restructuring of economies, architecture and social organization as foraging societies adopted food production and moved to the threshold of urbanism. The ways stone tools reflect these changes is demonstrated in our ongoing study of Epi-Palaeolithic, Neolithic and Chalcolithic artefacts from several sites in the southern Levant (Barkai 1999, 2001, 2002, 2003, 2004, 2005, 2006; Yerkes *et al.* 2003; Yerkes and Barkai 2004, 2005). We are examining the archaeological contexts where bifacial tools were found, and using replicative experiments and microwear analyses to study the techno-typological characteristics of the tools.

Levantine Epi-Palaeolithic, Neolithic and Chalcolithic Societies

The dramatic socioeconomic changes associated with the origin of farming were especially pronounced in the Southern Levant. During the early Epi-Palaeolithic period (19,000-12,500 BP), nomadic Kebaran and Geometric Kebaran groups lived in small seasonal sites (50-500 m^2 in size). These groups developed a microlithic flint industry, but they did not manufacture large bifacial tools. Late Epi-Palaeolithic Natufian (12,500-10,200 BP) hunter-gatherers gradually became more sedentary and produced some bifacial tools, perhaps "reinventing" some Paleolithic types to meet their new subsistence needs (Barkai 2005, p.267). However, most Natufian tools were microlithic, and the bifacial tools have no obvious prototypes. The Natufians produced crude, coarse heavy duty bifacial tools like the picks and pick/chisels from Einan ('Ain Mallaha) and Hayonim Cave (Belfer Cohen 1991; Barkai 2005, pp.86-94), but we do not know how these tools were used.

During the Neolithic (10,200- 6,300 BP) and Chalcolithic (6,100-5,150 BP) periods in the southern Levant, much larger settlements (up to 100,000 or even 150,000 m^2) were established with more substantial domestic structures, a productive agricultural economy, and a sophisticated flint industry associated with blade and bifacial tool production. The most distinctive Neolithic and Chalcolithic stone tool types are arrowheads that were used mainly for hunting, sickle blades that were used for harvesting, and bifacial axes, adzes, and chisels. Previous studies have showed us how the arrowheads and sickles were used, but the functions of bifacial tools are not as well understood.

Types of bifacial tools

Three main types of bifacial tools were examined in our study (Barkai 2002): (1) *axes*, which are bifaces with lenticular (biconvex) cross section and working edges shaped either by bifacial flaking, transverse (tranchet) blows or grinding and polishing. The working edges are >2 cm wide; (2) *adzes*, bifacial tools with plano-convex cross section. The ventral face is flat and the dorsal face is curved, trapezoidal or triangular. Working edges are usually shaped by bifacial flaking, polish or transverse blows. The working edges are also wider than 2 cm; and (3) *chisels*, bifacial tools with varied cross sections (lenticular, planoconvex, triangular etc.), and working edges that were shaped either by bifacial flaking, transverse blows or grinding and polishing. The working edges are <2 cm wide.

We have examined 2,448 bifacial tools from 24 sites covering the Natufian, Pre-Pottery Neolithic (PPN), Pottery Neolithic (PN) and Chalcolithic periods. Samples of bifacial tools and resharpening spalls from four of these sites were examined for microwear traces. Our research is still in progress, and we have not examined the wear traces on any Natufian or Middle/Late PPNB bifaces. However, our preliminary results indicate that most Neolithic and Chalcolithic bifacial tools were used for felling trees, chopping wood, and for carpentry and woodworking associated with house construction and wooden tool production (Barkai 2005; Yerkes *et al.* 2003; Yerkes and Barkai 2004, 2005). World-wide ethnographic, archaeological and replicative studies have shown that bifacial stone tools with ground and polished working edges were almost always used as woodworking tools (Mitchell 1959; Dickson 1981; Olausson 1982, 1983; Hansen and Madsen 1983; Keeley 1983b; Hayden 1989; Toth *et al.* 1991; Woodman 1992). The flaked and ground flint bifaces in our Neolithic and Chalcolithic samples certainly fit this pattern.

The form of bifacial axes and adzes changed from early Neolithic tranchet forms to flaked and polished types during the late Neolithic and Chalcolithic periods, but these larger bifacial tools were usually used for chopping and splitting wood, while the smaller chisels were used for lighter woodworking or carpentry. Some of the adzes in our samples had beveled edges, a common feature of woodworking adzes from Early Archaic Dalton sites (10,500 BP) in North America (Yerkes and Gaertner 1997). Beveling is also present on unifacial and bifacial woodworking tools from North America known as "gouges" (Hester *et al.* 1973). These implements may have been used to hollow out wooden objects. Not all of the bifaces in our samples were used for woodworking. A few were used for boring holes in wood, hides, and bone and for scraping hides and whittling bone (Yerkes *et al.* 2003; Yerkes and Barkai 2004, 2005).

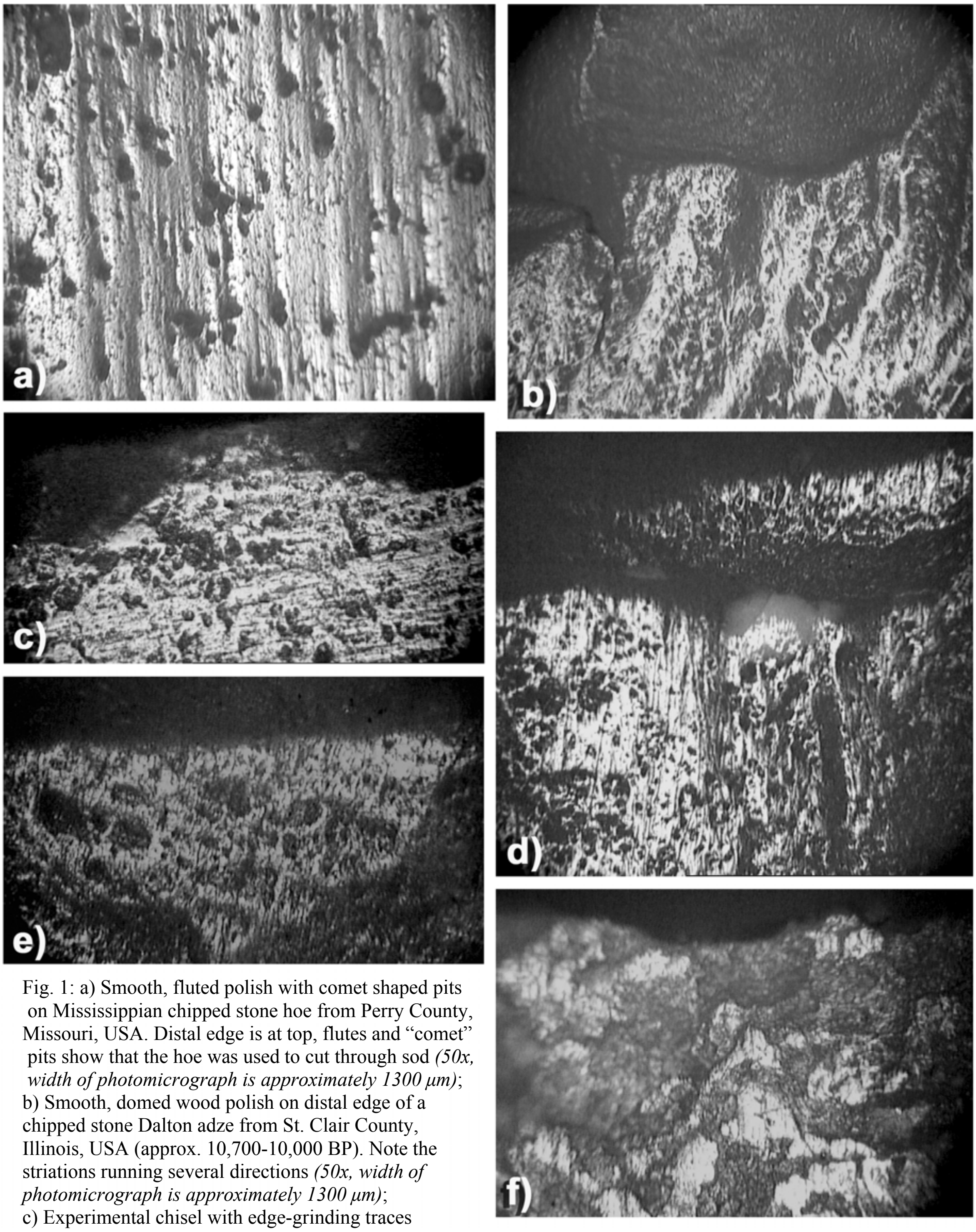

Fig. 1: a) Smooth, fluted polish with comet shaped pits on Mississippian chipped stone hoe from Perry County, Missouri, USA. Distal edge is at top, flutes and "comet" pits show that the hoe was used to cut through sod *(50x, width of photomicrograph is approximately 1300 µm)*; b) Smooth, domed wood polish on distal edge of a chipped stone Dalton adze from St. Clair County, Illinois, USA (approx. 10,700-10,000 BP). Note the striations running several directions *(50x, width of photomicrograph is approximately 1300 µm)*; c) Experimental chisel with edge-grinding traces running lengthwise (←) and smooth, domed wood polish and striations normal (↑) to the edge (*100x, width of figure is approx. 650 µm*); d) Bright domed polish on axe spall from the PPNA Netiv Hagdud site (Item#67, loc. 18, No. 13). Axe seems to have been used to chop or plane wood. Polish is similar to wear traces on adze in Figure 7. *(50x, photomicrograph is approximately 1300 µm)*; e) Smooth, domed wood polish with many small striations on dorsal face of Tranchet Axe from the Netiv Hagdud site (Item#6; loc. 8b, No. 119) approximately 8 mm in from the distal edge. Compare with Figures 1b and c. *(50x, length of photomicrograph is approximately 1300 µm)*; f) Edge damage, grinding traces, striations and wood polish on edge of an adze fragment from the Chalcolithic Giv´at Ha-Oranim site (*100x, width of figure is approx. 650 µm*).

Distinguishing woodworking tools from agricultural tools

None of the bifacial tools on our sample were used as hoes or harvesting tools. At some Near Eastern Neolithic sites, large bifacial tools have been classified as hoes (Cauvin 1968, pp.267-268), but microwear analysis showed that these hoes were actually woodworking adzes (Anderson 1999; Coqueugniot 1983). The edges of many of the tranchet axes and axe spalls, and some of the other bifacial axes, adzes and chisels in our samples were covered with a *macrosheen* or gloss that resembles the *sickle gloss* or *corn gloss* that is found on the edges of reaping tools. However, other activities besides harvesting cereals can produce similar-looking macrosheen or gloss. These activities include (1) cutting and splitting canes, reeds, and the stems of other plants, (2) digging through sod with a chipped stone hoe, or cutting the sod with an ardshare, (3) using chipped stone blades or flakes as the "teeth" on threshing sledges, (4) scraping clay with stone tools during the process of manufacturing ceramics, and (5) woodworking (van Gijn 1990, pp.36-41, 46-50; Anderson 1991, p.525; Skakun 1992, 1993, 1994; Juel Jensen 1994; Yerkes and Kardulias 1994; Rosen 1997, pp.55-57; Yerkes and Gaertner 1997, pp.59-66).

A macrosheen on chipped stone tools can also be produced when they are ground and polished. Experimental and ethnographic studies suggest that woodworking tools are usually given this treatment. In fact, edge grinding and polishing is one of the attributes that distinguishes Neolithic axes, adzes, and chisels from their Mesolithic and Palaeolithic counterparts. Some have suggested that stone axes, adzes, and chisels were ground to strengthen their edges and to reduce friction during use (Dickson 1981, p.8; Hansen and Madsen 1983; Hayden 1989; Mitchell 1959; Olausson 1982, 1983, p.30; Toth *et al.* 1992). Almost all of the Pottery Neolithic (PN) and Chalcolithic axes, adzes, and chisels in our sample had ground edges.

The "stone-on-stone" polishing traces could be distinguished from wear traces on the bifacial tools in our sample, but sometimes it was a challenge to identify the wear traces on the polished surfaces (Keeley 1980, pp.275-27; van Gijn 1990, pp.47-48; Yerkes *et al.* 2003)

Comparisons of the microwear on experimental tools and prehistoric artifacts with well-developed wood working traces (adzes, axes) and cultivation traces (hoes) suggest that the following characteristics can be used to distinguish bifacial woodworking tools from hoes and sickles: (1) flaked stone bifaces that were used as hoes develop a smooth, bright polish with comet-shaped pits and flutes oriented normal to the cutting edge. Striations on the edges of hoes may become "filled in" as the plant polish builds up (Figure 1a). (2) Similar plant traces form on sickles, but without the fluting. The striations and comet-shaped pits on sickles are not normal to the cutting edge, but are nearly parallel or at a low angle. This shows that sickles were used to cut, but not to chop. (3) Woodworking tools develop wear traces that lack the comet-shaped pits and flutes. Striations are more common and prominent on axes and adzes (Fig. 1b,c,d,e). They are often oriented perpedicular, or at a high angle to the cutting edge. The wood polish can extend back well beyond the edge of the tool, and can be domed and flat.

The only Near Eastern flaked bifacial tools with documented agricultural use-wear traces are the distinctive pear-shaped chipped stone hoes that have been found at Mesopotamian and Moroccan Neolithic sites (Bensimon and Martineau 1990; Cauvin 1979; Coqueugniot 1996). This type of chipped stone hoe is rare or absent at Neolithic sites in the southern Levant.

Changes in bifacial tool use over time

Axes were predominant in the PrePottery Neolithic (PPN) cultures, constituting over half of the bifacial tools. However, during the PPNA period (10,200-9,500 BP) the cutting edges of the bifacial axes were produced with transverse or *tranchet* blows (see Fig. 2a). The edges of PPNA chisels were also often produced with a tranchet blow. PPNA tranchet flint axes are relatively small and light, with an average weight of 37 grams (Barkai 2005). Many of the PPNA axes and chisels from the Netiv Hagdud site were lightly used, with minimal edge damage (Fig. 1d,e), suggesting that they were used for carpentry and woodworking rather than tree-felling (Yerkes *et al.* 2003). No flaked flint axes or chisels were polished, but almost all of the PPNA ground stone axes or celts (Fig. 2b) in the Sultanian assemblage at the Netiv Hagdud site were polished (Bar-Yosef *et al.* 1991; Nadel 1997; Barkai 2000, 2005; Yerkes *et al.* 2003). The PPNA ground stone axes are relatively large and heavy (the average weight of Netiv Hagdud stone axes is 191 grams, Barkai 2005). None of these ground stone celts seem to have been used, and their function may have been more symbolic than secular. New Neolithic tasks included refined woodworking – carpentry rather than tree-felling and trimming, and prompted the use of the tranchet technique to produce sharp, regular edges of the woodworking tools. This was a clear turning point in the production of bifacial tools, but only the beginning of a trend. The new symbolic value of axes and chisels is also reflected in the respect and care that went into their production and ownership (Barkai 2005).

During the PPNB period (9,500-7,600 BP), large and heavy (120 grams on average) flint axes were still common, but the working edges of most of the PPNB axes were ground and polished to produce a straight, sharp edge and the tranchet technique was almost completely abandoned (Fig. 2c). The tranchet method was not used to produce chisels either, but in many cases the edges of these smaller bifical tools were not polished. Adzes became more common during the PPNB period (Fig. 3), and the polished PPNB axes are considerably

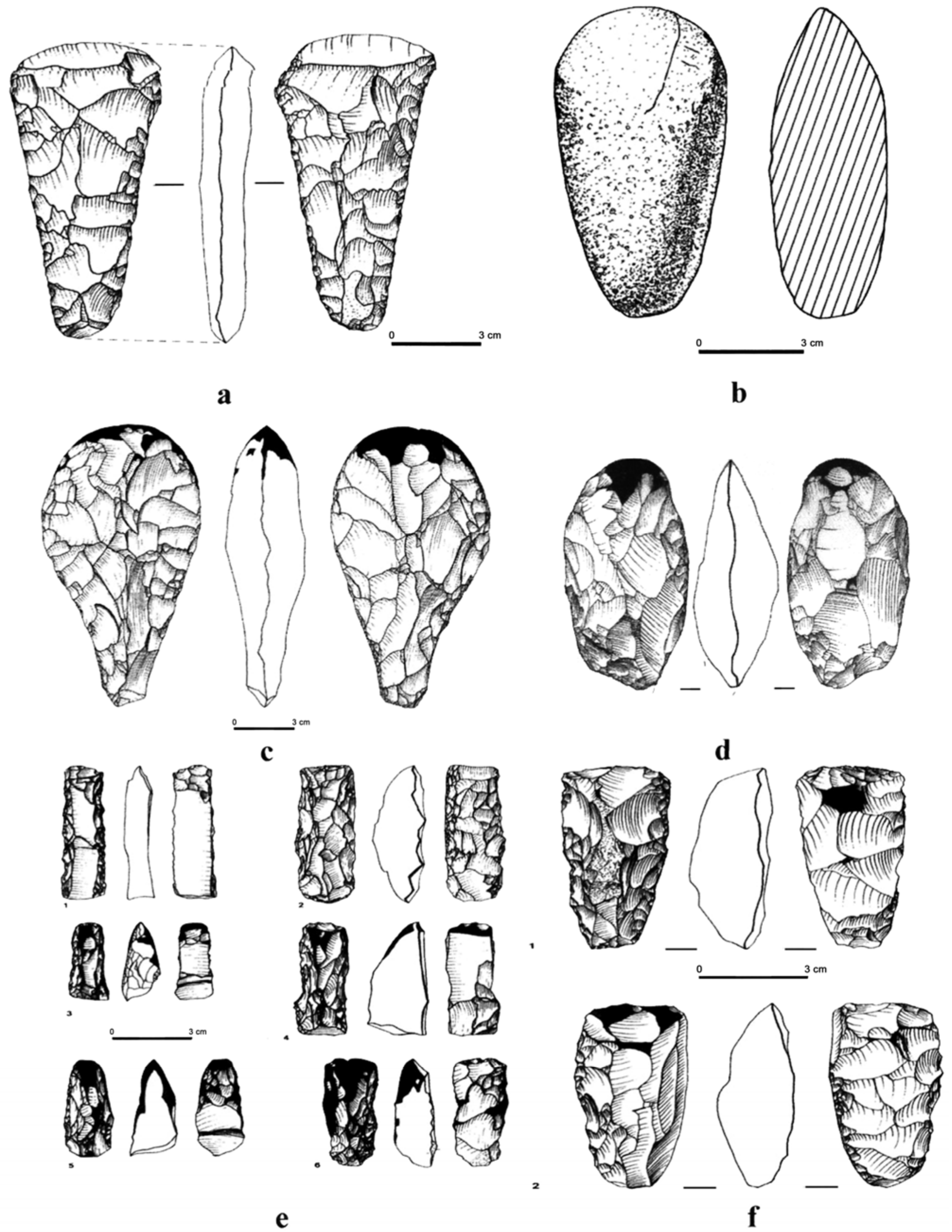

Fig. 2: a) Tahunian Tranchet axe from the PPNA Netiv Hagdud site; b) Ground stone celt from Netiv Hagdud; c) Flaked and Ground Flint Axe from the PPNB Beisamoun site. Blackened areas show extent of polishing; d) Flaked and ground flint axe from the early PN Yarmukian Nahal Zehora II site. Blackened areas show extent of polishing; e) Small flaked and ground flint chisels and adzes from the late PN Wadi Raba Nahal Zehora I site. Blackened areas show extent of polishing; f) Flaked and ground flint adzes from the Chalcolithic Giv´at Ha-Oranim site. Blackened areas show extent of polishing.

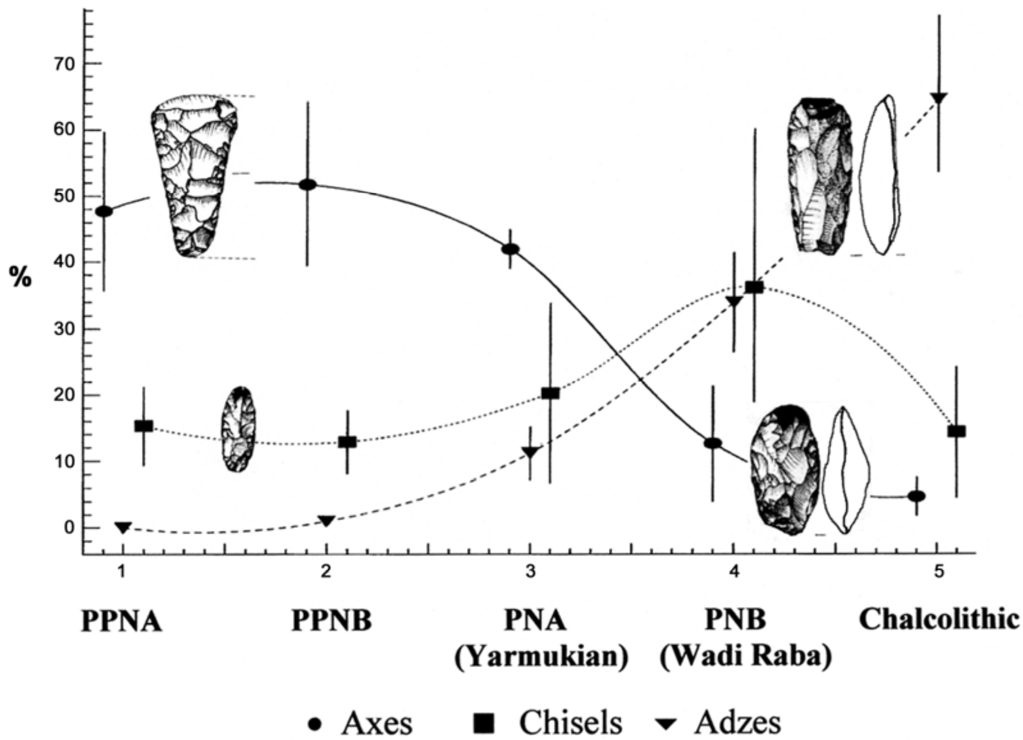

Fig. 3: Frequencies of flaked axes, adzes and chisels at Neolithic and Chalcolithic sites (average frequency in bifacial tool assemblages).

larger than the tranchet axes of the PPNA. The symbollic power of the axe seems to have been amplified during the PPNB and the tools make become a metaphor of human domination of the environment.

During the Pottery Neolithic (PN), axes were less common (Fig. 3), but it was not until the end of the PN period that their numbers were drastically reduced. As the axes declined in numbers, adzes increased. However, this transformation was not a smooth one. The increased use of the more versatile adze marks a further level of efficiency in agricultural activities and woodworking. During both the PPN and the early part of the PN, chisels were present, but their numbers varied. During the early PN Yarmukian period (7,600-7,100 BP), 40% of the bifacial tools were axes, 20% were chisels, and 10% were adzes (Barkai 2005, pp.360-361). The tranchet method was no longer used to produce the bifacial tools, but some of the chisels may have been re-sharpened with a transverse blow. Polishing was the primary method of shaping the working edges of the Yarmukian bifaces (Fig. 2d).

Nineteen bifacial tools from the Yarmukian occupation at the Nahal Zehora II site were examined for microwear traces (Yerkes and Barkai 2005), including 11 axes, two adzes, five chisels, and a "chopper" (really a uniface, see Gopher and Gophna 1993; Yerkes and Barkai 2005). The working edges of eight tools in the sample were ground and polished, 10 had microwear traces, and eight of them were woodworking implements (five were used for wood chopping or robust woodworking, two were used as chisels or planes, and one was used for chopping and planing or chiselling). One biface had unidentifiable wear traces. The chopper/ uniface seems to have been used to scrape hide (Yerkes and Barkai 2005). The variety of bifacial forms suggests that the Yarmukians at Nahal Zahora II were involved in fairly sophisticated carpentry or wood carving as well as tree felling, and log splitting.

In the late PN Wadi Raba culture (6,800-6,100 BP), bifacial tool assemblages are dominated by adzes (>33%) and chisels (33%), while only 10% of the bifaces are axes (Fig. 2e). Blade blanks were prefered for the production of these smaller bifaces which seem to have been used for lighter carpentry tasks rather than tree felling (Barkai 2005: 361; Yerkes and Barkai 2005). Among the Wadi Raba bifaces, only a few chisels had edges formed by transverse blows rather than grinding and polishing. A sample of 14 tools from the Wadi Raba Nahal Zehora I site (12 chisels and two adzes fragments) and 12 tools from the Wadi Raba component at the Nahal Zehora II site (three axes, eight adzes, and one chisel) were examined for microwear traces (Gopher and Orrelle 1989; Yerkes and Barkai 2005). In the sample from Nahal Zehora I, the edges of 13 tools were ground and polished, all 13 had microwear traces, and 12 of them were used for light woodworking or carpentry (the wear traces on the edge of one chisel could not be identified, see Yerkes and Barkai 2005). Eight of the Wadi Raba bifaces from Nahal Zehora II were polished, nine were utilized, and eight were used on wood (four were used for wood chopping, three were used as planes, and one was used for chopping and planing). The wear traces on the chisel could not be identified (Yerkes and Barkai 2005).

During the Chalcolithic period (6,100-5,150 BP), the number of chisels declines and adzes become the most common type of bifacial tool (Fig. 2f), accounting for 67% of the bifaces in the samples. There is variation in the production methods. Most of the Chalocolithic bifaces in this region were shaped by flaking, grinding, and polishing, but over three quarters of the adzes from the southern Levantine Beer Sheva sites were shaped by tranchet blows (Barkai 2005, p.362). In the Chalcolithic, the domination of the efficient, versatile adze, can no longer be doubted. It seems to take on all of the functional and symbolic values of the axe. The adze served as booth an instrument and a symbol of the new agricultural way of life that emphasized the efficient exploitation of the natural environment (Barkai 2005). A sample of 14 bifacial tools from the Chalcolithic Giv´at Ha-Oranim site were examined for usewear traces (one axe fragment, 10 adzes, and three chisels). Twelve tools were ground and polished (two were broken), all 12 had woodworking microwear traces, but one was broken, recycled, and used as a hide scraper. Seven were used for wood chopping or rough wood working, three were used as chisels or planes, and two were used for chopping and planing (Yerkes and Barkai 2004).

At the beginning of the Bronze Age, adzes disappear quite rapidly (unlike the gradual decline in the frequency of axes over time). The new metal tools that replaced them seemed to have been more efficient and easier to repair and recycle than the flint tools.

The changing frequencies of bifacial tools – from axes shaped by transversal blows to polished axes; to polished adzes; to metal tools – reflect a constant improvement and intensification in both the lithic production systems and in the exploitation of resources for food, shelter, and crafts. While technology changes during the Neolithic and Chalcolithic periods, axes, adzes, and chisels persisted as wood working tools, and as symbols of status, human dominance over nature, and improved production and efficiency.

Conclusions

Bifacial tools were used during the Neolithic and Chalcolithic periods to manipulate nature and make efficient use of natural resources. In these sedentary agricultural societies, many of the new craft items and architectural improvements could not have been produced without bifacial tools. The characteristics of the bifacial tools also reflect new worldviews and perceptions. Bifacial tools were part of the Neolithization process – the transition to agriculture, sedentary settlements, and social complexity. These tools were needed to perform new tasks that were not required of hunter-gatherers. Bifacial axes, adzes, and chisels were efficient tools and became symbols of this new age. Along with their functional role, bifacial tools also were used to express new emerging agricultural perceptions and beliefs. Changes in the form and function of the bifacial tools show us how Levantine societies were able to master the new crafts, economies, and symbolic systems that emerged during the transition to food production and the rise of complex societies.

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Mortar versus grinding-slabs function in the context of the neolithization process in the Near East

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Summary. *The development of grinding technology has been studied extensively in the perspective of plant exploitation. In the Levant, the substitution of mortars and pestles for grinding-slabs and handstones at the end of the Epi-Palaeolithic has been associated by some to a shift in the type of material processed and to a modification of the processing techniques. Others scholars have argued for changes in the social organization of work affecting the production and use of the grinding tools.*
In order to evaluate these hypotheses, ethnographic data are investigated. The variability uncovered regarding the utilization of mortars/pestles and grinding-slabs/handstones shows that the relationship between morphology and function is mediated by socio-economic organization, and therefore, is likely to differ between groups.
A use-wear study of Natufian grinding-stones provides additional data to explore the supposed dichotomy between mortars/pestles and grinding-slabs/handstones in the context of the neolithization process in the Near East. This analysis suggests that the increase of grinding-slabs and handstones at the end of the Epi-Palaeolithic reflects a greater emphasis on certain resources rather than a dramatic change in subsistence practices. Moreover, typological and technological observations indicate that the development of grinding-slabs and handstones is probably related to significant changes in tool production and the organization of the grinding tasks.

Résumé. *Au Proche-Orient, le développement des premières communautés agricoles semble s'accompagner d'une augmentation progressive des meules et molettes au détriment des mortiers et pilons au sein des assemblages d'outils de broyage. Ces modifications ont été interprétées par certains comme l'indice de changements dans les types de plantes exploitées, chaque couple d'outils étant relié au travail d'une gamme spécifique de végétaux. D'autres privilégient l'hypothèse d'un changement dans les techniques de transformation des matières ou encore dans l'organisation des activités de broyage.*
Une revue des données ethnographiques permet tout d'abord de constater que la gamme de matières travaillée par ces deux couple d'outils se chevauche. Ces résultats indiquent que les relations entre forme et fonction sont en partie déterminées par un ensemble de facteurs parmi lesquels on compte l'organisation socio-culturelle des groupes, et sont donc susceptibles de varier selon les populations étudiées.
Par ailleurs, l'analyse tracéologique d'outils de broyage suggère que l'augmentation des meules et molettes à la fin du Natoufien pourrait être le fait d'une intensification de l'exploitation de certaines ressources végétales. Combinées aux résultats de l'étude technologique et morphologique, ces conclusions nous amènent à favoriser l'hypothèse selon laquelle le développement des meules et molettes a probablement été associé à des modifications dans l'organisation des activités de broyage.

Key words: grinding stones, Natufian, socio-economic organisation.

Introduction

Grinding technology has been extensively used in models concerned with the evolution of plant exploitation by prehistoric groups. In the archaeological literature, plant processing is generally regarded as the primary function of grinding tools, an assumption based on ethnographic accounts. Yet, grinding tools are associated with a great diversity of functions. For instance, in the Guatemala Highlands, Hayden (1987) reported that grinding stones were used to process acorn, wheat, calcite, coffee, cacao, sugar, salt, pepper, spices, herbs, and also to make soap and wash clothes. Given this diversity, a functional analysis of archaeological objects seems critical to evaluating hypotheses about grinding tool use.

This paper explores variation in ground stone tool function and assemblage composition in the context of the transition from foraging to farming in the Near East. More specifically, the present study discusses the implications of these variations with respect to subsistence strategies. The first part of the paper gives a brief description of the main types of grinding tools used by prehistoric groups and their respective kinetics. Developments of grinding technology in the Levant are then examined with a particular focus on hypotheses put forward to explain assemblage composition variability. The relationship between grinding tool morphology and function, a key issue in these debates, is investigated, drawing on the ethnographic and archaeological literature. The results of a use-wear analysis of Natufian ground stone artefacts provide additional data to assess the signification of diachronic variation in assemblage composition. It is argued that hypotheses that assume a causal relationship between change in assemblage composition and change in processed material may overlook factors mediating spatial and temporal trends of grinding tool technology and use.

A brief description of two main categories of grinding stone implements

In the archaeological literature, "ground stones", "ground-stone tools" or "pecked and ground tools" refer to a broad category of tools transformed or used by pecking, abrading, and/or grinding (e.g. Wright 1992a, 1992b). "Grinding technology" as well as "grinding and pounding tools" relate in this paper to a specific category of ground stone tools, which encompasses objects used to reduce material into finer particles. This transformation

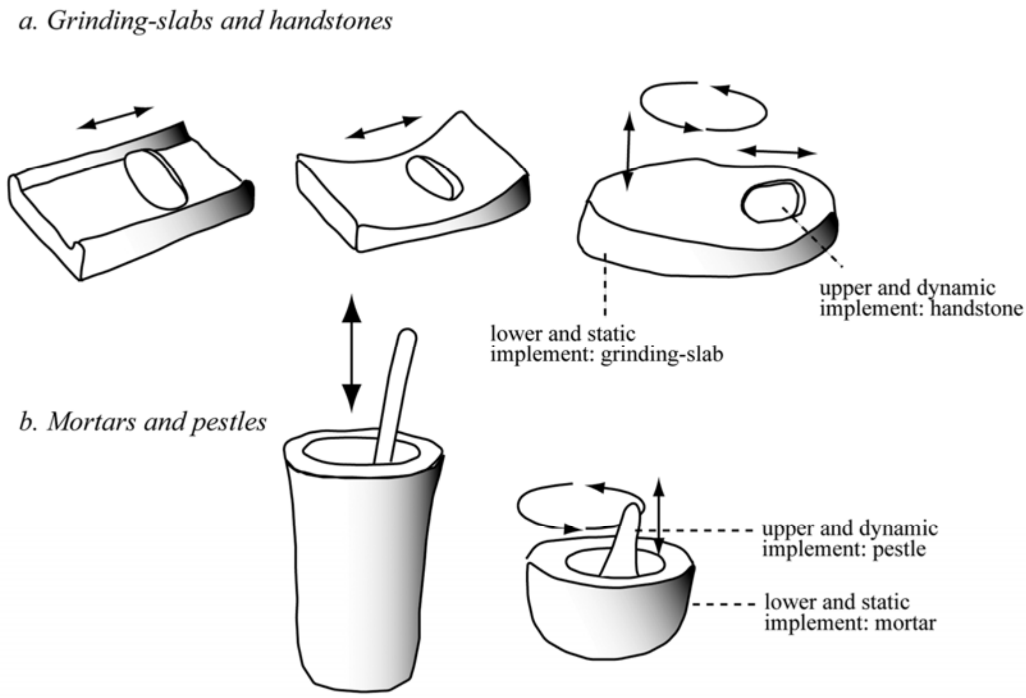

Fig. 1: Examples of mortars/pestles and grinding-slabs/handstones, with indication of their manner of use (modified from de Beaune 1989, p.43).

of the matter is achieved by the utilization of a lower-static implement in association with an upper-dynamic one.

Grinding technology includes two general categories of tools, which can be distinguished based on morphology and kinetics (Fig. 1). The first category, the grinding-slab/handstone, has a "flat" morphology compared to the second category, the mortar/pestle. In the flat implement category, the handstone is manipulated in a horizontal plan and the force is applied mainly by pressure. The term "grinding" is often used in the literature to describe this kinetics. In the second category, the pestle is operated with forceful downward and rotary strokes, an operation sometimes referred to as "crushing" or "pounding". In this last case, the matter that is processed is placed in the mortar concavity, the shape of which limits the spread of the by-products. Working with a handstone and a grinding-slab necessitates controlling the dispersion of the particles. This can be achieved by the shaping of the borders, the use of a basket or a skin, among others.

In addition, other factors, such as the morphology of the use surface and variation in tool motion, must be taken into account for understanding the kinetics of these tools (e.g. Bril 1984, 1993; Adams 2002). Yet, the general description presented above emphasizes significant differences in the tool operation modes, which are dictated by the morphological characteristics of the grinding-slab/handstone and mortar/pestle implements. Besides variation in tool operation, are there other functional implications to these morphological differences? Are these categories of tools designed for processing distinct matters? Addressing these issues may contribute to our understanding of variation in stone tool function during the emergence of agriculture in the Near East.

Variation in assemblage composition in the Near East

In the Near East, typical grinding and pounding implements (Fig. 2) are attested at least since the Upper Palaeolithic period (e.g., Ronen and Vandermeersch 1972; Gilead 1991; Wright 1992a, 1994). At the end of the Epi-Palaeolithic, a significant increase in the relative abundance of these implements and a diversification of tool types are observed (e.g., Bar-Yosef 1980, 1981; Wright 1992a, 1994). These changes are especially apparent during the Natufian period (approximately 15.200-11.600 cal. BP, Bar-Yosef 2001), a transitional phase between hunter-gatherer and farmer adaptations. The question of whether plants were first domesticated by the Natufian or not is a long-standing debate (e.g., Garrod 1957; Braidwood 1960; Perrot 1966; Unger-Hamilton 1991; Cauvin 1994; Bar-Yosef 1996; Kislev 1997; Moore *et al.*, 2000; Belfer-Cohen and Bar-Yosef 2000; Willcox 2000; Aurenche *et al.* 2001; Gopher *et al.* 2001; Bar-Yosef and Belfer-Cohen 2002; Bird 2005). Many have argued for an intensification of plant exploitation during that period. The increase in the relative abundance of grinding and pounding tools is often said to support this assumption. Direct evidence for an intensification of plant exploitation are scanty, given that the preservation of macro-botanical remains is generally poor in Epi-Palaeolithic contexts (e.g., Zohary and Hopf 1988; Miller 1991; Weiss *et al.* 2004). In addition to the increase in

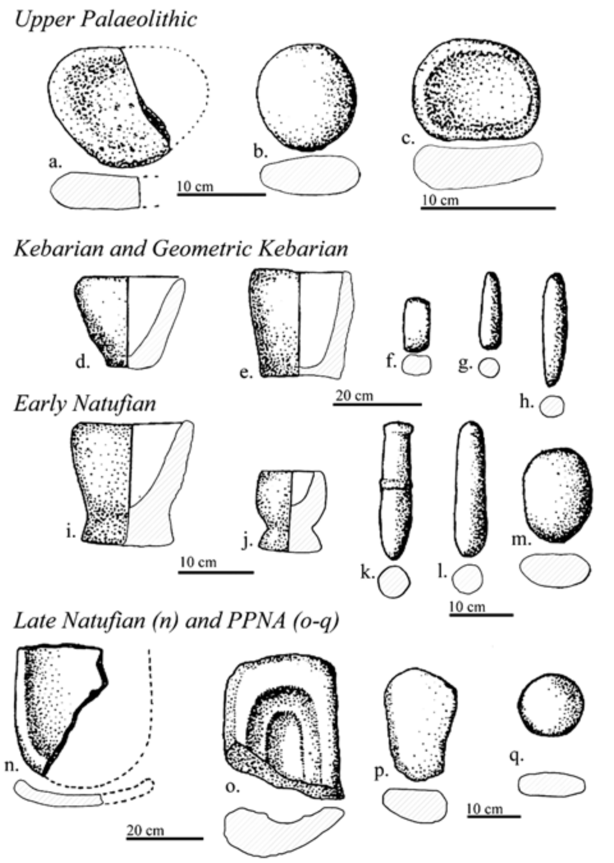

Fig. 2: Examples of Levantine grinding-stones from various periods: a and c: grinding-slab; b: handstone; d-h: mortar, handstone and pestle; i-m: mortar, pestle and handstone; n-q: grinding-slab, saddle quern, grinding-slab and handstone (modified from Wright, 1994, p.241).

grinding tool abundance, Wright (1992a) noted that, in contrast with previous periods, Natufian grinding stones show indication of significant expenditure in tool production. Another trend concerns change in assemblage composition. Several scholars argued that mortars and pestles were substituted for flat implements at the end of the Natufian period (e.g., Bar-Yosef 1980; Goring-Morris1987). This trend would have culminated during the first phase of the Pre-Pottery Neolithic (PPNA, approximately 11.600-10.200 cal. BP, Bar-Yosef 2001), an episode corresponding to the development of agricultural communities.

An extensive typo-technological study undertaken by Wright (1992a, 1994, 2000) confirmed that grinding slabs and handstones became common at the end of the Natufian period, and more particularly, at the beginning of the PPNA. This pattern is illustrated at Mallaha (Upper Galilee, Israel), where the number of flat implements increases dramatically during the last phase of the Natufian occupation (Valla *et al.* 1999, 2001, 2004; Dubreuil 2002, 2004). Farther South, Goring-Morris (1987) indicated that cup marks are well represented during the Harifian, a period spanning the end of the Natufian period and the beginning of the PPNA (approximately 10,800-10,000 BP, Goring-Morris and Belfer-Cohen 1997) in the Negev desert. Cupmarks belong to the general category of "pitted and cupped stones," as defined by Adams (2002), which comprises implements having one or more small depressions. Goring-Morris (1987) noted striations, suggesting a back-and-forth motion, within these depressions. Based on these observations, cupmarks have been associated with grinding-slab/handstone kinetics, as the force would have been applied by pressure rather than by downward strokes. The increase of cupmarks in some of the Negev sites may be considered as another manifestation of the emphasis on flat implements at the end of the Natufian period. However, Wright (1992a, 1994) stressed that some assemblages do not conform to this pattern. For instance, Samzun (1994) reported that at the site of Hatula (near Jerusalem, Israel), mortars and pestles are the most frequent tools throughout the Natufian period and the beginning of the PPNA occupations. In contrast, grinding-slabs and handstones would be more abundant during the last phase of the PPNA.

Yet, inter-site variation in grinding stone assemblages may be more important than diachronic variation during the Epi-Palaeolithic to Neolithic transition (e.g. Dubreuil, 2002, 2003). For instance, some have suggested that flat implements would have been more common in Northern Levantine sites during this episode than in the South (Valla and Khalaily1997). However, more research will be necessary to clarify the chronology and geography of these variations in assemblage composition.

Several hypotheses have been put forward to explain changes in the relative proportions of mortars/pestles versus grinding-slabs/handstones during the period corresponding to the rise of agricultural communities. For some authors, the increase in the number of flat implements is related to a shift in the type of material processed, and more specifically, to an intensification of cereal exploitation**.** Commonly**,** mortars and pestles are associated to the processing of nuts and greasy materials, and flat implements to the processing of cereals. Other scholars have related the shift towards flat implements at the end of the Natufian period to a modification of the processing techniques. For instance, Wright (1992a) suggested that stone mortars were being replaced by wooden ones. She also suggested that wooden implements might have been favoured for dehusking domesticated cereals, their envelope being more fragile and easier to remove than their wild counterparts. Lastly, some have argued that the increase in flat implements at the end of the Natufian period reflects changes in the social organization of work affecting the production and use of the tools (e.g. Belfer-Cohen 1988). Belfer-Cohen and Hovers (2005:304) suggested that the utilization of mortars might have been communal, these tools requiring considerable investment in production, whereas grinding-slabs and handstones might have been personally owned: *"[i]n the Natufian the processing of the vegetable material was done jointly by members of the group with* *communally owned tools. During the Neolithic there was a shift from communal to private activity, when the processing of the vegetable material was done by smaller units, nuclear family (?), with family owned utensils*."

Central to these hypotheses is the functional interpretation of the tools. Therefore, identifying the function of grinding-slabs/handstones versus mortars/ pestles represents a critical step in the testing of these propositions. In the following section, this issue is discussed using the ethnographic and archaeological literature.

Ethnographic case studies

Data on the utilization of grinding-slabs/handstones and mortars/pestles by various populations of hunters-gatherers, horticulturists, and agriculturists, have been collected in order to assess the relationship between grinding tool type and function (see references in Dubreuil 2002). These data demonstrate that both sets of tools are used to process the same range of materials. Mortars and pestles are generally considered more efficient at processing hard and oily matters, whereas grinding-slabs and handstones would be better at processing soft and dry matters. Figure 3 shows that although some groups do conform to this assumption, it is not difficult to find societies that depart from this rule. For instance, the utilization of flat implements for processing hard seeds and hard-shelled fruits has been observed among the Modoc of California (Kroeber 1925), and the Paiute of the Great Basin (Steward 1934) in North America, as well as in Western (David 1998), and Southern Africa (Boshier 1965). Moreover, it is important to stress that some ethnographic groups used grinding technology to reduce a great variety of matters into powder, including non-edible products such as mineral substances (e.g. Kelly 1978; Lapena 1978; Levy 1978).

Population and reference	Matter commonly processed with mortars/pestles	Matter commonly processed with grinding-slabs/handstones
Australian aborigines (Smith, 1985; McCarthy, 1941)	hard seeds	soft seeds
California Amerindians (Kroeber, 1925)	acorn *Modoc: fish and meat	« dry » seeds * Modoc: hard seeds (wokas nuts)
Navaho (Kluckhohn *et al*, 1971)	meat and mineral	acorn and various plants
Sukur plateau (Nigeria-Cameroon) (David, 1998)	cereals, non-oily products, breaking shelled groundnuts and earthpeas	cereals, tabacco, other leaves and vegetables, oily nuts, groundnuts, beans, cattle bones, iron bloom, sherds
Village of Bata, Nepal (Baudais and Lundström-Baudais, 2002)	dehusking soft seeds trimming cereals, grinding rice and stem	dehusking soft seeds grinding cereals, legumes, nuts, aromatic plants, pepper, salt

Fig. 3: Examples of materials processed with grinding tools by populations using both mortars/pestles and grinding-slabs/handstones.

The ethnographic literature also suggests that in groups who use both categories of tools, a pattern in the distribution of the tasks is generally observed. In some cases, hard and greasy materials are processed with mortars and pestles, while soft or dry materials are transformed with grinding-slabs and handstones. In other cases, both categories of tools are used at different points during the reduction process. For example, when processing cereals, some agriculturists dehusk the grains using a mortar and a pestle, but use a grinding-slab and a handstone to reduce the seeds into flour (e.g. Hillman 1984, 1985). Others task distributions are also found in the ethnographic record (Fig. 3). This variability reflects the fact that-several technical options may yield similar results. As pointed out by Horsfall (1987), and more recently, by Adams (2002:8) *"[m]orphological variation should not be viewed as the primary way to determine function. Furthermore, multiple morphological solutions are possible for performing similar functions. These solutions may be delimited by sociocultural standards that can be met trough group-specific technological traditions*." In addition, factors not directly linked to the operation of the tool also affect morphology (e.g. Schiffer and Skibo 1987). For instance, the organization of tool production has been argued to be an important variable determining grinding tool shape (e.g., Horsfall 1987; VanPool and Leonard 2002). Overall, one of the main conclusions of this review of the ethnographic literature is that the relationship between morphological variation and function is mediated by socio-economic organization, and therefore, is group-specific.

Archaeological case studies

As discussed above, some have argued for a substitution of mortars and pestles by grinding-slabs and handstones at the end of the Epi-Palaeolithic in the Levant. Concerning this pattern, it is of particular interest to note that archaeological studies of the California Indians also document diachronic shifts in the relative proportions of these tools (e.g. Kroeber 1925; Heizer 1971; Olson 1971; Wallace 1971). Some archaeologists have proposed that the shift towards a greater emphasis on mortars and pestles during the mid-Holocene in California was caused by a climatically-induced modification of the diet, which triggered an evolution of the grinding techniques (see references in Jones 1996). However, this interpretation was challenged by Jones (1996) using data from sites located along the Big Sur coast in Central California. This author suggested that this shift would be most parsimoniously explained by the reinforcement of the sexual division of labour aimed at intensifying production in a context of reduced mobility and population circumscription. Jones based his interpretation on several lines of evidence, such as the increased number of items of exchange, the intensification of marine resource exploitation, and changes in flint tool assemblages.

In the U.S Southwest, some have argued for a relationship between flat implement morphology and dependency on agriculture (see references in Diehl 1996 and Adams 1999). This view has also been challenged (e.g. Stone 1994; Adams 1999). Building on ethnographic and experimental data, Adams stressed that grinding-slab design is more closely related to food processing, especially to the production of flour, than to food procurement strategies. According to her, the availability of floury varieties of maize would have played a more important role in the evolution of tool morphology than the degree of dependency on agriculture. Modification of storage techniques, as well as social arrangements of food-grinding and distribution strategies, are also considered key factors contributing to changes in grinding tool design (Adams 1999).

These case-studies demonstrate that multi-disciplinary approaches and detailed analyses of grinding tools may improve our understanding of the evolution of prehistoric adaptations. In this perspective, a typological, technological, and functional analysis of Natufian artefacts has been carried out in order to evaluate hypotheses about plant exploitation during this period (Dubreuil 2002, 2004). This last study provides additional data to discuss the supposed dichotomy between mortars/pestles and grinding-slabs/handstones in the context of the neolithization process in the Near East.

A use-wear analysis of Natufian implements

An experimental program focusing on use-wear formation on grinding stones was undertaken with the aim of refining the functional analysis of Natufian implements. Criteria have been proposed to distinguish, based on use-wear characteristics, flat grinding tools from abraders and polishers, and for determining the kind of material that were processed with these tools (Dubreuil 2002, 2004).

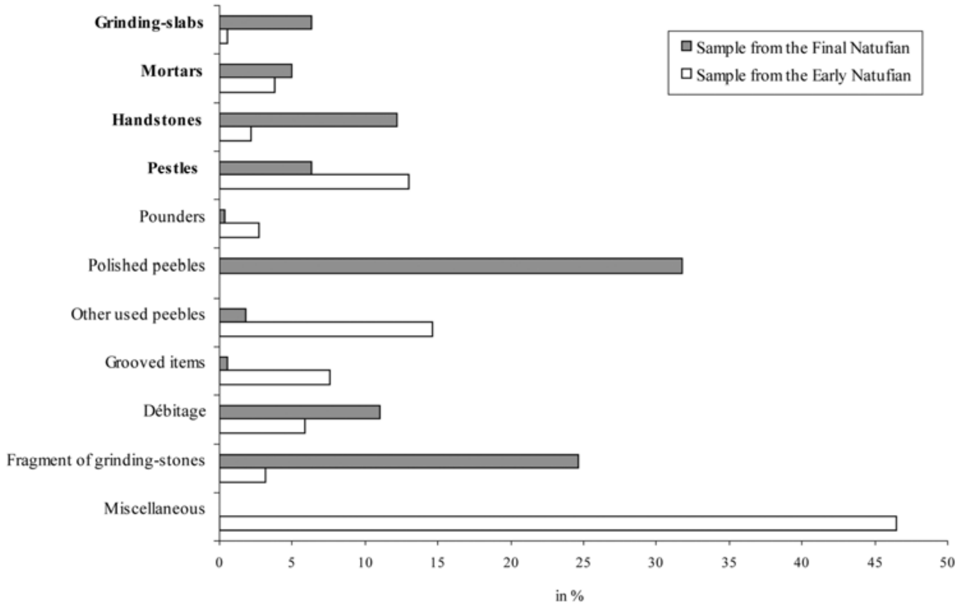

Fig. 4: The ground-stone tool sample from Mallaha. Assemblage composition for the Final (in grey) and Early (in white) Natufian. Categories with * are grinding and pounding implements.

These criteria were used in the study of the Natufian assemblage of Mallaha. This sample consists mostly of Early, and especially, Final Natufian artefacts, while only a few objects were available for the Late Natufian (an intermediate phase in the Natufian sequence). It is worth stressing that only objects with secure stratigraphic information were included in the analysis. At Mallaha, grinding-slabs and handstones increased in proportion at the end of the Natufian period, whereas mortars and pestles decreased significantly (Fig. 4).

Regarding flat implements, the typo-technological and use-wear analyses suggest that the increase in the proportions of these objects in the Final Natufian is associated with a relative standardization of tool morphology, greater investment in curation, and specialization on plant processing (Fig. 6). At the beginning of the Mallaha sequence, more types of flat implements and a wider range of tasks appear to be documented compared to the end of the sequence. In the Final Natufian, bifacial handstones, discoid in plan and oval in section, dominate the sample, and saddle-shaped querns (a type of grinding-slab) increase in abundance (Fig. 5). The use-wear analysis suggests that most of these artefacts were used for processing cereals, and more particularly, legumes. The same types of saddle-shaped querns and handstones, associated with the same types of use-wear, are also found in the Early Natufian sample. This constitutes strong evidence for continuity in the production and utilization of the flat implements. Therefore, these data suggest that the increase in the relative abundance of grinding-slabs and handstones at Mallaha reflects intensification in the use of certain resources and/or modes of processing rather than dramatic changes in subsistence strategies.

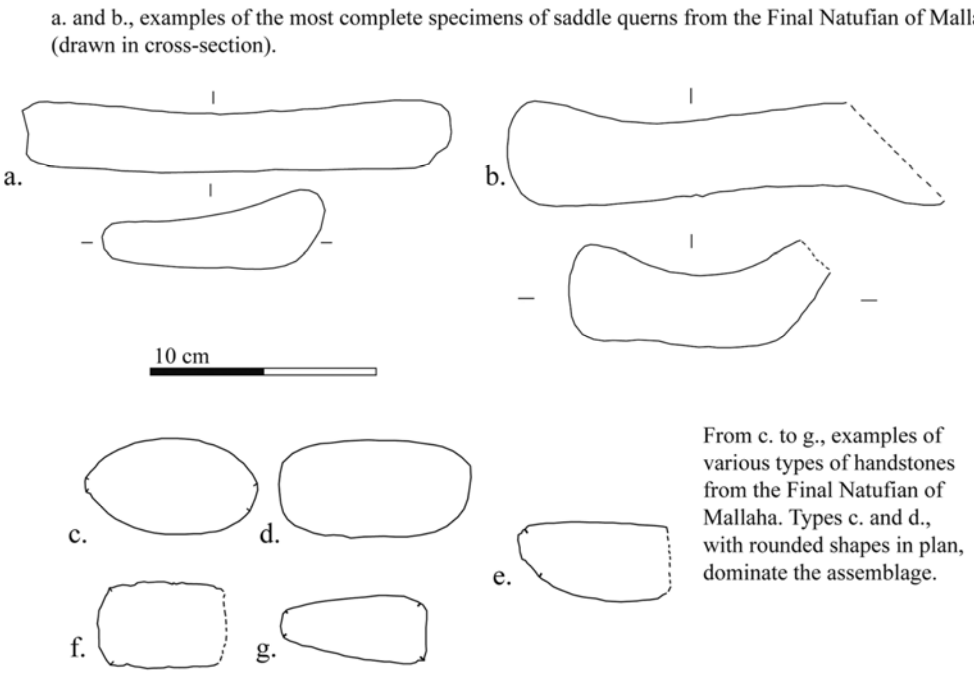

Fig. 5: Flat implements from the Final Natufian of Mallaha.

Conclusion

A review of selected ethnographic studies indicates that temporal changes in grinding tool morphology may be mediated by several parameters related to raw material availability, type of economy, technological knowledge, and the social organization of production and use of the tools. For these reasons, models assuming a direct relationship in the Levant between change in grinding tool morphology and change in processed material may overlook significant aspects of assemblage variability.

The functional analysis of Natufian artefacts suggests that the increase of flat implements at the end of this period might reflect significant modifications in tool management (Dubreuil 2002, 2004). At Mallaha, these trends appear to be related to intensification in legume and cereal processing. An emphasis on tool standardization and curation at the end of the Mallaha sequence may corroborate this interpretation. These patterns may be symptomatic of changes in the organization of tool production and grinding tasks (Belfer-Cohen 1988).

To test these hypotheses further, it is important to enlarge the use-wear sample for flat implements and to refine the functional analysis of mortars and pestles. A better understanding of spatial and temporal changes in assemblage composition may clarify the evolution of grinding technology in the Near East. To meet this goal, combining typological, technological, and functional analyses of grinding artefacts appears as a very promising approach.

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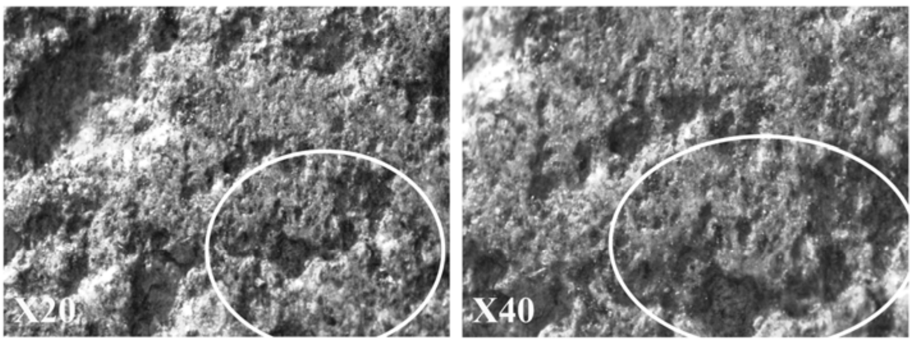
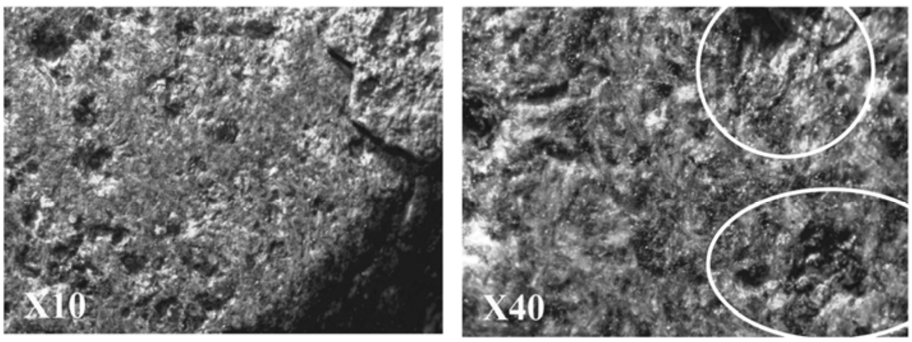
Evidence of surface reroughening from the Final Natufian at Mallaha. On the left, thin flakes that removed part of the grinding surface. On the right, a handstone with traces of pecking on a worn-out grinding surface.



Surface of a handstone from the Final Natufian of Mallaha with traces of reroughtening by pecking. Impact scars are posterior to the levelling of the surface trough utilization. Note the irregular outlines of the hollows, especially in the right corner, compared to the images bellow.



Surface of a handstone from the Final Natufian of Mallaha that has not been reroughtened. Note the regular and neat outlines of the hollows.

Fig. 6: Evidence of surface reroughtening of flat implements in the Final Natufian of Mallaha.

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Economic efficiency of Meso-Eneolithic settlements in southern Caucasus: the results of the traceological analysis of stone instruments

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Summary. *A new interpretation of a traceological research method is here presented. Earlier methods were based on prof. G. Korobkova's classification, i.e. on quantitative account of stone instruments. This classification depends on absolute quantity of instruments in collections. Therefore in collections with different quantity of instruments we have different absolute errors. Such classification studies only microeconomic parameters of prehistoric economy. But it is important to know, how this economic system developed, i.e. how much it produced. The latter is possible only through the study of macroeconomic (qualitative) characteristics of paleoeconomy, as much as it occurs in modern economy.*
We propose here a new classification considering a virtual "domestic product" created at ancient settlements. We assume that each instrument created a final product of consumption. With the increase of the "virtual product", economic relations also increased. For identification of collections with different tools we normalized all groups of tools on the basis of instrument size, in main groups. Thus we "evaluated" all groups of instruments creating a "virtual product". The sum of separate significances gives the complete "cost" of a collection, which correlates with a created product. It is possible to consider such parameters as macroeconomic and to evaluate their size as an economic element on settlements. High costs correspond to more developed economic systems. Interpretation of classification is given for settlements of Southern Caucasus and Central Asia, based on data resulted from our research and from prof. Korobkova's work (Korobkova, 1987). It is shown that certain economy types are present at a certain point in the chronology.

Résumé. *Dans cet article est présentée une nouvelle méthode de recherche tracéologique. Précédemment était utilisée la classification du Professeur G.F. Korobkova fondant le décompte quantitatif des instruments lithiques. Cette classification dépend de la quantité absolue des objets dans la collection. Par conséquent, dans les collections avec différentes quantités d'instruments nous avons différentes erreurs absolues. Une telle classification étudie seulement les paramètres micro-économiques de l'économie préhistorique. Mais il est important de connaître comment ce système économique est développé, i.e. combien de production il généra. Ce n'est possible qu'en étudiant les caractéristiques macro-économiques (qualitatives) de la paléo-économie. Nous le savons de l'économie moderne.*
Nous proposons une nouvelle classification considérant une " production domestique" virtuelle dans les sites. Nous supposons que chaque instrument génère un produit final de consommation. Avec l'augmentation du "produit virtuel" les relations économiques s'accroissent aussi. Pour l'identification de collections avec différentes proportions d'outils nous avons normalisé tous les groupes d'outils selon la dimension des instruments dans le groupe principal. Ainsi nous avons "évalué" tous les groupes d'instruments créant un "produit virtuel". La somme des valeurs séparées donne le "coût" complet d'une collection, qui va de pair avec un produit constitué. Il est possible de considérer de tels paramètres comme macro-économiques et d'estimer à partir de leur taille un état de l'économie selon les sites. Un coût élevé correspond à l'économie la plus développée.Une interprétation de la classification est donnée pour les sites du sud Caucase et d'Asie centrale, sur la base de données résultant de nos recherches et des travaux de Korobkova (1987). Il est montré que certains types d'économie sont présents à un certain point dans la chronologie.

Key words: traceology, paleoeconomic, microeconomic, macroeconomic, "domestic product", "virtual product", normalization, histograms.

Prehistoric Economy of Ancient Settlements of Southern Caucasus

Research into prehistoric societies is defined by the study of prehistoric economy. In archaeological science there are some theories about probable structure of prehistoric economic relations. The majority of such theories is based either on abstract reasoning of "formal" economists, or on parallel research into economic anthropology. In both cases modern economic and ethno-economic relations have been extrapolated to create prehistoric economic models. Such approach often depends on the outlook of the researcher and is very subjective. An example is given by the wide use of Marxist economic theory in paleoeconomy. In earlier work (Esakia 2003) we showed the hopelessness of such approach.

Other results will occur, if paleoeconomic relations generate by means of economic analysis undertaken on real archaeological material. We do not agree with some authors' statements concerning the limited application of economic laws in past societies. Laws reflect an objective reality and operate irrespectively of time and subject. We are the only responsible for fixing such laws and supply attributes for their interpretation in different economic systems, in order to provide a more exact and universal research method that results in more reliable economic interpretation.

With such universal methods was concerned S.A. Semenov's (1957) traceological research on stone tools and their classification, continued by G.F. Korobkova (1975). We shall note that this classification considers microeconomic tool assemblage characteristics. All assemblages have in common groups of the same instrument type. On the basis of group size, the

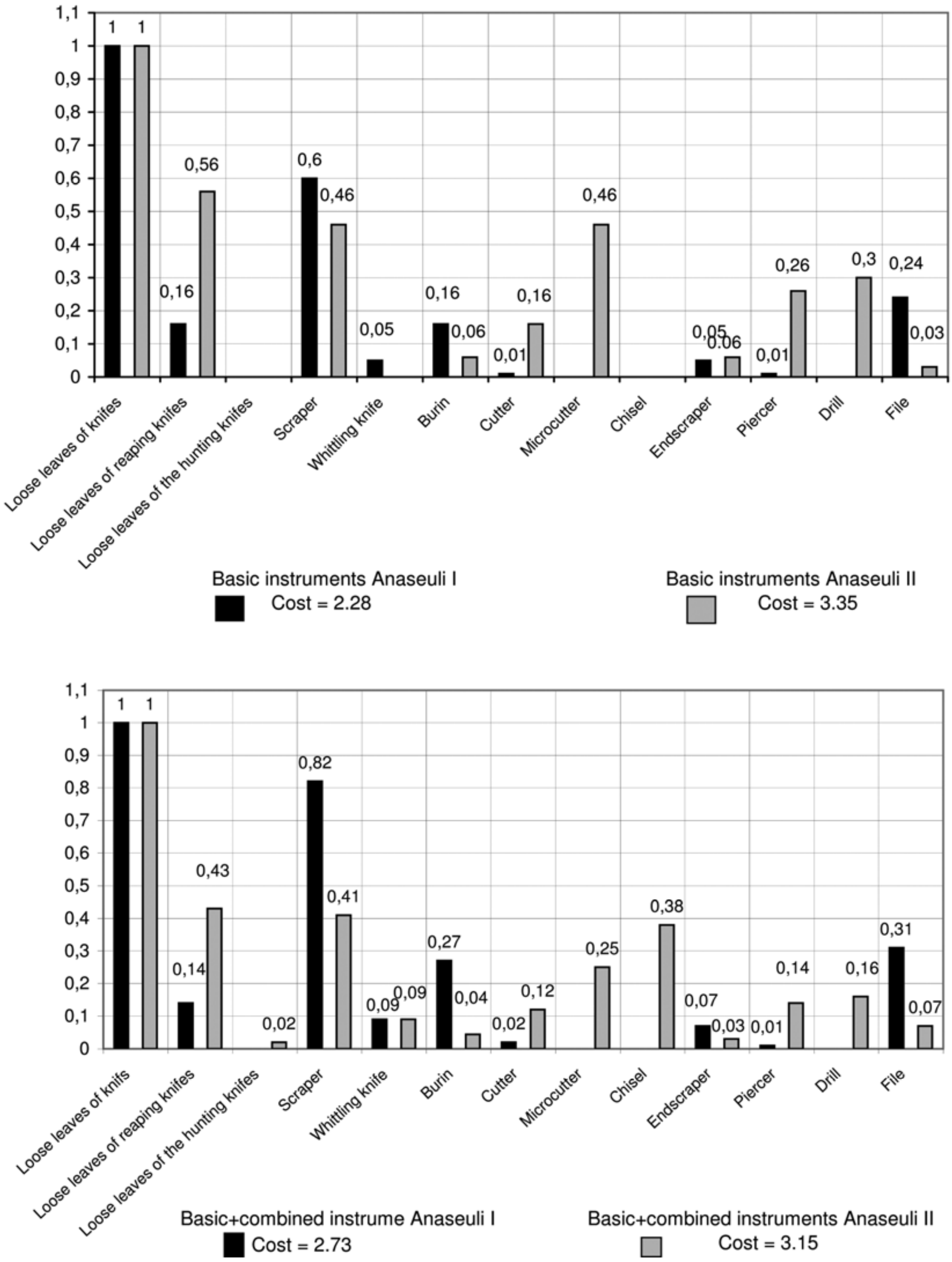

Fig. 1: Histogram of the normalized values of instruments quality in settlements Anaseuli I and Anaseuli II.

dominating type of equipment is determined. We argued (Esakia 2003), that this type of classification is good within the limits of one settlement. Quantitative analogies describing a degree of tool development, are impossible in this case. To define the tool development level it is necessary to know how much it produced, i.e. its macroeconomic characteristics.

For retrieving macroeconomic information the qualitative structure of groups and type of economy is not important. In this case it is important to know how advanced the economic system under study was, or how much it produced.

In modern economics, the concept of "domestic product" is estimated in conditional units (money) and it is created by all subjects of a society. If the production is high, so is the economic system of that society. The domestic product enables to easily compare the economic structure of different economic systems. We have tried to extrapolate this technique in paleoeconomy.

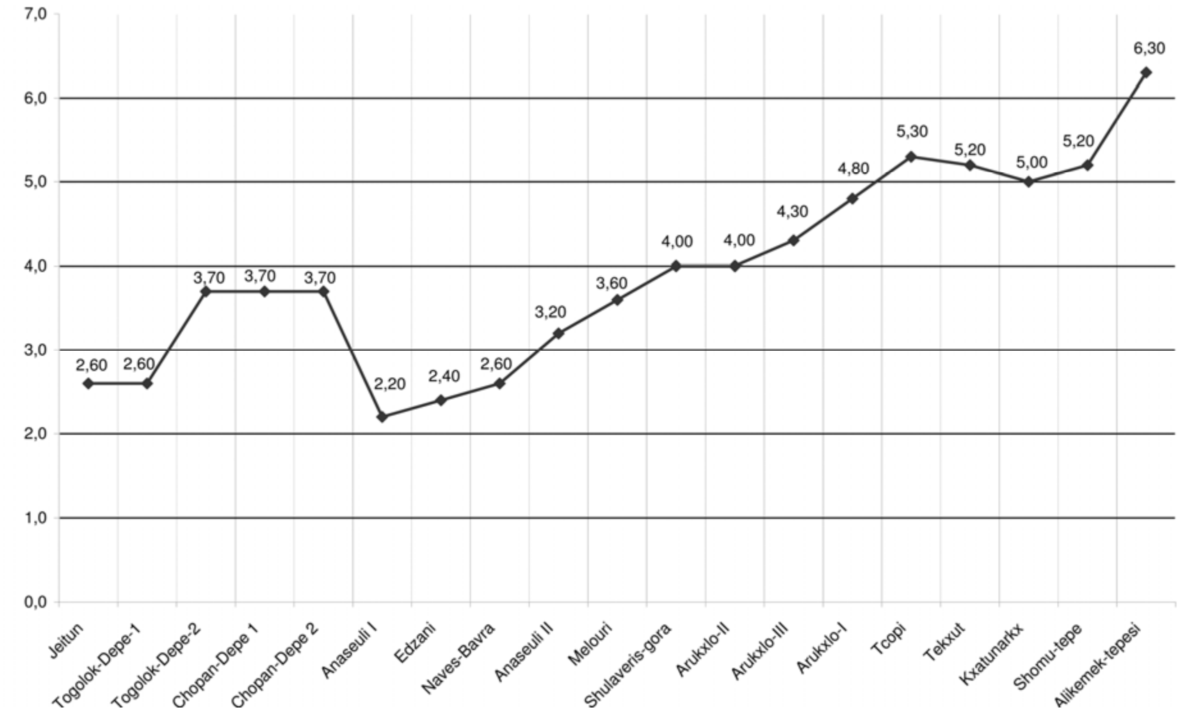

Fig. 2: Economic efficiency of ancient settlements of central Asia and Caucasus.

The use of working tools by a given prehistoric community created a certain type and quantity of produce which we shall name “virtual produce”. This produce was created by those who were engaged in the ‘basic’ work (agriculture, stock-breeding) and those who were engaged in minor manufacturing. With the increase of the “virtual produce”, economic relations also increased. For a moment, we will assume that on an ancient settlement there was one main manufacturer who supplied tools of the basic group, and minor manufactures who covered the production of all other groups of instruments. For the minor manufacturer it is possible to expand using only additional resources (human and technical). When overall resources are limited, such expansion can occur by means of adding other manufacturers. It is highly probable that development of minor manufactures occurred thanks to the main basic manufacturer. In a small-scale society, such redistribution is possible only by increasing the technical and technological level of the economy, i.e. where minor manufacture is more advanced, the level of economic development is higher. Minor manufacture is a division of labour in separate crafts. Once again we shall repeat that the process of redistribution should occur without damage to the main economic direction.

Thus, on all settlements we may choose the main group of instruments for one unit criterion of “virtual produce” estimate. If the quantity of tools in this group is accepted for one unit cost, it is possible to estimate all tools assemblages costs. Such distribution is called ‘normalization’. We take the quantity of instruments in the main group as normalization coefficient and divide contents of all groups into this coefficient - the basic and minor. The basic group will cost one conditional unit, all other groups, less. In order to combine costs of all groups, we shall have conditional costs of all tool assemblages.

Between conditional cost of an assemblage and quantity of a virtual produce there is a direct correlation. We should highlight the fact that normalization is an operation with relative numbers, therefore irrespective of absolute quantity of instruments in different collections, the relative error of measurement in all cases will be one order.

We would like now to apply our reasoning to the interpretation of the settlements Anaseuli I and Anaseuli II. Settlements are located in western Georgia, at a distance of 1 km from each other. Anaseuli I dates to the Early Neolithic, Anaseuli II to the Final Neolithic (Nebieridze 1986). Near these settlements there are rich flint deposits, but in a stone tool assemblage obsidian is found to prevail. At Anaseuli I, were recovered the earliest Neolithic reaping knives of the Southern Caucasus region. Histograms in Fig.1 show normalised sizes of tool assemblages from Anaseuli I (dark column) and Anaseuli II (light column). The top histogram takes into account only the basic instruments, the bottom one- the basic tools plus combined ones

Histograms give sufficient material for micro-economic analysis. Basic groups at both sites are loose leaves knifes, suggesting that the dominant direction of an economy is connected to meat processing. In Anaseuli I other types of economy are undeveloped. Loose leaves reaping knifes make only 0.16 conditional units. Therefore, if there was any agriculture, this was very limited. At Anaseuli II harvesting of grains increases, it is possible to speak about the existence of a production. The economic level increases too: - up to 3.35 conditional units. In view of the combined instruments cost of collection Anaseuli I is 2.73 conditional units, and Anaseuli II decreases until 3.15 conditional units.

What does all this mean? Combined instruments characterize secondary processing, therefore reduction of normalized combined characteristics at Anaseuli II specifies that the role of imported obsidian scaled down: the technological advantage of expensive obsidian changed to the advantage of cheaper flint.

What macroeconomic information is given when determining the cost of a stone instrument assemblage? It is renown that in the archeological literature there are two theories of development of a prehistoric economy: evolutionary and crisis. There are many examples, that economic production increased in the worse ecological conditions. In the Far East agriculture was already present during the 9th-7th millennia B.C., in the Near East and in Central Asia in the 6th millennium on Caucasus in the5th-4th millennia.

How do the total normalized characteristics of stone tool assemblages behave in chronological terms? Fig. 2 shows total distribution for settlements of Central Asia and Caucasus, based on data resulted from our research and from prof. Korobkova's work. Once again, it is possible to notice that the study of stone tool assemblages from the bottom and top layers of Turkmen settlements (Togolok-depe-1 and 2 and Chopan-depe-1 and 2) did not show any differences in quantitative ratio and types of economic values. Economic changes were therefore possible to suggest only through analogies with other settlements. At the same time, differences in level of economy at Jeitun and Togolok-depe-1, on the one hand, and Togolok-depe-2, Chopan-depe-1 and Chopan-dep-2, on the other are clearly visible. It is possible to see that certain economy types are present at a certain point in the chronology. Anaseuli I, an early Neolithic settlement, carries on a Mesolithic type of economy, even though its level is lower than that of Mesolithic settlements such as Edzani, Canopy Bavra, Jeitun. According to the Jeitun data, despite the existence of advanced agriculture, the level of economy proper of a Mesolithic type-site is kept.

Because of limited time, we may not continue the analysis of the diagram though it is clearly visible how much time chronology meets economics. Hence there is an opportunity of creating a chronological economic scale. We hope, that it is not coincidental concurrence.

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Harvesting technology during the Neolithic in South-West Europe

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Summary. *Agriculture technology during the Neolithic is poorly understood. This topic may be a good way to get some information about the spread of agriculture and the conditions in which agriculture was transmitted and practiced. In this paper we collect the data gathered by several specialists in use-wear analysis about harvesting techniques in different Neolithic sites in Spain and SE France. Three different areas can be clearly distinguished with respect to harvesting techniques: 1) the Lyon Gulf (Catalonia-Languedoc-Provence), where sickle blades in parallel insertion were used and where sickle gloss showed different degrees of abrasion, 2) the Levantine Spanish coast, where bent sickles with dented edges were used and sickle gloss was not abraded, and 3) Cantabrian Spain, where no sickles were used for harvesting. We will try to explain this variability by resorting to ecological conditions, socio-economic contexts and intercultural contacts in which the first agriculture was carried out.*

Résumé. *La technologie agricole pendant le Néolithique est peu connue. Ce sujet peut être une bonne voie pour obtenir des renseignements sur l'expansion de l'agriculture et sur les conditions dans lesquelles l'agriculture a été transmise et pratiquée. Dans cet article nous collectons les informations réunies par quelques spécialistes en analyse fonctionnelle sur les techniques de récolte des céréales dans quelques sites Néolithiques de l'Espagne et du Sud de la France. Nous pouvons distinguer trois zones par rapport à la technique de récolte : 1) le golfe de Lyon (Catalogne-Languedoc-Provence), où les des lames-faucille majoritairement en insertion parallèle ont été utilisées et le lustre de céréale montre plusieurs degrés d'abrasion, 2) la côte levantine espagnole, où les faucilles courbes avec les tranchants dentés ont été utilisées et le lustre de céréale ne montre pas la composante abrasive, et 3) l'Espagne Cantabrique, où les faucilles n'ont pas été utilisées pour la récolte des céréales. Nous essayons d'expliquer cette variabilité en relation avec les conditions écologiques, les contextes socio-économiques et les contacts culturels dans lesquels la première agriculture a été développée.*

Key words: *harvesting techniques, crop agriculture, curved sickles, use-wear analysis, Neolithic.*

Introduction

Crop agriculture was a basic resource among the first farming communities in Europe. Soil tilling and crop sowing, harvesting, processing and stocking were strategic technical activities for these communities. The spread of new crops, brought from the East into Europe, was surely accompanied by the parallel spread of new technologies associated with them. Agriculture was carried out all along Europe in a considerable variability of ecological, economical and social contexts existing among the Neolithic groups. That is why the variability of agriculture technology in Neolithic Europe may be a good way to fathom out the spread of agriculture itself and the conditions in which that new technology was transmitted and practiced.

The reconstruction of agriculture technology should be ascertained through interdisciplinary study including that from archeobotanists, micromorphologists, palynologists, use-wear analysts, etc. In this paper we deal with a part of this massive topic: harvesting technology in SW Europe, according to a group of use-wear analysts who have been working on the subject for the last 15 years. We now show the results of our analysis carried out in Spain and in SE France (Languedoc and Provence).

The archaeological sites (Fig. 1)

In Catalonia, we have analyzed the lithic tools recovered in some Neolithic sites dating[1] from the end of the 6th millennium up to the beginning of the 4th millennium. Some of the sites are domestic habitats in open air sites, as La Draga and Ca n'Isach or cave sites as La Cova del Frare (Martín *et al.* 1985). We have also studied the function of the tools deposited as burial offerings as those recovered in the necropolis of Sant Pau del Camp, Bòbila Madurell and Camí de Can Grau (Martín *et al.*1997. All tools found in the sediments filling the galleries of the variscite mines of Can Tintorer, which have also been submitted to use-wear analysis, should be considered as the rejects of domestic activities in a garbage context (Gibaja 1997, 1999, 2000, 2002, 2003 and 2004).

[1] All the chronological data will be presented in calibrated C^{14} years bC.

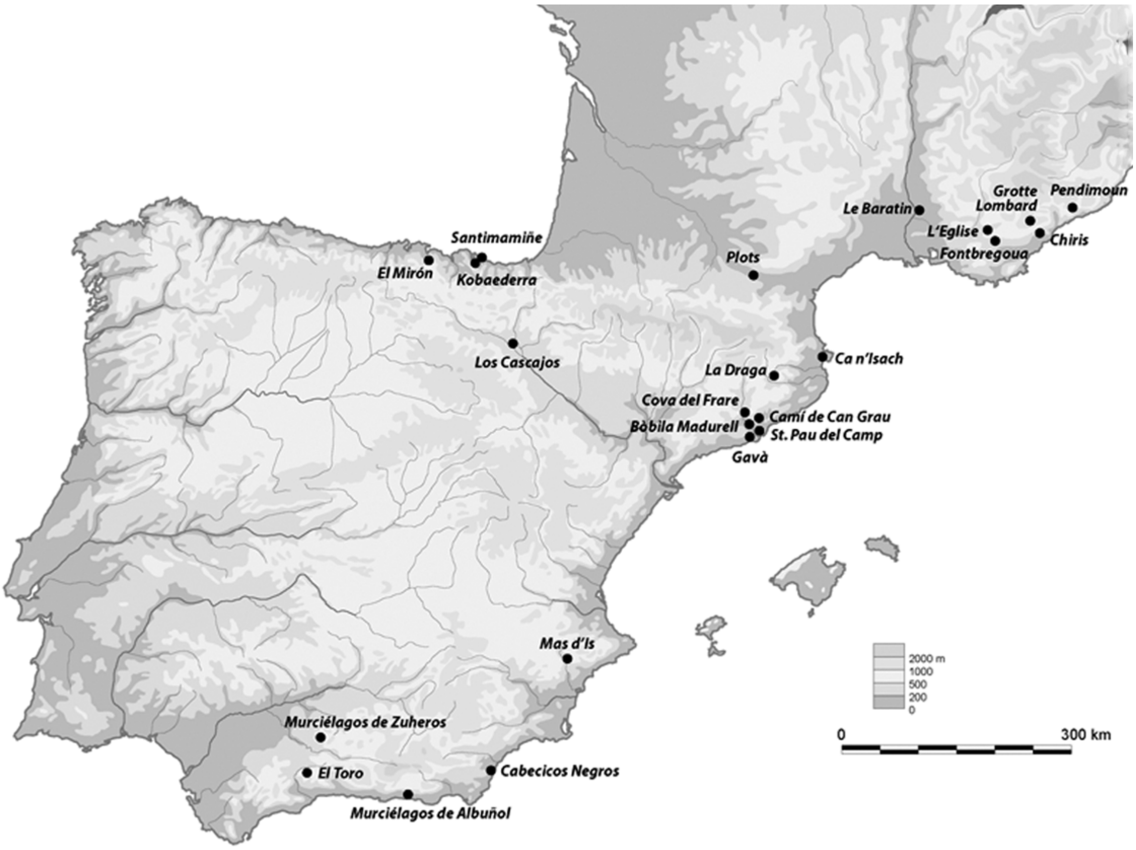

Fig. 1: Location of sites studied.

Some Provençal Neolithic sites, dating from the beginning of the 6^{th} millennium to the beginning of the 4^{th} millennium BC, have been studied as the rock shelter/cave sites of Lombard (Gassin 1991), Pendimoun, Le Baratin (Gassin *et al.* 2004), La Grotte de l’Eglise supérieure (Gassin 1996) and the open air sites of Giribaldi (Gassin *et al.* 2004), Fontbregoua (Gassin 1999), Chiris (Gassin1997; Beugnier and Gassin unpublished)

In Cantabrian Spain, facing the Atlantic sea, we have studied the tools from the cave sites of Kobaederra (Zapata *et al*. 1997; Ibáñez, 2001), El Mirón (González and Ibáñez, unpublished) and Pico Ramos (Ibáñez and Zapata 2001), dating back to the end of the 5^{th} millennium, representing the first regional Neolithic. Not far from these sites but in the Ebro River basin, in a Mediterranean climatic area, the open air site of Los Cascajos (García Gazólaz and Sesma 1999) has offered an important collection of glossed tools which have been analyzed as well (González and Ibáñez unpublished). Two different habitation levels have been distinguished in this site, an old Neolithic one, dating from the end of the 6^{th} millennium, and another mid Neolithic one dating from the second half of the 5^{th} millennium.

In Andalusia, we have studied the tools coming from two cave sites located on inland mountains: Cueva del Toro (Rodríguez Rodríguez 1994, 2004; Rodríguez Rodríguez *et al*. 1996), dating from the beginning of the 5^{th} millennium and Murciélagos de Zuheros (González Urquijo *et al*, 1994 and 2000), dating between the end of the 6^{th} and the end of the 5^{th} millennium. The open air site of Cabecicos Negros (Goñi Quinteiro *et al*. 1999; Rodríguez Rodríguez 1999), located in the coastal plain is attributed to the regional middle Neolithic. The study of Neolithic tools recovered during the prospecting activities carried out in the Cadiz landscape (Ramos *et al.* 1999), also contributed to this study.[2]

In Valencia, the open air site of Mas d’Is (Bernabeu and Orozco 2005) shows three occupational levels: a first dating from around 5.400 cal. BC; the second one, dating from around 5.100 BC, and the most recent one, dating from around 4.500 BC. The sickle elements that we have studied come from the 6^{th} millennium levels (Gibaja, in García *et al*. in press).

In the French region of Languedoc, the site of Les Plots has been studied, dating from the second half of the 5^{th} millennium BC (Vaquer 1995; Philibert unpublished).

This group of archaeological sites is spread irregularly in a much extended geographical area. Some regions have been intensively studied as Catalonia and Provence, while others have been approached in a more superficial way, as the Cantabrian Spain or Andalusia, both only studied in their western areas. For other regions only one site has

[2] Use-wear analysis was carried out by I. Clemente.

been studied as Valencia or Languedoc. Indeed, some important areas are still completely unexplored as those in Portugal or inland Spain. Given these facts, one should consider all conclusions drawn from this paper as preliminary ones. They are to be corroborated in upcoming studies.

Nevertheless, the work carried out up to the present allows us to show some interesting tendencies dealing with the distribution of different harvesting methods in the area. We are able to distinguish three main areas in this respect: 1) Andalusia and Valencia, that is, the Spanish Levantine coast, 2) Catalonia, Provence and Languedoc, the Lyon Gulf, and 3) Cantabrian Spain.

Curved sickles with dented edges in the Spanish Levantine coast

The sickles used in Andalusia and Valencia were made with wooden curved shafts in which the flint elements were obliquely inserted. These elements were made with fragments of flint blades which were glued to the shaft with mastic. The obliquely inserted elements protruded from the shaft creating a dented edge.

A complete sickle of these characteristics was found in the XIX century in the dry cave of Los Murciélagos de Albuñol, in Granada (Fig. 2). The sickle is lost, but a witness of the discovery depicted it to M. de Góngora, who published it (Góngora 1868: 199; Vayson 1918-19). A similar and also complete sickle was found in the lake site of La Marmotta, near Rome (Fugazzola Delpino and Pessina 1999).

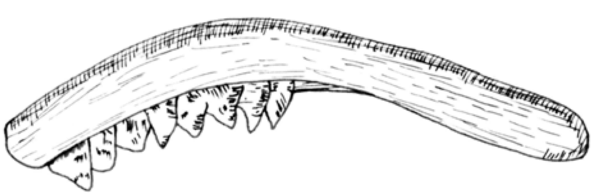

Fig. 2: Reconstruction of the sickle found at Murciélagos de Albuñol (Góngora 1868; Vayson 1912-13).

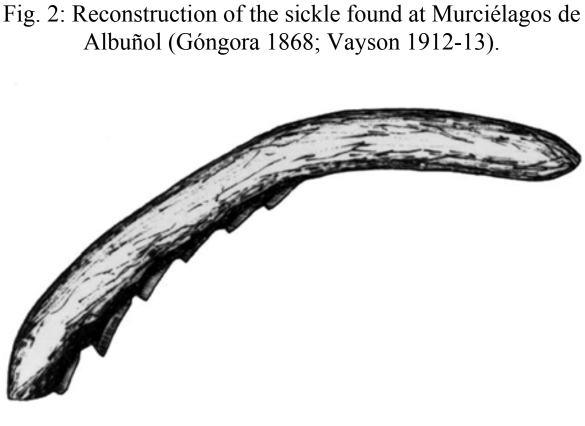

Fig. 3: Reconstruction of the sickle used at Murciélagos de Zuheros (González *et al*. 2000).

The morphology of the sickle elements and the oblique distribution of the gloss allowed us to infer that in some other Spanish Levantine sites this type of sickle was also in use (Fig. 3). This was the case of 12 sickle elements in the cave site of Los Murciélagos de Zuheros (Fig. 4), one of which was still inserted in the mastic that had glued it to the shaft, clearly indicating an oblique position (González Urquijo et al. 2000). Naked wheat (*T. aestivum/durum*) and barley (*H. vulgare*) were cultivated at the site (Peña-Chocarro 1999). The Neolithic levels of the cave site of Cueva del Toro reflected an occupation focused on the exploitation of animal resources, especially livestock (Martín Socas et al. 1999). Plant remains are very scarce and they mostly correspond to wild species, although einkorn, emmer, naked wheat and barley are present too (Buxó 1997: 164-165). Only one sickle element was found in these levels and the distribution of gloss fits well with the aforementioned model (Rodríguez Rodríguez et al. 1996).

Los Murciélagos de Zuheros, Los Murciélagos de Albuñol and Cueva del Toro are located in a mountainous environment. On the contrary, the open air site of Cabecicos Negros is located on the coast, in the Province (County) of Almeria. The site has been interpreted as a settlement specialized in the craft of mineral objects (ornaments), while the indications of the acquisition of primary resources are scarce (Goñi Quinteiro *et al*. 1999). Again, one isolated sickle element shows the gloss in an oblique disposition (Rodríguez Rodríguez 1999). Surveys carried out in Cadiz allowed the discovery of several Neolithic sites. Among the material of La Mesa site (Ramos et al. 1999), two small sickle elements with the gloss in the same disposition could be found.

In the open air site of Mas d'Is, in Valencia, we found 15 sickle elements made on blades and flakes. This site is located 15 km off the coast, by the Serpis River. The archeobotanical study has documented the use of barley, einkorn (*Triticum monooccum*) and naked wheat (Pérez Jordá 2005). All these elements show the sickle gloss in an oblique position. This distribution of gloss had already been mentioned by Juan Cabanilles (1984) for the sickle elements of Cova de l'Or and Cova de Sarsa. Both sites are located in Valencia and they dated from the end of the 6th millennium. In Cova de l'Or the cultivation of naked (*Hordeum vulgare var. nudum*) and hulled barley (Hordeum vulgare var. vulgare), naked wheat, einkorn and emmer (*Triticum dicoccum*) has been documented (Hopf 1966; López 1980), while in Cova de Sarsa only naked wheat and emmer have been identified (López 1980).

The morphology of the sickles is quite homogenous in these Spanish Levantine sites. The features of the harvesting use-wear traces are also similar. These elements show the typical harvesting polish: shiny, quite flat and with comet-shaped pits. Certain variability was possible with respect to the quantity of striations present on the polished surface, but, in any case, the abrasive

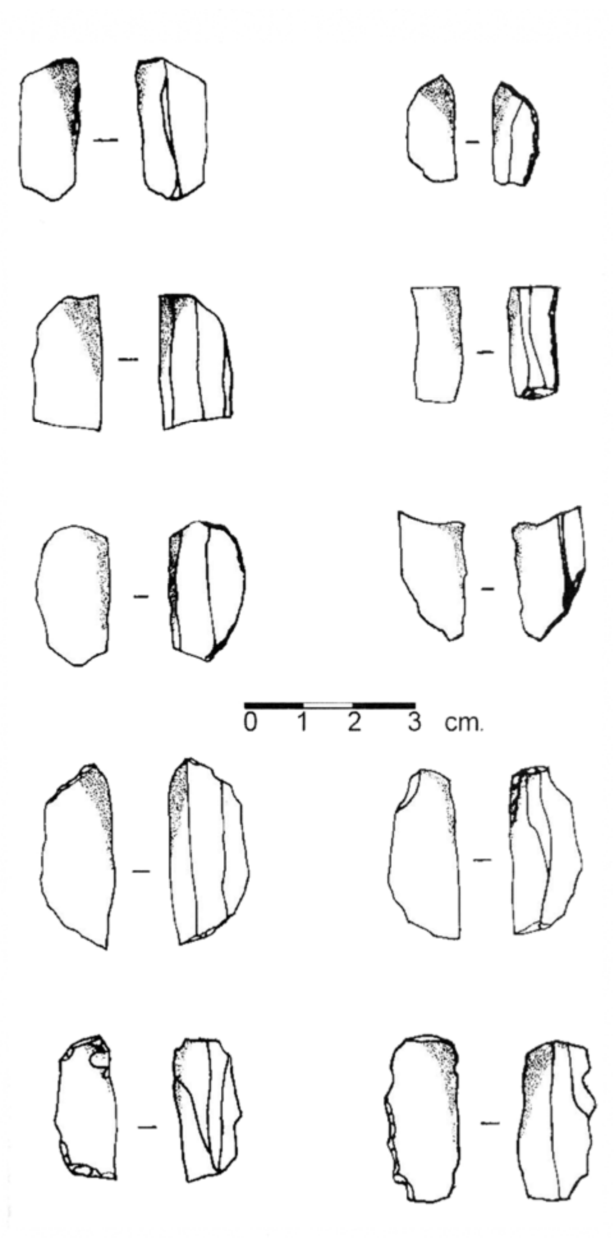

Fig. 4: Sickle elements from Murciélagos de Zuheros.

component of the polish was not that intensive. The variability in the degree of striations can be explained by the lower or higher harvesting of the plants or by how much loosen the soil was when the cereal was harvested. (Unger-Hamilton 1988; Anderson 1992; Domingo 2005).

Other than this Levantine area, only the older levels of Los Cascajos site, in Navarre, dating from the end of the 6th millennium, show sickle elements that were originally obliquely inserted into the shaft. All the sickle elements recovered in the older levels (no. 21) showed this gloss position. They bear the typical harvesting polish (Fig. 5), again with certain variability in the quantity and intensity of striations. Emmer is the most common cereal in this site, although, einkorn and barley were usual as well (Peña-Chocarro and Lydia Zapata unpublished).

Blades in parallel insertion in Catalonia, Provence and Languedoc

The morphology of sickles must have been quite different in Catalonia, Languedoc and Provence, as the sickle elements were made in longer blades and the harvesting gloss was parallel to the edge, indicating that the blade was inserted in parallel to the shaft (Fig. 6). The characteristics of the use-wear traces also differ from those in southern sites. Although some of the sickle elements show the typical harvesting polish with more or less striations, as in the south, many other tools related to harvesting activities bear an abraded polish, showing this abrasive component different degrees of intensity and disposition along the cutting edge.

In the lake site of La Draga (Bosch *et al*. 2005), dating from the end of the 6th millennium, 42 sickle blades have been studied. The most common cereals were hulled barley and naked wheat, while naked barley and emmer were rarer. In the cave site of Cova del Frare (Martín A. *et al.* 1985), located in the middle of a mountain chain and dated from the mid 5th millennium, 12 sickle elements were detected. The sickle blades recovered among the offerings found in the individual graves of the

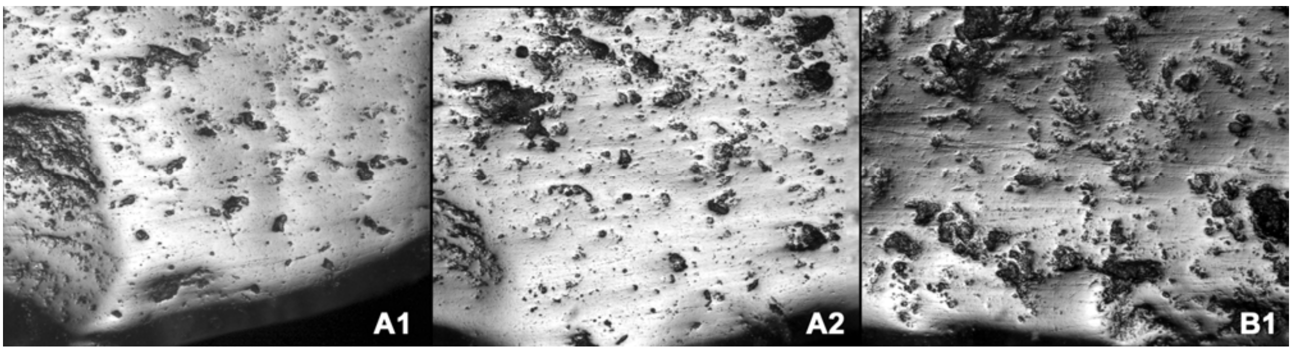

Fig. 5: Typical harvesting traces on two sickle elements from Los Cascajos.
A1: LC239 (100x); A2: LC239 (200x); B1: LC549 (100x).

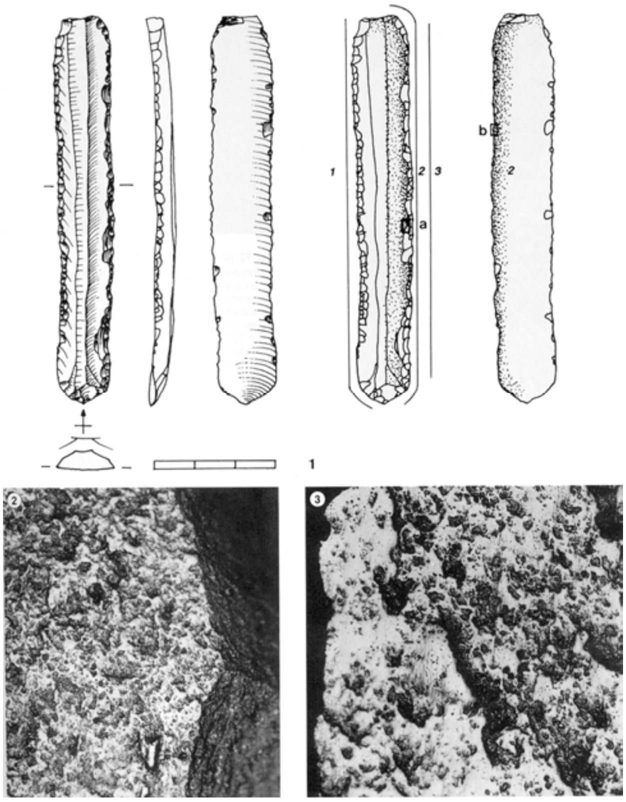

Fig. 6 : Sickle blade from La Grotte de l'Eglise supérieure. Typical harvesting polish.

necropolis of Sant Pau del Camp (Granados *et al*. 1991) (no.13), dating from the 1st half of the 5th millennium (Granados *et al*. 1991), Bòbila Madurell (no. 81), dating from the end of the 5th to the mid 4th millennium, and Camí de Can Grau (Martín M. *et al*. 1997) (no.15), dating from the 1st half of the 4th millennium, have been analyzed too. Garbage pits corresponding to the habitat of Bòbila Madurell (Bordas *et al*. 1993) have also been studied, where 46 sickle blades were found. Einkorn, emmer, naked wheat and barley were the cereals documented for this site. The open air site of Ca n'Isach (Tarrús *et al*. 1996),which is located very close to the northern coast of Catalonia, and has two archaeological levels, the older dating from the 5th millennium and the closest one dating from the 4th millennium, 45 sickle elements have been studied. Pollen analysis documented cereal cultivation in this site (Burjachs, 1990, cited in Tarrús *et al*. 1996). In the variscite mines of Can Tintorer (Villalba *et al.* 1986; Bosch and Estrada 1994) 9 sickle blades were found. Cereal remains consisted of naked barley, hulled barley, naked wheat and emmer.

In Provence, these sickle elements are present from the beginning of the 6th millennium to the 1st half of the 4th millennium. In the early Neolithic rock shelter site of Pendimoun (Alpes Maritimes), in a mountain context, two bladelets with parallel wear are present in the Impressa culture levels, dating from 6000-5500 BC, associated to emmer and naked barley. In the Cardial levels of Pendimoun, dating from 5600 – 5400 BC, 4 short fragments of bladelets with parallel wear are present, one of them bearing a micro-denticulated retouch. Associated cereal remains are naked wheat, naked barley and emmer (Binder *et al.* 1993). In the open air Cardial site of Le Baratin, In the Rhône Valley, near a marsh, dating from 5360 – 5080 BC, 4 blades have a wear resulting from a parallel insertion.

Sickle elements have been found in some sites dating from the 2nd half of the 5th millennium and the 1st half of the 4th millennium: the caves of Fontbregoua (Salernes, Var) and Grotte de l'Eglise supérieure (Baudinard, Var) and the open air sites of Giribaldi (Nice, Alpes Maritimes) and Chiris (Grasse, Alpes-Maritimes). The cave of Fontbregoua was used as a stable in the Middle Neolithic (Pré-Chasséen), in the levels dating from 4600-4300, one bifacial flake with traces showing parallel insertion has been analysed; associated cereals are naked wheat *(Triticum aestivum/durum and Triticum sp)* and, in lower quantity, naked barley *(Hordeum sp. Hordeum vulgare var. nudum)*. The open-air site of Giribaldi, dating from 4600-4200 BC, has been interpreted as a specialized site for intense craft production (mainly ceramic) (Gassin and Binder 2004). Many cereals were consumed: naked wheat, emmer, einkorn and naked barley. One blade shows the gloss in a clear parallel disposition; 3 other blades have probably the same kind of use, but they are fragmented or retouched for recycling and re-use. More sickle elements were found in the Chassey culture levels; most of them show a parallel use-wear. In the cave of Fontbregoua, (4000-3700 B.C.) three blade fragments have a parallel use-wear, but they are broken and the mode of insertion is not sure. Naked wheat was present in the site. In the Grotte de l'Eglise Supérieure, 17 sickle elements were analysed (Gassin 1996). One of them is complete and has a parallel insertion. Three other are broken blades or bladelets and could have the same insertion. At Chiris, 13 sickle elements have been found. They all have a parallel use-wear, but they are so badly damaged that the mode of insertion cannot possibly be inferred.

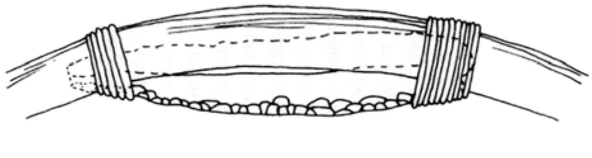

Fig. 7: Reconstruction of sickle blade inserted in a bended shaft (Gassin 1996).

Two sickle blades from L'Eglise and one from Chiris show a particular distribution of gloss. In all three cases the polish is more invasive in the medial zone of the edge, while in both ends it is marginal or simply absent. This distribution should correspond to sickle blades inserted in bended shafts (Fig. 7). One of the blades of L'Eglise and the one from Chiris bear the typical harvesting polish, while the other from L'Eglise show a heavy abrasion in the proximal area of the edge; this abrasion seems to be a voluntary modification of the edge. No information is available about the cereals used in these sites. Most of the sickle blades from these sites are shattered into small fragments showing a parallel wear, so it is impossible to distinguish between the insertion in a straight shaft and the insertion in a bended shaft.

Sickle blades with gloss parallel to the edge are documented at the site of Les Plots at the Early Chassey culture, during the 2nd half of the 5th millennium BC (Vaquer 1995). These unretouched, retouched or micro-denticulated blades, show typical harvesting polish, with a weak abrasive character (Philibert unpublished). This type of sickle coexists with another made out of big blades with gloss disposed in half moon along the edge, as we saw in some blades of L'Eglise and Chiris. Cultivated cereals were naked wheat and naked barley (Marinval unpublished).

In the middle Neolithic levels of Los Cascajos (Navarre), dating from the 2nd half of the 5th millennium, these types of elements are also present. Eleven blades show traces related to harvesting, with different degrees of abrasive component in their polish. Emmer, einkorn and barley were cultivated in this site (Peña-Chocarro and Zapata unpublished).

What was the morphology of the sickles in which these blades were inserted? The length of the blades and the distribution of sickle gloss, parallel to the edge, indicate that the blade was inserted in parallel to a straight shaft. That insertion could correspond to a simple harvesting knife, that is, a straight shaft with two different parts, one intended for handling and one designed for cutting. This harvesting knife might have been used to take the cereal bundles with the free hand and to cut the bundles with the knife. The problem of this harvesting system is that the working motion is quite discontinuous, since the stems have to be gathered before cutting. In fact, the advantage of the bended sickle is that it allows the worker to assemble the stems towards him before cutting the bundle with a sickle. The addition of a specific element to the harvesting knife, a transversal branch, could have been the solution to the problem of gathering the stems. In the lake site of La Draga, five complete sickles have been found so far (Bosch et al. 2005). Three of them show an "L" shape. The straight shaft has a proximal part intended for handling and a distal one to fix the flint blade in parallel, while the perpendicular branch was to be used for gathering the stems together (Fig. 8). Once the stems were assembled with this perpendicular branch, they were fixed with the free hand and they were cut off with the flint blade. This type of sickle, with a lateral branch for gathering the stems has been found in other sites of the Cortaillod culture as well (Schlichtherle 1992). We think that, probably, this was the type of sickle used in the Neolithic sites of Catalonia, Languedoc and Provence,

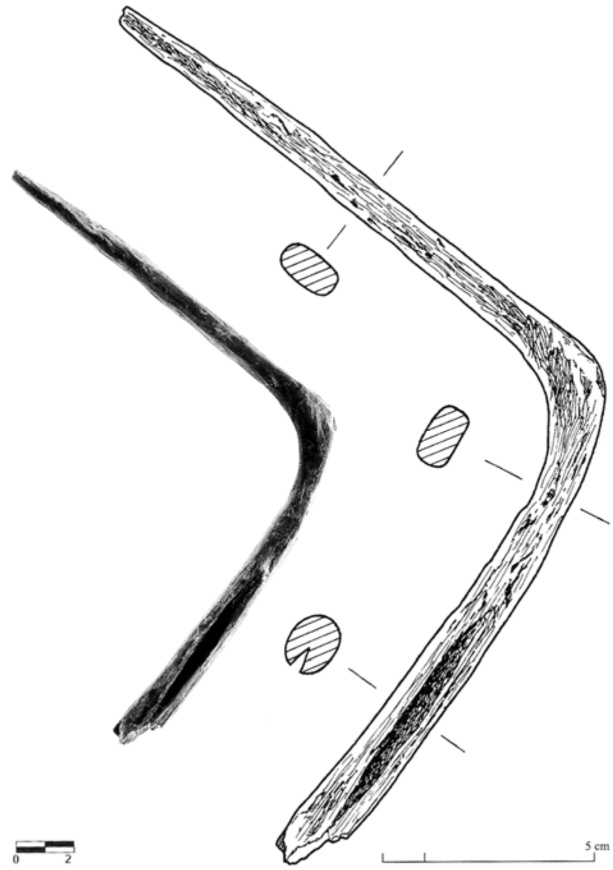

Fig. 8: Sickle with blade in parallel insertion recovered at La Draga (Bosch et al. 2000).

where blades with gloss in parallel to the edge were present.

The use-wear polish of these blades shows certain variability. In some of the blades we observe the typical harvesting polish (Fig. 9A), but other important group of tools show a clear abrasive component related to the plant polish (Fig. 9B). The abrasive component found in the tools is: round edge, deep and numerous striations and pitting. Most of the striations are parallel to the edge, showing the principal component of the motion of the tool, but we also documented oblique and transversal striations, especially near the edge. Thus, we observe some blades in which both the plant and the abrasive polish are interrelated, being the intensity and distribution of the abrasive component variable. Sometimes the abrasive component is limited to the mere edge, being less developed in the inner part of the edge. Other times it is restricted to one end of the edge, in which the abrasive component is progressively replaced by the plant polish, which is dominant in the other end of the edge. The observation of the micro-topography of the polish suggests that the abrasive component scratches the flat plant polish surface.

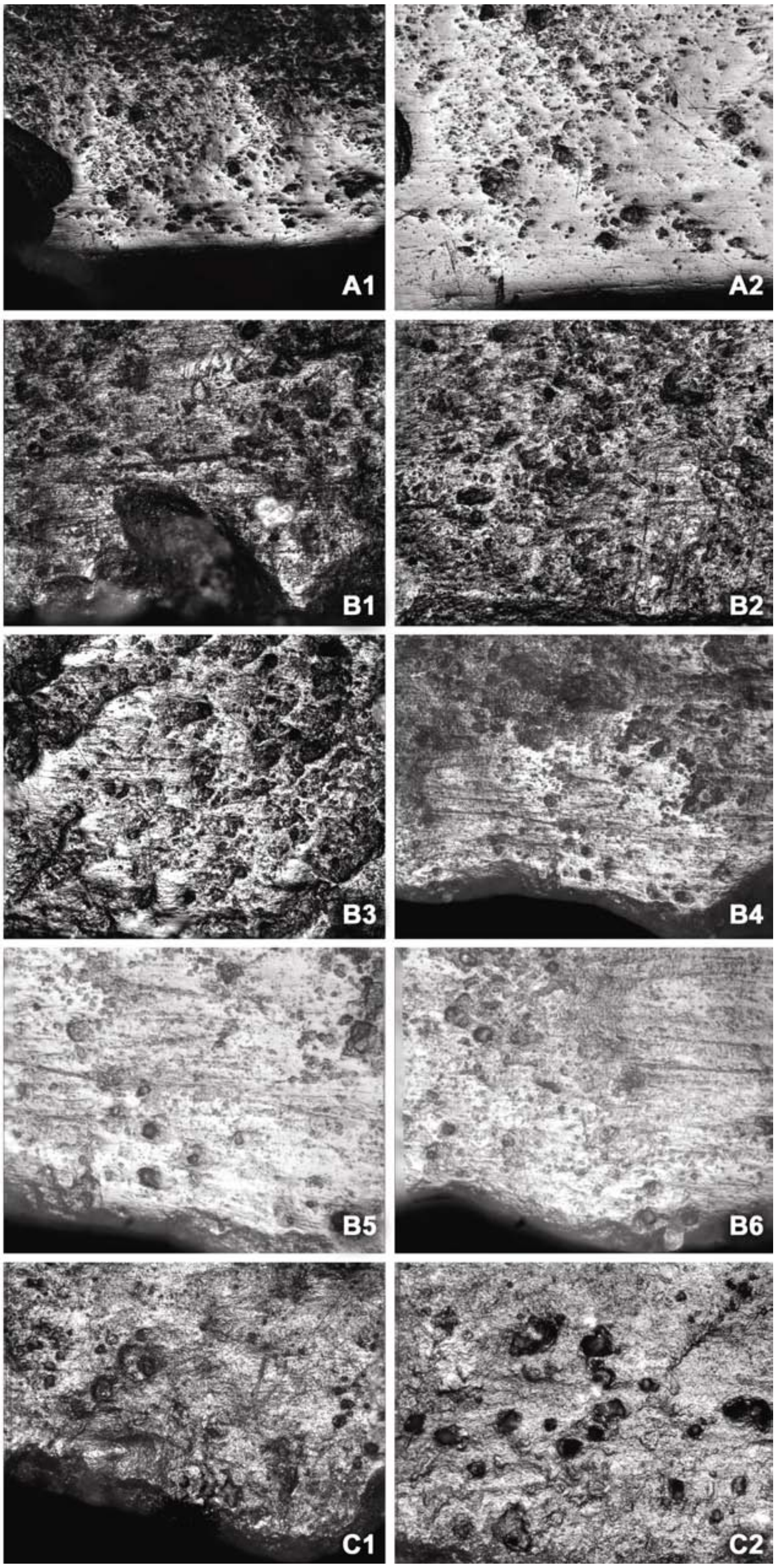

Fig. 9: Use-wear polish in the Middle Neolithic sickle blades from Los Cascajos. A: Typical harvesting polish: A1: LC98 (100x), A2: LC98 (200x). B: Plant polish with abrasive component: B1: LC217 (100x), B2: LC217 (100x), B3: LC217 (200x), B4: LC175 (100x), B5: LC175 (200x), B6 LC175 (200x). C: Abrasive polish: C1: LC404 (100x), C2: LC404 (200x).

The abrasive component of some harvesting tools was documented in use-wear studies quite early (Perlès and Vaughan 1983). It was first explained, as the recycling of harvesting tools for dry hide working. Afterwards, the phenomenon reached such an extension all over the Neolithic that a more general theory was needed to explain it. Some of us have experimentally developed how the abrasive component is generated by the contact of the tool with the ground (Clemente and Gibaja 1998). But, what for? It has been suggested that tools with similar traces could have been made part of a tribulum tool (Anderson 1992, 1998). However, this theory does not quite fit with our archaeological tools:

1. The morphology of the blades (usually long and narrow) is not the right one to be deeply inserted into the tribulum,
2. The amount of detected blades in the sites is quite short in comparison to the amount of blades needed for a tribulum;
3. Some tools show a differential distribution of the abrasive component along the edge, while we would expect more even traces along the edge in a *tribulum* wear;
4. The intensity of the traces, especially those of edge rounding and micropitting, is more developed in the ethnographic *tribulum* elements than in the archaeological hypothetical counterparts.

The contact of the tool with the sediment could have taken place when harvesting, if this activity was carried out very close to the ground. This contact could have also taken place after harvesting, when cutting the straw on the ground. Their goal might have been using the straw for different technical activities (actually, in certain Neolithic Swiss sites ears were stocked complete, showing part of the straw still attached to the basal rachis as the result of knife cutting (Maier 1999). The meaning of this abrasive component is not completely clear, but we think that the most probable explanation for such an erosion was the secondary use of the sickle blades in other technical activity as the cutting of the straw on the ground. It could explain the variability in the degree and position of the abrasive component along the active edge, just as the fact that the abrasion would alter the previous plant polish. Some blades only show the abrasive component and no typical plant polish (Fig. 9C). This can be easily explained by the unique use of the tool in the task of straw cutting on the ground.

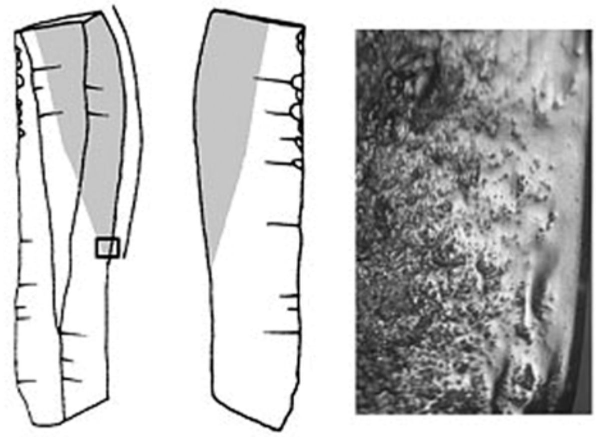

Fig. 10: Sickle with blade in oblique insertion recovered at La Draga (Bosch *et al*. 2000).

Despite most of the sickle elements in these 3 regions show the distribution and nature of use-wear polish that we have pointed out, in some sites, some other types of sickles are also present, although always in a minor proportion. Some of the sickle blades of La Draga, Lombard and Fontbregoua bear an oblique disposition gloss (Fig. 10). Lombard is an early Neolithic cave site, dating from 5300-4850 BC, only occupied for the summer when wild animals were hunted and meat was prepared. No cereal has been found whatsoever (Binder 1991). Fontbregoua is a cave used for shepherding; the oblique sickle element was found in the Chassey culture levels (1st half of the 4th millennium BC), associated to naked wheat.

The length of the blades found in these three sites indicates that they were inserted as unique cutting elements in the sickles. This type of insertion was also present in the site of Egolzwill 3, in the old Cortaillod culture, dating from the 2nd half of the 5th millennium (Schlichtherle 1992). This interpretation is reinforced by the complete sickles recovered in the lake site of La Draga (Bosch et al. 2005). The sickles consisted in a main straight shaft, in which a flint blade was obliquely inserted, and a branch which was transversal to the main shaft, that was used for gathering the cereal stems together when harvesting (Fig. 11). The sickle blades with oblique gloss coming from the 3 mentioned sites, show typical harvesting polish, without any abrasive component.

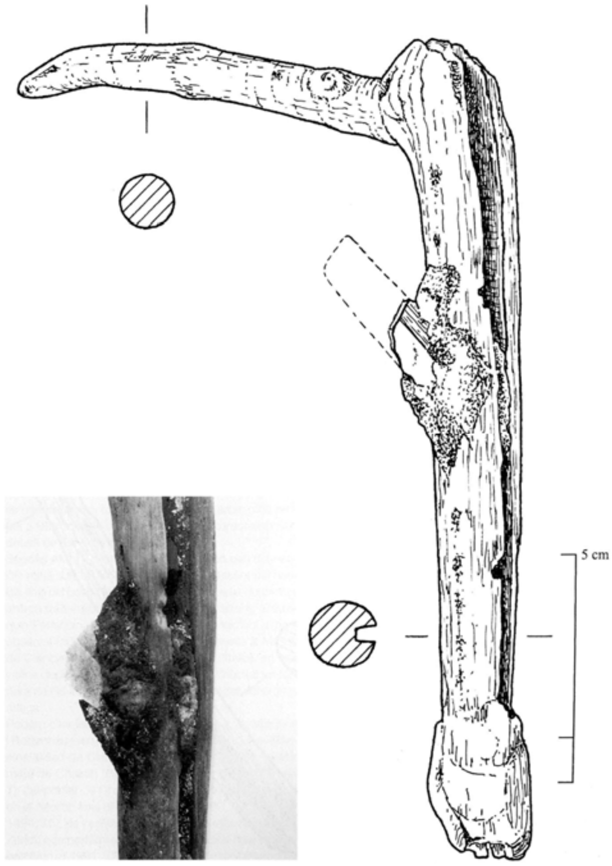

Fig. 11: Sickle blade with oblique gloss distribution from La Draga.

Harvesting without sickles in Cantabrian Spain

For the Cantabrian region the beginning of the Neolithic showed a certain delay with respect to the southern neighbour regions. The first proofs of cereal agriculture date from the end of the 5th millennium, in the sites of Kobaederra (Zapata 2002) and El Mirón (Peña-Chocarro and Zapata, unpublished). Moreover, the process of incorporation of the Neolithic way of living by the Cantabrian populations seems to be quite slow and progressive (González Urquijo et al. 1999). Wild resources (hunting and gathering) are more important than livestock and agriculture at least for 5 centuries approximately. The delay and progressive acceptance of the Neolithic is probably due to the fact that these Atlantic coastal environments are very rich in wild resources, allowing the hunting and gathering economy to be perpetuated. Indeed, these are humid and less insolated environments not making them proper for cereal growing.

Some authors have stressed the absence of sickle elements in the Cantabrian Neolithic, has been interpreted as a proof of the lack of agriculture. However, recent archeobotanical analysis (Zapata 2002) has demonstrated that cereals (emmer, naked wheat and barley) are present in some Neolithic sites as El Mirón, Lumentxa, Pico Ramos and Kobaederra. Our use-wear analysis of the lithic tools recovered in the sites of El Mirón, Kobaederra

Fig. 12: Harvesting einkorn by plant uprooting in Mokrisset (Northern Morocco).

Fig. 13: Harvesting spelt (*Triticum spelta*) with mesorias, in Zureda (Asturias, Spain).

and Pico Ramos has confirmed that sickle elements were not used in these sites. The existence of cereal remains and the lack of flint sickle elements indicate that another alternative method to harvesting with sickles was implemented (Ibáñez et al. 2001).

Alternative methods to sickle harvesting are ear plucking or plant uprooting (Fig. 12). Ear plucking can be applied when harvesting hulled wheat as the basal rachis of the ear is fragile. Ear plucking can be carried out by hand (Peña-Chocarro 1997) or by using a tool to snatch off the ears from the straw. For this activity, two wooden logs of around 50 cm, can be used. This tool is still in use in the Asturias for spelt harvesting (Fig. 13) and is called mesorias (Ortiz and Sigaut 1980; Peña-Chocarro 1996 and 1999). A similar tool is also documented in the Caucasus (Steensberg 1943; Sigaut 1978) and the Nepal (Toffin 1983). The uprooting method is documented by Plinius in the Roman period.

Trying to explain the variability

In our study of the harvesting methods during the Neolithic in SW Europe, we have detected three different geographical areas. The first one is SE Iberian Peninsula, where curved sickles with dented edges were in use. The second one spreads along the area of the Lyon Gulf, where sickles with straight insertions, and incidentally other types of sickles (with one oblique insertion or with parallel insertion in curved sickles) were preferred. Finally, we noted Cantabrian Spain, where alternative methods to the use of sickles were used.

Let us begin by dealing with the third case. Some regularities are present in our study of the ethnographic cases where ear plucking or plant uprooting were used. In all cases ear plucking and plant uprooting are preferred when the extension of the cultivated fields is limited. Other factors that could induce to the use of these methods are ecological conditions (humid mountain climates play in favour of these methods) or the scarce technical capability of the person who is harvesting (Ibáñez et al. 2001).

During the Neolithic, Cantabrian Spain shared similar features with the ethnographic places where alternative methods to sickle harvesting were used. Neolithic communities settled down in this environment with mountainous humid atmospheres. These people relied in wild resources very much being crops a minor part of daily subsistence. Thus, the extension of the fields was nor that important. Moreover, hulled wheat was the preferred crop, allowing the use of the ear plucking method, either by using a mesorias type of tool or just using their hands. Besides, in this humid environment, the harvesting season was quite long, making it possible to use slower harvesting methods. In fact, sickles allow the development of very quick systems of crop collection, although the post-harvesting activities are heavy duty tasks (threshing, winnowing, etc.). This method is adequate when extended cultivated surfaces must be harvested in a short period of time, especially in dry environments during the harvesting season.

Different types of sickles were used in the area of Catalonia, Languedoc, and Provence with respect to the Spanish Levantine coastal area. The differences in the characteristics of the use-wear polish indicate the way crop processing was also particular to each area. In the North, cereal bundles were probably processed by separating the ears from the straw. This activity must have been used to stock complete ears, which would improve the preservation of the crops in the regions where winters are more humid. When the need arose, these ears could be progressively converted into grain and then the grain into flour during the Autumn-Winter-Summer. This way of stocking the ears and processing the crops is well documented in the Neolithic sites in Switzerland (Maier, 1999). On the contrary, in the South of the Iberian Peninsula the crops must have been threshed and stocked in the form of grain. The use of both types of sickles in each area seems to begin with the appearance of the first farming communities in the two areas, during the 6th millennium, and it remains the same up to the 4th millennium. In this sense, we can speak about the existence of two technical traditions of cereal harvesting, as both are developed in two neighbouring regions during a parallel span of time.

In the site of Los Cascajos we have observed a shift in the technical tradition from the level dating from the 6th millennium with respect to the level dating from the mid 5th millennium. In the older level they would employ the southern sickle type. In the more recent level, the northern type of sickle would be used, and the processing of the crops by cutting the straw on the ground would be carried out. One should notice that this site is located in the Ebro valley, an area that could have been submitted to the cultural influence of both, NE and SE areas. It looks like if for the first Neolithic, the site was more related to the South, as far as harvesting technical tradition is concerned, while in the more recent levels the influence changed, being more related to the North-East.

Besides these two main technical traditions, associated to different types of sickles, we can distinguish the use of other types of sickles in the Catalonia-Languedoc-Provence area. Although the most common sickle in the North was made by inserting flint blades in parallel to the shaft, two other models have been documented in some sites. In La Draga, Lombard and Fontbregoua, isolated sickle blades were obliquely inserted to the shaft. This type of insertion has also been documented in the Swiss site of Egozlwill III (Schlichtherle 1992). We are dealing with two sites of the early Neolithic (La Draga and Lombard), dating from the end of the 6th millennium, and a mid Neolithic one (Fontbregoua) dating from mid 5th millennium. The oblique insertion of one blade seems to allow a deeper cutting capability compared to the straight one. Therefore, this type of insertion might have been used when cereal stems were too scattered. Another type of sickle used in the North was made by inserting flint blades in parallel to curved shafts. This type of blade was used in L'Eglise, Les Plots and Chiris, in a Chassey cultural context, dating from the 1st half of the 4th millennium BC.

Conclusions and perspectives

The variability in the harvesting technology put forward by the first Neolithic communities in SW Europe gives some information about the way in which agriculture was spread to these areas, as the conditions in which this early agriculture was carried out. The distribution in a map of the two main technical traditions shows a dichotomy between the northern and southern Mediterranean areas of SW Europe. These two technical traditions seem to be already present in the older Neolithic communities of both areas, and stay the same for more than one millennium. The site of Los Cascajos, which is in an intermediate area, seems to bear a southern influence for the older periods and a northern influence for the more recent ones. How could all these facts be explained?

If we accept, just as we established at the beginning of this paper, that agriculture technology must be tightly tied to the spread of seeds, then we could infer that this variability might be an indicator of two different origins of agriculture in the Iberian Peninsula and SE France. These two sources remained as two differentiated technical traditions for many centuries. If this were the case, the example of Los Cascajos could suggest that the southern focus was responsible for the spread of agriculture in inland Iberian Peninsula, but in the following centuries the dynamism of the northern focus influenced this area more intensively.

Another alternative or even complementary explanation would deal with the different ecological conditions of both regions or with differences in the most common types of harvested cereals. Maybe the dented edges are more suitable for cutting dry cereal stems. We have observed that a huge variety of cereals were cultivated both, the North and the South, and, at a first glimpse, there does not seem to exist big differences among them. However, this is a qualitative comparison and it could be crucial to evaluate the importance of every type of cereal in both areas.

For the time being, these ideas must be considered as hypothesis of research, as we need to study some more Neolithic sites. We have to gather some information on the harvesting techniques in Portugal and from inland Iberian Peninsula. We are going to develop these lines of explanation in our future research projects, taking into account other factors that could reinforce the definition and possible origin of these two technical traditions. Nevertheless, it is worth mentioning that the distribution of the different models of exploitation of animal resources in western Mediterranean areas during the Neolithic fits well with our model of two technical areas for agriculture (Vigne 1998). Catalonia, Languedoc and Provence constitute a region with similar use of animal resources in contrast with the regions to the South of the Ebro River in the Iberian Peninsula. Another matter to be developed in upcoming papers will be how a similar distribution of sickle morphology might have happened in the Italian Peninsula and the Alps. We assume the curved shaft with dented edges was restricted to the South (example from La Marmotta) and the straight ones with lateral branches spread to the North (Swiss examples).

Harvesting technology in Cantabrian Spain can be explained by the specific characteristics of the regional Neolithic. In a very rich natural environment the last groups of hunter gatherers maintained their way of living longer than in other areas of the Iberian Peninsula. When the Neolithic influences began to be accepted, at the end of the 5th millennium BC, local inhabitants very slowly changed their way of living, still relying on wild resources as a base for their subsistence. At the beginning, the Neolithic must have had a mosaic distribution, showing this way the coexistence of human groups at different levels of acculturation (see for example the contrast of the site of Arenaza with respect to Herriko Barra). This model of cultural change has already been established for other areas of the Atlantic Europe (Arias 1999). In all these areas the first agriculture does not show the use of sickles. We think that the marginal economical relevance of crops and the consequent small size of the fields could have allowed the use of technologies of low technical investment, specially bearing in mind that local humid environments permitted the extension of the harvesting season, and, therefore, the use of slower harvesting methods.

All in all, we have shown some of the complex cultural implications when trying to explain why a precise way of collecting crops was chosen. We would like to finish by stressing the preliminary nature of these reflections, still under research.

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Activities on 7 Early Neolithic houses belonging to Darion in Belgium. First results of lithic use-wear analysis

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Summary. *Darion-Colia, the first Belgian Rubané or Linien Pottery Culture site wich has been extensively and systematically excavated, has been subjected to an exhaustive spatial analysis; up to this point only its functional analysis (i.e. lithic) was pending. This paper relates to the in progress analysis of the lithic material found in pits located both inside and outside village dwellings of Darion.*

We have in our possession exhaustive data on village grounds up to and including the surrounding wall. The material we recovered was homogeneously scattered on most of the site and represents a valid sample that is typical of the late Rubané period in the area. Pottery remains have been arranged in series and reassembled in a way that suggests the unity of the site. The distribution of lithic material confirms the existence of living, grazing and craftsmanship areas. Plant remains made it possible to specify cleaning methods of cereals as well as their distribution on the original site. Research of greater scope allows us to connect it to chronologically and geographically similar sites (Jadin 2003).

Lithic material from one village area, especially from pits where stone cutting was done as well as from the backyard of three houses, has been first analyzed, at the traceological point of view (Caspar 1988). Types of worked matters and cutting techniques have been identified, which make it possible, through comparisons with other sites, to draw conclusions for the Rubané period.

The present use-wear analysis aims at validating some hypotheses concerning six houses located inside the village and at investigating three crucial areas: the two trapezoidal houses and their surroundings, what appears to be the site of three houses, and the area located at the south entry of the village. It also leads to a paleoethnographic analysis of which the objective is to link recovered material and identified work techniques to specific activities that are typical of the rubané period. In that perspective, it seems essential to determine the function of the pits located next to the houses. Many studies on Linien Pottery Culture or rubané houses deal with building methods and few mention hypotheses on the function of pits, waste disposal or functional relationships between different structures.

Résumé. *Darion-Colia, le premier site rubané belge à avoir connu des campagnes de fouilles extensives et systématiques, fait l'objet d'une analyse spatiale multi variée pour laquelle ne manque a ce jour que la dimension fonctionnelle, entre autre lithique. La présente communication porte sur l'analyse tracéologique en cours des matériels lithiques trouvés dans les fosses à l'intérieur et autour des maisons du village.*

Nous disposons en effet pour ce site, des données de terrain couvrant l'essentiel de l'espace intérieur du village et aussi de l'enceinte. Le matériel, récolté de façon homogène sur l'essentiel du site constitue un échantillon représentatif de la vie de ce petit village, exemple de la denière phase du Rubané dans la région. La céramique a déjà été l'objet d'une sériation. Les remontages des vases garantissent l'unité du site. La répartition de l'industrie lithique confirme l'existence d'aires d'habitat, de pâturage et d'activités artisanales. Les macro restes végétaux ont permis de préciser les méthodes de nettoiement des céréales et d'en localiser la mise en oeuvre sur le site. Une étude plus générale met en rapport ce site avec d'autres du même contexte chronologique et géographique (Jadin, 1999).

Une première analyse tracéologique (Caspar, 1988) a porté sur le matériel lithique d'un secteur du village, notamment de quelques fosses de la zone où se concentre la taille lithique et de la zone arrière de trois des maisons. L'auteur a déterminé des matières travaillées et des gestes en relation avec différents types d'outil, ce qui lui a permis, grâce à des comparaisons, de généraliser des conclusions pour le Rubané.

L'étude des traces d'usure actuelle, cherche a valider quelques hypothèses pour les zones fouillées, ce qui concerne à six maisons situées à l'intérieur du village et en concret à trois secteurs cruciaux : l'environnement des deux maisons en trapèze, les trois maisons supposées et l'espace d'entrée sud du village. L'objectif est aussi de dégager les activités associées aux matériaux et gestes identifiés ainsi qu'à d'autres marqueurs.

Les données présentées dans cette communication concernent les analyses des aires plus proches des maisons et visent à identifier la fonction de ces fosses et leur rapport entre les différentes maisons.

Key words: Rubanè culture, lithics, use-wear analysis, spatial analysis.

Introduction

Darion-Colia is a fortified village of the Late Rubané, located in the Hesbaye region (Geer, Province of Lieja, Belgium), where several fieldwork campaigns have been carried out from 1981 to 1985. The site has been completely destroyed in order to construct two pools to decant the water used by a local sugar company, which caused a necessary rescue campaign carried out in 1989.

The site is located on a hill of smooth slope, just in the confluence between the river Geer and its main tributary, the Faux Geer or the Omal Stream. The Neolithic occupation extends to the north and west on the top of the ridge and on the south-eastern slope towards the Faux Geer.

Darion-Colia is one of the first sites of the Belgian Rubané, where extensive and systematic fieldwork campaigns have been carried out. The study of this site

Fig. 1: Trapezoidal house.

Fig. 2: Debris of flint debitage into a pit.

has included a spatial multivariant analysis, to which an updated functional study is now added.

It is a small village, with no more than 2 Ha of surface and bordered by a fortification. This one is made by a double discontinuous moat with an inner palisade, and it is crossed by four bigger accesses, which are located in the four cardinal points. These accesses are carefully defended by a fence system, some of them in a zigzag arrangement.

The seven identified houses are located in the south area. One of them (M7), partially preserved, is outside the area, near the entrance, whereas the other ones are inside it. In four of the houses most of the pole pits are well preserved; on the other three houses have been identified thanks to the pole alignments. Houses M2, M3, M4 (and probably M6) have a trapezium-shaped plant. Another pole alignment has been identified in the village, but its meaning or function remains still unknown.

The northern side of the site, where no structures have been documented, seems to have been aimed to pasture and other activities, such as flint knapping, since there is a concentration of pits in this area, containing thousands of lithic debitage. Bone remains are not preserved because of the sediment nature.

Several researchers from different disciplines carried out studies in Darion-Colia: D. Cahen, I. Jadin and P. Jardón Giner, for general studies of the site, lithics, technology, radiocarbon dating and functional analyses; P.L. van Berg, for pottery and potters in general; J. P. Caspar and P. Jardón Giner for lithic use-wear analysis; J. Heim for carpology and palinology; R. Langohr and J Sanders for pedology; Fr. Damblon and Chr. Buydens for charcoal analysis, and so on.

The current use-wear analysis is focused on the lithic tools recovered in the pits documented inside and around the houses of the village. In this site, the record mainly covers the inner part of the village and the area occupied by the fortification itself.

The archaeological materials, systematically recovered, constitute a representative sample of the life in this small village during the last phase of Rubané culture in the region. In calibrated radiometric dates, Darion-*Colia* occupation develops at c. 5000 BC. There is no archaeological evidence of the existence of more than one phase of occupation.

Spatial distribution of the remains in the site and lithic knapping economy

The refitting of pottery fragments has shown the temporary unity of the site. The fine pottery of Darion includes 751 individual vases, belonging to 110 different pits, and it seems to point out to a foreign stocking up, in contrast to the site of Oleye, where evidences of a local pottery production have been documented.

The distribution of lithic tools confirms the presence of different areas for habitat, pasture and artisan works.

The vegetal macro-remains have allowed the documentation of certain methods of cereal cleaning and the places where this activity was carried out.

In Darion, there are evidences of intensive knapping activities in a non-built area (in the north), earmarked to artisan works and pastoral activities. Just over five pits concentrate the 75% of flint lithic tools. They show all the stages of the *chaîne opératoire*: specialized production of blades, intensive knapping carried out in a specific area of the site, independent of the rooms, which produces a big amount of lithic debitage and a particularly high number of non retouched blades, both completed or fragmented. There, the first stage of the *chaîne opératoire* has been documented: the cortex removal and the core shaping. The massive appearance of lithic debitage and its preferential location show the specialized nature of one sort of flint knapping, focused on the exportation of blank, coexisting with another kind of knapping that could be labelled as domestic. The lithic debitage from Darion comprise a high number of non-used blades, both completed or fragmented, which do not seem to be the result wanted or they are out of the aimed

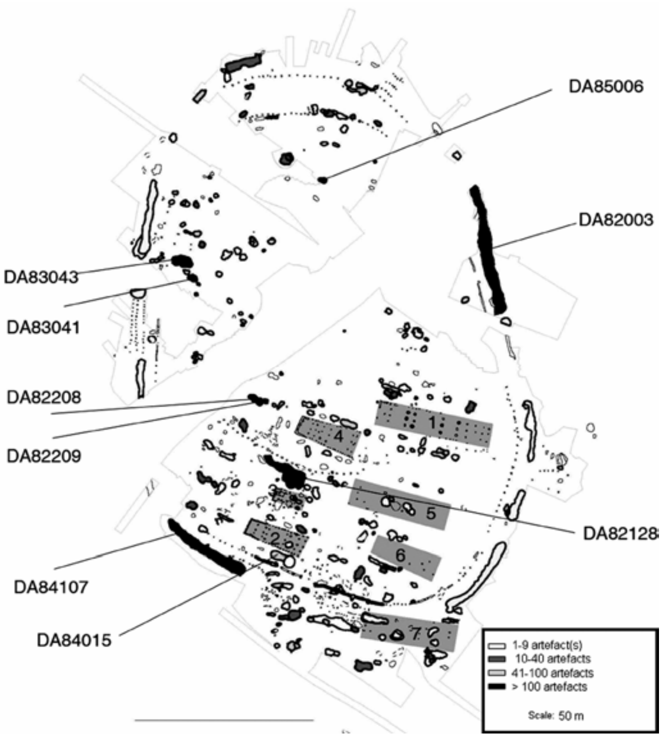


Fig. 3: Distribution of non retouched blades and numbers of pits cited on text.

Fig. 4: Tools distribution and numbers of pits analysed.

dimensional model. The importance of the flake tools in Darion comes from an opportunistic valuation of the non-standardized random blanks among the lithic debitage.

A significant presence of tools has been documented in the concentrations of the knapping areas (338 pieces among 1396 tools recovered in the site, were found in the knapping area). The first use-wear analysis by J.P. Caspar was carried out in the area which had been excavated still: the pits of the area, in which knapping activities are concentrated, and in the rear area of three of the houses. The results show worked materials and some actions related to different kind of tools. After his study, the fieldwork mainly continues with the houses area and two *chaîne opératoire* have been identified in the village: a surplus production of blades recovered in the no-built area, or artisan work area, destined for exportation, and certain retouched blades and flakes that characterize the domestic knapping, near the houses.

More than half of the cores are of *frites* and only one of every two tools is made on a blade. The debris of blades knapping is restricted to the uninhabited area of the village, whereas in the houses area finished products and cores reused as hammer predominate. The cores knapping on flakes appear everywhere in the habitat and it seems to be the only knapping method performed around the houses.

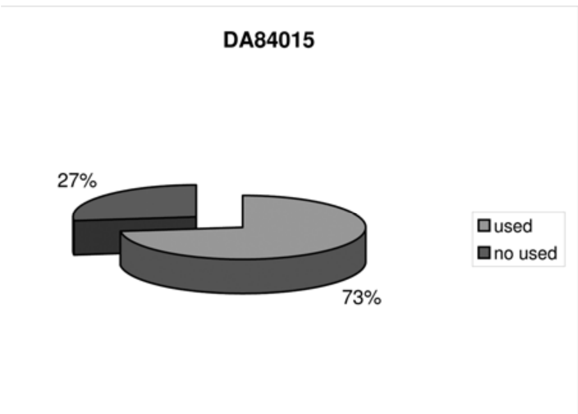
As for raw materials, a single kind of flint predominates.

A big amount and variety of flake tools of no-standardized shape has been documented: denticulated, notch, scaled pieces...

The distribution of preserved remains shows the following patterns:

- Some structures differ from the others because they contain a big amount of lithic and ceramic remains: two areas of the moat (84107 and 82003), a big pit in the village centre, next to the poles alignment, which seems to subdivide the habitat area (82128), two pits behind House 4 (82208 and 82209) and three pits in the artisan knapping area (83043, 83041 and 85006).
- The pits located inside the houses contain less than 10 lithic tools.

Fig. 5: Distribution of pottery.



Graphic 1		
used	89	73%
no used	33	27%
total	122	

Fig. 6: Proportion of used and non used lithic artefacts into the DA84015 pit.

- The pits located in both sides of the houses contain about 40 lithic pieces.
- Comparing the distribution of retouched pieces and sickle elements with that of the blades, and before the use-wear analysis, the following regularities can be observed:
- Two inner pits (82209 and 82128) and an outer one (82003) contain a high amount of retouched tools and blades.
- The southern moat (84107) and the pits in the artisan work area (83043, 83041), as well as the little pits behind the House 4 (82208) contain less retouched pieces.

Objectives

The current study aims to identify the functionality of the inner areas of the village, near the houses: the function of the pits and the relationships among houses.

The functional analyses carried out by J.P Caspar were mainly focused in the areas located far from domestic spaces, except the big pit behind the House 4. His analysis includes: pits from the artisan work sector and the outside eastern moat, having identified the features of the houses in subsequent fieldworks campaigns. The conclusions of his study offer information about the relationship between typology and functionality and also about the economy of raw materials. It has been confirmed that the lithic debitage were not used in workshop contexts, but where detritus appeared (up to 40%).

The analysis present has the following objectives:

- To distinguish the functionality of the different pits, including those next to the houses, and their relationship with the built features.
- To set an interpretative model about waste arrangement in the village, comparing the treatment given to the lithic debitage and to the rest of the wastes, as well.
- To check if there are areas of activity or specialized structures.

At the same time, we have begun documenting the patterns of behaviour regarding detritus in prehistoric and ethnographic villages, since in some Neolithic sites pits with a domestic use for detritus has been documented near the houses, related with the existence of openings, different from the main entrance: side doors or windows.

Graphic 2		
used	64	79%
no used	17	21%
total	81	

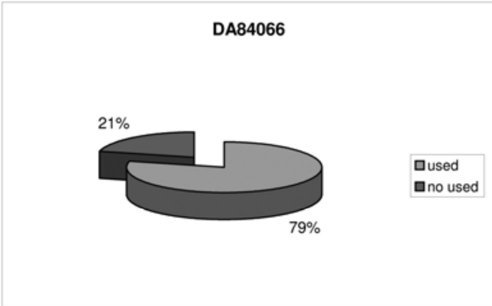


Fig. 7: Proportion of used and non used lithic artefacts into DA 84066 pit.

Graphic 3		
worked materials		
cereals	4	6%
hide	16	24%
wood	12	18%
wood/hide	4	6%
wood/bone	1	2%
wood/veget	3	5%
hard materi	5	8%
indetermina	19	29%
meat/burch	1	2%
pottery	1	2%
total	66	

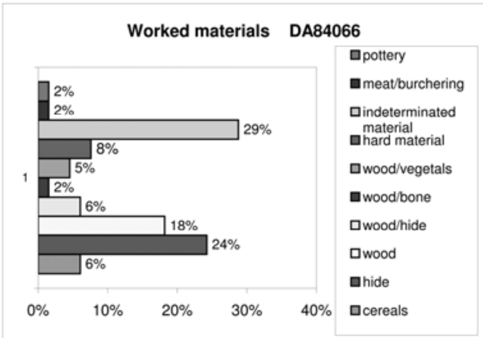


Fig. 8: Proportions of worked materials by the artefacts into DA 84066 pit.

Graphic 4		
worked materials		
cereals	4%	5
hide	16%	19
wood	16%	19
wood/hide	3%	4
wood/bone	3%	4
wood/veget	4%	5
hard materi	7%	8
indetermina	17%	20
meat	1%	1
pottery/soil	2%	2
antler	7%	8
soft materia	6%	7
bone	4%	5
others	8%	9
	100%	116

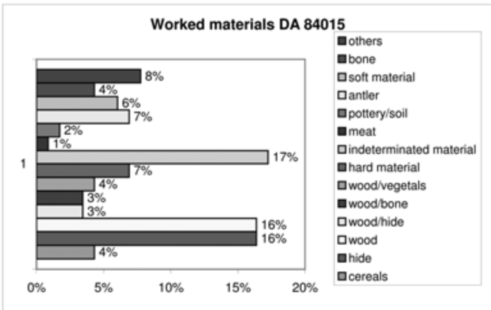


Fig. 9: Proportions of worked materials by the artefacts into DA 84015 pit.

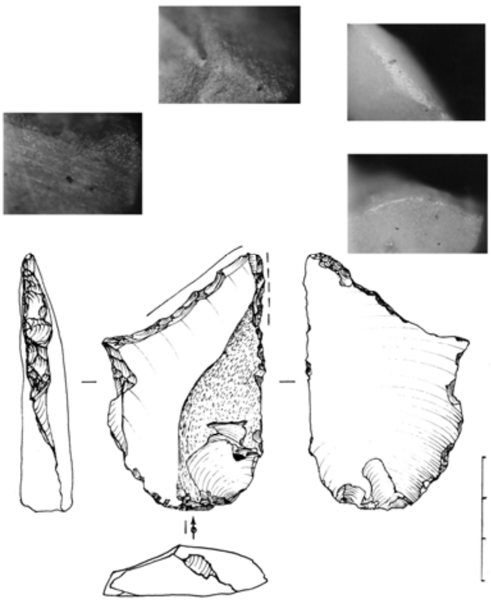


Fig. 10: Multi-purpose flake tool for wood working. Lateral side have scraping traces and distal denticulated side present striations and polish produced by cutting wood. Da 82260.

Methodology

The selected sample for the analysis includes, remains from all the pits with lithic materials located around and inside the houses, except splinters. It consists of 1193 artefacts. The first part of this study refers approximately to half of the collection. The functional analysis is based on the observation of use-wear in the lithic tools by exploring the surface, edges and cutting edges through a binocular magnifying glass (up to 40 magnifications) and through a metallurgical microscope (from 50 to 400 magnifications). The first observation aims to identify jagging, erosion and grooves, and relate them to the morphological context of the pieces, in order to postulate functional hypotheses.

Later, the hypotheses are checked with experimental material, previously prepared, and, when necessary, specific experimentation with reproductions of the identified tools is made.

After the use-wear observation of some lithic tools, we were interested on certain processes of production of vegetal fibres. At the moment, we have not succeeded in relating these actions to concrete *chaîne opératoire*, so we are preparing a specific experimentation.

Results

So far, our study has been focussed on the pits related to the House 2: one of them located inside the house (Da82260), containing 8 lithic tools, and two other ones located on both sides of the same house (Da 84015 and Da 84066).

Comparing the results of the use-wear analysis carried out on the materials located next to this house and the results from other areas further from the structures identified as houses (Caspar 1988), it is remarkable that a higher percentage of used tools appear in the pits next to the houses. Two thirds of the artefacts recovered in this area present use-wear marks. Seven out of the eight tools from the pit in the house have been used.

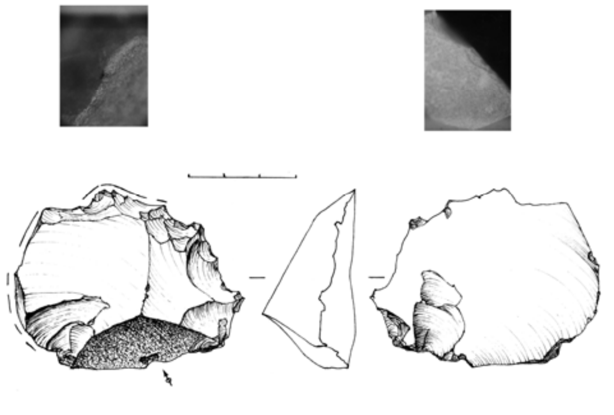


Fig. 11: Flake used as chisel.

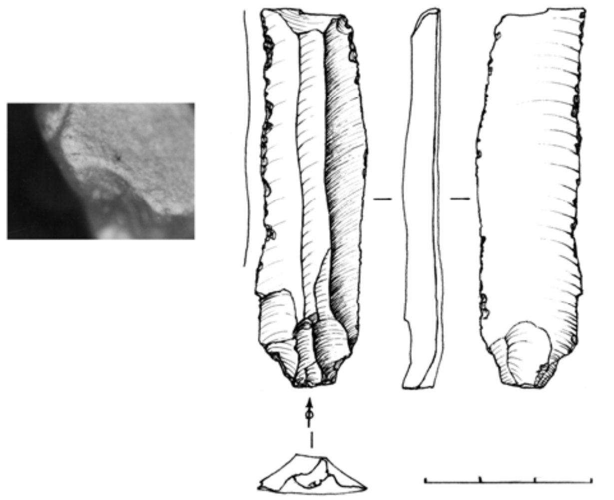


Fig. 12: Blade used for cutting an abrasive material like hide with left lateral. Da 84066, D, 0-10 cm, Near house 2.

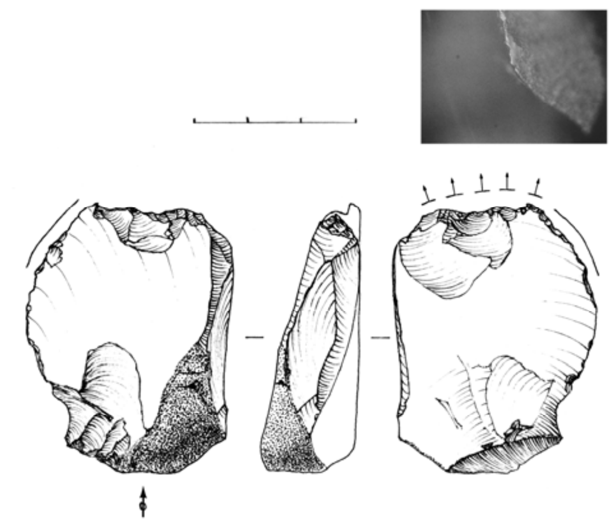


Fig. 13: Polish produced by scraping bone at a flake.Da 84066, carré C, -10-20 cm.

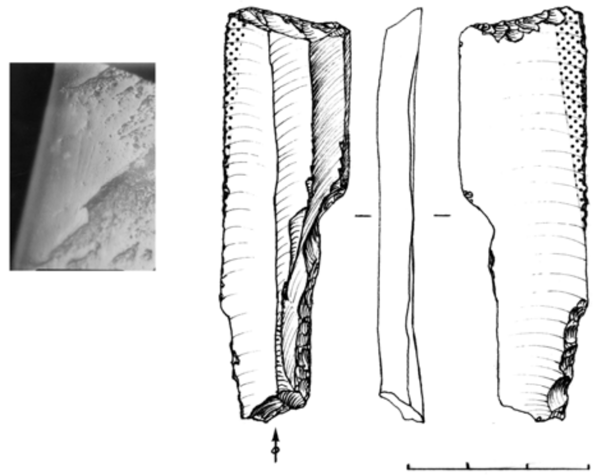


Fig. 14: Sickle. Da 84066, carré A, -20-30 cm.

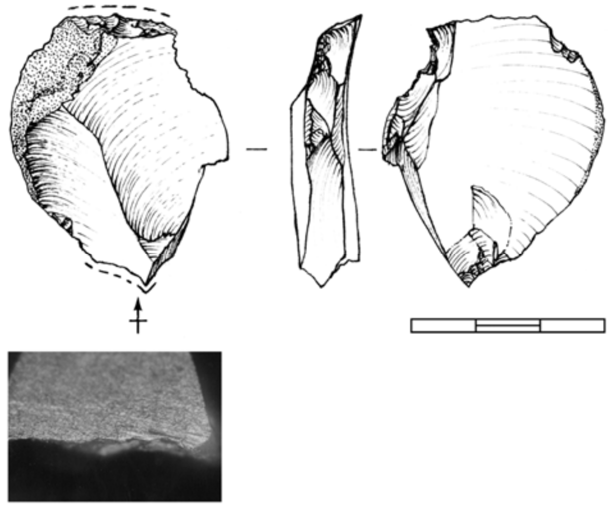


Fig. 15: Use-wear produced by grooving antler at the ventral face of a flake. Da 84015, carré A, -40-10 cm. Polish and striation.

As for the kind and intensity of the use, we have documented that a lot of tools have been intensely used, sometimes even for working on several materials.

The most frequently worked materials are animal skin and wood, although we would like to clarify that the work on these materials produces more intense use-wear marks and they are better preserved.

One of the two outer pits is related to a well (I. Jadin). All kind of activities and worked materials are present in both of them. Animal skin and woodworking predominates, but in the second pit we have found a higher number of tools used for working on hard animal materials and fragments of tools.

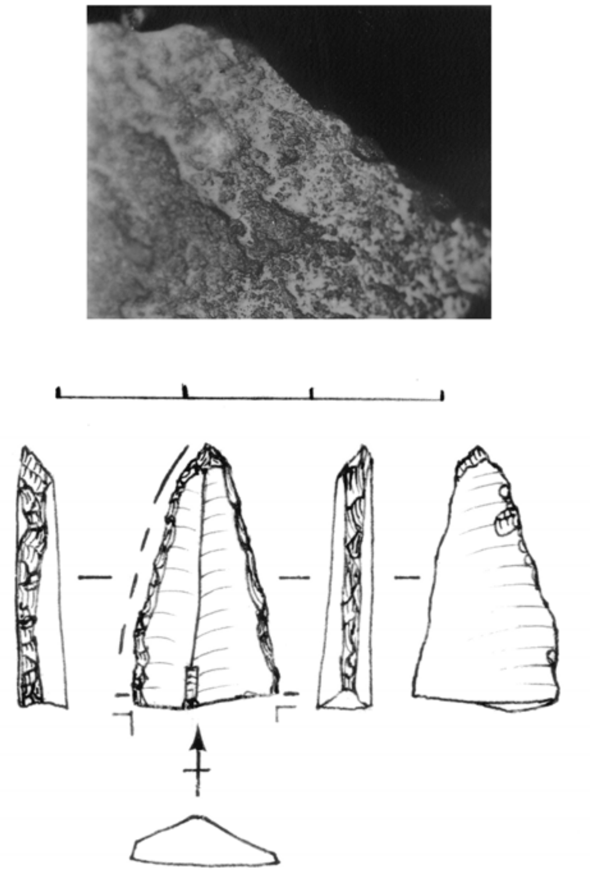


Fig. 16: Wear of piercing wood over the ventral face of a piercer. Da 85/84015 puits. Polish.

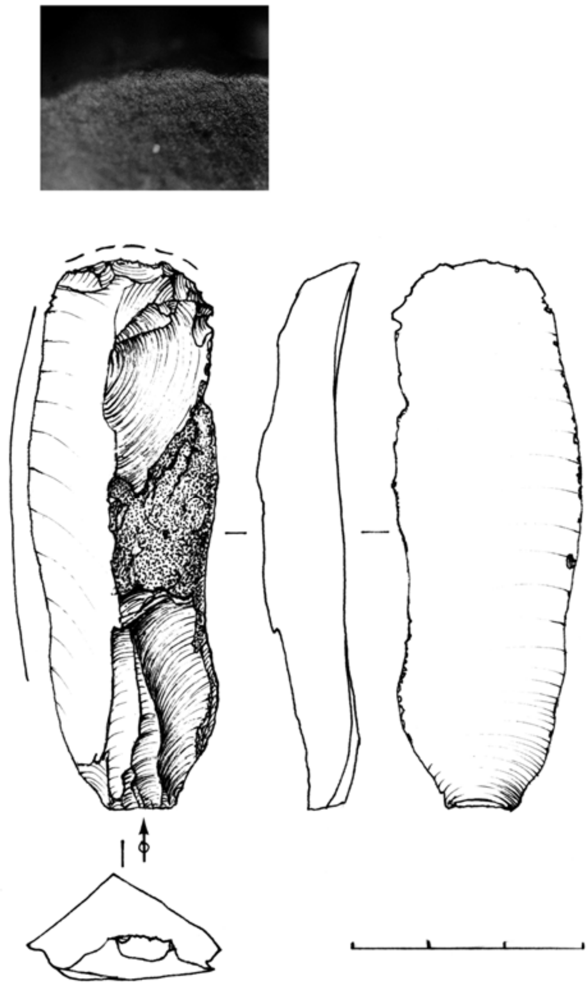


Fig. 17: End scraper used for scraping hide with front and for cutting wood with the left lateral margin. Da 84066, D, 0-10 cm**.**

Discussion and conclusions

The first objective of this study is the palaeo-ethnographic reconstruction. For this task, after determining the influence of post-depositional processes, it is necessary to analyse the distribution of the remains, the structures and the artefacts and their relationships (Djindjian 1994).

After the identification of the existing structures and the analysis of the distribution of the different categories of remains (Jadin 2003) we began a discussion about the patterns of occupation and use of the inner space of the village, with the results of the use-wear analysis. The conclusions we present are still preliminary, due to the limits of the studied ensemble, but they try to guide the current analysis.

The distribution of the lithic remains could be related to both the areas of use and the areas in which detritus was found. For this reason it is very important to determine if the areas where lithic materials are accumulated are the same ones where other materials were abandoned: bones, ceramics, etc.

In Darion-Colia, the acidity of soil has not allowed the bones preservation, so we are deprived of the information necessary to identify the domestic rubbish. Nevertheless, the survey about distribution of animal remains carried out in Cuiry-les-Chaudardes (Hachem 1994), seems to show the same behaviour between lithic debitage and bone wastes, both of them concentrated in pits beside the houses. In this village, there seems to be a preference for dumping in one of the sides of the houses. It seems to be different in Darion, where we find similar concentrations in both sides of the houses.

There are parallels with Jablines "La pente de Croupeton" and some lacustrine villages when we analyse other distribution features: the front side of the houses and a great part of the inner space are especially poor, while waste concentrations are located on both sides and behind the houses (Lanchon *et al.* 1994).

In some zones of the village, habitat, lithic knapping and plant management areas have been identified. The pits analysed in this site seem to collect the wastes of activities carried out in the houses, because it is not possible to differentiate the content in tools and the materials worked with lithic artefacts coming from the pits inside and outside the houses.

The use-wear analysis of the pits next to the other six houses in Darion-Colia can offer some interesting information about the existence or lack of areas of specialized work in the village.

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Looking for prehistoric basketry and cordage using inorganic remains: the evidence from stone tools

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Summary. *Prehistoric basketry and cordage are rare finds but wear traces on archaeological flint tools can be used to indicate such activities. Experiments using a range of soft plant materials suitable for making basketry and cordage were conducted using plain and serrated flint edges. The tool edges were chosen because of known archaeological Neolithic pieces which have wood and plant wear traces. All the experiments were informed by a professional basketmaker who worked closely with the project and advised on season of harvesting, tools needed and the processing techniques for different plant-types and products. The experimental wear traces are summarised and compared with Neolithic wear traces from the tools found near the Neolithic Sweet Track, Somerset (a wetland area of Britain) to show that some of the archaeological pieces closely match wear traces from working soft plants and willow traditionally used for basketry and cordage production.*

Résumé. *Au temps préhistorique, les examples de vannerie et cordage sont rares, mais il y a une autre méthode d' établir ces industries - la tracéologie des outils en silex. L'effectuation d'expériments sur plusieurs éspèces de plantes souples bien connu pour faire la vannerie et le cordage, et utilisant des outils au bords droits et microdenticulés. Les types d'outils sont choisis parce qu'il y a des pièces néolithiques avec les microtraces de 'plante' et 'bois'. Toutes les experiments bénéficient de l'avis d'un vannier professionel qui connait la saison de récolte, les outils necessaires, et les processus pour les éspèces de plantes et les types d'objects. Les microtraces expérimentales sont résumées et on a fait des comparison avec les microtraces observées aux outils néolithiques venant du Sweet Track, Somerset (un milieu humide en Angleterre) pour montrer plusieurs bonnes adéquations entre les microtraces archaéologiques et les microtraces experimentales.*

Key words: plants, wear traces, polish, basketry, cordage, ethnography, traditional crafts, Neolithic tools, serrated flakes, micro-denticulates.

Introduction

Organic material culture rarely survives in the archaeological record yet ethnographic analogies show this craft sphere is likely to be very rich with different functional and cultural styles (Barber 1991; Bernick 1998; Mowat *et al.* 1992). Wear traces are an important means of studying organic material culture production and many analysts contribute to or initiate such research projects (e.g. see Aranguren *et al*. and Beyries *et al.* this volume). Prehistoric basketry and cordage are especially difficult to study because there are so few surviving examples, though more finds are accumulating (e.g. Adovasio *et al*. 1996; Bender-Jørgensen 1986; Bennike *et al*. 1986; Coles 1992; Coles and Coles 1989; Rogers 1994; Spindler 1995). It is timely to study the technologies and decorative styles of basketry and cordage, but even so, the finds from any one area are often too few to be able to draw cultural conclusions. However, the scarce prehistoric remains of baskets and cordage and the sometimes biased environmental evidence (Bradshaw *et al.* 1981) could be supplemented by considering inorganic materials in a novel way. Thus the basketry and cordage project at Exeter University focuses on the use of *inorganic* artefacts to study basketry and cordage. It has long been recognized that pottery can be decorated by deliberately impressing cord into the surface, and there are also chance impressions of mats and cords (Hurley 1979; Liddell 1929; Semenov 1955, translation 2005). Furthermore, it is now recognised that some pots are skeuomorphically decorated to imitate basketry (Knappett 2002; Manby 1995). Plants are likely to be cut and processed with the aid of flint tools. Certainly, some plant wear traces on flint tools can be interpreted as basketry and fibre production tasks rather than food-gathering activities, and usewear researchers have for some time been concerned to illuminate plant processing activities as a wide material culture phenomenon and part of complex craft activities (e.g. Van Gijn 1990, 1998a&b; Hurcombe 1992, pp.79-94, 1994a&b, 2000a&b; Juel Jensen 1994; Owen 1998, 1999, 2000). It is the lithic evidence aspect of the overall project which is reported here. Evidence from lithic usewear traces, experiments and ethno-analogy were combined and supplemented throughout by interaction with a basketmaker. The experimental results and insights were then used to reassess some Neolithic archaeological tools identified in a previous wear study as 'wood' and 'reed' working tools (Morris 1984).

Craft specialist and archaeologist interaction

Linda Lemieux is a professional basketmaker who has learnt basketry traditions in Ireland, Scotland, England, France and Cameroon with exhibitions at craft shows and in museums. She works with willow, rush and hedgerow material, harvesting and preparing all her own materials. She has her own willow beds and manages a section of riverbed in Somerset for harvesting rushes and sedges (Figs. 1a and d). She was an invaluable source of information on suitable plant species and their harvesting and processing techniques and she provided samples of plants and technologies, all of which formed a set of reference material for conducting experiments and interpreting archaeological evidence. She knew the tasks required (growing, harvesting, drying, soaking, preparing, making) and advised us where stone (or other) tools would be essential vs optional and we gave her stone tools to use and obtained her comments and insights on their performance for basketry/cordage related tasks (edge shapes, edge angles, hafting and balance issues, length of the cutting edge, stone vs metal).

For willow harvesting she preferred longer cutting edges and hafted tools or at least heavier tools that were easy to hold in the hand. Despite having very strong hands she found small tools too difficult to both grip and also apply force. She felt that a good resting place for a leading index finger to apply pressure was essential. A concave cutting edge was included to see if this edge shape was preferred: the tip broke off after cutting 80 stems suggesting that this area of the tool was indeed well-used and subject to strong forces. In contrast to the traditional image of a sickle as a curved wooden haft extending slightly beyond the inset flint cutting edge, her ideas about keeping the cutting edge clear of the handle (see also Juel Jensen 1994, pp.79-83) led us to experiment with end-hafted tools. Figure 1b illustrates some of these tools; i) was an attempt to keep the cutting edge clear of the haft end but still provide an L-shaped backstop for the flint; ii) was an end-hafted tool fixed in place with only 50% beeswax and 50% pine resin applied around a cordage wrapping, and with bark still on the haft as LL felt this was smoother to hold, - surprisingly, the flint stayed in the haft despite the forceful use-actions; iii) was a small awl with a nock in the haft for applying thumb pressure which proved a useful aspect. She agreed with preconceived ideas that cutting edge angles for harvesting tools should be neither too large or small, although she also pointed out that fine trimming of some plant ends and shaving and slanting (in basketry terms 'slyping') activities could be carried out with more delicate flint edges. From a usewear perspective it might be hard to 'see' such trimming rather than harvesting basketry tools as the overall contact time might be too short to leave distinctive traces. The stone tools with good angles worked effectively for cutting 100-120 cm high willow stems near the base where there was less vibration as the stem was cut. This size stem or larger could have been harvested using polished stone axes but much depends on whether the stem can be cleanly detached. Even metal axes can bounce off the springy stems. Pollarding (where the willow shoots are harvested off of a trunk well away from the ground) rather than coppicing (harvesting at ground level) might have affected such issues, but a sharp handheld flake tool will always cut cleanly and precisely. LL had some concerns that uneven or ragged cuts might affect re-growth or leave the plant open to disease. Since these willow beds were part of her livelihood this was obviously a cause for concern and she took considerable care that the cut should be neat as part of part of the husbandry of resources.

Linda Lemieux and a wide range of written sources (e.g. Atzori 1980; Adovasio 1979; Aranguren and Revedin 2001; Aranguren *et al*. 2004; Burton 1891; Densmore 1974; Dreyer *et al*. 1996; Dunsmore 1985; Earwood 1998; Florance 1962; Gabriel and Goymer 1991; Gallinger and Benson 1975; Gillooly 1992; Hall 1989; Kuoni 1981; Latz and Stewart 1973, Maynard 1989, Peabody Turnbaugh 1986, Richardson 1989, Robinson 1954, Stephenson 1977, Wright 1983; Zola and Gott 1992) described the variety of plants available for basketry and cordage and for other purposes such as thatch (well over 200 species are named in some basketry books). All sources confirmed that season of harvest, processing techniques and suitability for intended purpose were important and that the terms 'rush' and 'reed' are commonly misapplied. The English word 'reeds' is most often referring to *Phragmites*, but can also be used for reed mace *Typha* sp. and, though inaccurate, for rushes such as *Scirpus lacustris.* Linda Lemieux (LL) was adamant that the term 'rush' should be restricted to round stemmed water-loving plants e.g. *Scirpus lacustris*. There is an English rhyme describing terms for this range of plants *'Sedges have edges and rushes are round, true reeds are found where water abounds*' but often the term 'reeds' is used for all of these types of plants. Thus when wear experiments with 'reeds' are reported without a further species description, it is difficult to establish precisely what plants might be being cut and how silica-rich these might be. Furthermore, the intended purpose affects both the season of harvest and whether the cut is made above or below water, all factors which will affect the wear traces. LL's knowledge of plant usage and harvesting details confirmed that soft plants used for basketry/cordage, generally require strength and length. They are harvested towards the end of their growing season, but before the plants deteriorate with the weather. Plants growing in water are generally more accessible when the water levels are low in a dry period. Also harvested plants intended for later use can be stored if dry, so a period of good weather after harvest is essential. All these aspects favour a Summer harvest. In contrast, willow is best harvested before it comes into leaf e.g. March. *Phragmites* stems are excellent as a traditional thatching material, for which tensile strength is not required, nor are the side leaves. They are thus harvested in Winter as yellowed skeletons of the main stem without leaves.

Using LL's knowledge and access to resources a new set of experiments were conducted that adopted a task-oriented approach ie. species selection, harvest season and style of cutting were all related to intended usage for basketry and cordage production.

Experiments with plants suitable for basketry and cordage production

The aims of the experimental programme were to investigate the wear traces left by cutting soft plants suitable for use in basketry and cordage production in order to make comparisons with archaeological flint tools with plant polishes. The experiments focussed on a limited range of 'soft plant' materials known from the practical knowledge of LL and research (see discussion and references in Hurcombe 2001) to be suitable for craft purposes. The species chosen were; *Uritica dioica* (bast fibres for cordage and textiles), *Scirpus lacustris* (whole plant for basketry), *Iris pseudacorus* (leaves for cordage/basketry), *Salix* sp. (mainly wicker basketry although also known for bast fibre), *Typha* sp. (used for cordage e.g. Aranguren *et al*. 2004; Aranguren and Revedin 2001) and a tall sedge - possibly *Carex riparia* (used as a weaver in rush basketry). *Phragmites* sps. was *not* worked because, as LL explained, it has a jointed stem making it unsuited for basketry/cordage. The rate of formation of wear traces, seen as an important aspect of the experimental programme, was investigated by setting common times for the experiment duration of 5, 10, 20 and c. 60 minutes where possible. Since the whole approach was task-oriented the times are task-times not contact times. Material was gathered into ordered bundles for transport as part of the overall task times. The experiments were conducted at times of the year and in a manner best suited to the plants' intended use as advised by LL. *Scirpus* and the sedge were cut in June and early July, at the end of the growing season but before the plant has time to deteriorate; *Iris*, *Urtica* and *Typha* were cut in August for similar reasons, and *Salix* was cut in March before coming into leaf. Sedge and *Scirpus* were cut underwater in order to obtain the greatest possible cut stem lengths and *Typha* and *Iris* were likewise cut underwater to improve the lengths available and because the material is easier to transport if gathered by stems rather than as individual leaves. Some experimental tools were hafted on wooden handles with a mixture of 50% beeswax and 50% pine resin but these proved problematic in wet conditions and so the rest were handheld.

All flints were from the local sources at Beer, Devon, UK (Newberry 2002) and within this were drawn from nodules of grey speckled flint with all tools knapped by Bruce Bradley. The tools used on *Salix* sp. were at first sight similar but the flint was tougher and proved more difficult to photograph. The wear traces may have formed more slowly on this tougher flint than on the other experimental pieces.

The experiments investigated one other aspect. It has long been recognised on the continent (Van Gijn 1989; Juel Jensen 1994) that there are special tools with a very distinctive set of wear traces which could be due to working plants but no one has as yet successfully replicated the wear traces via experiments. Some of these tool edges are 'microdenticulate' or 'serrated' and such tools with similar wear traces are known from Neolithic contexts in Britain (Hurcombe 2001). The wear traces may not have been successfully replicated because of additives or special conditions or because the tools are used in a set of activities all related to the same task. It was thought that since they could be fibre processing tools, the characteristics and performance of serrated edges should be investigated as part of a longer term experimental programme; these will form a further publication and only some of the results are briefly reported here. Likewise, some wear traces on archaeological pieces show a transverse motion and these actions are also part of continuing investigations which space does not permit to be reported here. The differences between the traces from the different species are thus presented here using unretouched edges in a longitudinal motion and for 50-60 minutes task-time.

The experiment times and numbers and a summary of any resulting wear traces are presented in table 1., with further details of the conditions of the experiments for each species discussed below. All tools were examined prior to cleaning, and after cleaning the edges with 10 % HCl and NaOH for 5 minutes. Observations were made at 500, 200, 100, and 50 X using an Olympus BM microscope, and lower magnifications using an Olympus SZ microscope with digital cameras. In practice, the plant residues were bright and extensive and so true wear traces had to be evaluated after cleaning.

Rush: Scirpus lacustris All the experiments took place in early July at LL's managed rush beds on the River Brue, Somerset, UK. The rushes were 15 mm diameter, up to 2.5m high (figure 1a&c) and cut underwater to achieve maximum length. The tools used for 5, 10, 20 and 50 minutes had been hafted and fixed by 50% beeswax and 50% resin. However the fixings loosened despite the same hafting arrangements having worked very well for much more forceful actions on harder materials. The loosening was thought to be due to using the tools underwater and raised the possibility that handheld tools might be preferred for working in wet conditions. The flint edges all performed well and though the unretouched edge was noticeably more blunt after c 30 minutes, both serrated and unretouched tools were still cutting effectively after 50 minutes (c. 3 bolts or bundles of rush). The cutting action was predominantly uni-directional although the larger stems might take more than one pass to cut through; with smaller ones, several could be cut in one go. Harvesting from a boat (coracle) and by standing in chest-high water were both effective though it was easier to cut with the flint tool and to cut the stem lower down whilst standing in the river. The cut stems were carefully placed in groups in bundles on the surface of the water and transported to the bank where they could be dried.

Reedmace: Typha sp. (Fig. 1e-f) All the experiments took place in August in a shallow pond at the University of Exeter. Tools cut the stems under water. This made sense because whole stems can more easily be gathered together into a bundle in the water and then taken to the bank, even if the leaves were to be separated subsequently as these can easily be stripped from the cut stem and then processed further on the bank. The stems were a mixture of mature and immature plants but many of the stems were substantial with oval cross-sections of 45 x 75 mm, and cut stem/leaf heights of 2.5 m. The

Fig. 1: a) Linda Lemieux at her rush beds using her coracle to harvest *Scirpus lacustris*, b) some of the hafted tools made after discussion with Linda Lemieux, c) Standing in the river to cut stands of *Scirpus lacustris* underwater; the hafted flint tool had come loose due to immersion in water, d) Cutting *Salix* at LL's willow beds with a hafted flint tool, e) Harvesting *Typha* sp. (right) in a shallow pond at Exeter University with some *Iris pseudacorus* (left), f) Detail of cutting *Typha* underwater, g) Stand of tall red-stemmed *Urtica dioica*.

unretouched tools with long edges could cut the longer plant side effectively and with one main motion but all unretouched tools , especially the bigger tools, tended to use more sawing motions for the biggest stems. The smaller (width) tools worked best by cutting the stem's shorter side and working across. The serrated edge was used mostly uni-directionally as this action alone proved sufficient. The serrated tool was also small and before the experiment it was considered perhaps too small to last or that it would be awkward to hold. It was fine to hold and cut very well and lasted the full length of the experiment (1 hour). No tools were hafted because of the experience of cutting the *Scirpus*.

Nettle: Urtica dioica. Stands of plants over 1 m in height and commonly up to 1.5 m (Fig. 1g) were harvested in August by cutting near the base using a mostly bi-directional motion because the stems were very woody (1 cm diameter). The red-stemmed plants and stands in open grassland were chosen as these gave tall straight stems (Mears 1990, 2002, pp.137-159, 2005) but Grieve (1931, p.576) suggests that plants growing in woodland might be less woody and give better lint. The two experimenters were typically each cutting 20-30 stems every 5 minutes. Although it is possible to grasp nettles so firmly that they do not sting, cutting was done in amongst the other nettle plants and stings from them would have been inevitable so protective clothing and especially plastic gloves were used. The flint tools were handheld but hafts would possibly have helped keep faces away from the other nettle plants. The unretouched and serrated edges were still functioning effectively after 60 minutes of task-time. Following LL's advice, the stems were individually cut and gathered into bundles in August towards the end of the growing season and before the plants began to die back. Previous experiments harvesting nettle had been conducted in November when the leaves had dropped off the nettles, but at this time they were noticeably weaker as handfuls of stems could be cut in one slice. It is thought that the processing of the bast fibres for string is better with nettle harvested before die-back. Some plants were pulled out during harvesting and certainly this method could be used to obtain some plants but it might have an adverse effect on subsequent year's harvesting in the same area and not all plants had sufficiently shallow roots, so if this harvesting method were employed for a stand of plants a digging tool of some kind would have been essential but using it might have knocked down other plants before they could be pulled out. Pulled plants with roots attached could have been retted using the methods of submersion in pits (e.g. Martin and Murphy 1988), slow rivers or ponds, but if the technique was boiling with wood ash, the roots would need to be removed to make effective use of vessel space. Experiments with nettle fibre processing are ongoing.

Sedge: Carex riparia? One small stand of triangular stemmed sedges of c 2.5 m and 60-70 mm width were cut in early July whilst standing in the River Brue at LL's rush beds. One handheld unretouched edge was used underwater for 10 minutes since LL uses sedge only as a weaver for colour variation. The material is not strong enough to form the passive elements of basketry nor to use as the sole weaver so no further experiments were undertaken.

Yellow flag: Iris pseudacorus. Only one experiment was possible due to the limited number of plants available. The stand of plants was in a shallow pond at Exeter University (Fig. 1e). The tough stems were cut near water level as this enabled the leaves to be kept together although sometimes a mixture of stem and leaves were cut in one handful. The stems (30 mm x 20mm) contained a lot of water. Cut stem heights were up to 2 m. The tool was handheld and the only possible motion was uni-directional because the tool was so narrow it was difficult to apply pressure with the index finger.

Willow: Salix triandra. LL cut 150 of her own willow rods for one hour in March (Fig. 1d) for each of experiments 40 and 42. The species is common in the willow growing industry and the plants were up to 1.5-1.8 m in height. The experiments were part of a set with tools of different edge angles and edge shapes which were given to her to see what edge characteristics she preferred for the task. It may be that experiment 40 showed no distinctive polish because its edge angle of 30-35° meant that edge damage was removing the areas of most wear in comparison to the more robust edge angle of 40-45° on experiment 42. The flint was from the same source as the other experiments but was a much tougher flint which may have affected the rate of wear formation.

Discussion of experimental wear traces

The experimental wear traces were evaluated and briefly summarised in table 1. This confirmed that the experiments with a task-time of between 50-60 minutes showed the most distinctive wear. The developed wear was examined for edge damage at 100X (very little was visible macroscopically), summarised in table 2, and polish formation at 200 and 500X as summarised in table 3. The descriptions were tabulated to facilitate comparisons and in particular tried to describe the types of polish visible in surface high and low spots and how these merged. Figure 2 illustrates the wear traces at all three magnifications: all fifteen of these wear photos plus fifteen others are available at high resolution on the CD-Rom accompanying this volume. This documentation is designed to allow other wear analysts to make effective use of the data in their own interpretations. Some general conclusions from the experiments are drawn below.

Use times. The times given in table 1 are to cut and place in ordered bundles the plant stems, as happens when the material is required for a purpose. Our working process followed LL's practices. Thus the 'use-time' is not all 'contact-time' but more a 'task-time' which is believed to be more realistic. There is a rhythm to these kinds of plant harvesting task e.g. a 'handful' is gathered and then

Expt No.	Use Time	Use Action	Use Material	E	Scars (100X)	Polish (200X)
32	5 mins	Reap-cut (uni-directional)	*Typha sp.s* cut underwater in pond with a lot of fine sediment	P	Very few scars	Generic weak
31	10 mins	Reap-cut (uni-directional)		P	Few scars	No polish
28	20 mins	Reap-cut (bi-directional)		P	No scars	No polish
29	1 hour	Reap-cut (bi-directional)		P	Few scars	Developed polish
30	1 hour	Reap-cut (uni-directional)		S	Some scars	Generic weak polish
25	10 mins	Reap-cut (uni-directional)	*Scirpus lacustris* cut underwater in gently flowing river with suspended material	P	Some scars	No polish
24	20 mins	Reap-cut (uni-directional)		P	Very few scars	Generic weak polish
23	c. 50 mins	Reap-cut (uni-directional)		P	Very few scars	Developed polish
22	c. 50 mins	Reap-cut (uni-directional)		S	No diagnostic scars	Generic weak polish
36	5 mins	Reap-cut (bi-directional)	*Urtica dioica* tall stands of red-stemmed nettles cut in dry weather	P	Few scars	No polish
37	10 mins	Reap-cut (bi-directional)		P	Few scars	No diagnostic polish
13	25 mins	Reap-cut (uni-directional)		S	No diagnostic scars	No polish
35	60 mins	Reap-cut (bi-directional)		P	Scars	Developed polish
34	60 mins	Reap-cut (bi-directional)		S	Some scars	Some polished areas
33	50 mins	Reap-cut (uni-directional)	*Iris pseudacorus* Flag iris, Cut underwater in pond	P	No diagnostic scars	Generic weak polish
42	60 mins	Cut (bi-directional)	*Salix triandra,* stems up to 5-6 feet	P	Some scars	Some polished areas
40	60 mins	Cut (bi-directional)		P	Some scars	No polish

E= Edge type, P= plain edge, S= serrated edge

Tab. 1: Experiments with plant materials suitable for cordage and basketry production and overview of resulting wear traces

Species	Edge damage characteristics at 100X in polished areas
Willow *Salix triandra*	Almost continuous line of large (200+ µm long) half moon snaps but not invasive
Nettle *Urtica dioica*	2 levels: (1) intermittent small (c. 100 µm long) half moon snaps and very fine occasional scalar scars (not illustrated on image) (2) occasional scalar invasive scars (100-200 µm) (location suggests due to localised higher pressure eg on protruding areas)
Iris *Iris pseudacorus*	Almost continuous tiny half moon and half scalar scars between 50-100 µm long though some scalar scars more invasive
Reedmace *Typha sp.*	A few tiny scalar scars (<50 µm), some scalar scars are diagonal showing some directionality
Rush *Scirpus lacustris*	Few tiny (<50 µm wide) scalar scars just on the protruding areas.

Tab. 2: Edge damage on unretouched experimental tools used to cut plants suitable for basketry and cordage for 50-60 minutes.

	Microtopography (at 200 and 500X)			
Species	Surface prominences	Boundary between high-low spots	Surface lows	Very edge
Willow *Salix triandra*	Weak 'plant' polish with some bright areas, some domes beginning to form; occasional bright spots away from the edge	Distinct	Weak 'generic' polish if any	Slight rounding at 500X but not at 200X; Weak plant polish; beginning of some domes; not continuous
Nettle *Urtica dioica*	Soft plant polish; some smoothing joined up on prominences at 500X	Slightly blurred	Soft plant polish, high spots linking into lows occasionally at 500X	Slightly rounded at 200X; distinct but very thin line of 'soft plant' polish almost continuous along the edge at 500X
Iris *Iris pseudacorus*	Soft plant polish; Some rounding but not domed	blurred	Soft plant polish in low spots, even in the edge scars	Rounded at 500X (even scar ridges) but appears only very slightly rounded at 200X. 'Bumpy' polish on original edge and a micro-bumpy texture in some scars
Reedmace *Typha sp.*	Well developed plant polish, bright and smooth; Distinct rounding at 200X; Very linked polish elements on the surface prominences; invasive over surface.	Slightly blurred at 200 and 500X	Soft plant polish; frequently linking in to the high spots	v. rounded at 500X, smoothly rounded at 200X with linear features at 200 and 500X; 'bumpy' plant polish
Rush *Scirpus lacustris*	Developed plant polish on some linked high spots at 200X, smooth and rounded high spots of polish at 500X and linking up well at 500X	Distinct at 500X, very slightly blurred at 200X	Weak 'generic' polish: Linking occasionally near the edge	Slight rounding intermittently at 200X and distinct but not linked rounding at 500X. Slightly bumpy aspect to polish (area A)

Tab. 3: Wear traces on unretouched experimental tools used to cut plants suitable for basketry and cordage for 50-60 minutes.

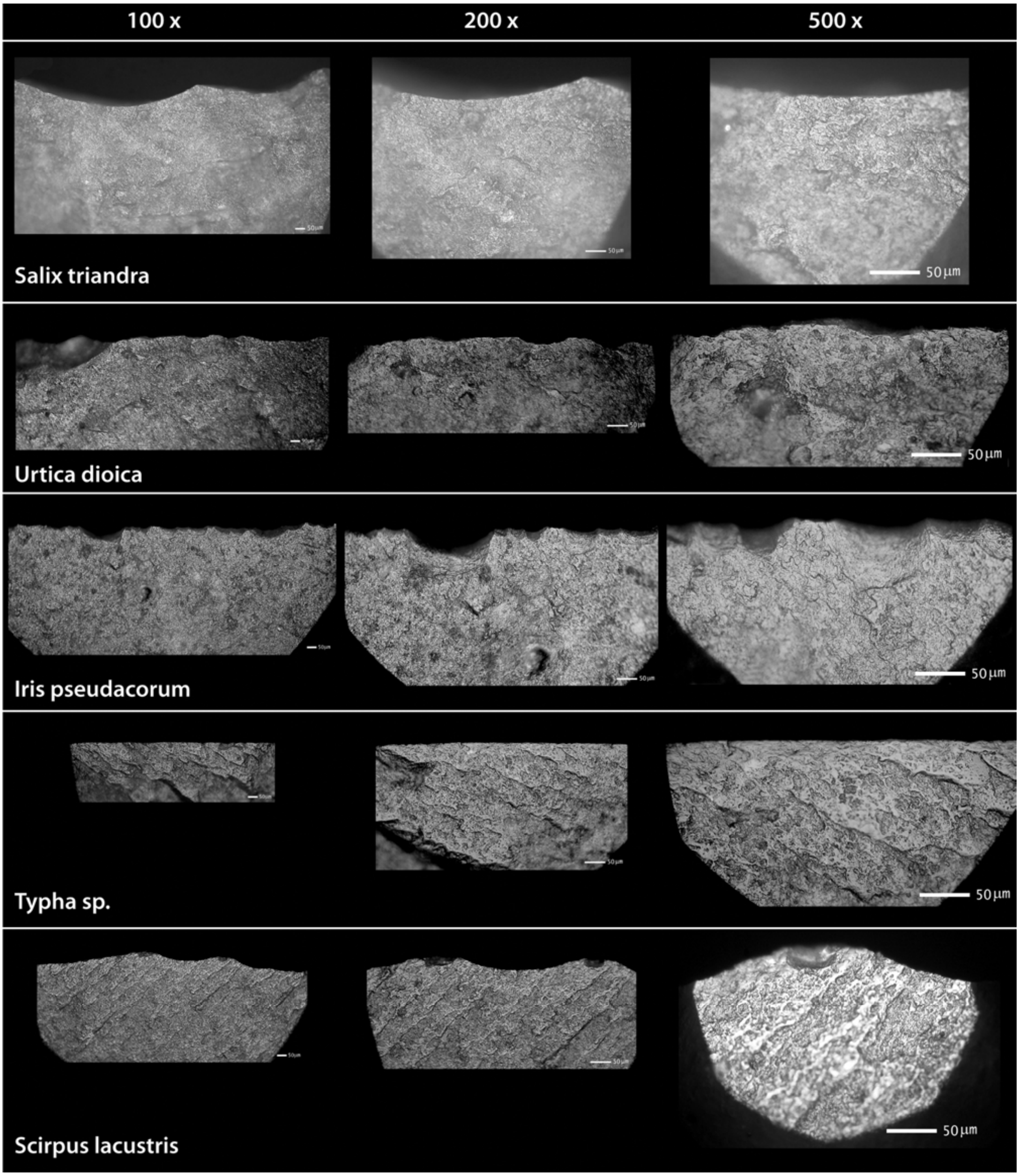

Fig. 2: Wear traces from experimental flint tools used for 50-60 minutes to cut *Salix triandra, Urtica dioica, Iris pseudacorus, Typha* sp. and *Scirpus lacustris* at 100X, 200X and 500 X original magnification.

the plant or plants are drawn out of the water and placed carefully on the surface of the water (or in a boat) with stem bases aligned to make bundling up and subsequent transport easier. The serrated flakes performed at about the same level as the plain edges initially, but the plain edges were noticeably more blunt after 20-30 minutes although they were still usable and effective. The polish on tools that had been used for more than 50 minutes could possibly be distinguished, but lesser use–times showed very weak generalised polished areas which could be interpreted as possibly post-depositional effects or simply 'weak generic polish' (Vaughan 1985, pp.30-31). The 50-60 minutes should be regarded as a minimum harvesting period and given that a craftsperson would appreciate the best season to harvest material for all of the coming year it is envisaged that this period of time is a minimum to collect material. Further experiments with much longer task-times are part of the next phase of the project.

Use actions. It seems that larger stemmed plants cut with plain edges are more likely to result in two directional sawing motions. Serrated flakes are used in a more uni-directional way because each stroke tends to cut through another section of even the biggest (*Typha*) stems.

Tool characteristics. The bigger pieces were very easy to hold in the hand. Corticated edges were more comfortable than the backed ones. Hafted tools used under water seem to be problematic. Whilst the ergonomics of the action improve, the longevity of the composite tool is perhaps reduced. Certainly the same kinds of hafting arrangements used with much more forceful actions but in dry conditions showed no loosening of the flint in the haft whereas all the hafted tools used under water started to loosen after about twenty minutes. When the archaeological tools were re-examined this factor could explain why some had been backed and some had natural cortex backing. The smaller sized archaeological pieces had been assumed to be used hafted, but experience of cutting soft plants with narrow tools suggests that as long as there is good purchase for the index finger to apply pressure and for the thumb and at least one other finger to grasp the tool, it can be used effectively. In every case the serrated tools performed as well or better than the plain edges but conversely had less developed wear traces than their unretouched experiment counterpart.

Use-materials. The tabulated data show that there are subtle wear distinctions between some of the plant species used in the experiments. *Typha* and *Scirpus* experiments certainly show a more silica-rich soft plant polish. More subtle differences and combinations of edge damage and polish traces may allow some distinctions to be made in the category normally described as 'soft plant'.

Neolithic tools from the Sweet Track, Somerset Levels, UK

The archaeological study focused on flint tools from the Somerset Levels Project for several reasons; this wetland area is still used for its reeds, rush and willow resources which would also have been available in prehistory (Caseldine 1984); the publications are accessible (e.g. Brown 1986; Coles *et al*. 1973; Coles and Coles 1986) and include a microwear study of some of the Neolithic Sweet Track flint artifacts (Morris1984). The whole assemblage was re-assessed, especially those tools identified by previous wear analysis as used on 'wood' or 'reeds'. This was specifically to see whether highly siliceous reeds such as *Phragmites* could have given rise to the wear traces or whether soft plants known to be associated with basketry and cordage production could have caused the wear. It was assumed that 'wood' traces could include young willow shoots suitable for basketry.

A macroscopic search of all the pieces (several hundred) from the Somerset Levels Project showed some new identifications. Eight pieces had a gloss visible to the naked eye and three more 'serrated flakes' were identified. The latter often have a gloss and form part of the distinctive set of implements known as 'micro-denticulates' on the continent (Juel Jensen 1994, pp.50-68). In Britain these implements are found on a range of neolithic sites (e.g. Middleton 1998 and see references in Hurcombe 2000b). Thus the wider assemblage was worth detailed analysis for wear traces but this was outside the scope of this study. The microscopic wear analysis then concentrated on the artifacts specifically associated with the excellent dated context of the Sweet Track and especially on the pieces previously identified as having 'wood' and 'reed' traces.

The re-assessment suggested that 'reed' traces contained two different edge types with associated wear. One set had no or very light damage formed mostly of half-moon fractures at the macroscopic level with associated polish suggesting parallel motions, but the other had robust, often bifacial, scalar damage *or* deliberate but very uneven serration associated with transverse actions. 'Wood' tools were surprising because the polish traces did not have classic domed wood traces with linkage and clear areas of less developed traces but had much more blurred boundaries and seemed to be showing some soft plant characteristics. The 'wood' tools were small and had delicate edge angles (average 31.3°). Given the personal observations and experience of LL it could be suggested that these pieces might be trimming tools for the finer details of basketry production. Further experiments testing this possibility are needed but the tools would have to be used for long periods. The 'reed' plants also showed possibilities for basketry and cordage. A few tools and their wear are described below to illustrate some of the issues.

SW17A &B Figure 3 (originally identified as 'wood' traces). The two portions join to form a long acute edge with natural cortex backing. The polish distribution suggests parallel motion. Rounding on scar ridges and the edge and invasive polish suggest a very soft plant material and one that is not silica-rich. Overlapping half-scalar scars and smooth but fine bumpy polish texture (fig. 3a) in those scars, are similar to half-scalar overlapping scars formed cutting Iris (see Fig. 2, 200x and 500x images) and also to the polish texture within them, though the archaeological piece did not have so many linked sections of polish. Generally wear features suggest it cut tough, not very siliceous, soft plant.

SWRV 2. Figure 3 (originally identified as 'reed'). The tool has distal and proximal used areas which could be all related. There is some evidence of slight transverse motion, but mostly the distribution suggests parallel motions though there are very few striations. The polish (Fig. 3b) suggests a slightly harder soft plant, but not highly siliceous ones. If the use material was more

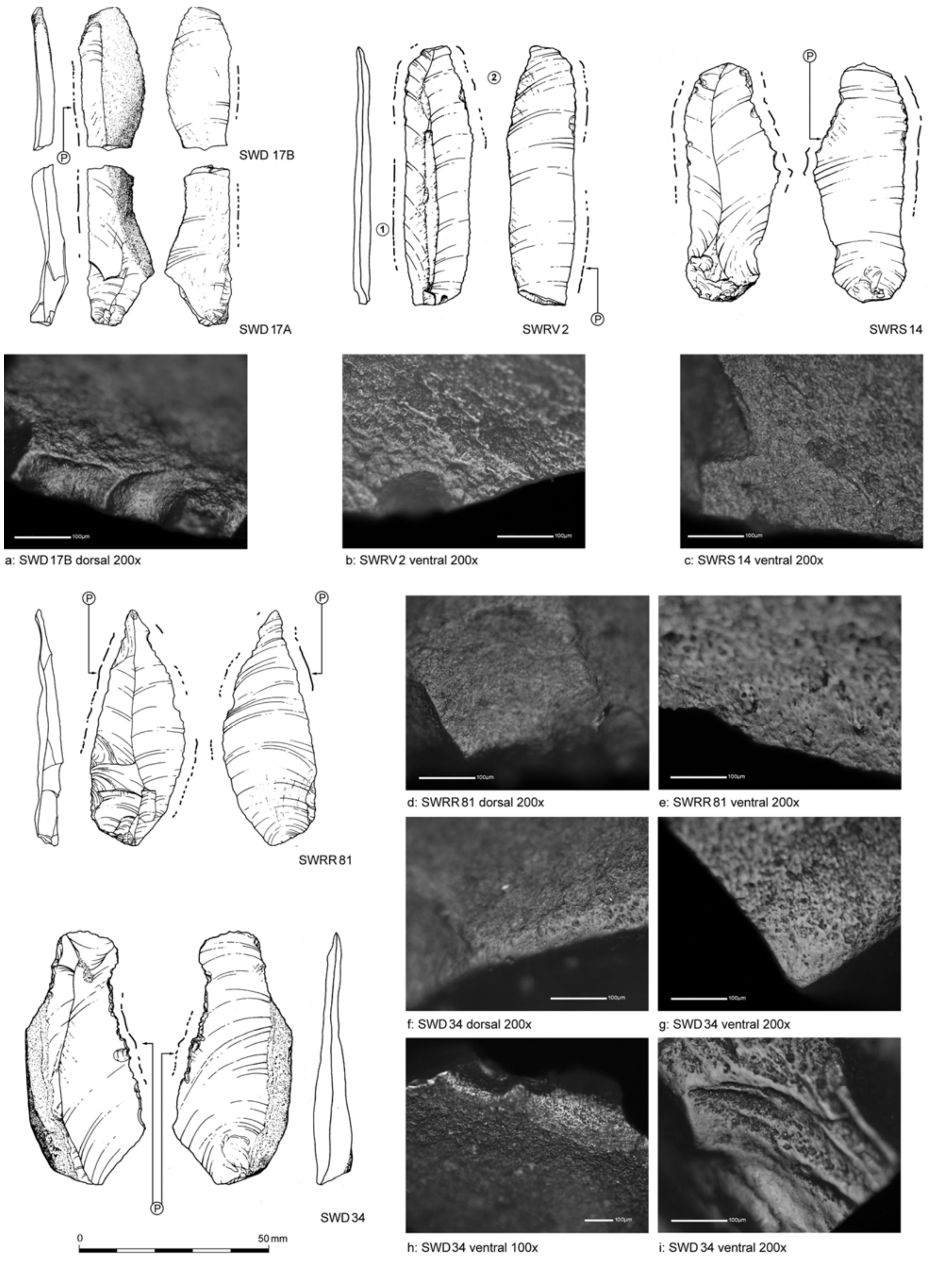

Fig. 3: Selected tools from the Neolithic Sweet Track, Somerset Levels.

siliceous, e.g. *Phragmites,* more rounded, bright and smooth aspects to the highspots of the surface topography could be expected, although the distribution which concentrates on the surface high spots is characteristic of such hard plants (See Juel Jensen 1994, e.g. plates 22, 28, 32; Van Gijn 1990: 38 – 40 and Fig 25). The edge damage comprises occasional half-moon or half-scalar scars at the macroscopic level and at the microscopic level consists of small scalar scars on slight edge prominences, very similar to those seen on the experimental tool edge used to cut *Scirpus* (Fig. 2). The two photos are strikingly similar, but one is at 200x and the other at 500x. (whilst the higher magnifications generally highlight the features seen on more developed examples at lower magnification, the case is not demonstrated). It is likely that the polish is due to a harder and slightly silica rich soft plant.

SWRS 14 Figure 3 Large half moons and some more invasive scars with stepped and uneven rims and weak generic polish (Fig. 3c) were observed suggesting a tough, forceful contact. These are similar to those observed from cutting *Salix*. None other of the experimental 'soft plants' cut produced such scars, although the edge *may* have had some deliberate but irregular 'serration' retouch in the light of observations on other pieces below.

SWRR81 Figure 3. Assymmetrical polish on dorsal/ventral surfaces (Fig. 3d-e) and polish distribution suggests a very shallow scraping action. The ventral polish has a bumpy aspect, despite the polish being smoothed and very well developed. There is edge rounding and some small half-moon fractures. On the other side, the polish is a weak generic spread and lustrous and has evidence of some scalar scars. The tool, like others, has extensive areas of used edge and it may have been used for cutting prior to the transverse motion polish now dominating it. At least some portions of the edge might have been subject to deliberate 'irregular serration'. The used areas could all relate to similar tasks but with the photographed area being the most well developed portion. The bumpy aspect of the polish is similar to areas of developed polish on some of the experimental pieces (see below). The polish asymmetry and some aspects of the two textures share some features with the 'microdenticulates' and *debitage en frites* e.g. see Juel Jensen (1994, pp.50–68), though more differences with Van Gijn (1990, pp.83-86.) since the polish is not 'flat' on the developed side. It is widespread and flows over high and low spots. On the rougher face there is no evidence of multiple striations and a hide-like polish. However, similarities become greater with the tool described below and thus SWRR 81 and SWD 34 could be used for similar tasks with differences in the degree of wear.

SWD 34 Figure 3. The tool has natural backing and damage or irregular serration retouch on both faces of the working edge, which was used in a transverse motion. There is a bevel on the dorsal edge (Fig. 3f), with a well developed, slightly pitted polish on the bevel itself, but fading quickly into a weaker polish. The ventral face has a more extensive band of bright but bumpy polish (Fig. 3g-i), which covers the surface at the edge and goes partly into surface lowspots. This bumpy polish has similarities with that observed on the *Typha* and *Scirpus* experiments and has similarities with wear on SWRR 81. The bevel, disposition of the polish, and asymmetry all suggest a shallow scraping motion. Preliminary experiments with transverse motions on soft plants suggest that these scraping motions may be associated with soft plants and further experiments replicating basketry/cordage processing techniques are planned.

The re-assessment of the wear traces opened up the possibilities of at least some of these 'reed' and 'wood' identifications incorporating tools used for basketry and cordage production. Some flints suggest a transverse motion on 'soft plant'. Experiments with transverse motions on nettles were conducted, though space did not permit these to be reported here, but others are ongoing and require the plants to come into season again, in keeping with our realistic experiment design. The 'reed' identifications are not on the whole from silica-rich plants such as *Phragmites* but are more in keeping with the kinds of plants used in the experiments. Scraping motions could certainly be from 'craft processing' activities although further experimentation is required. Likewise the delicate edges and 'soft plant' features of some of the 'wood' polishes could be more usefully seen as basketry style wood working and are certainly not from large timber working.

Conclusions

The project has shown that there is the potential to investigate prehistoric basketry and cordage using the evidence from stone tools. The ethnographic data collected commonly available plants suitable for basketry and cordage production, gathered information about the harvesting seasons and processing tasks associated with these, assessed the role stone tools could play in these material culture production activities and provided a solid basis for a task-oriented approach to the experimental programme. The experiments investigated a range of relevant species and the accumulation of wear traces, then presented descriptions of the resulting developed wear. These reference descriptions should assist other researchers in the interpretation of plant wear traces. Certainly, the plants for such basketry/cordage activities are not necessarily silica-rich and can be distinguished from traces caused by silica-rich plants such as cereals, grasses and *Phragmites*. There are also subtle differences between the plant wear traces reported here and these can be used to expand on interpretations of 'soft plant' wear traces. The archaeological case study demonstrates this potential and shows the possibilities of turning 'reed', 'wood' and 'soft plant' wear into a more cultural interpretation of possible basketry and cordage production tools. These stone artefacts are always going to be more prevalent in the archaeological record than preserved basketry and cordage and, as such, the archaeological perception of these important organic material culture items can be enhanced by lithic use wear analysis.

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Toolkits and technological choices at the Middle Neolithic site of Schipluiden, The Netherlands

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Summary. *The Middle Neolithic site of Schipluiden is located on a coastal ridge near the present day town of The Hague. The 2003 rescue excavation yielded an enormous amount of artefacts of flint, various types of stone, as well as amber, bone and antler objects. A technological and functional analysis of these artefacts demonstrated the presence of different toolkits, thus providing insight into the technological system. The characteristics of these toolkits suggest the existence of a long term tradition of tool making and using in the wetlands of the Rhine/Meuse delta.*

Résumé. *Schipluiden, un site du Néolithique moyen, est situé sur une dune côtière auprès la ville actuelle de La Haye. Les fouilles de sauvetage de 2003 ont produit une quantité énorme des objets de silex, d'autres types de pierres, d'ambre jaune, de l'os et de bois de cervidé. Une analyse technologique et fonctionnelle des outils produit des matières diverses démontre la présence des toolkits pour les tâches différentes. Ces données donnent d'information sur le système technologique préhistorique. Les attributs du système technologique ont individué l'existence d'une longue tradition de production et utilisation des outils dans les marécages du delta.*

Key words: Middle Neolithic, toolkit, functional analysis, technology.

Introduction

This paper starts from the premise that technology is a cultural phenomenon that plays an active part in the reproduction of society and in processes of change. Technological choices have a social-cultural background (Appadurai 1986; Dobres and Hoffman 1994; Lemonnier 1986, 1993). People make choices that may not always be the most effective from an economic point of view, but that fit in the existing technological system. Technological solutions have to be in harmony. Such choices can be studied, not by looking at one category of artefacts that, but rather by incorporating a technological system in its totality.

Use wear analysis is a method *par excellence* to investigate the technological system, provided that not only flint implements are subjected to analysis but also implements made of other materials. In this way material culture can be studied as a coherent system, investigating the technological and functional interrelationships between the various categories of material culture. The addition of use wear analysis to the morphological studies carried out so far makes it possible to also track the more *hidden technological choices* related to the selection of specific implements for specific purposes. I believe that in this way use wear analysis can contribute to issues about cultural tradition and more specifically to the issue of the long term continuities and discontinuities in the technological system.

Obviously, in archaeological context this is never completely possible because of preservation problems. The approach is therefore more applicable to the wetland sites in the western part of the Netherlands, due to excellent preservation conditions. The site of Schipluiden is such a site, providing the opportunity to study material culture from a more holistic point of view, examining the technological and functional inter-relationships between different categories of material culture.

The site of Schipluiden

Schipluiden was excavated in the summer of 2003, financed by the Hoogheemraadschap Delfland who was building a large water cleaning plant on the spot. It dates to c. 3750-3400 cal. BC and can be attributed to the Hazendonk 3 group, which is contemporaneous with the Michelsberg culture further south and east. The site is located on a small dune in the marshlands, behind the coastal barriers (Fig.1). It was surrounded by perfect grazing territory. Hunting, gathering and fishing were probably providing a large portion of the diet, but crops like naked barley were also grown. The dune was continuously inhabited for 200-300 years and the spatial evidence suggests that four, probably complete, households were present on the same spot during the entire period of occupation. The palaeobotanical, archaeozoological and other evidence point to year-round occupation of the dune. A few graves were found as well (Louwe Kooijmans and Jongste 2006).

Sampling and methods

Sampling
All artefacts except the ceramics, the wooden objects and the basketry and fabrics, were brought to the Leiden Laboratory for Artefact Studies. Schipluiden has yielded over 15,000 flint artefacts, 5106 of which were described, including the sieved material. This sample included all artefacts displaying traces of modification or use, as well as all technologically relevant implements such as cores, decortification flakes, core preparation and rejuvenation pieces and so forth. Splinters and pieces of waste were excluded from analysis. All artefacts selected were described for raw material, typology and technological and morphological characteristics. For various reasons the material from the sieve was removed from the analysis, resulting in an operating file of 2666 artefacts (see Van Gijn *et al*. 2006). Out of this number a sample

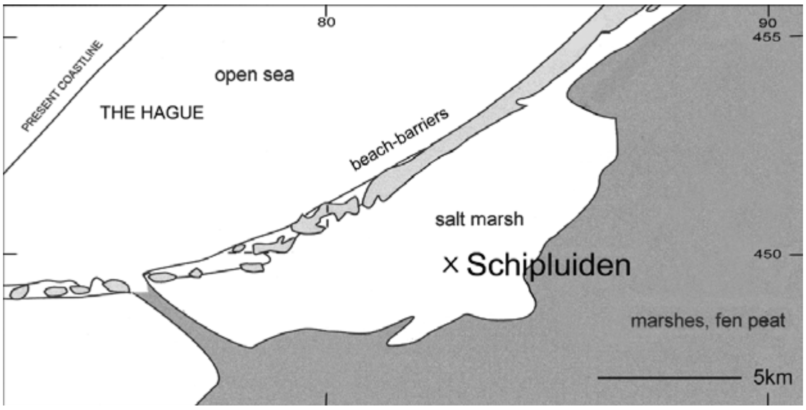

Fig. 1: Location of the site of Schipluiden in relation to the paleogeography (after Louwe Kooijmans and Jongste (eds.), 2006).

contact material \ motion	longitudinal	transverse	boring	diagonal	pounding	shooting	transverse / longitudinal	hafting	hafting with tar	indet.	totals
plant											
plant unspec.	-	-	-	-	-	-	-	2	-	-	2
soft vegetal	1	-	-	-	-	-	-	-	-	-	1
siliceous plant	17	8	-	-	-	-	1	-	-	3	29
reeds	1	-	-	-	-	-	-	-	-	-	1
cereals	3	-	-	-	-	-	-	-	-	-	3
wood	2	3	-	-	-	-	-	-	-	1	6
animal											
bone	-	1	-	-	-	-	-	-	-	-	1
hide	1	14	-	-	-	-	1	-	-	-	16
fresh hide	-	2	-	-	-	-	-	-	-	-	2
soft animal	2	1	-	-	-	1	-	-	-	1	5
mineral											
mineral unspec.	1	7	6	1	-	-	-	-	-	-	15
soft stone	1	-	-	-	-	-	-	-	-	-	1
pyrite	-	-	-	-	32	-	-	-	-	-	32
jet	3	-	-	-	-	-	1	-	-	-	4
uncertain material											
bone / wood	2	1	1	-	-	-	-	-	-	-	4
hide / siliceous plant	4	1	-	-	-	-	2	-	-	-	7
soft material unspec.	1	2	1	-	-	-	-	-	-	1	5
unknown use	9	8	3	-	-	2	1	2	-	4	29
hafting											
with tar	-	-	-	-	-	-	-	-	9	-	9
material indet.	-	-	-	-	-	-	-	8	-	-	8
indet.	-	-	-	-	-	14	-	-	-	6	20
Totals	***48***	***48***	***11***	***1***	***32***	***17***	***6***	***12***	***9***	***16***	***200***

Tab. 1: Results of the microwear analysis of the flint tools: contact material versus motion (the figures represent used zones rather than individual artefacts).

motion \ contact material	plant unspec.	cereals	wood unspec.	bone	miniral unspec	soft stone	flint	granite	unknown use	indet.	totals
cutting	-	-	1	-	-	-	-	-	-	-	1
scraping	-	-	1	-	-	-	-	-	-	-	1
chopping	-	-	-	-	-	-	-	-	-	1	1
wedging	-	-	1	-	-	-	-	-	-	-	1
pounding	-	-	-	-	-	-	-	-	-	16	16
grinding	-	-	-	-	-	1	19	1	-	7	28
polishing	-	-	-	1	-	1	-	-	-	1	3
rubbing	1	-	-	-	1	-	-	-	-	4	6
milling	-	6	-	-	-	-	-	-	-	-	6
crushing	-	-	-	-	1	-	-	-	1	1	3
hafting	-	-	-	-	-	-	-	-	-	1	1
indet	-	-	-	-	-	-	-	-	-	4	4
Totals	***1***	***6***	***3***	***1***	***2***	***2***	***19***	***1***	***1***	***35***	***71***

Tab. 2: Results of the microwear analysis of the hard stone tools: contact material versus motion (the figures represent used zones rather than individual artefacts).

of 304 artefacts was taken for use wear analysis, taking a random sample from each typological category. The results are depicted in table 1.

Similarly, the amount of hard stone amounted to over 55 kg, a large part of which came from the sieve. All artefacts larger than 2 cm were described, except when it concerned clearly modified artefacts like the ornaments made of amber or jet. A total of 1728 artefacts have been examined for raw material, typology and technological characteristics. Only 60 artefacts were examined for traces of use, taken randomly from the various typological categories. This resulted in 71 used edges, with several tools having three or four used zones. The activities carried out with hard stone tools were quite diverse (table 2) (Van Gijn and Houkes 2006).

Only a relatively small amount of worked bone and antler was found, all of which was studied (no. 90). A total of 50 artefacts were studied for traces of use. Bone tools were for the most part used for chiselling wood and for piercing plant material (table 3) (Van Gijn 2006a).

Methods

The artefacts were described according to the standard code list used at the laboratory, including such variables as tool type, raw material, kind and extent of cortex and various technological features. Attention was especially paid to the flint and hard stone types present in the assemblage because the area is pretty much devoid of stone sources. This means that virtually all the stone material came from afar, obtained either directly or by exchange.

The use wear analysis was done with the aid of a Wild stereomicroscope with oblique light, a Nikon stereoscope with incident light and different types of Nikon metallographic microscopes, one of which with a free arm, allowing the examination of large tools. As has been argued before (Van Gijn 1990) the differentiation between high and

motion / contact materia	boring	chiselling	wedging	piercing	scraping	shooting	unknown	no traces	total
hide	1	-	-	-	1	-	-	-	2
wood	-	5	1	-	-	-	-	-	6
pottery	-	-	-	-	1	-	-	-	1
reed	1	-	-	-	-	-	-	-	1
slilicious plants	2	-	-	1	-	-	-	-	3
soft material	-	-	-	-	-	-	2	-	2
unknown	3	-	1	-	-	1	7	-	12
indet.	-	-	-	-	-	-	3	-	3
no traces	-	-	-	-	-	-	-	20	20
Totals	*7*	*5*	*2*	*1*	*2*	*1*	*9*	*23*	*50*

Tab. 3: Results of the microwear analysis of the bone tools: contact material versus motion (the figures represent used zones rather than individual artefacts).

low power analysis is not considered to be productive. Instead we need both approaches in order to incorporate as much evidence as possible in our functional inferences. The high-power analysis of bone and antler tools is a relatively recent development (Cristidiou 1999; Maigrot 2003; Van Gijn 2005). Hard stone tools have for the most part been studied for the presence of traces of use by means of binoculars (see the excellent study by Hamon 2004). The presence of a metallographic microscope with a free arm has allowed us to explore further the possibilities of a high power approach for the analysis of hard stone grinding-, milling-, and polishing implements. Until recently such tools were too large to fit a metallographic microscope. However, it has now become clear that polishes are indeed visible on hard stone tools and that they show variability consistently related to specific activities (see Van Gijn and Houkes 2006; Verbaas 2005).

The metallographic microscopes were fitted with polarizing filters and Nomarski DIC. All implements, flint, stone, bone and antler, were subjected to the same treatment. The tools were not cleaned except for the use of alcohol for wiping off grease. A few bone implements were still covered with dirt and were therefore briefly immersed in the ultrasonic cleaning tank filled with distilled water. Chemical cleaning was not deemed necessary.

Toolkits

Semenov in his book *Prehistoric Technology* (1964) studied traces of both manufacturing and use. He also incorporated artefacts made of stone as well as bone in his functional studies. This integral approach was somehow lost when functional analysis was taken on in the West. Pioneers like Keeley (1980) and Tringham (Tringham *et al*. 1974) and Odell (1977) concentrated on flint tools only and left the manufacturing traces out of consideration. Most research in the past 30 years has been directed at flint assemblages. "Other" materials such as bone and hard stone have only recently been subject of functional analysis certainly of high power ones (Cristidiou 1999; Maigrot 2003; for bone and antler tools, Dubreuil 2002; Fullagar and Field 1997; and Hamon 2004 for stone tools). However, it is rare that integral functional analyses are done on tools made of different raw materials deriving from the same site. An exception is the cooperation between Maigrot and Beugnier on the bone and flint material from the Neolithic site of Chalain in the Jura (Beugnier 1997; Maigrot 2003).

The integral study of the Schipluiden material is an attempt to demonstrate the advantages of studying the traces of manufacture and use on tools made of different raw materials, in order to see the technological and functional interrelationships between these various tools. By doing such an integrated study it is possible to detect tool kits, sets of tools used in the same *chaîne opératoire*. The composition of these toolkits, the choice of tools for specific tasks, is part and parcel of the cultural identity of past peoples. At Schipluiden a number of such toolkits could be distinguished.

The toolkit for harvesting and processing cereals
The find location, on a dune in the salt marshes, had initially led us to believe that crops were not grown on the spot. However, the palaeobotanical research revealed the presence of both seeds and chaff of naked barley and emmer. The fact that chaff of the free threshing naked barley has been found, indicates local cropping (Kubiak-Martens 2006). This was corroborated by the presence of at least two probable flint sickles with polish from cutting cereals (Fig. 2b). The polish is very smooth, highly reflective and slightly undulating. It is possible that there may actually be more harvesting implements present among the tools with traces from contact with siliceous plants. Although it is possible to distinguish experimental polishes from reeds and cereals, this is not always the case with archaeological tools.

There is also evidence for cereal processing: several querns were encountered, for the most part made of sandstone. The querns were examined for wear traces and display a somewhat matt, rough polish with short striations, resembling the polish observed on experimental grinding stones (Fig. 2a). Phytolith analysis of five querns indicates the presence of spodograms and ground rods (see Nieuwenhuis and Van Gijn, this volume). The querns were probably used for dehusking emmer, as suggested by the presence of spodograms of leaf sheaths. However tiny broken phytolith fragments suggest that the querns were also used for flour making.

Toolkit for making basketry from vegetal fibres
The use of wild plants for fibre processing is testified by the presence of three pieces of basketry (Fig. 3). The fibres were made of bark, possibly from willow. For the manufacture of basket loopings were sawn around a foundation, a process for which it was necessary to make small holes to pass the looping through (Kooistra 2006). Several bone awls displayed a bright polish and striations indicating they were probably used in a rotating motion

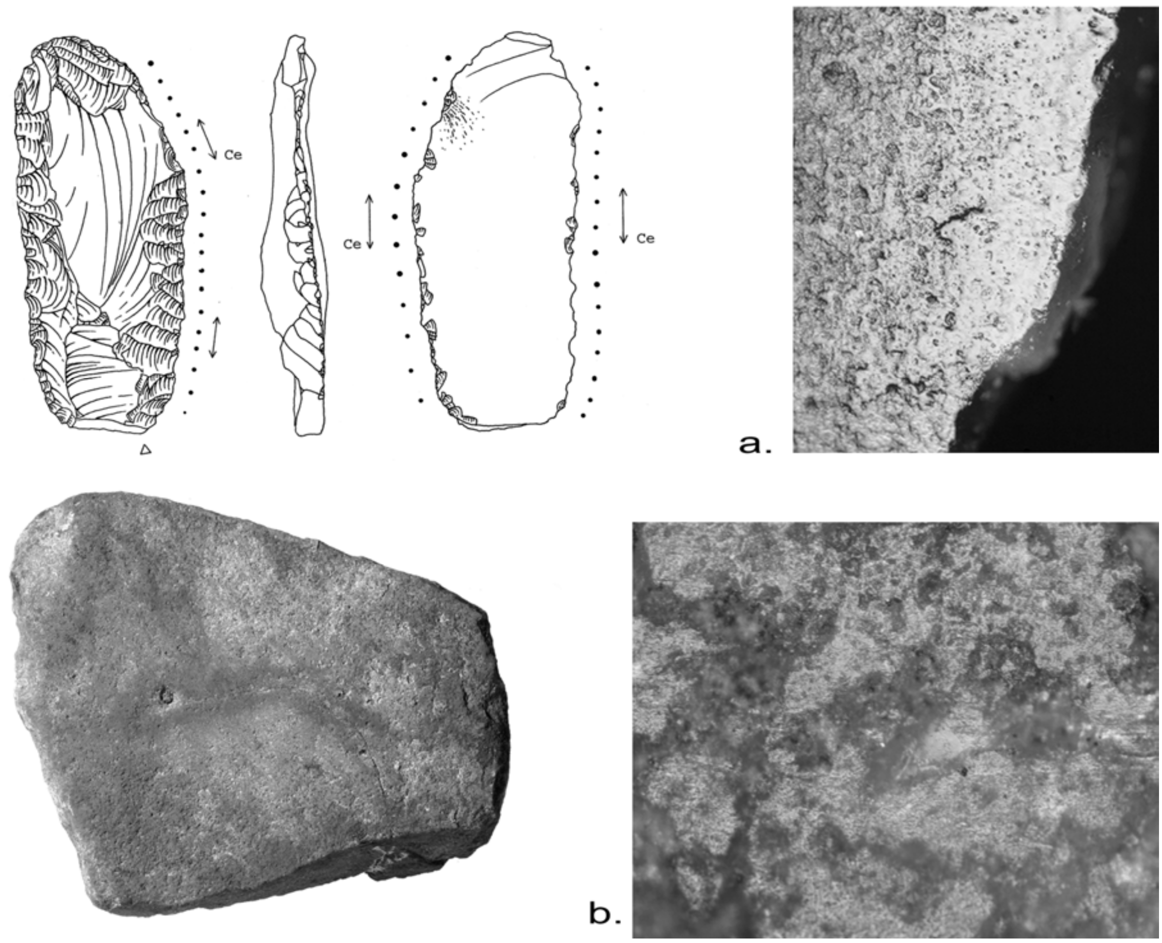

Fig. 2: Toolkit for harvesting and processing cereals; a) quern of sandstone with wear traces (orig. magnif. 200x); b) flint sickle with a picture of the wear traces observed (orig. magnif. 200x).

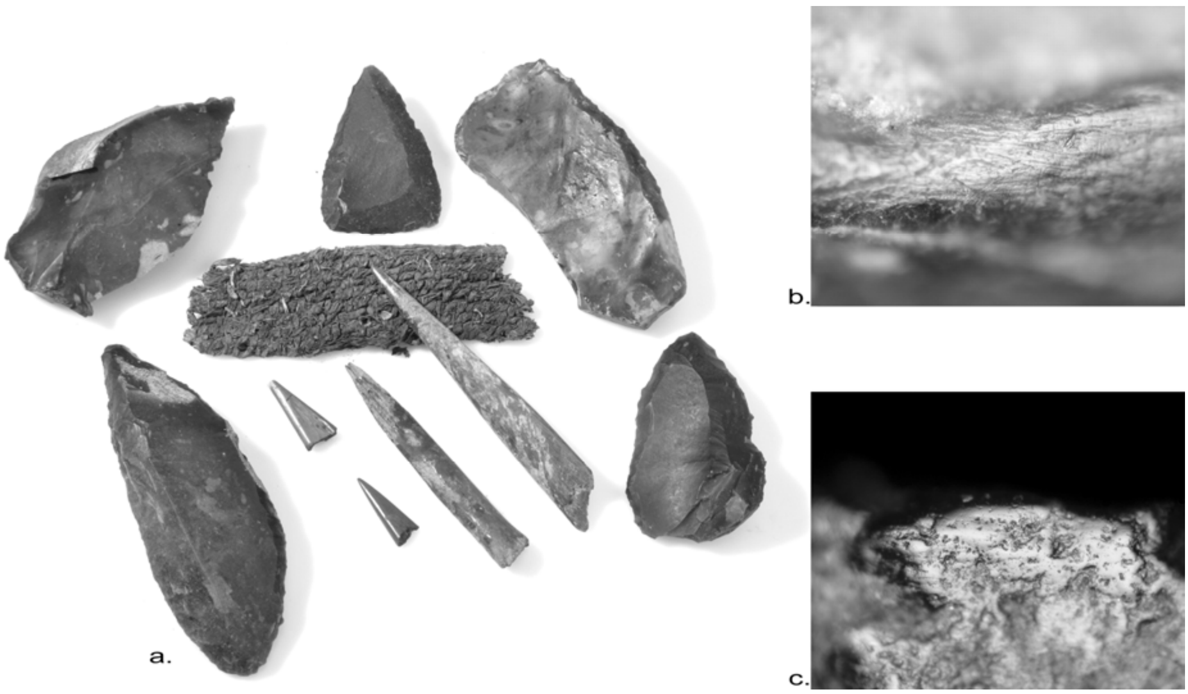

Fig. 3: a) Toolkit for making basketry with basket fragment; b) wear traces from piercing plant seen on a bone awl (orig. magnif. 200x); c) wear traces from cutting plants seen on flint blade (orig. magnif. 200x).

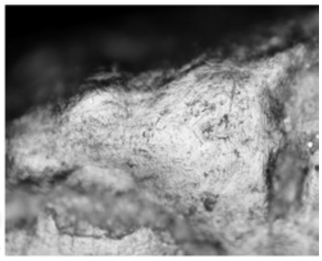

Fig. 4: a) Tookit for fine wood working; b) wear traces observed on bone chisels (orig. magnif. 200x).

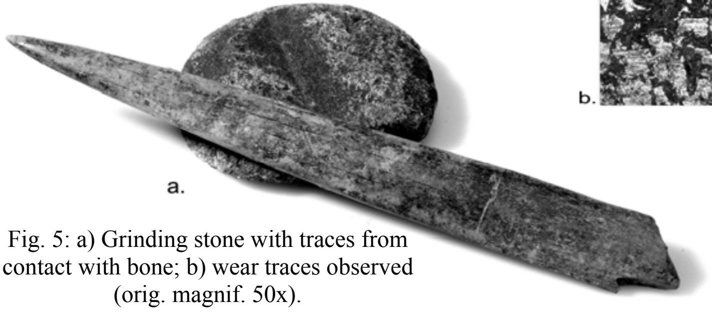

Fig. 5: a) Grinding stone with traces from contact with bone; b) wear traces observed (orig. magnif. 50x).

on (siliceous) plants. They may have been used in the process of basket making, to pierce openings in the foundation to weave the looping through.

We also have quite a number of flint tools that were used to cut siliceous plants. These blades may have been used to gather the raw material for the production of fibres. Remarkably, the very bright, perpendicularly oriented polish, commonly interpreted as resulting from plant processing, was not encountered. This type of wear traces, invariably located on small blades, is highly characteristic for late Mesolithic assemblages and also for sites of the Neolithic Swifterbant culture (Bienenfeld 1986; Van Gijn 1998). It is possible that these blades were associated with subsistence tasks such as peeling roots like *Typha*, but more likely they played a role in craft activities like basketry and matting. The fact that these specific flint plant-processing tools are absent in Schipluiden indicates a significant difference in craft activities compared to the preceding periods.

Toolkits for coarse and fine wood- working
Working wood seems to have been an important activity at the site. We have found objects like paddles, axe shafts and so forth (Louwe Kooijmans and Kooistra 2006). Moreover, the site is partially surrounded by a fence made of small stakes. It is clear that wood-working must have been an important activity for the Schipluiden inhabitants. Not surprising quite an extensive range of wood working tools has been found. A distinction can be made between coarser tasks involving the gathering and rough shaping of the wood and implements used for final shaping. The toolkit for coarser wood-working includes tools as stone and flint axes, stone wedges and big quartzite flakes for sawing. All of these tools may have been involved in collecting the wood necessary for tools and building activities. Some pieces of wood display the marks of the cutting edge of a flint or stone axe (Louwe Kooijmans and Kooistra 2006). Unfortunately it has not been possible to match the marks on the wooden artefacts with any of the axes retrieved. This is not entirely surprising as broken axes were repaired and rejuvenated, and in a last stage even used as core for the production of flakes.

Many of the wooden objects from Schipluiden display fine workmanship and objects are carefully shaped. The tools associated with shaping wooden objects include small bone chisels and flint blades. All of the chisels displayed traces from working wood (Fig. 4). Most of them are broken and are small in size, probably due to recurring re-sharpening. Flint implements played a role in shaving wood.

The production of bone and antler tools
The metapodium technique is a very effective way of producing bone tools such as awls and chisels. Metapodia of red deer or deer are split and further shaped into tools (Van Gijn 1990, Fig. 59). The technique has been in use since the Mesolithic and was also used throughout the Neolithic. At Schipluiden we have found both the waste products from metapodial production, as well as the end products like awls and chisels. Surprisingly enough however, we find very few flint tools with bone working traces. It is of course possible that we missed these implements, but it could also indicate that bone tool making occurred only rarely at the site. Certainly bone awls were polished and sharpened locally, as indicated by a small grinding stone with traces from polishing bone or antler (Fig. 5).

Antler tools were also made on the site, predominantly made on red deer antlers. Very remarkable is the fact that use was made of the groove and splinter technique, a technique so far limited in our region to the early Mesolithic. Even though the cut marks on the antlers clearly derive from a flint blade, no such tools were found at the site. Few antler tools were made into finished tools, with the exception of a few broken antler axes. All in all, it seems that bone and antler tool production was not a major activity at the site, in contrast to the late Mesolithic sites of Hardinxveld-Giessendam Polderweg and De Bruin, where bone and antler tools abounded.

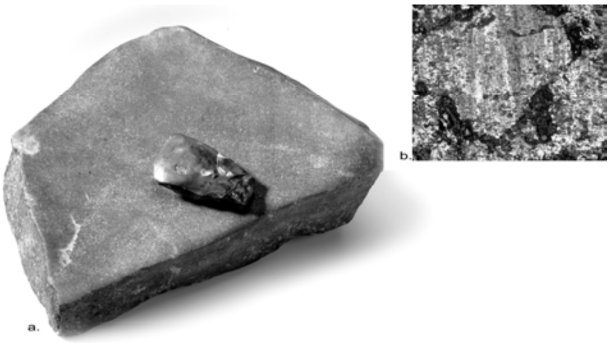

Fig. 6: a) Grinding stone used for grinding and polishing flint axes; b) wear traces from contact with flint (orig. magnif. 100x).

Maintaining and repairing stone axes and other flint implements
A lot of grinding or polishing stones were found, the majority of which displayed traces that were interpreted as being from contact with flint (Fig. 6). Several of them display more than one facet of use. The polish is very flat, bright, metallic and highly striated. These grinding stones were probably used to sharpen and maintain axes, rather than produce them. Virtually all axes were made on import flint, and most likely they were not actually produced on the site, but brought as finished products. The number of complete axes is very limited, and they are invariably small in size. It can be assumed that the large import axes incidentally broke during use, most likely during the chopping of wood. The large broken axes were then transformed into smaller versions, an activity that also involved sharpening and polishing the axes on grinding stones. At some point in their life cycle, it became impossible to shape the broken axes into small versions. Instead, they served as cores from which axe flakes could be removed. Several axe flakes are modified into distinct tool types such as triangular points. The fact that large axes are lacking in the find layers of Schipluiden is not surprising, as such precious tools would have been taken along upon deserting the site.

Other maintenance activities included hafting and repair of flint implements. Evidence for hafting is present on nine tools, mostly points, in the shape of small black spots interpreted as birch bark tar. Another twelve tools displayed friction gloss, rounding or an abrupt ending of the use wear, features that were interpreted as being the result of hafting. Direct evidence of the occurrence of hafting comes form the presence of a piece of birch bark tar, with tooth impressions (Fig. 7). Mass spectrometry revealed the admixture of beeswax (Van Gijn and Boon

Fig. 7: Piece of birch bark tar displaying tooth imprints.

2006). Beeswax is added to make the tar less brittle. The mixture was chewed to make it supple for use as an adhesive

Making beads and pendants
Beads of jet and amber have been produced locally. Most probably the raw material could be collected on the nearby beaches. Amber of Baltic origin could (and still can) be collected along the shores in the North of the Netherlands, but was probably quite rare as far south as Schipluiden. Jet must have been a common occurrence, as we find a lot of blocks of unmodified jet and unfinished waste pieces. The nearest sources are the outcrops near Whitby, Yorkshire, but it is not clear whether this material could have been washed ashore from that direction (Van Gijn 2006b).

Fig. 8: The production of jet beads: unmodified pieces of jet, blanks and flint tools with traces from contact with jet.

The complete production sequence of the jet beads has been found at Schipluiden. Flint tools were used to cut the blocks of jet into blanks. Alternatively, the blocks were first perforated. The perforations were made with a solid drill, resulting in an "hour-glass shape" (Fig. 8). Flint drills were used in this process, amongst which one very large drill made of import Belgian flint, displaying traces closely resembling experimental traces. After perforation the blanks were then ground into their final shape. Experiments have shown that this can be done on a fine-grained sandstone, resulting in a very bright smooth polish. Only one of the grinding stones from Schipluiden displays a polish that resembles the experimental wear, but it is somewhat flatter. The absence of jet-grinding traces may find an explanation in that the grinding stones were multifunctional, also used to grind flint axes, thereby obliterating the jet working traces. The last step of jet bead manufacture was straightening and smoothing the perforation. It is not clear how this was achieved, but it may have been done with some siliceous plant like *Equisetum Hyemale*. A total of seven finished beads were found, three tubular and four disc-shaped.

Amber was only incidentally worked on the site. One piece displays traces from flaking, a technique to shape a piece of amber into a blank. Amber can also be cut into shape, but no traces were found for this practice. After bringing a piece of amber into a rough shape, the blanks were perforated. This seemed to have been done with a hollow drill, possibly a bird bone, as testified by the presence of a plug at the bottom end of one of the perforations. The amount of amber waste was very limited. A total of six, often tiny, beads and three pendants were encountered.

Bird bones were cut up to make bone beads. Two of them were found in a grave of a young child. They display cut marks, probably from flint, but again, we have found no flint blades with bone cutting marks.

Processing hides

Hide working traces were mostly found on flint tools. A total of 16 edges were used on hide, fourteen of which concerned scraping motions. There is a strong relationship between scrapers and hide working. One small piece of bone waste also displayed traces from scraping hide. This is very different from what has been observed on the find assemblage from the late Mesolithic site of Polderweg. Here most hide working was done with bone or antler implements, with flint scrapers being exceedingly rare and flint tools almost never used for this activity (Van Gijn 2005).

Making fire

A considerable number of strike-a-lights were found (No. 34). They always have an elongated shape and one or two rounded points. The use wear analysis showed that several other types of tools, such as an unfinished point, display the same type of wear.

Two of these tools were found in one of the burials, along with a piece of pyrite. The position of the grave goods - in the hand held in front of the mouth - suggests the blowing of sparks when the pyrite is struck with the flint. Because fire traditionally has a special connotation it is proposed that the dead man buried with these objects may have had a special role in society like a religious specialist, e.g. a shaman (Van Gijn *et al.* 2006; Van Gijn and Houkes 2006).

The technological system of Schipluiden

The wide range of activities that took place at the site points to a long-term presence of complete households. This is in support of the outcome of the palaeobotanical and archaeozoological research (Louwe Kooijmans and Jongste 2006). The activities included cereal harvesting and processing, wood-working, the production of beads and pendants, hide working and so forth. Most of these activities involved a toolkit composed of various implements made of different raw materials. Studying the flint tools alone would provide only a limited picture of the range of tasks carried out.
Wood working involved tools made of flint, hard stone and bone. Hard stone axes and wedges are imminently suitable for chopping and splitting large tree trunks because most hard stones absorb impact shocks very well. The flint axes were small in number and size and probably represent the last stage in the life cycle of previously much larger axes imported from Belgium. Large quartzite flakes were used to saw wood, whereas the smaller cuts were done by means of flint implements. Flint implements were also served for shaving wood. Bone chisels were used for the final shaping of implements. The chisels we find all represent exhausted specimens, either broken or re-sharpened to such an extent that their size had greatly diminished.

An important feature of the technological system of Schipluiden is the evidence of harvesting and processing of wild plants. A number of flint blades, often quite large ones, made of imported flint from southern Belgium, displayed traces indicative of cutting siliceous plants. Some must have been used for a very long time as they display extensive gloss. The typical late Mesolithic and early Neolithic plant processing tools with the bright polish oriented perpendicularly to the edge are absent, possibly indicating a different technique of basketry making. This may be an example of a specific technological choice because environmental reasons cannot have been responsible. Bone awls served to widen holes in the foundation of baskets in order to allow the looping through. This tool type was used for the same purpose in late Mesolithic times and continues to be used until at least the time of the Vlaardingen group.

Cereals were grown on the dune and we find both the harvesting implements as well as the stone querns used to process the grain (see Nieuwenhuis and Van Gijn, this volume). Together they form a toolkit involved in agricultural activities.
Hide processing constituted an important activity at Schipluiden but involved only a very limited toolkit: flint scrapers for the most part. Bone and antler tools only incidentally played a role in this task. Again, this can be interpreted as a technological choice.

Other activities include the making of beads and pendants from amber, jet and bone. The toolkit used for this craft includes some flint blades, used to cut blanks out of the

raw material, and flint borers used to make the perforations. There are quite a lot of borers, many of which display polish from contact with mineral material. The grinding stones that certainly played a role in grinding and polishing the beads in shape have not been found. One highly polished bead displays faceting attributable to the polishing on a hard surface, presumably of stone (see Van Gijn 2006b, Fig. 9.1).
Bone and antler objects were most likely made locally because we find production waste from both the groove and splinter technique and the metapodial technique. However, even though flint tools certainly played a role in their manufacturing, such tools were not encountered. The toolkit for bone tool manufacturing consists therefore of only one grinding stone displaying traces from contact with bone.

A last toolkit that could be distinguished is the one to make fire, consisting of strike-a-lights and pyrite. A large number of strike-a-lights were found, many of which were used at both ends. In addition, several other types of tools also displayed traces from such a use (Van Gijn *et al.*2006). Most probably this toolkit was especially valued as one of the dead, a man, was buried with three strike-a-lights and a piece of pyrite in his hand, which he held against his mouth. This evokes the image of someone blowing the sparks resulting from striking the pyrite with the flint. As fire plays an important role in many traditional societies it may be suggested that the man had a special role in society.

The various toolkits observed at Schipluiden only gain meaning in terms of cultural choice if they are compared to toolkits found at sites spatially or chronologically removed. The only sites where a technological and functional analysis of different categories of material culture was performed are the late Mesolithic sites of Hardinxveld-Giessendam Polderweg and De Bruin (Van Gijn 2005), so comparisons are difficult to make. However, the material culture found at these sites, along with the finds from various other Neolithic sites from the Rhine/Meuse delta, seems to point to a specific long term tradition of tool making and using in the wetlands.

The wetland tradition

The study of the material culture of Schipluiden has provided further insight into the tradition of tool making and using in the Rhine/Meuse delta. Some aspects of the technological system seem to display a remarkable continuity with the late Mesolithic, as exemplified by the use of the metapodial technique for the production of bone tools. We find this technique from the late Mesolithic to the late Neolithic. The groove-and-splinter technique may also serve as such an example but we lack examples from the late Mesolithic, the technique being especially characteristic for the early Mesolithic. It may be that we simply have not found examples yet from this period.

Plant processing tools are a distinctive feature of wetland flint assemblages. Initially, during the late Mesolithic and during the Swifterbant period, it concerns small blades or regular flakes used in a transverse motion on most probably reeds. Such tools are absent in the middle Neolithic and instead we find for the most part plant cutting tools. Bone awls with plant working traces occur through the entire period and are almost always associated with the metapodial production. Still, it is clear that many objects must have been made with plant material, such as baskets, fish traps and so forth.

Another feature of the wetland technological system is the dichotomy between import flint and locally produced material. This is visible from late Mesolithic until at least the middle Neolithic. The way people treated the import tools seems different from the way they used the tools made of local flint materials (see also Van Gijn 1998). At Schipluiden this is for example illustrated by the fact that most tools of Belgian flint found are more heavily used than tools made of local material.

The wetland technological system is also characterised by an *ad hoc* use of bone and antler. Pieces of production waste are used as tools if they display a suitable edge for a specific task. Both in the late Mesolithic sites of Hardinxveld and in Schipluiden examples are numerous.

More technological and functional research of flint, hard stone and bone and antler assemblages may point to more characteristics of this apparent wetland tradition. One problem in comparing the technological system of different sites is that locations are not all excavated and sampled in the same manner, and the preservation conditions also differ greatly. However, hard stone and flint are usually preserved and it may eventually be possible to compare the technological traditions of different areas. Use wear analysis, applied to different categories of material culture, can play an important role in this approach, following the direction already advocated many years ago by Semenov.

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The role of techno-functional analysis of flint assemblages for the interpretation of internal arrangement of Eneolithic dwellings in the Vyatka river basin (Kirov Oblast, Republic of Tatarstan, Russia)

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Summary. *In this article the readers can find an analysis of the dwellings of two Eneolithic settlements, excavated in the Vyatka river basin by T.M. Gusentsova and N.P. Devyatova: the Kotchurovskoye IV site (with two adjacent houses) and the Oust-Kurynskoye site (one house). Spatial analysis allowed to localize the places with obvious density of the finds. Artefacts at the Kotchurovskoye IV dwellings concentrated in the north-eastern part near the short walls of the house, whereas in the Oust-Kurynskoye habitation these were found in the centre and around the hearths. Flint assemblages from both settlements were studied from a functional point of view. Various wood processing tools represent half of the tool-kit discovered at the dwellings. Overall, stone tool manufacture and maintenance activity took place within the settlements open-air areas. Everyday task were, on the other hand, carried out inside the dwellings.*

Résumé. *Dans cet article les lecteurs trouveront l'analyse d'habitations de deux gisements chalcolithiques fouillés dans le bassin de la rivière Vyatka par T.M. Gusentsova et N.P. Devyatova : les sites de Kotchurovskoye IV (deux maisons adjacentes) et de Oust-Kurynskoye (une maison). L'analyse spatiale permit de localiser des zones avec des concentrations évidentes d'objets. A Kotchurovskoye IV celles-ci étaient du côté nord-est, près des courts murs de la maison, tandis qu'à Oust-Kurynskoye elles étaient au centre et autour des foyers. Les assemblages de silex des deux gisements furent étudiés d'un point de vue fonctionnel. La moitié de l'outillage découvert dans les habitations est constituée de différents outils à travailler le bois. D'une façon générale, la fabrication des outils lithiques et la maintenance avaient lieu à l'extérieur, tandis que les tâches quotidiennes se déroulaient à l'intérieur des habitations.*

Key words : Eneolithic settlement, Vyatka River basin, spatial analysis, lithic assemblage.

Dwelling is regarded as one of the most important elements of culture by the ethnologists. An ancient settlement structure, its internal arrangement, reflect social and ideological organisation of primitive society. Archaeologists have to deal with fragmented remains, such as shape and size of a foundation pit. Fragments of decoration and features of the internal structures can be found occasionally.

It is reasonable that archaeologists try hard to reconstruct the arrangement of an ancient habitation structure using all possible information. From my point of view, the study of the flint equipment including its distribution, technological and functional analyses can give us additional information about internal arrangements, details of the interior and dynamic spaces of dwellings.

The structure of two Eneolithic dwellings in the Vyatka river basin is described below. The first of them is Kochurovskoe IV (two joint buildings) and the second is Ust-Kuryinskoe (consisting of one house) (Fig.1). Those sites were excavated in 1977 by T.M.Gusentsova (1980, pp.70-95) and N.P.Devyatova in 1993 (1997, pp.53-54). Substantial culture of two dwellings have much in common. Ceramics of Kochurovskoe IV have more ancient face (Solovey 1992, pp.59-60). Pottery of Ust-Kuryinskoe dwelling have the features both of novoilyinskaya (earlier period) and garino-borskaya (later period) cultures. Presence of mixed pottery in monument points the date. (Devyatova, 1993, pp.75-76). Besides, we have the radiocarbon date for Ust-Kuryinskoe dwelling. It is dated 3510 +- 290BP. (Le-5006)

Flint assemblages from both dwellings were studied with the help of the functional method. (Medvedeva 1999, pp.61-62; Zigvinceva - Medvedeva 2003, pp.139-140). Kochurovskoe IV has 1389 flint pieces, 448 of them were found inside the buildings and 158 of them are represented by tools.

Buildings for living of Kochurovskoe IV were located along the dune from north-east to south-west. Evidently they were parallel to the ancient river bed. The first structure is a semi-pit dwelling of 97.5 m^2 and rectangular shape.

According to different samples studied in ethnography, we can say that about 28 to 48 people could live in it (Smolyak 1966, p.15; Taxami 1969, pp.64-65). At the foundation level, evidence for numerous columns and storage pits were found. The foundation trench went as deep as 0,25-0,30 m. The entrance (wide 0,9m, longitude 2 m and of 0,3 m depth) was located in the south-western wall, opposite the river. Near the entrance fragmented pieces of ceramics were found on the floor, in addition to an oval-shaped area rich in charcoal (1.2 m x 0.6 m) (Gusentsova 1980, p.72).

There were no stone tools or flakes near the entrance. It is very likely that the second entrance was where the long passage-like depression was located in the south-eastern wall (a sizes of 4 m x 1 m. and depth – 0,22 m.). At both sides of it there were two storage pits with smashed pots and flakes. Other house pits were located along the walls and outside. The fireplace was situated at the centre and all of housekeeping activities concentrated there. Inside

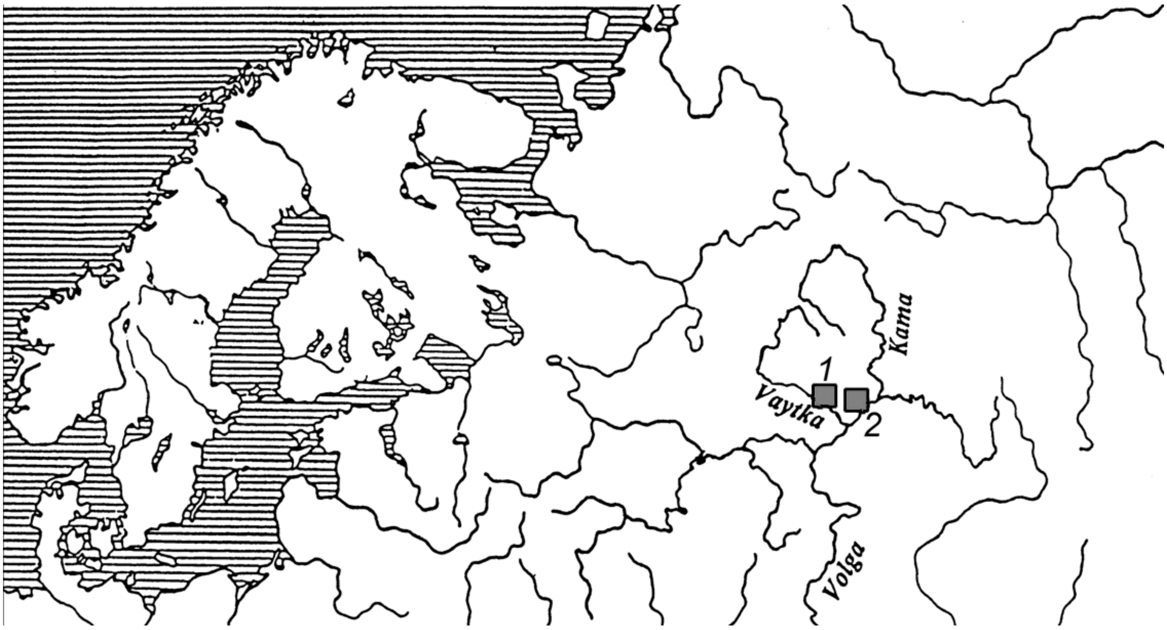

Fig. 1: Map of the studied area: 1) The Kotchurovskoye IV site; 2) The Oust-Kyrynskoye site.

Fig. 2: The dwellings of Kotchurovskoye IV site.

the building tools were all over, however it is still possible to find distinctive patterns. For example, near the entrance there were numerous wood-working implements and tools for skin-processing. The tools closest to the entrance were two gouges, two chisels, an drill, a planing-knife, a scrapers for wood, a push-plane and a wood-reamer. Also there were two scrapers, a carving knife and an elf-bolt. Only in this place worn and discarded tools were found.

Near the passage to the next building two scrapers, a scrapers for wood**,** three elf-bolts and a (stone) auger were also discovered. Near the pit at the centre of the house a skin-processing tool, an adze, an engraver and a stone-carver were revealed. In the eastern part of the building, tools lay in a similar order, but skin-scrapers prevailed in quantity over others (Fig. 2)

The second dwelling is also a semi-pit dwelling of rectangular shape and 144 m^2 (Fig. 2). According to ethnographic parallels, about 28 to 52 people could live in it (Smolyak 1966, p.15; Taksami 1969, pp.64-65). The depth of the foundation trench was 35-50 cm, the floor was uneven, sloping down in the south-western part. Numerous niche-like features, peculiar only to this hut, existed (Gusentsova 1980, p.73). Two exits looked at the river, the other two faced the opposite side. Their sizes: 2.25 x 0.65-0.95 m., 1.9x1 m; 1.1x1.05 m; 1.5x0.8-1.2 m. At the north wall, a wide niche (2.3 x 2.2 m) was revealed. At the floor level the niche took the shape of an oval pit. The bottom of the pit was covered with a deposit of ashes and fired soil 8-10 cm thick. Possibly, the pit was a part of the entrance, which connected both huts (Gusentsova 1980, p.74). The quantity of entrances can be associated with the big size of the building. Another explanation is that entrances were built in different periods (Gusentsova 1980, p.74). Hearths were situated mostly along the longitudinal axis. At the bottom of the south-west entrance a concentration of charcoal was discovered.

In the second building, tools were located near the hearths and doorways. On the left of the south-west entrance there were implements for skin-processing such as a scraper and a borer. Wood processing tools were found on the right: two strickles, an adze, and a chisel. Also there were an elf-bolt and an arrow point. In the middle of the structure, beside the hearth-pits, wood-processing implements were left: 3 drills, 3 strickles, a scraper, a planing knife and an adze. But also there were four tools for skin-processing: a scraper, 2 borers and a knife. In proximity of the north-east part of house, near the passage leading to the other building, tools for skin and wood-processing were found more often. Wood was processed with strickles (6 pieces), scrapers (2 pieces), chisels (2 pieces), drills (1 piece), engravers (1 piece), planing knives (1 piece). Judging by the tool-kit, the final processing of wooden artefacts took place here. Only 3 skin scrapers, a borer and a knife were revealed at that place.

In addition, stone-processing implements were found only in the second building. In the first house there were 3 blanks, in the second 29 blanks and rejects. Only in that place the hammer-stones, bigger than cores and by-products, were revealed. Here 8 fragments of elf-bolts and darts were also found. They were smashed by a blow. It is likely that the shafts were more valued in arrows then elf-bolts. Possibly somebody living in the second house was a craftsman of weapons and implements.

The majority of the processing tools as well as blanks and rejects were concentrated in one place – at the centre of the structure. Besides the stone-working tools there where 3 augers, a reamer, a gouge, a chisel and 3 hidescrapers (Fig. 2).

Functional analysis has shown that half of the implements found in the dwellings consists of different wood-processing tools (gouges, chisels, adzes, planing knives, drills, strickles). Apparently we can make a conclusion that development of highly specialized crafts, such as wood-processing, began in this period. (Medvedeva 1999, p.62)

Technological analysis of flint assemblages has shown that primary flaking of chert took place within the settlement area. Inside the houses, implements were prepared and finalised. It looks like the final tool working process was typical of the second house.

In both houses flakes were discarded around the centre without any evident system. Spatial patterning and functional analyses allowed us to distinguish the functional zones in the dwellings of Kochurovskoe IV (Fig. 4). These were described according to the level of tool concentration and to manufacturing process type (e.g. area for skin, wood or stone processing). Of course, few instruments were also found in others areas.

It the first dwelling such zone segmentation is relative because artefacts were found scattered around. Wood and hides were processed near the riverside entrance. However hides were further worked in the centre of the dwelling, around the hearths. There are 2 flake concentrations both near the entrance pit and north-eastern pit which could be used for rubbish accumulation (Fig. 2,4).

In the second dwelling functional areas are more evident. Skin and wood were processed near the south-western entrance. In the centre near the hearth people knapped stone, shaped blanks, repaired tools. Wood-working took place at the other side of the hearth (in the north-eastern part of the dwelling (Fig. 2,4). Along the big north-west walls a few implements and flakes were found. It is likely that beds were located here because this area was kept overall clear from artefacts. On the plans, sleeping areas appear as rather narrow strips. (Fig. 4), which might suggest the presence of high banks, under which artefacts were lost.

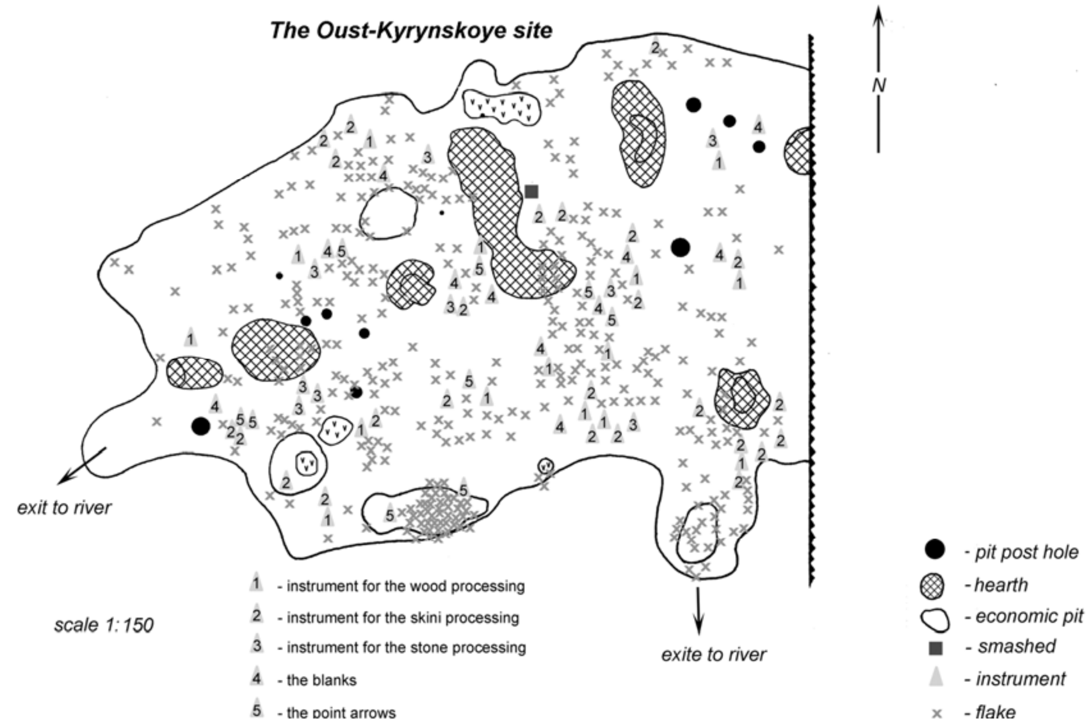

Fig. 3: The dwellings of Oust-Kyrynskoye site.

According to the stratigraphic observations recorded by the excavator T.M.Guzentsova (1980, p.76), the dwelling existed for a long period. This is confirmed by a thick archaeological stratigraphy, hearths and hearth-pits, found at different levels and used in different periods. Another scholar, A.M. Zhulnikov (2003, p.64), argued that it was possible to live in semi-pit dwellings for a long time including in winter. Functional and technological analyses of flint assemblages from Kochurovskoe IV confirm this argument. Flint knapping took place outside in the summer and inside during the winter.

Archaeologists found 6388 stone artefacts at the Ust-Kuryinskoe settlement site. 1392 of those (including 66 tools) were found within the habitation structure. The dwelling at Ust-Kuryinskoe settlement, occupies 137m^2 and it could give shelter to 25 to 50 people (Smolyak 1966, p.15; Taxami 1969, pp.64-65). The depth of the foundation trench is about 30-45 cm, because dwelling was a semi-pit dwelling. There were 7 hearths. Pits were located along the walls and near the entrances. (Devyatova 1997, p.53)

The construction had an entrance 35-40 cm deep at the south-west wall (sizes 1.85 x 2.8 m), which faced the river. Five open-fire hearths were situated down the long axis. Archaeological find concentrated near them.

Two other hearths were located opposite the entrance and niche in the south wall, they heated the semi-pit dwelling. A rather shallow pit was dug in the hut floor and filled with charcoal. Charcoal concentrations along the walls were probably part of the habitation heating system (Devyatova 1997, p.55)

The majority of the artefacts were found at the centre of the building near the south wall.

Stone- and wood-processing tools were found along the big hearths, opposite the entrance. Mostly primary and rough wood-processing took place here. For that process, adzes (2 pieces), gouges (2 pieces), planing knives (2 pieces) were used. The tool kit for tool production consisted of cores (3 pieces), blanks (5 pieces), percussors (2 pieces) and a grinding stone. Percussors and grinding stone lay near each other.

In the Ust-Kuryinskoe settlement as in Kochurovskoe IV dwellings, all arrowheads were fragmented. The debris were found both in areas of wood-processing and stone-working. Probably arrow-shafts were also made there.

A heap of wood-processing tools was found near the south wall. In that place there were represented not only the primary flaking but also the final phase. Near the adze and gouge there were found a chisel, an auger, a strickle and a planing knife.

Implements for skin processing were grouped to the east of the biggest hearth and near the niche. It was a usual tool kit – 5 scrapers, 2 borers and 2 knives.

Flakes were equally scattered all over the floor. Only one flake concentration was found in the pit near the south wall. This was probably a refuse pit located near the stone-processing zone (Fig. 3).

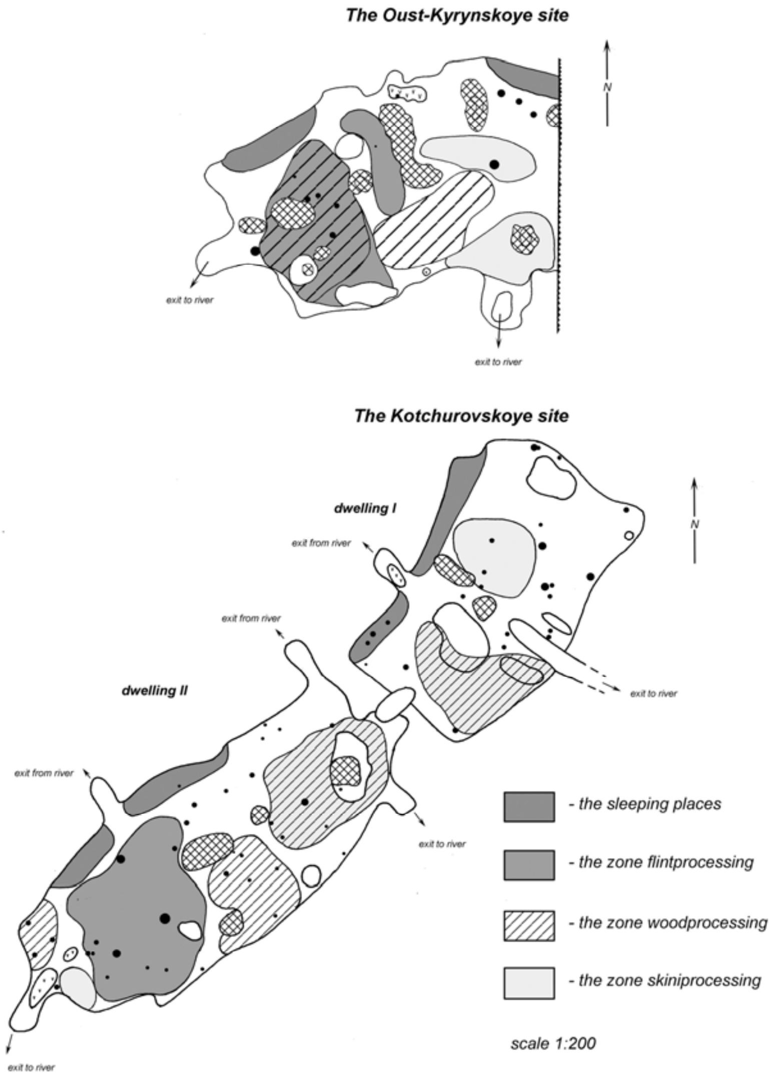

Fig. 4: The functional zones of sites.

Primary flint knapping took place in the open and more delicate work (shaping and retouching tools) was held inside the house, next to the exit and near the hearth.

Since cores, fragments, blanks and debitage were found inside, it is possible that in winter-time flint was flaked inside.

Instruments for wood-processing were the most numerous among the tool kits.

By comparing the spatial patterning data and functional analyses, functional areas at Ust-Kuryinskoe can be distinguished. The sleeping area was located near the long northern wall which was opposite the river. Next to the western entrance stone processing took place. Butchering and meat processing was carried out in the eastern part of the house. Next to the hearths; in the centre people were busy with wood-processing (Fig. 4).

Using technological and functional analyses of the flint assemblages from Kochurovskoe IV and Ust-Kuryinskoe habitations, the following conclusions can be drawn.

- Primary flint knapping and stone-processing took place in the open.
- Unimportant everyday operations were carried out in the dwellings.
- People carried out household activities at the centre, near the hearths. They tried to save sleeping areas from flakes of flint and ceramic fragments.

Comparing functional areas inside the dwellings in both settlements it can be concluded that:

- Firstly, sleeping areas were situated near the long walls opposite the riverside entrance.
- Secondly, technological zones were regularly located next to hearths and entrances. In both cases holes for posts were noticed near the place. Probably working areas were separated with partitions.

Consequently, use-wear and technological analyses allow to reconstruct the internal arrangement and planning of habitation structures, piece together constitute day-to-day way of life of the Eneolithic inhabitants of the Vyatka basin. Based upon these data, it is possible to create a social reconstruction of the ancient society. It is very likely that craft specialization began around 3000 BC, because the functional areas in the houses were divided according to the social status of members of ancient society.

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5.4. Complex Polities

Lithic perspectives on metallurgy: an example from Copper and Bronze Age South-East Iberia

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To the memory of Volker Pingel

Summary. *One of the centres of early development of metallurgy is the South-East of the Iberian Peninsula, where it played a key role in the formation of the so called Los Millares and El Argar "cultures" during the 3rd and first half of the 2nd millennium BC. Yet, most arguments about the importance of metalworking are derived from the funerary evidence, i.e. from the finished objects used as grave goods, while direct evidence of the production processes is still scant.*
During the last years systematic analyses have been carried out in South-East Iberia concerning the (macro-) lithic artefacts coming from a series of Copper and Bronze Age settlements and necropolis. The observation of features and traces related to metalworking on some of these labour instruments has allowed to identify the final stages of metallurgical production, as well as to the maintenance of metal artefacts.
The functional analysis of these tools and their spatial distribution at a regional as well as local scale reveals important aspects of the social organisation of the process of metal production. Finally, the different technical situations are evaluated in order to understand the changing relationship between metallurgy and the emergence of new forms of domination and exploitation.

Résumé. *Un des centres les plus anciens de développement de la métallurgie est le sudest de la péninsule ibérique, où cette technologie a joué un rôle crucial pour la formation des « cultures » de Los Millares et El Argar, pendant le III millénaire et la première moitié du II millénaire BC. Jusqu'aujourd'hui la plupart des arguments au sujet de l'importance de la métallurgie se sont fondés sur les évidences provenant du mobilier funeraire (objects de parure, armes, outils), tandis que les évidences directes concernant le procés de production sont peu connues.*
Pendant les dernières années, des études systématiques ont eté réalisés au sudest péninsulaire sur les outils (macro)lithiques découverts en plusieurs habitats et nécropoles chalcolithiques et de l'Âge du Bronze. L'observation sur quelques de ces matériaux lithiques de traces produïtes pour le travail métallurgique a permis d'identifier les dernières étapes de cette production, de même que le maintien des outils métalliques.
L'analyse fonctionnelle au sujet des outils lithiques mentionnés et sa distribution spaciale à niveau régional et local montre des importants aspects de l'organisation social du procés de production métallurgique. On s'évalue finalement les situations techniques envisagéés pour mieux comprendre les relations changeantes entre la métallurgie et le développement de nouvelles formes de domination et d'exploitation.

Key words: metallurgy, Los Millares, El Argar.

Introduction

Metallurgical production has been considered as one of the most outstanding technological achievements in prehistory (Childe 1930). The uneven distribution of mineral outcrops and the complexity of the chain of labour processes implied in the manufacture of metal tools and ornaments supposed, in the long term, a radical change in the economic and social organisation of the Neolithic societies of Asia and Europe. One of these centres of early development of metallurgy was the South-East of the Iberian Peninsula, where it played a key role in the formation of the so called Los Millares and El Argar "cultures" during the third and first half of the second millennium BC. While copper was the dominant metal in the beginning, the use of arsenic-copper alloys became more and more important through time, until tin bronze was introduced around 1800-1700 BC. Gold and silver was worked at least since the middle and the end of the third millennium respectively. Yet, no evidence of mining activities has been found so far, and only few of the known metallurgical workshops have been studied in detail. While hoarding was not a common practice in southern Iberia until the late Bronze Age either, metal objects are seldom encountered in domestic contexts, due to the high value of this raw material and the ability to recycle it. Consequently, most of our understanding on the exploitation, distribution and manufacture of copper or bronze artefacts is based either on typological or on characterisation analyses of the abundant funerary objects. The available evidence and analytical results are often inconclusive, and have led to contradictory views on the scale of metal production (e.g., Lull 1983; Chapman 1984, 2003) or on the origin of the exploited resources (Montero 1994; Stos-Gale *et al.* 1999).

Given the difficulties in moving further in the present debate without increasing significantly the already existing collection of metal artefacts and analytical data, it seems convenient to consider alternative approaches to ancient metallurgy. During recent years systematic analyses of macro-lithic assemblages from different third and second millennia settlements and cemeteries have been carried out (Delgado 2003; Risch 1995, 2002). On a small number of artefacts use traces and residues related to metalworking have been identified. Semenov (1969) already noticed and described some of these tools, and other authors have drawn attention to their presence in some Copper and Early Bronze Age tombs throughout Europe (Butler and van der Waals 1967-68). Yet, their unexciting aspect and the general lack of habit in later prehistoric research to describe and analyse macro-lithic artefacts, implies that these tools and, most importantly, the activities related to them have remained largely unnoticed in the archaeological record. The aim of this study is to develop the identification of the instruments of labour used in metallurgy, in order to gain a better understanding of the social organisation of this production process.

The technical and social conditions of metal-working.

Usually, the metallurgical production process is considered to be organised into a *smelting,* a *shaping* or *melting* and a *post-casting* or *finishing process.* Forging, sheeting, polishing, decorating, assembling and sharpening of artefacts represent the main activities involved in this last working phase (Mohen 1992; Pernot 1998). Maintenance activities and repairing are further aspects of metallurgy, if efficient tools and weapons or showy ornaments are required. All of these operations are carried out by means of specialised tools, many of which had to be made out of stone, in order to fulfil the necessary technical requirements in terms of hardness and thermal resistance. A second implication is that the whole production sequence, from the smelting of the metal to the finishing and maintenance of the metal artefacts, can be divided into spatially and chronologically different operations. In fact, the separation of a *primary* production, concerned with the procurement of workable metal, from a *secondary* processes, devoted to the finishing of the objects, is a common observation in ethnographic cases. While archaeology has mainly been concerned with the mining, procurement and smelting of minerals, much less effort, in terms of field work, experimental replications or analytical studies, has been dedicated to the final stages of metal production.

The importance of this secondary phase of early metallurgy becomes evident in view of the existing casting technology. During the Iberian Copper Age (3000-2250 cal BC), the melting process was probably carried out with moulds formed with sand or unburned clay of which no traces have preserved in the archaeological record. The first stone moulds represent, as in many other parts of Europe, one of the technological innovations of the early Bronze Age, and their appearance seems to be linked with the intensification of production and the working of harder metal alloys. Sandstone moulds are part of the standard metal working tool kit from El Argar onwards. But even in this period (2250-1550 cal BC), a comparison between the melting shapes of the moulds and metal types shows, that only 65% of the objects, mainly axes, awls and rings, seem to have been cast in these tools at some stage of their production process. Especially surprising is the lack of moulds for knifes and daggers, one of the most common grave goods in El Argar tombs. In other cases, it is the casting matrix which does not seem to have an equivalent among the known metal types. Consequently, it has to be concluded that in Los Millares, but also in El Argar contexts, the finishing activities had a crucial importance in the transformation of ingots, bars and casts into usable artefacts.

Metallographic analysis carried out on objects from different third and second millennia sites have confirmed that forging through hammering formed part of the technical skills of ancient metal working (Nocete *et al.* 2004; Rovira and Delibes 2005). Annealing was only used occasionally and with limited technical control during the Copper Age, but became a standard procedure combined with cold hammering during El Argar (Montero 1994). The result was a more homogenous metal, which increased the resistance and hardness of tools, weapons and ornaments.

Sheet gold was produced in South-East Iberia at least from the later Copper Age. Although this tradition continues during the Bronze Age, a characteristic of El Argar metallurgy is the working of silver. Such sheeting processes must have implied, as in the case of forging, the use of stone hammers and anvils with hard and polished working surfaces. Other copper and silver objects, such as spirals, rings and bracelets were produced through the hammering, bending and twisting of cast bars. Grinding and polishing can be necessary at all production stages, especially after the object is taken out of the mould and after each hammering session. The aim of this operation is to remove the so called *casting skin* or any irregularities left on the surface. Artefacts with a cutting edge also need to be sharpened regularly in order to prevent dullness. All these activities require a good technical control, adequate instruments, and ultimately they determine the efficiency of tools and weapons, and the quality of the ornaments.

An interesting aspect of early metallurgy is the presence of stone instruments related to the secondary metallurgical process in a restricted group of tombs of the third and first half of the second millennium BC throughout Europe. Moulds, anvils, hammers and polishing stones appear for the first time in some of the Kurgans of the northpontic area. Their position close to the skeleton has led to define these tombs as "metal worker's graves". An outstanding example is the recently discovered tomb 32 of the Great Ipatovskij Kurgan, near Stavropol, dated around 2200 cal BC (Belinskij and Kalmykov 2004). Inside this large wooden chamber a 35-45 years old man was buried together with a set of stone instruments, as well as a series of metal ornaments, tools, weapons and a complete wagon, a grave good which distinguishes the most important tombs, also called "Adelsgräber".

In central and north-western Europe metal working tools seem to enter the funerary record during the Bell Beaker period, in the second half of the third millennium (Butler and van der Waals 1967-68). A recent find of special importance is the male beaker burial discovered in Amesbury, Wessex (Fitzpatrick 2002). It contained more than 100 objects of flint, pottery, bone, copper and gold, as well as an anvil and two so called “archers wristguards”, which could have been used as sharpening stones. The Early Bronze Age burial mound of Leubingen (Thüringen), dated around 1900 cal BC, is another well known funerary context including metal working tools. Apart from an anvil and a perforated stone axe-hammer, its central wooden chamber contained several golden ornaments and an important number of bronze weapons and tools, some of which seem to be damaged and were meant to be recycled. Such an exceptional assemblage places this tomb among a small group of very rich funerary structures or “Fürstengräber” of the Unetice complex.

The deposition of metallurgical instruments in a restricted group of funerary assemblages is also documented in the Early Bronze Age of the eastern Mediterranean. One interesting case is the tomb 21 of Pyrgos in north-western Cyprus. Again, we are dealing with a male burial with an extraordinary funerary outfit, including about 110 ceramic and bronze objects of great quality. Further grave goods were two stone slabs, four polishing stones and three more tools for bending and hammering metal sheet (Belgiorno 2002). Around the same time, the social importance of the transformation of metals was also emphasised in some Egyptian tombs belonging to state functionaries of the 5th Dynasty. In this case, the melting, forging and polishing processes are represented as complete scenes on stone reliefs (Müller and Thiem 2001, Figs. 147-154).

At the other extreme of the Mediterranean, metal working tools have been found in at least three of the c. 1800 known tombs of the El Argar complex. The best known example is the large cist nr.3 of Los Cipreses (Lorca) dated around 1800 cal BC (Martínez *et al.* 1996). It contained a man more than 50 years old, which, according to his funerary outfit, belonged to the dominant class of El Argar. Next to his skull lay two anvils, a perforated polishing stone or so called “archer’s wrist guard” and a piece of scrap metal, forming a close set of objects. In the shaft a large polishing/sharpening stone had been carefully placed. Two urn burials (T 580 and 597), excavated at the end of the 19th century at the site of El Argar, contained a further set formed by a possible anvil and a stone slab. Unfortunately, these artefacts are only known to us through drawings (Siret and Siret 1890, lám. 23; Risch 2002, pp.103-104).

The common trait in this trans-European group of burials is the combination of male adult individuals, with metal weapons and an often exceptional outfit in terms of the quality or quantity of the grave goods. Independently if the association with metal working tools pretended to express a direct involvement of the buried person in a particular craft, or, rather, to signal a political control over a given production, it cannot be overlooked that in all cases the economic emphasis is placed on the secondary phase of the metallurgical process, and not on the mining or smelting activities. Not only the type of tools, but also the distance of some of the funerary structures in relation to metal sources, manifests the social relevance of the finishing processes in these communities of the third and first half of the second millennia. The economic principle underlying such social organisation of the forces of production seems to have been the control of one of the productions with the largest added value at that time, and, consequently, from which most surplus value could be extracted. In modern economic terms, this means that the exchange value of a product increases exponentially as more and more raw materials, labour force and technology are invested in its manufacturing process. Consequently, in a context of social inequality, much more surplus value, i.e. value above labour costs, can be obtained from its exchange for other products or services. The close connection repeated in the funerary record between these specialised activities and the accumulation of wealth by some individuals, turns the study of the metal worker’s instruments into a priority for our understanding of the social and economic structure of early Bronze Age societies.

Metal working tools of the third and second millennium BC in South-East Iberia

The identification of tools implied in the metal production process depends primarily on the functional analysis of the rich assemblages of macro-lithic artefacts. Although the development of this methodology in relation to non flaked industries is still at an initial stage, during recent years important progress has been made in determining the basic principles underlying the formation of wear patterns on different rock types. Further information has been gained through residue analysis, experimental work and the study of ethnographic materials (e.g., Hayden 1987; Adams 1989; Risch 1995, 2002; Fullagar 1998; Dubreuil 2002; Hamon 2004; Procopiou 2004). In the context of the South-East of the Iberian Peninsula, several thousand macro-lithic tools coming from a series of recently excavated Copper and Bronze Age settlements have been analysed according to a standardised recording procedure (Fig. 1).

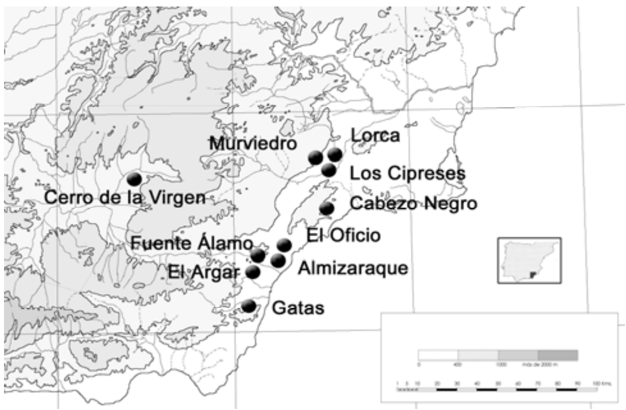

Fig. 1: Copper and Bronze Age settlements of southeast Iberia, for which systematic analysis of macro-lithic artefacts are available (map S. Gili).

Macroscopic production traces	Microscopic production traces	Morpholgy of the microtopography	Bibliography
-	Edge-rounding of grain	Sinuous	Hayden 1979, 18-19 Adams 1989 Risch 1995
-	Grain extraction	Irregular	Hayden 1987, 86 Adams 1993
-	Crushing or shattering of grain	Irregular	Hayden 1979, 19; 1987, 89-91
Levelling	Levelling	Flat	Adams 1989 Risch 1995 Dubreuil 2002 (“plage”) Hamon 2004
Polish	Polish	Flat / sinuous	Semenov 1981 Plisson & van Gijn 1989
Plaque	Plaque	Sinuous	Hayden 1987, 87-88
Linear traces	Striations (width < 0.5 mm)	Irregular	Semenov 1981
	Scratches (width >0.5 mm)	Irregular	Semenov 1981
	Polish striations	-	Grace 1989
	Pigment striations	-	Delgado Raack (in press)
Pitting	Pitting	Irregular	Hayden 1987, 86-87 Adams 1989; 1993
Checks	Checks	Irregular	Hayden 1987, 85-86
Frosted appearance	Frosted appearance	Irregular	Hayden 1979 Adams 1989
Stepped fractures	Stepped fractures	Irregular	Hayden 1979, 19; 1987, 91
Concoidal fractures	Concoidal fractures	Irregular	Hayden 1979, 19; 1987, 91
Residues	Residues	-	Delgado Raack (in press)
Thermal alteration	Thermal alteration	Irregular	Delgado Raack (in press)

Fig. 2: Wear traces which can be observed on macro-lithic artefacts.

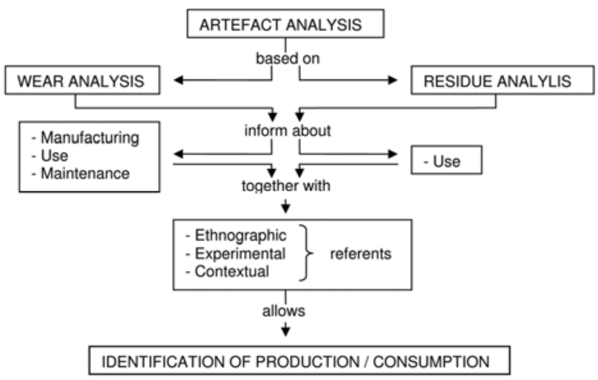

Fig. 3: The study and interpretation of lithic artefacts.

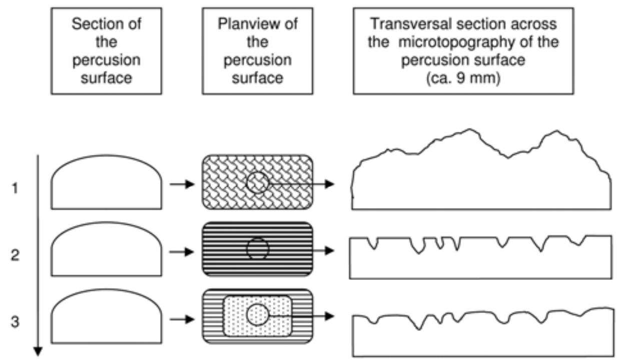

Fig. 4: Development of wear along the production and use of forging artefacts. Moment 1: natural surface of a water worn cobble; Moment 2: dense and fine striations parallel to the longitudinal axis of the active surfaces, caused by grinding processes on hard material (manufacture traces); Moment 3: striation becomes more and more superficial as the surface flatens during hammering (use wear).

Its starting point is a standard orientation of the artefact and its division into six separate faces, each of which can be described in terms of shape, size and the presence of natural or anthropogenic wear traces and residues (Risch 2002, pp.35-54). The identification of wear patterns and artefact categories is achieved through a combination of different variables:

a) Petrographic characteristics of the rock (texture, hardness), which determine the behaviour of the rock in contact with other materials.
b) Morphology and size of the artefacts and, particularly, of the active surfaces generated through work processes.
c) Production traces, understood as all the modifications caused by the working and use of artefact (Risch, this volume). A number of traits are identified through macro- and meso-scopic observation (10-80X) and recorded according to their weft, depth, shape, placement and orientation (Fig. 2). Of special importance is the description of the topography of the surfaces and the degree of invasiveness of the use-wear (high and low topography). Experimental tests, ethnographic observation and contextual information allow us to

establish causal relations between wear patterns and particular activities (Fig. 3).

d) Residues can provide further information on the use of a particular artefact. Unfortunately, it has been observed that mineral particles disappear rapidly even on modern metal working stone tools.

Casting tools

Moulds (Fig. 5,1)
Artefact morphology: The characteristic feature of this artefact category is the presence of one or more casting matrices worked into a surface which has been ground flat. Usually, the other faces are only roughly prepared through percussion or abrasion.
Geology: Slabs of fine grained sandstone (0,13-0,25 mm) or, rarely, calcareous sandstone (0,06-0,13 mm). Grains are embedded in a carbonate matrix.
Morphology of the active surface: Most of the known early and middle Bronze Age casting matrices of South-East Iberia conform to axes and awls or ingot-bars. Other shapes are indefinable in terms of finished metal artefacts.
Production traces: Thermal alteration of the rock grains is a characteristic feature visible in the melting shape and its margins (Figs. 9; 10). The casting surface often presents an irregular micro-topography due to grain extraction, which is probably caused by the loosening of mineral particles from the rock matrix during the casting and subsequent separation of the metal blank from the mould. This wear is not comparable with abrasive traces, where grains show micro-fractures and angular shapes. Rather, complete grains with a rounded or blunt surface are visible (Fig. 9).
Validating information: None of the artefacts analysed so far preserved metal adherences either on the grain surfaces or in the interstices. Nevertheless, abundant contextual data identifies this artefact category as a metal working tool.

Forging tools

Hammers (Figs. 5,3-5,6)
Artefact morphology: While axe-shaped hammers have been identified in several Los Millares sites (Fig. 5,3), so called “mining hammers” with hafting grooves or notches are a characteristic tool type of the El Argar and Post-Argaric periods (Figs. 5,5; 5,6). Small cylindrical artefacts form a third type of hammers (Fig. 5, 4).
Geology: Axe shaped hammers are always made out of micro-gabbro or similar hard and dense rocks with an ofitic texture; the same material and, occasionally, quartzite are used as grooved hammers; quartzite is also the rock employed for the few known cylindrical tools.
Morphology of the active surface: The distinctive feature of all these artefacts is a smooth and slightly convex working surface. This obliges us to consider “mining hammers” with signs of heavy battering (fractures, checks, etc.) as a different artefact category.
Production traces: All active surfaces show an intense levelling of the mineral particles, together with a shiny polish, which mainly appears on the highest spots of the topography. These spots are high plateaus located between series of very fine, dense and superficial striations, which cover the hammering front in a longitudinal sense. These striations tend to blur, without completely disappearing, towards the centre of the active surface (Fig. 12). Additional traces are small pits, scattered over the percussion surface. Quartzite artefacts have slightly more irregular surfaces than gabbros, and do not present striations, due to the different petrological characteristics of these rocks (Fig. 13).
Validating information: According to experimental tests, intensive levelling and fine regular striation on this type of hard rocks are the result of grinding on more or less abrasive rocks, and consequently represent fabrication traces. Instead, the blurring of these patterns and the development of a shiny surface can be related to the hammering of metal. The order and location of the observed patterns allows us to propose a general model of wear development (Fig. 4).
No metal residues could be identified, but examples of these stone tools have been found associated with other metal working equipment in burials (Lebedi, Kuban; Soesterberg, central Netherlands), hoards (La Petite Laugère, Saône-et-Loire; Wageningen, central Netherlands) and workshops (Campos, Almería; Cerro de la Virgen, Granada; Kültepe-Karum, Kayseri).

Anvils (Fig. 5,2)
Artefact morphology: According to their more or less square shape, slightly rounded edges and intensely polished surfaces, these artefacts have also been named “cushion stones” (Butler and van der Waals 1967-68).
Geology: Micro-gabbro. It should be taken into account that the grinding of such rocks into small ashlars is more labour intensive, than the production of any other known metal working artefact, apart from the axe shaped hammers (Risch 2002, Fig. 4,11).
Morphology of the active surface: Obverse and reverse sides tend to be flat, while the lateral ones usually are plano-convex.
Production traces: All sides present a shiny polish, resulting from the intense levelling of the mineral particles. As in the case of the hammer stones, this polish impregnates fine and dense striations. Under the microscope, these linear traces are especially visible on the rounded edges of the artefacts, while their presence, rather than frequency, is much more subtle in the central area of the active surfaces. Here, longer striations appear randomly spread, without a recurrent orientation above the first weft of striations. Small pits can also be observed on the flat faces (Figs. 11a, b).
Validating information: Again, we seem to be dealing with a combination of manufacture and use traces, according to which these artefacts could have been used as hard supports, and as hammers. Experimental tests have proved the importance of the flat polished surfaces on the forging tools, in order to prevent the extraction of

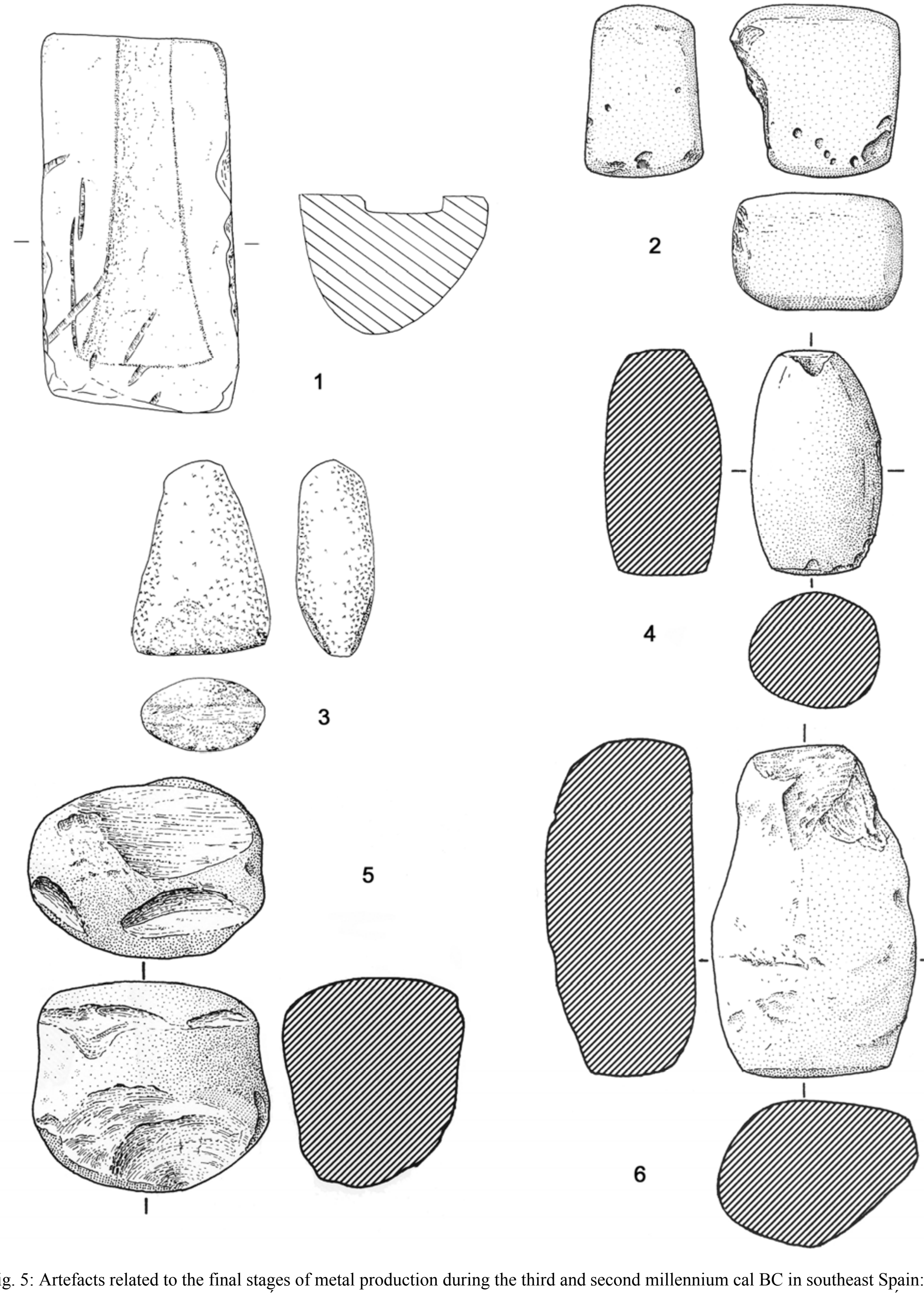

Fig. 5: Artefacts related to the final stages of metal production during the third and second millennium cal BC in southeast Spain: 1. Mould (Murviedro); 2. Anvil (Fuente Álamo); 3. Axe shaped hammer (Cerro de la Virgen); 4-6. Grooved hammers (Fuente Álamo) (scale 1:2).

scars and flakes during hammering and, consequently, to maintain the full area of the working surface.

In the case of an anvil coming from the post-argaric site of Murviedro, Lorca (ca. 1550-1300 cal BC), tiny dark brown metallic spots were detected on the surface coinciding with pits (Fig. 11c). The particles were analysed in the laboratories of the Universitat Autònoma of Barcelona through SEM-EDAX, and turned out to be pure iron, as well as iron oxides.[1] This suggests that we are dealing with post-depositional formation of goethite in an iron rich sediment, rather than with residues resulting from the forging activity. Metal traces resulting from work processes could be observed on the experimental replicas, but only seem to be preserved in exceptional cases on archaeological artefacts (Fig. 11d). This is the case of an anvil found in Dalverzin in central Asia, on which Semenov (1969) detected the presence of iron particles. Another example comes from the late Bronze Age workshop found in Choisy-au-Bac (Oise, Francia). In this case, traces of gold remained trapped in linear pits on the active surface (Èluere 1985). The presence of anvils in metallurgical workshops (Arslantepe, Malatya; Newgrange, Ireland), deposits of scrap metal (Wageningen, Netherlands), as well as in so called "smith's graves" (Zutovo, Volgograd) further supports their interpretation as metal working tools.

Polishing, cutting and sharpening tools

Polishing and sharpening slabs (Fig. 6,1)
Artefact morphology: Rectangular stone slabs.
Geology: Siliceous or carbonated sandstone with middle sized quartz grains (0,25-0,5 mm). The geology clearly distinguishes them from cereal processing or other grinding tools.
Morphology of the active surface: A large (ca. 15-30 x 7-17 cm), oval and slightly concave surface appears in the central part of the obverse side of the slab. The lateral margins can be worn down in a similar way too.
Production traces: The complete obverse surface appears more or less levelled and covered by pits (Fig. 15a). In the central and lateral facets these pits are worn away by intense levelling (Figs. 14a; 15b). Quartz grains present flat surfaces and micro-fractures. Longitudinal and transversal parallel striations represent a further trait of these areas.
Validating information: According to experimental replications such intense levelling, crushing and scratching of siliceous material corresponds to an abrasive wear produced by hard materials (stone or metal). Prior to this use wear the stone slab surface had been prepared through a rough abrasion and regular pecking, probably with stone tools. This sequence and arrangement of the production traces follows an inverse order in comparison to cereal grinding tools, where periodic pecking roughens primarily the central part of the work surface, while the margins remain smooth.

On the upper margin of a stone slab found in an El Argar context at Fuente Álamo (Almería) a significant amount of metal residues was preserved (Fig. 14b). The ICP-OES analysis at the Deutsches Bergbau Museum (Bochum) revealed that they contained 30,9% of copper and 4,85% of tin, apart from other trace elements.[2] Yet, it remains unclear if the worked material was mineral or metal. The fragility of the carbonated sandstone and the abrasive traces rule out that the stone slab was used to crush mineral. Rather, use wear traces conform to what has been observed on ethnographic examples of sharpening tools (Fig. 15c).

Polishing tools (Figs. 6,2-6,3)
Artefact morphology: Two types of small sized sharpening stones have been identified. The first is a semi-oval artefact with a longitudinal groove. These artefacts can easily be taken for so called "arrowshaft straighteners" (Fig. 6,2). A small cylindrical object found in Fuente Álamo (Almería) seems to represent another type of metal polisher (Fig. 6,3).
Geology: The grooved polishers are made out of fine to middle grained sandstone (0,13-0,25 mm), which can be more or less cohesive, depending on the nature of the matrix (carbonate or siliceous). Instead, the cylindrical artefact is worked out of a very fine grained (< 0,0039 mm) slate clast.
Morphology of the active surface: The straight grooves present a V or, occasionally, a U shaped profile. This incision cuts through a surface, which is straight in the longitudinal and slightly convex in the transversal axis. The active facet of the slate polisher is limited to a flat surface placed diagonally at its upper end.
Production traces: The surface of the grooves shows an uneven aspect and is covered by short and irregular striations, which run in a longitudinal direction (Fig. 16c). Frequently, the complete artefact has acquired a dark colouring due to its exposure to fire and in one case we recognized some residues adhered to the ground of the groove (Fig. 16b). The slate, which is a much softer material, has been levelled completely, while dense, parallel striations cross the active surface mainly in a vertical direction (Figs. 17a, b).
Validating information: The formation of striations suggests, in principle, the working of hard material, such as metal. The polishing also seems to have implied some form of heating of the tool. The described functional particularities allow to distinguish these artefacts from similar ones used for the working of wood and bone. Wear patterns similar to those observed on the slate polisher could be reproduced working copper sheet for one hour (Fig. 17c).

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[1] The analysis was carried out and interpreted by Francesc Bohils and David Gómez-Grass from the Department of Geology of the U.A.B.

[2] We wish to thank Andreas Hauptmann and Karsten Hess for having carried out these analyses.

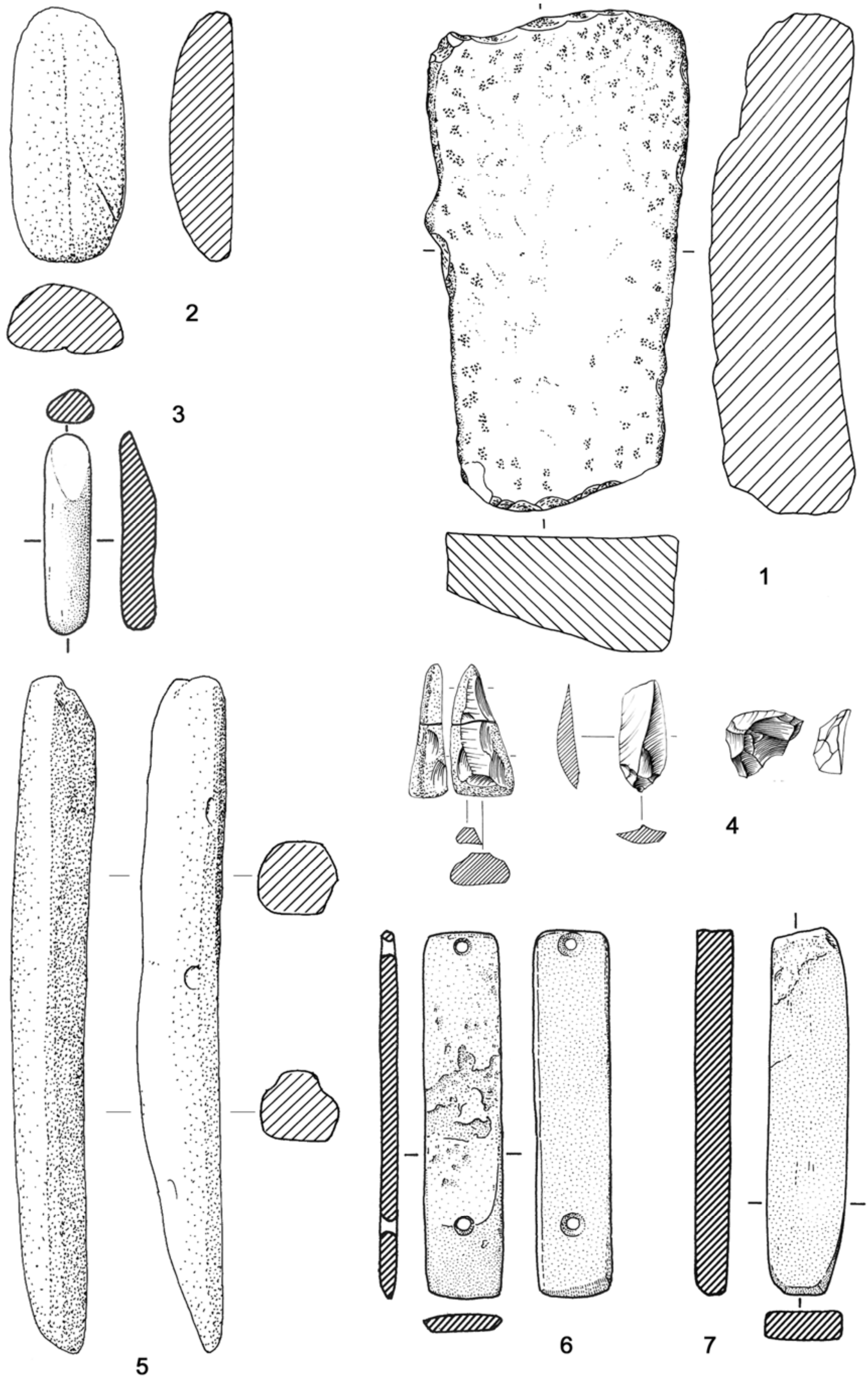


Fig. 6: Artefacts related to the final stages of metal production during the third and second millennium cal BC in southeast Spain: 1. Slab (Los Cipreses, scale 1:5); 2. Polisher with central groove (Gatas); 3. Polisher (Fuente Álamo); 4. Scrapers (Fuente Álamo); 5. Sharpener (Gatas); 6-7. Sharpeners (Fuente Álamo) (scale 1:2).

Sharpening plaques (Figs. 6,5-6,7)
Artefact morphology: Small rectangular slabs, either perforated or unperforated at one or both ends, are a characteristic late third and second millennia artefact of South-East Iberia. Archaeology tends to pay attention only to the perforated examples, known as "archers wristguards" (Fig. 6,6). The site of Gatas has provided a so far unique type of sharpener, which is longer and thicker than the plaques, but similar in terms of geology and production traces. Originally, it must have been a rectangular plaque with a deep groove crossing the obverse and reverse sides. After it broke in two, the preserved half continued to be used (Figs. 6,5; 19b).
Geology: Fine grained psamitic or micaceous slate and schist, which are relatively hard and still highly abrasive rocks.
Morphology of the active surface: Generally flat, although the transversal profile often presents a slightly convex shape.
Production traces: All sides of the plaques have been shaped by abrasion, but the obverse face presents a distinct wear pattern. The dominant feature is an intense levelling of the grain surfaces (Fig. 18d). Scratches and striations, which follow a transversal and occasionally also diagonal direction, can be visible even by eye, especially towards the margins of the surface (Fig. 18a). While scratches are loosely scattered, the striations form an irregular pattern of juxtaposed, dense and more or less parallel traces. Occasionally, the active surface presents a slightly undulating micro-topography, with grooves following the same direction as the linear traces. In the case of the oblong plaque from Gatas, analogous wear traces on the obverse and reverse faces are covered furthermore by long and dense striations (Fig. 19a). Their aspect on the surfaces of the original grooves is more dense and superficial (Fig. 19b).
Validating information: All these traces have been observed on traditional sharpening stones used to whet knifes and sickles (Figs. 18b, c). Striking similarities with the modern sharpening stones also exist in terms of the selection of raw materials. Surprisingly, neither on the modern nor on the prehistoric artefacts could metal residues be identified. The only example, known to us, where this is the case is a perforated plaque found in Mallorca (Waldren 1982, Fig. 41,2).
Further support for their identification as sharpening tools is provided by contextual information. In the South-East, but also in other parts of the Mediterranean, such as Crete, perforated plaques are found in burials together with metal tools and weapons, but not arrowheads. A direct association with a bronze knife has been observed in two Argaric tombs (Zapata nr.15 and El Oficio 205), and in the north Italian lake dwelling of Fiavé. Only for artefacts with less developed wear can an ornamental function not be ruled out.

Cutting and scraping tools (Fig. 6,4)
Artefact morphology: Flakes of 20-45 cm.
Geology: Fine grained flint.
Morphology of the active surface: Abrupt edges.
Production traces: Strong rounding, numerous wide, long and deep striations, combined with a flat, dense and very brilliant micropolish with a metallic aspect (Gibaja 2002).
Validating information: According to experimental tests, these wear patterns suggest a scraping action on very abrasive and hard materials such as stone or metal.

Results

Petrographic, morphological and functional analysis have allowed us to distinguish a group of tools which served to hammer, abrade, scrape or cut very hard materials, such as metal and stone. Given that the production of polished stone became marginal from El Argar onwards, the working of metal seems to be the most probable explanation for the identified use traces. In most cases, contextual information and residue analysis confirm the participation of these instruments in the post-casting or secondary metallurgical activities (Figs. 5; 6).

Most of the traces identified by functional analysis, such as the intense levelling of the mineral particles, striations and the additional presence of pits, have a mechanical origin. In general terms, where the direct contact with metal was intense and/or lengthy, roughness is low and totally flattened surfaces are dominant in comparison to depressions or fractures, which are practically absent. Chemical alterations, such as shiny polish and thermal modifications are more exceptional.[3] The first appears related to the intense levelling and compression of the mineral particles on forging tools such as hammers and anvils made out of gabbro, and, to a certain extend, on polishing slabs of siliceous sandstone. On other rock types, surfaces seem to be too unstable, due to grain extraction, to allow the development of shiny polish. A further variable, which significantly conditions the intensity of polish is the grain size of the rock. Thermal alterations have only been detected on moulds and some grooved polishers.

While the different wear patterns allow us to distinguish between abrasive and percussive activities, it is more difficult to imagine the specific task carried out with these tools, and the position of these tasks in the metallurgical production sequence. More experimental tests and better contextual data are needed in order to shed light on this issue. However, the variety of specific working instruments identified is indicative of the degree of technical specialisation and the complexity of the finishing processes, in terms of knowledge, means and skills. This increasing specialisation might explain why at a certain moment, a politically and economically dominant position of certain men became linked to the control of precisely the secondary stages of metal

[3] We use Plisson's and van Gijn's definition of glossy polish as "a structure of the flat surface, which results out of the modification of the original microrelief, which itself comes from the extraction and adding of material, caused by a natural or artificial chemical process" (Plisson and van Gijn 1989).

MATERIAL	silex	quarzite	gabro		schist/slate		sandstone		
hardness	+++	+++	++		+		++	+	
cohesion	++	++	+++		+		++	+	
abrasiveness	-	-	+		+++		++	+++	
ACTIVITY	Scraping	Percusion			Abrasion		Abrasion		
CATEGORY	Flake	Hammer	Anvil	Hammer	Polisher	Sharpener	Slab	Polisher	Mould
Morphology of the active surfaces	Ed (≥45º)	Cx	Fl/Cx	Cx	Fl	Str/Cx	Cv	"U" "V"	Cv
TRACES									
Levelling	x	x	x	x	x	x	x	(x)	
Striations	x		x	x	x	(x)	x	(x)	
Scratches						(x)	x	x	
Polish	x		x	x			(x)		
Pitting		x	(x)	(x)			(x)		(x)
Stepped fractures		x							
Grain extraction						(x)	x	x	x
Grain crushing		x					x	x	
Grain rounding	x	x							(x)
Residues			(x)				(x)	(x)	
Thermal alteration								(x)	x

Fig. 7: Overview of the manufacture and use traces identified on the different artefact categories. Ed = edge; Cx = convex; Cv = concave; Fl = flat; "U" or "V" = groove with "U" or "V" shaped section; X = dominant trace; (X) = occasional trace.

	LOS MILLARES	EL ARGAR	POST-ARGAR
Raw Materials	Copper/Arsenical copper (Gold, after 2500 BC)	Arsenical copper / Silver / Gold (Bronze, after 1800 BC)	Bronze / Arsenical Copper/ Gold / Silver (Iron)
Specialisation of the labour instruments (simplification of tasks)	*Low* (axe shaped hammers), until late Beaker Phase (axe shaped hammers, anvils, sharpening plaques)	*High* (moulds, anvils, , axe shaped hammers, grooved hammers, grooved polishers, polishing slabs, sharpening plaques, etc.)	*High* (apparently the same tool kit as during El Argar)
Specialisation of production spaces (spatial exclusiveness 1)	*Moderate to High*, inside settlements *Low*, at a territorial level	*High*, inside settlements, as well as at a territorial level	*Moderate to Low*, inside settlements *Low*, at a territorial level
Division of the production process (spatial exclusiveness 2)	*Low* All tasks can be carried out at the same place	*High* Smelting / Melting / Finishing	*Moderate* Smelting / Melting & Finishing (?)
Relative volume of production (according to metal working tools)	+	+++	++++
Social access to metal (consumption)	*High*: Communal	*Low*: Class based	*High*: Domestic-Segmented

Fig. 8: Technical conditions and economic organisation of metallurgy in southeast Iberia (analytical criteria according to Risch, this volume).

production where these skills and artefacts became relevant. Again, the social implications of the introduction of most of these artefacts, such as moulds, grooved hammers, grooved polishers, or sharpening plaques, in the second half of the third millennium, that is at the transition from the Los Millares to the El Argar period, need to be considered.

The changing social relations of metal production in South-East Iberia

The working of copper became a widespread technology in South-East Iberia around 3000 cal BC, at the beginning of Los Millares. Most of the systematically excavated settlements of this period have provided some evidence of metal working, such as crucibles or reduction vessels, kilns, ores or copper droplets (Keesmann *et al.* 1991-92; Montero 1994). At least in the settlements of South-East Iberia, the complete production sequence, from the reduction of the mineral until the finishing of the metal objects, seems to have been carried out inside settlements, independent of their size, geographical location or architectural complexity. The analysis of the macro-lithic assemblage of the classic site of Cerro de la Virgen (Granada) has revealed that the majority of the metal working tools (hammers, slabs, sharpening plaques), as well as other evidence related to a metallurgical production cluster in one area of the ca. 50

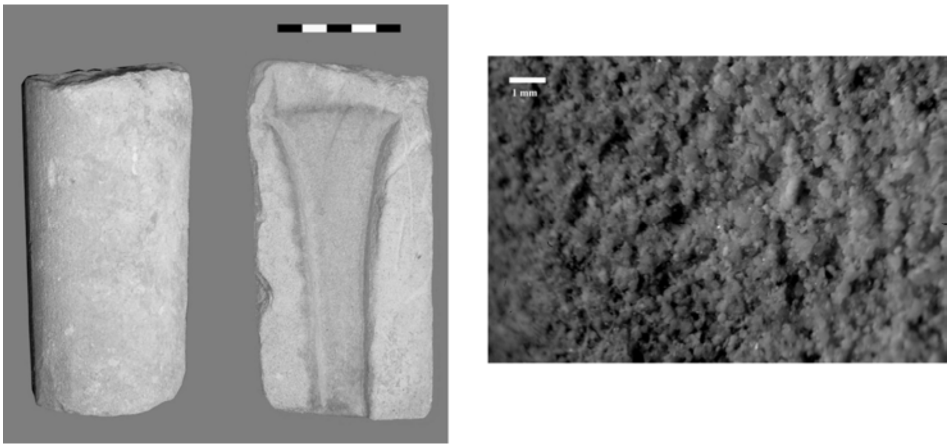


Fig. 9: Mould from Murviedro (Lorca).

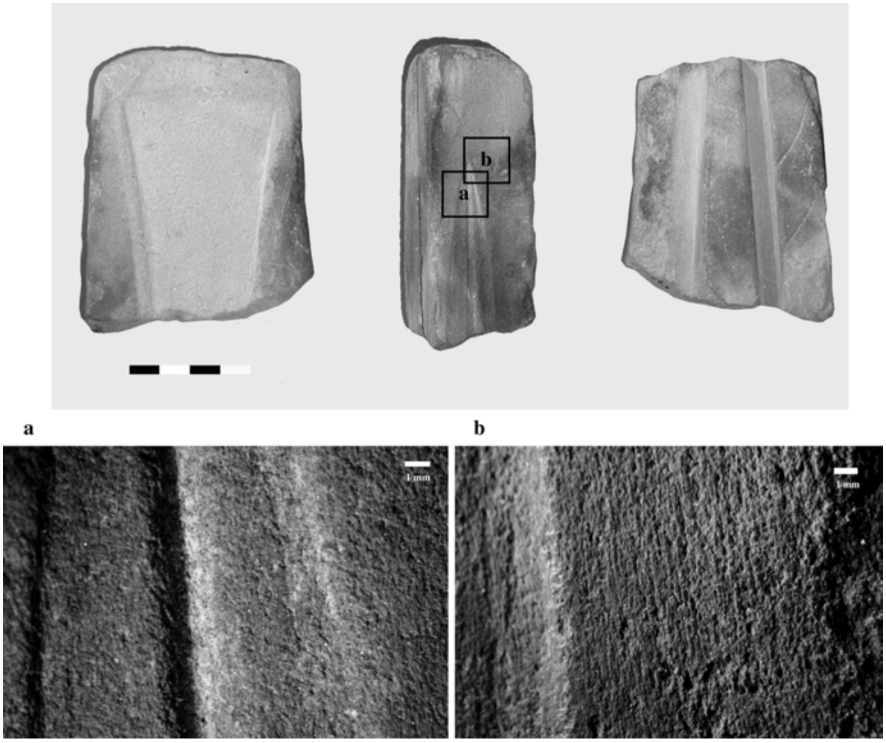


Fig. 10: Mould from the city of Lorca.

m² excavated in this 0,7 ha settlement (Delgado 2003). The workshop was placed in the open air and surrounded by round dwellings, which did not stand out in terms of wealth, size or other features which could hint towards an unequal access to metallurgy. The distribution of sharpening plaques inside and outside many buildings further suggest that the produced metal tools were used and maintained by all members of the community. The widespread distribution of metal objects, as well as other materials with a high social value (e.g. high quality pottery, ivory, non-local flint and other raw materials) also supports the idea that metal production and craft specialisation in general played an important role during Los Millares, but did not lead towards the emergence of a class society (Castro *et al*. 1998; Chapman 2002).

As we have mentioned above, the end of the third millennium is a period of drastic changes. Apart from the introduction of new technological devices, many of which are linked to metallurgy, most of the previous settlements are abandoned and a completely new settlement pattern and territorial organisation emerged. Contrary to the situation observed before, evidence of metal workshops becomes extremely scant during El Argar. The only exception is Peñalosa (Jaen) and probably other sites located at the southern slopes of Sierra Morena, where most buildings participated in the reduction of metal (Contreras 2000). The exceptional number of crucibles (43) and moulds (50), most of which served to cast ingots, shows that this production exceeded the domestic sphere and must have been linked to an over-regional distribution network. None of the settlements of the "central" area of El Argar (north-eastern Almeria and southern Murcia) have produced any evidence of such large scale smelting and casting activities. Specialised workshops, with clear evidence at least of the melting process, have been identified in one building of El Argar (Almeria) and another one in La

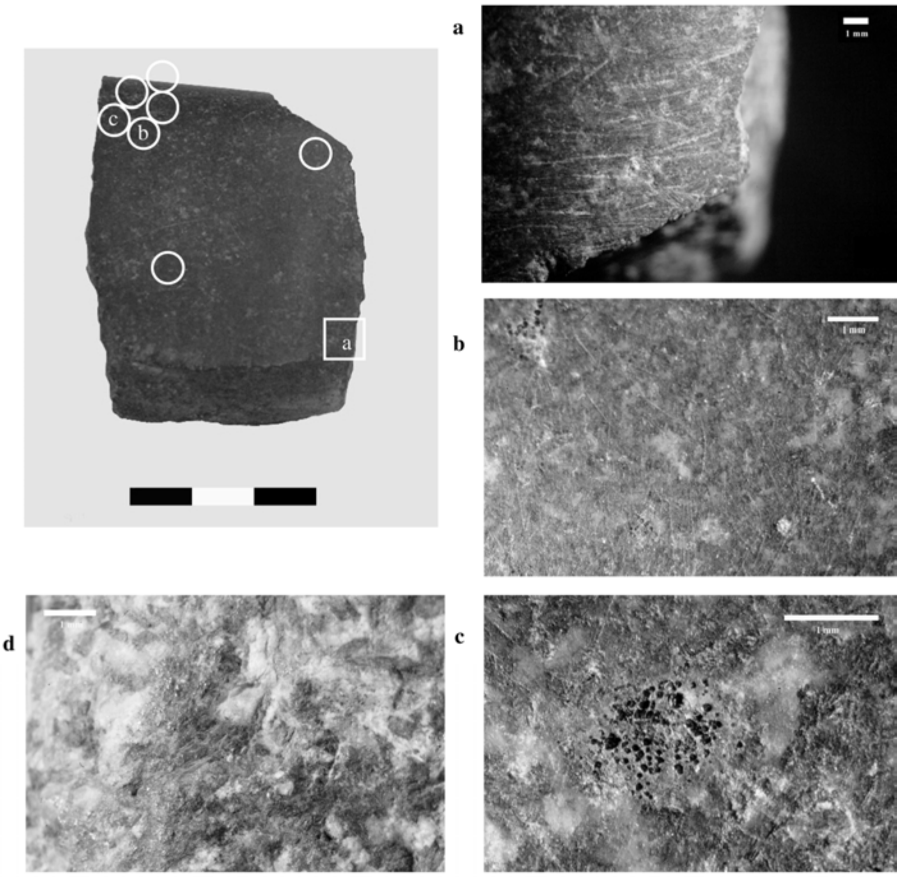


Fig. 11: a-c) Anvil from Murviedro (Lorca), circles indicate the position of the residues; d) residues of copper on an experimental forging artefact.

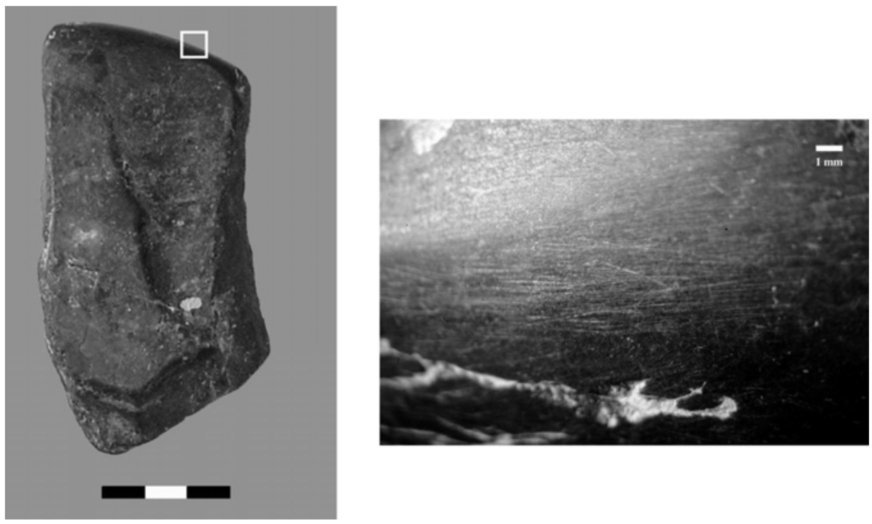


Fig. 12: Hammer from the city of Lorca.

Bastida (Murcia), two of the most important centres at that time. Yet, the functional analysis of lithic tools discussed above reveals that metal objects were worked and maintained on other sites too.

In Fuente Álamo (Almería), a hill settlement, which has been extensively excavated by the German Archaeological Institute between 1977 and 1998 (Schubart *et al.* 2001), the spatial distribution of the lithic artefacts shows that most of the forging, polishing, scraping, as well as sharpening tools come from the summit of the hill, and more specifically, the northern sector of the so called "Eastern Slope". This was a prominent area, often named "acropolis", where monumental buildings (square towers, possible granaries, industrial buildings, etc.) and the 'richest' burials were placed. Around 90% of all the metal weight recovered from over 100 intramural funerary contexts of Fuente Álamo, was deposited in this sector. Such a concurrence of production, maintenance and consumption spaces reveal 1., that the social access to metal tools, weapons and ornaments was asymmetric, and 2., that this

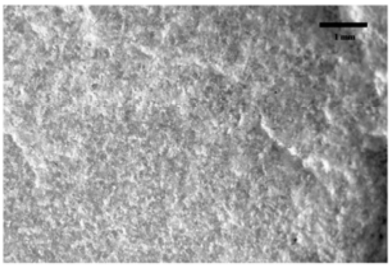
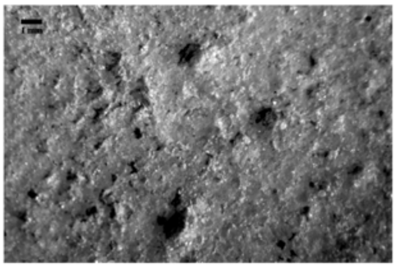
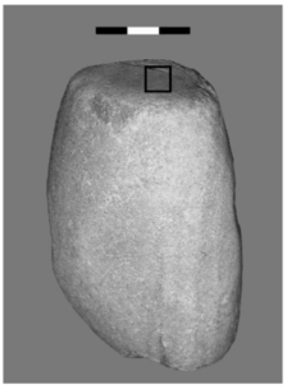



Fig. 13: Hammers from Fuente Álamo and Murviedro (Lorca).

inequality was warranted by the direct control of the secondary phases of metal production by a dominant group. In other terms, the funerary practices only seem to sanction ritually the fact that metal had now become the private property of an emerging dominant class. Thus, the socio-economic organisation of Fuente Álamo confirms the meaning given to the presence of anvils, polishing tools, etc. in some of the most outstanding male tombs of the third and early second millennia in Europe.

According to the presently known distribution of metal working tools in the Argaric territory, metallurgy appears as a strongly divided production process, both in technical as well as in social terms. Although much more information from systematically excavated and studied settlements is necessary, a model seems to emerge in which 1., the reduction of the mineral and production of ingots was taking place at a large scale in some marginal regions, 2., central places could include workshops specialised in the casting and forging of metal tools, weapons and ornaments, 3., specialised workshops in second order settlements were primarily carrying out forging, repairing and maintenance activities, and 4. small scale sites depended on the previous two centres in relation to metal artefacts.

The sudden collapse of El Argar around 1550 cal BC supposed again a new situation, as the analysis of the metal working tools begins to show. Until the 1970s it was practically impossible to distinguish the Post-Argaric from previous occupation phases, and all the materials coming from multiperiod settlements were classified as Argaric. The absence of hardly any funerary evidence after 1550 supposed a further difficulty in the identification of metal artefacts. Yet, as more stratified information becomes available, metallurgy appears as an important aspect in post-Agaric economic organisation. At a technological level, the same means of production continued to be used as during the previous phase. Yet, their distribution at a territorial as well as at a settlement level changed notably. At Gatas, another important Bronze Age hill settlement excavated since 1986 by the Universitat Autònoma of Barcelona (Castro *et al.* 1999), metal working tools, such as moulds, grooved hammers, sharpening plaques and a crucible, have been found in four different contexts located at two opposed sides of the hill. Also in Fuente Álamo a considerable number of such means of labour has been identified. They are distributed over five of the seven habitational spaces which could be explored on the summit of the site (Risch 2002, pp.200-208). In a similar way, the recent excavations at Murviedro (Murcia) have provided evidence of metalworking in several larger and smaller buildings. Yet, neither in these nor in other sites is it possible to talk about specialised workshops. Usually, metal working instruments appear associated with a variety of other tools, as well as common domestic remains. In general, the qualitative differences between structural units in terms of available means of production and, consequently, the spatial division of labour during Post-Argaric period seem to have been rather limited. It can be suggested that metallurgy or, at least, the casting and finishing processes became a more widespread technology, no longer controlled directly by a dominant class.

This brief discussion of the forces and relations of production related to the metallurgy of South-East Iberia during the third and second millennia BC, reveals some of the social and economic issues which begin to be raised once the instruments of labour participating in this activity are identified (Fig. 8). Future research will probably determine new artefact categories and production wear patterns, and provide more validating information in terms of contextual data, experimental work, residue analysis, etc.. However, the picture which starts to emerge is much more complex than expected, and has clear implications for the way we understand how differently societies can organise and dispose of means of production which have become crucial in their further development. None of the technical variables (tools types, raw materials, specialisation, etc.) nor the volume of

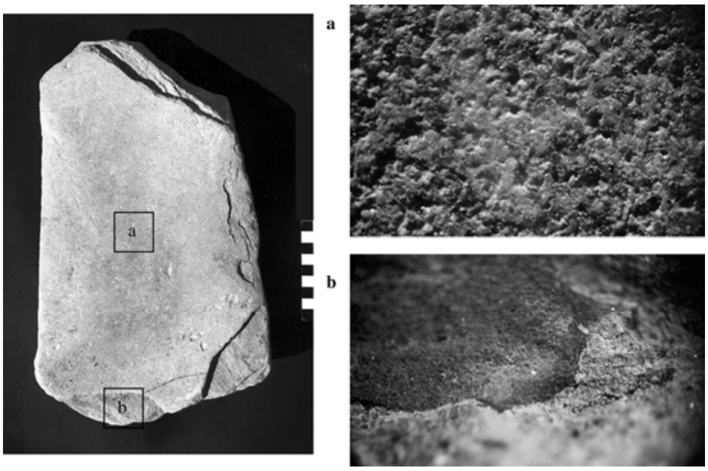


Fig. 14: Stone-slab with metal residues from Fuente Álamo.

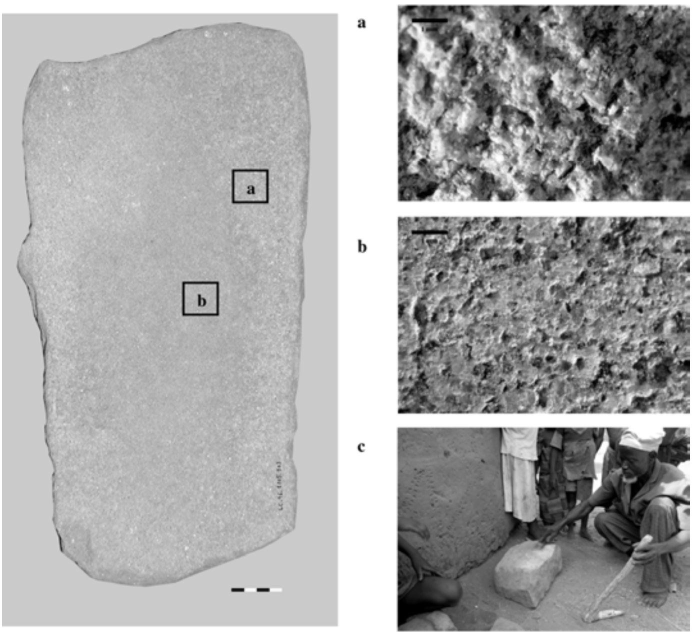


Fig. 15: a-b) Stone-slab from tomb number 3 of Los Cipreses (Lorca); c) sharpening of an iron axe on a stone-slab in the village of Bende, Ghana (Photography J. A. Soldevilla).

production determine by itself the organisation of and access to metallurgy. Rather, it is the social control over production or, in other words, the introduction of certain property relations, which leads to an unequal distribution of metal products. The new forms of domination and social exploitation emerging in different parts of Europe during the third and early second millennia were apparently linked to the concentration of certain means and skills in the hands of a group of men, which gave them the effective command of the production and circulation of a growing range of weapons, tools and ornaments.

Acknowledgments

We wish to express our gratitude to Robert Chapman, Vicente Lull and Rafael Micó for their useful comments and editing of the text. The investigation of the prehistory of South-East Iberia is supported by the Spanish Ministry of Science and Technology (BHA2003-045546) and by the *Direcció General de Recerca de la Generalitat de Catalunya* (2001SGR000156).

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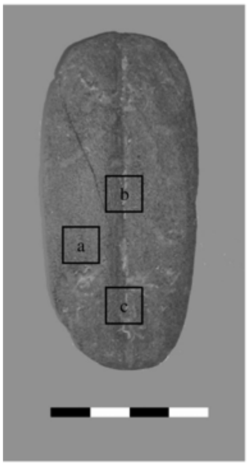

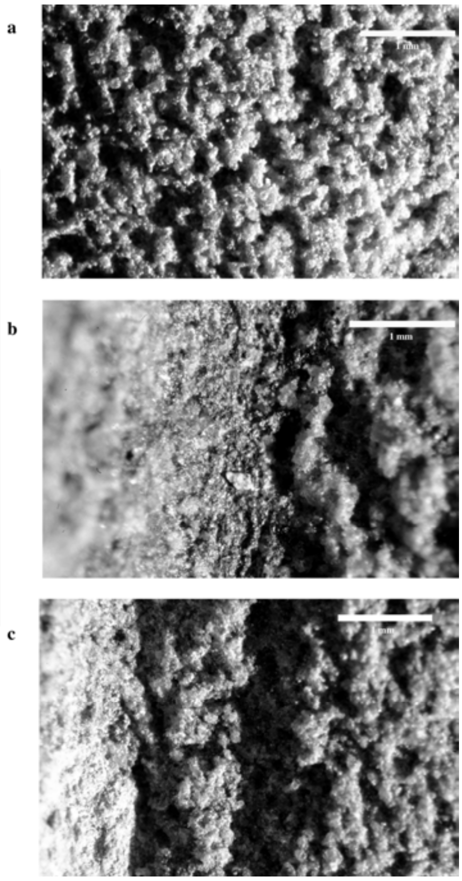

Fig. 16: Polisher with central groove from Fuente Álamo.

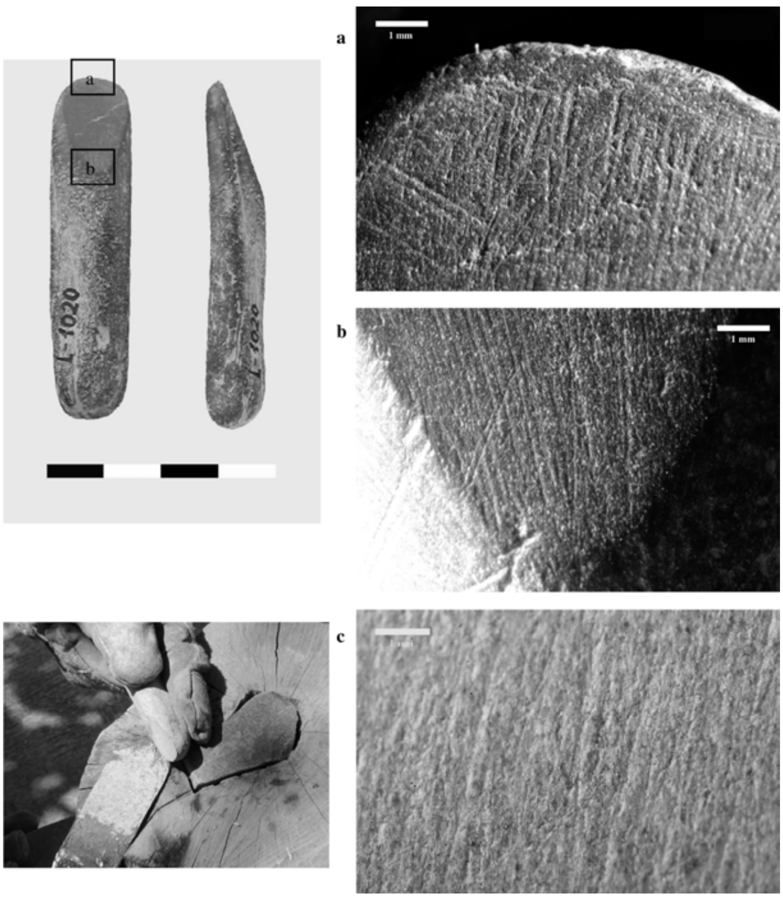

Fig. 17: a-b) Polisher from Fuente Álamo; c) experimental polisher during the forging of a copper sheet (Photography M. Rosas).

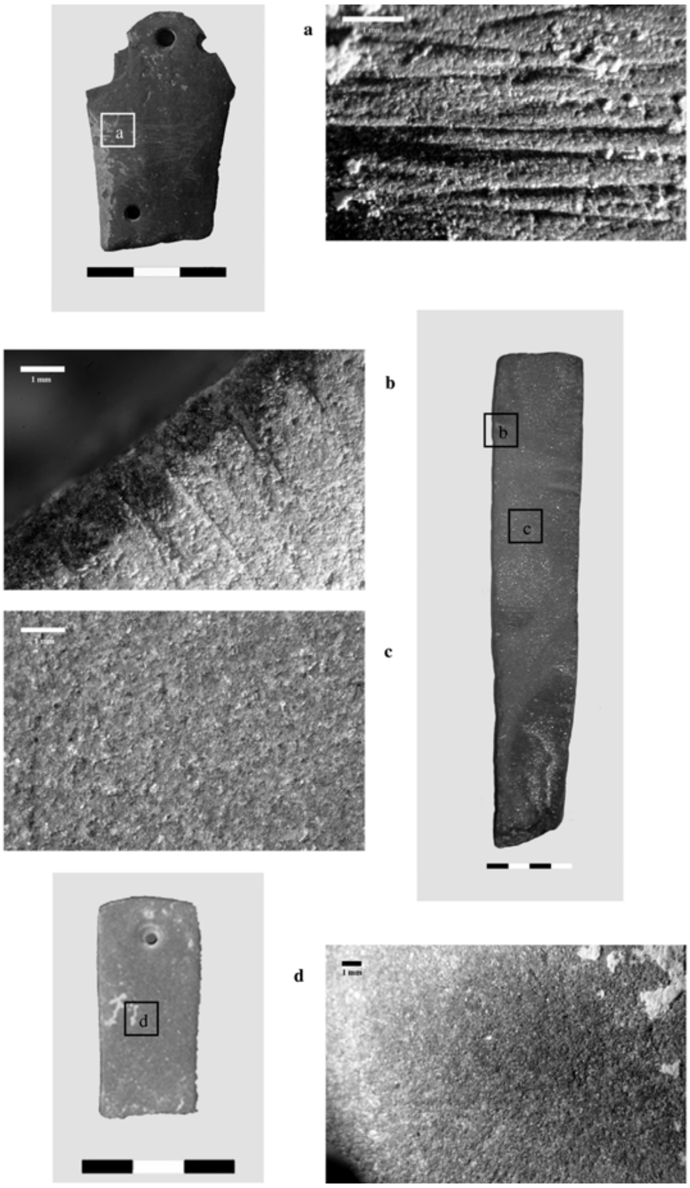

Fig. 18: a) Sharpeners from Murviedro; b-c) ethnographic knife sharpener; d: sharpener from Los Cipreses.

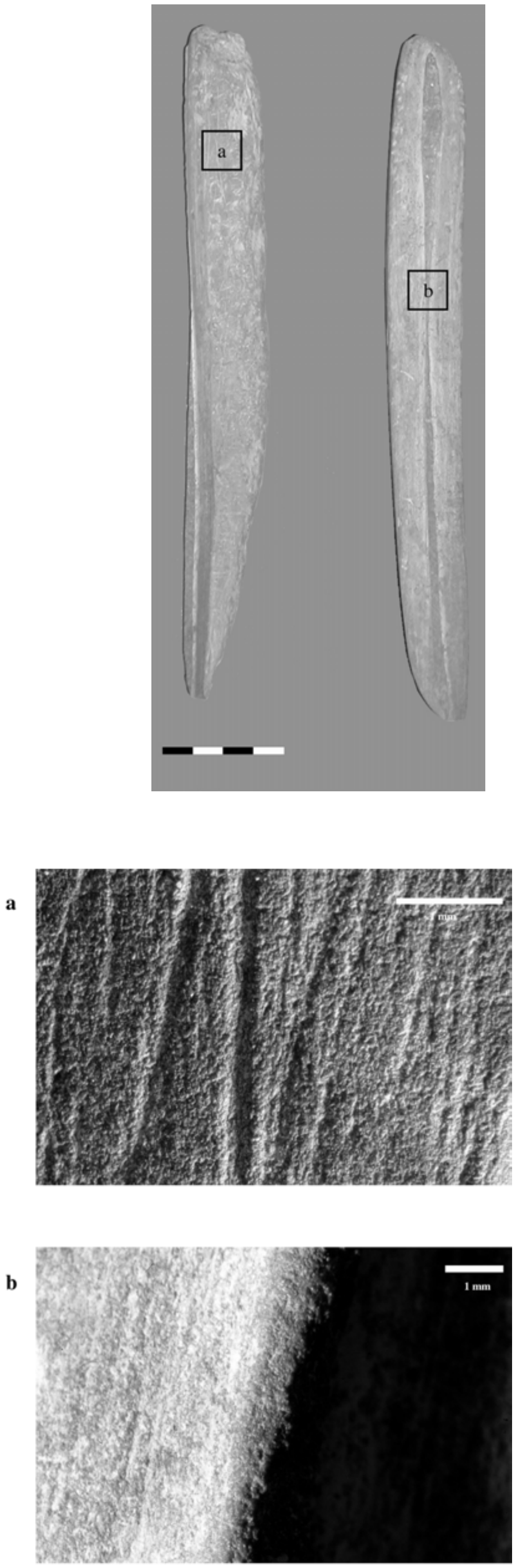

Fig. 19: Sharpener found in Gatas; a) striations; b) edge rounding.

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The use of metal tools in the production of bone artefacts at two Bronze Age sites of the south-western Balkans: a preliminary assessment

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Summary. *Analysis of the manufacturing traces on the bone artefacts from two Bronze Age sites, Angelohori, north-western Greece and Sovjan, south-eastern Albania suggests that metal tools were employed to cut deer antler at the former site. Evidence from Sovjan shows reliance on stone tools for manufacturing bone objects, including those made from deer antler. Available data concerning the use of this bone from Angelohori do not imply specialized production. At this site, metal axes and chisels could, maybe, substitute for their counterparts made from other raw materials. These tools served to process deer antler and not other bones. This would, then, be the reason for which metal tool use has been connected with deer antler.*

Résumé. *Les traces de fabrication sur les objets osseux qui proviennent de deux sites de l'Âge du Bronze, Angelohori (Nord-ouest de la Grèce) et Sovjan (Sud-est de l'Albanie), ont été analysées. A Angelohori, des haches et des ciseaux métalliques étaient utilisés pour débiter le bois de cervidé. A Sovjan, la production des objets osseux, y compris ceux en bois animal, était fondée sur l'emploi des outils en pierre. Selon les données disponibles, le travail du bois de cervidé à Angelohori ne serait pas une activité spécialisée. Il est possible que sur ce site les haches et les ciseaux métalliques aient remplacé leurs équivalents fabriqués à partir d'autres matières premières. Ceci se refléterait dans le débitage du bois de cervidé parce que ces outils servaient à travailler cette matière et non les autres os.*

Key words: bone, bronze tools, optical microscopy, wear analysis.

Manual experiments and high-power optical microscopy are implemented in research investigating since 2004 the nature and scale of the production and use of bone artefacts at two Bronze Age sites of the south-western Balkans. Based on experimental evidence, metal tools were used mainly to cut deer antler. The discussion on manufacture focuses on this material. Technical, including functional, and typological data relating to artefacts worked with stone tools are also examined in order to get an insight into the role played by the metal tools in the production.

Background of the study

The material discussed here comes from Sovjan and Angelohori. Sovjan is a tell settlement in the Basin of Korçë, south-eastern Albania (Fig. 1). Excavations at this site began in 1993 and with short intermissions continue to date. They have revealed a broadly continuous sequence of deposits covering the Middle and Late Bronze Age, and the Early Iron Age (Prendi and Touchais 1999; Lera and Touchais 2005). The Middle Bronze Age has been dated by ^{14}C to 2000-1650 BC and the Late Bronze Age to 1650-1150 BC. Angelohori is a Late Bronze Age settlement mound situated in the Plain of Veroia-Yiannitsa, north-western Greece (Fig. 1). It was excavated in 1994 and 1996-98, and again from 2000 to 2003. Radiocarbon dates place the Late Bronze Age at the site in the period 1650-1150 BC. (Stefani 1999, p.106, and personal communication, November 13, 2005).

Bone artefact assemblages from the Bronze Age in the study region and adjacent areas have received very little attention, and this limits our potential for comparisons at the inter-site level. The best example of published analysis (Hochstetter 1987) is offered by Kastanas, a Bronze/Iron Age tell settlement in Central Macedonia, Northern Greece (Fig. 1). The Bronze Age bone artefacts examined from this site belong to the latest phase of the period. The study centred on their morphology and the taxa and anatomical parts used to make them. Basic questions pertaining to the production and use of the bone objects have not been explored. Sovjan and Angelohori constitute primary sources of information on the tools and techniques employed to work bone, and on the use of the products.

Fig. 1: Sites mentioned in the text.

To date, 292 bone objects have been inventoried from Sovjan, of which 146 have been analyzed. Of these 146, 51 are assigned to the Middle and 30 to the Late Bronze Age (Table 1). Fourteen are connected to mixed and transitional deposits from the Middle to the Late Bronze Age. Some levels may belong to the later Late Bronze Age or the Iron Age, and work on the stratigraphy is

				SOVJAN			ANGELOHORI
	MBA	MBA/LBA	LBA	LBA or IA	IA	No date	LBA
SKELETAL BONE							
Small awl	8	2		2		3	9
Large awl	5					1	
Double point			2				
Needle	1		1				1
Pin			1	13	1		
Distal frg of pointed tool or pin							2
Edged tool made from long bone or mandible body frg	9	2	4		1	2	9
Edged tool made from rib	1		2				3
Toothed tool made from pelvis frg							2
Handle made from pig metapodial							5
Rib spatula	4	1	2	1		1	
Drilled tooth	3	1					
Non classified (frg of) finished object	8	1	6	1	1	3	
Waste from long bone processing	2	1	1			2	
DEER ANTLER							
Small awl based on splinter						1	
Large awl made from tine							1
Pin							1
Barbed point			1				
Distal frg of pointed tool or pin							1
Large axe	1	2					
Small axe	3					1	
Axe (*ad hoc* tool)							1
Chisel made from tine			3			1	
Chisel with small proximal perforation		1	2			1	
Sleeve with transverse perforation for haft		1	1			3	
Butt of axe or sleeve	1	1				1	
Non classified (frg of) finished object					2	1	
Waste	3	1	4	2		5	12
Unidentified (debitage waster or shaped product)	2			1			
TOTAL	51	14	30	20	5	26	47

Tab. 1: Artefact classes (abbreviations: MBA: Middle Bronze Age; LBA: Late Bronze Age; IA: Iron Age; frg: fragment).

ongoing. In table 1, material from these contexts is indicated. Twenty-five objects cannot be associated with a particular phase. All of the artefacts derived from 1994 and 1996-98 excavations at Angelohori have been analyzed. Study of these samples and preliminary scanning of the remainder showed that:

1) Tools make up the majority of the Bronze Age assemblages (Table 1; Fig. 2, 3), with the greatest typological variability being observed at Sovjan. This site has provided axes, chisels, and sleeves made from deer antler (Fig. 3.1, 3.3-4). Such tools are absent from the Angelohori sample. In fact, a deer antler axe has been found at this site, but it is an *ad hoc* tool based on a debitage waster (Fig. 3.2); only the central perforation indicates shaping; the active area of the tool was put at the cut base of the brow tine which had been broken obliquely, thus forming the cutting edge used. Small sample size does not seem to adequately explain the lack of the well-formed deer antler tools mentioned above; these artefacts are absent from Kastanas, too (Hochstetter 1987). There may be, then, a difference between the two Macedonian sites, Kastanas and Angelohori, on the one hand and Sovjan on the other.

2) There is a non-negligible quantity of waste derived from deer antler processing, which, at Angelohori, contrasts with the limited number of utilized products (12 and 4 specimens, respectively). These latter comprise, apart from the *ad hoc* axe, a pin (Fig. 3.6) and two fragments of pointed objects (e.g. Fig. 3.5). Small sample size could explain over-representation of refuse antler at

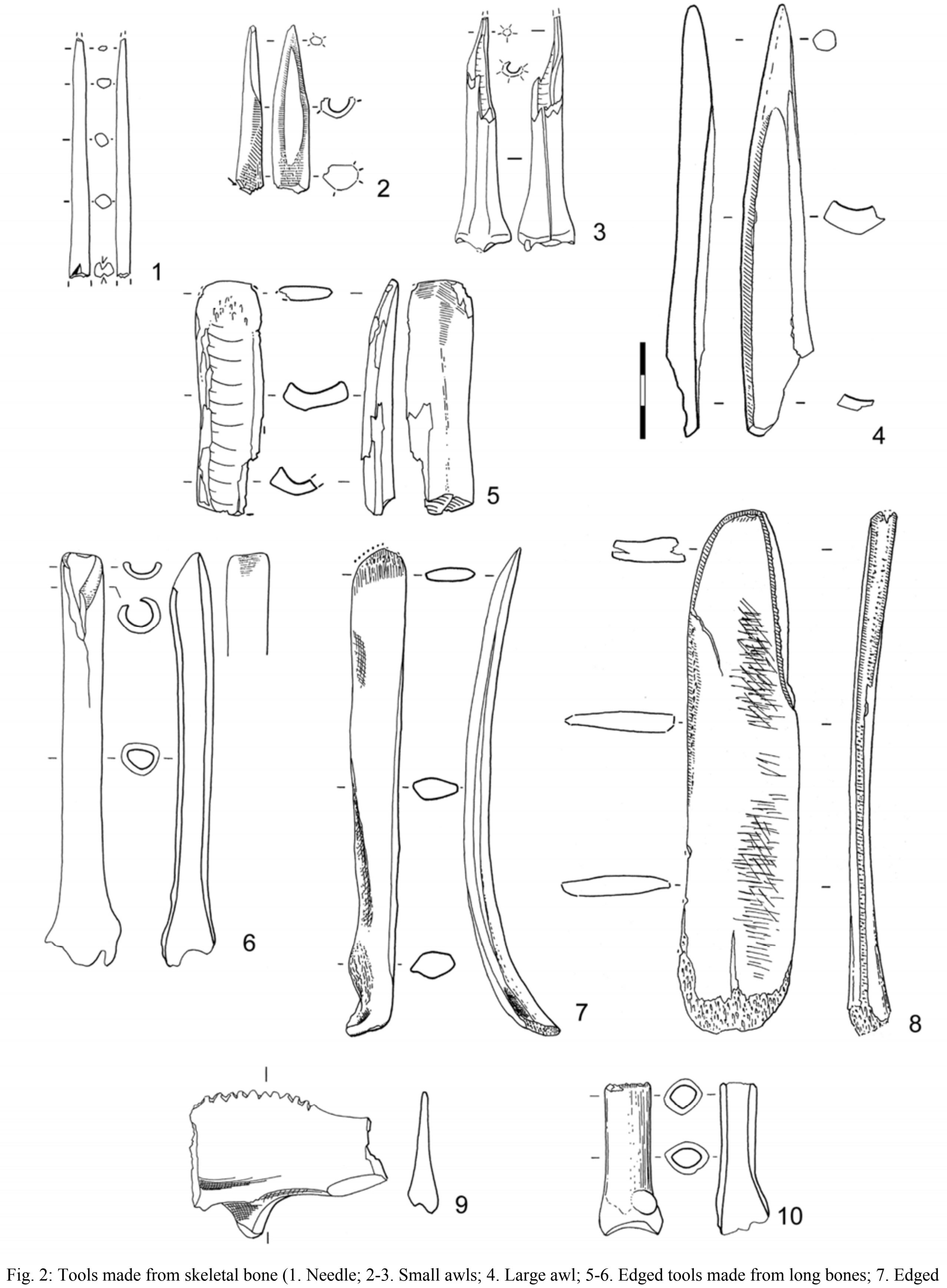

Fig. 2: Tools made from skeletal bone (1. Needle; 2-3. Small awls; 4. Large awl; 5-6. Edged tools made from long bones; 7. Edged tool made from rib; 8. Rib spatula; 9. Toothed tool made from pelvis; 10. Handle from pig metapodial).

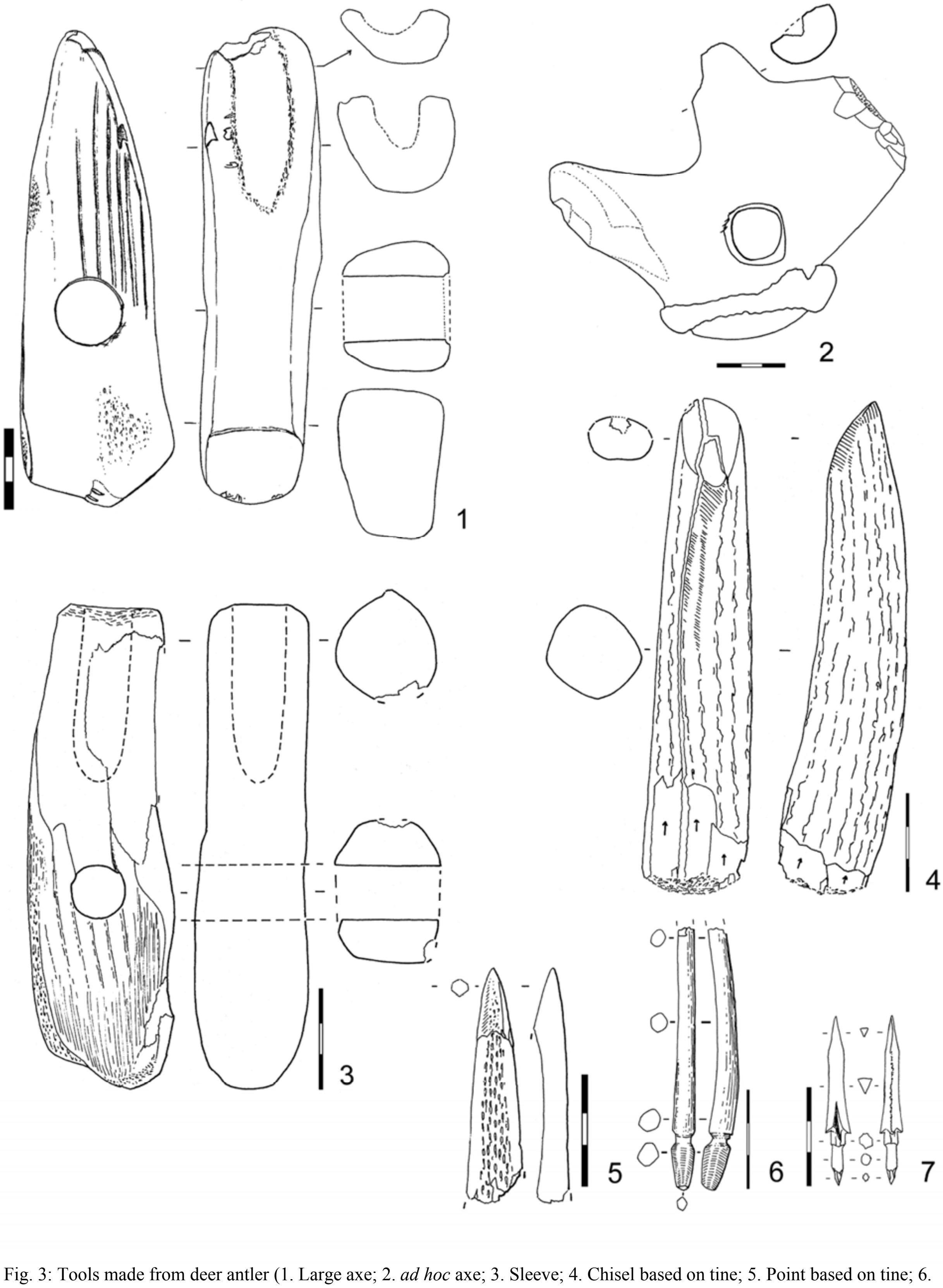

Fig. 3: Tools made from deer antler (1. Large axe; 2. *ad hoc* axe; 3. Sleeve; 4. Chisel based on tine; 5. Point based on tine; 6. Pin; 7. Barbed point).

Angelohori. Nevertheless, the situation is very similar at Kastanas, where several dozens of specimens were recovered (Becker 1986, pp.100-115; Hochstetter 1987, pp.66, 77-78, 80-82). This pattern is also probably significant and must be scrutinized.

3) Pins appear mainly in deposits from the latest part of the Late Bronze Age or the Iron Age. Bone pin production and use seem to have been a late development in the Late Bronze Age of Kastanas; the majority of pins have been assigned to the Iron Age (Hochstetter 1987, pp.66-67). This is also possibly true for Sovjan. Late occurrence of the barbed point (Fig. 3.7) at this site is in harmony with evidence from other Balkan contexts (ibid. pp.61-62). Drilled carnivore teeth would belong to the earlier Bronze Age (ibid. 80; see also Lera and Touchais 2005, p.32).

Even at an early stage of the study, differences between sites and chronological phases are traced. Variability may reflect different technological and economic backgrounds which can influence the structure of the assemblages. At the same time, similar trends observed at different sites suggest that these latter cannot be viewed as closed systems.

Experiments and equipment used for recording traces

One of the most striking features of the samples studied was the presence of objects which displayed surface modification similar to that seen on bones worked with modern steel tools. Concise descriptions of slots and cuts shaped on bone with metal burins and adzes, respectively, were given by Semenov (1970, pp.165-166). At the time the study of the Balkan Bronze Age material began, few published experimental data that could guide the analysis were available. In these studies, emphasis is put on butchering (e.g. Greenfield 1999; Walker and Long 1977) and scraping marks (Cristiani and Alhaique 2005; Olsen 1988) observed with scanning electron microscopes at magnifications up to 100×. In order to positively identify and describe traces on bones worked with metal tools, an experimental programme was set up. Ten bronze tools- axes, chisels, blades for knives, a double point, and a burin- which simulated archaeological specimens from the Balkans and the Aegean, were prepared. Saws have not been replicated because their manufacture is different from the other tools. This has not been considered as a serious handicap to the study because sawing marks are easily recognized (e.g. De Cupere 2001, pp.154-155).

The experiments focused on the major basic techniques of bone-working, namely, scraping, grooving, and percussion[1]. Differences in the direction of the movement and the contact angle were examined, in all experiments, as possible factors affecting variability in traces. In order to minimize potential effects of the nature of the raw materials on the aspect of the traces, the bones worked were limited to sheep metapodials and shed antler of red deer. Both fresh and dry metapodials were processed. Deer antler and dry bones were soaked in plain water prior to processing. Modified surfaces of experimental and archaeological specimens were examined under the stereoscopic and the metallographic microscope at magnifications up to 200× that I regularly use in order to analyze wear on bone.

Manufacture

Of all the Bronze Age objects, the most evidence for use of metal tools is provided by the waste from deer antler processing found at Angelohori (Table 1); all of these specimens as well as the *ad hoc* axe mentioned above bear metal tool marks. They show cutting of the deer antler perpendicularly to its long axis, using sawing and percussion, and in one case shaping of one side of a longitudinal fragment using percussion. By contrast, only two wasters from deer antler working out of a total of sixteen examined from Sovjan and a fragment of debitage waster or shaped object display similar traces. The latter specimen is dated to the Middle Bronze Age; one of the two wasters is associated with Late Bronze/Iron Age deposits and the other with disturbed strata of uncertain date. Another two objects from Sovjan, the barbed point and the pin, both dated to the Late Bronze Age, exhibit traces of scraping and longitudinal grooving using metal blades. Scraping had served to fashion these artefacts and grooving to produce the blank of the barbed point. The pin, based on a fragment of long bone, is the only example of metal-worked product made from a material different than deer antler and dated to the Bronze Age.

Based on the experiments, it was possible to recognize the metal tools used to work these objects. Only one waster was sawn off. This waster comes from Angelohori. The other specimens show use of axes and chisels. Variants of percussion recognized are:

- Repeatedly striking the deer antler with an axe and cutting high angles into it. The cut plane on the deer antler tine shown in figure 4.1, displays two ranges of rectangular, shallow, and flat negatives of removals, some of which have smoothed edges; a lip appears at the points where the cut is deep and the chip bent and broken off. This plane is likely to be the surface put in contact with the upper aspect of the axe, which, on experimental specimens, forms an angle of ca. 110^{o} with the outer surface of the deer antler. Smoothing appears when blows overlap each other and put the bone repeatedly in contact with the metal. The opposite surface presents an inner zone vertical to the bone's long axis (Fig. 4.2). This zone, which also exhibits smoothing, forms an obtuse angle with the outer zone, an irregular ring bearing both negatives of removals and V-shaped chopping marks made during the first stages of the work.

[1] An extensive account of the variables tested in the experiments and of the traces on the experimental specimens is given in Christidou 2005 and forthcoming.

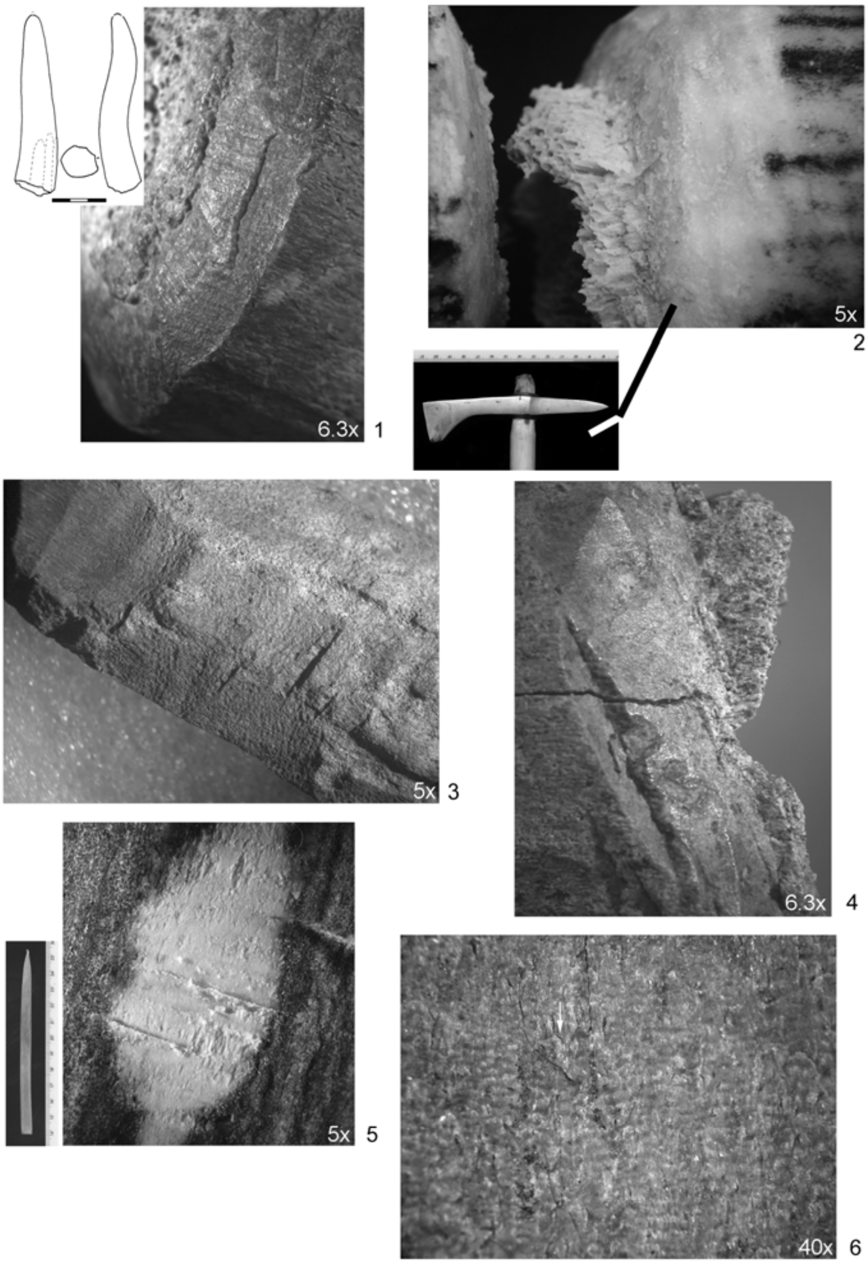

Fig. 4: Percussion (1. Cuts made at a high angle probably with an axe, archaeological specimen, stereoscopic microscope, 6.3×; 2. Cut made at a high angle with an experimental axe, inner zone, stereoscopic microscope, 5×; 3. Cuts made at a low angle probably with an axe, archaeological specimen, stereoscopic microscope, 5×; 4. Cuts made at a low angle probably with a chisel, archaeological specimen, stereoscopic microscope, 6.3×; 5. Cuts made at a low angle with an experimental chisel, stereoscopic microscope, 5×; 6. Chattering on negative of removal on the object shown in figure 4.3. The arrow indicates lifting of bone, stereoscopic microscope, 40×).

- Repeatedly striking the deer antler with an axe and cutting low angles into it. The negatives (Fig. 4.3) are shallow, slightly concave or flat, and they intersect. However, no superimposition is observed, as every new cut obliterates traces previously formed on the bone. The sides of the negatives are more or less smooth, and so can be the edges between negatives, except if thick chips are broken off.

- Cutting low angles with a chisel (indirect percussion). The negatives (Fig. 4.4) are flat and tend to be shorter than those produced by the axe used for working with a low angle. Their direction and depth vary, due to cut angle variations. Successive blows struck down to the same direction and with the same angle create an oval mark with wavy sides and crossed by ridges, each of them corresponding to a single movement of the chisel downwards (Fig. 4.5). In the sites studied, indirect percussion served to divide deer antler transversely. When the spongy tissue was exposed, the bone was snapped, leaving a lip at the broken edge of the fragment (Fig. 4.4).

I used the microscopes in order to observe in detail the aspect of the negatives, which at low magnifications often appear shiny, and display chattering (Fig. 4.6) as well as chipping and splintering (Fig. 4.5). Lifting of bone in the opposite direction of the cutting motion is also observed. This allows recognizing the direction of the movement. At high magnifications, the topography appears shaped by dark unpolished valleys of various morphology and size (Fig. 5.1-2). These valleys represent natural channels and faults formed between fibres or fibre bundles. The elevations have rounded profiles and display rough-textured polish; the highest points of the topography may present smooth polish.

The associations of different techniques on the barbed point can be examined. As mentioned above, this is one of the two metal-scraped objects recognized and the unique example of bone grooved using a metal tool. In addition, the barbed point shows removal of thick shavings for sharpening its proximal end. High magnifications facilitate the observation of grooving and scraping traces. Grooved planes are slightly concave and show chattering in the form of smooth undulations. They present an outer zone with extensive polished areas (Fig. 5.3-4); the edge is also polished and rounded. Abrasion features seem very often completely or partially worn

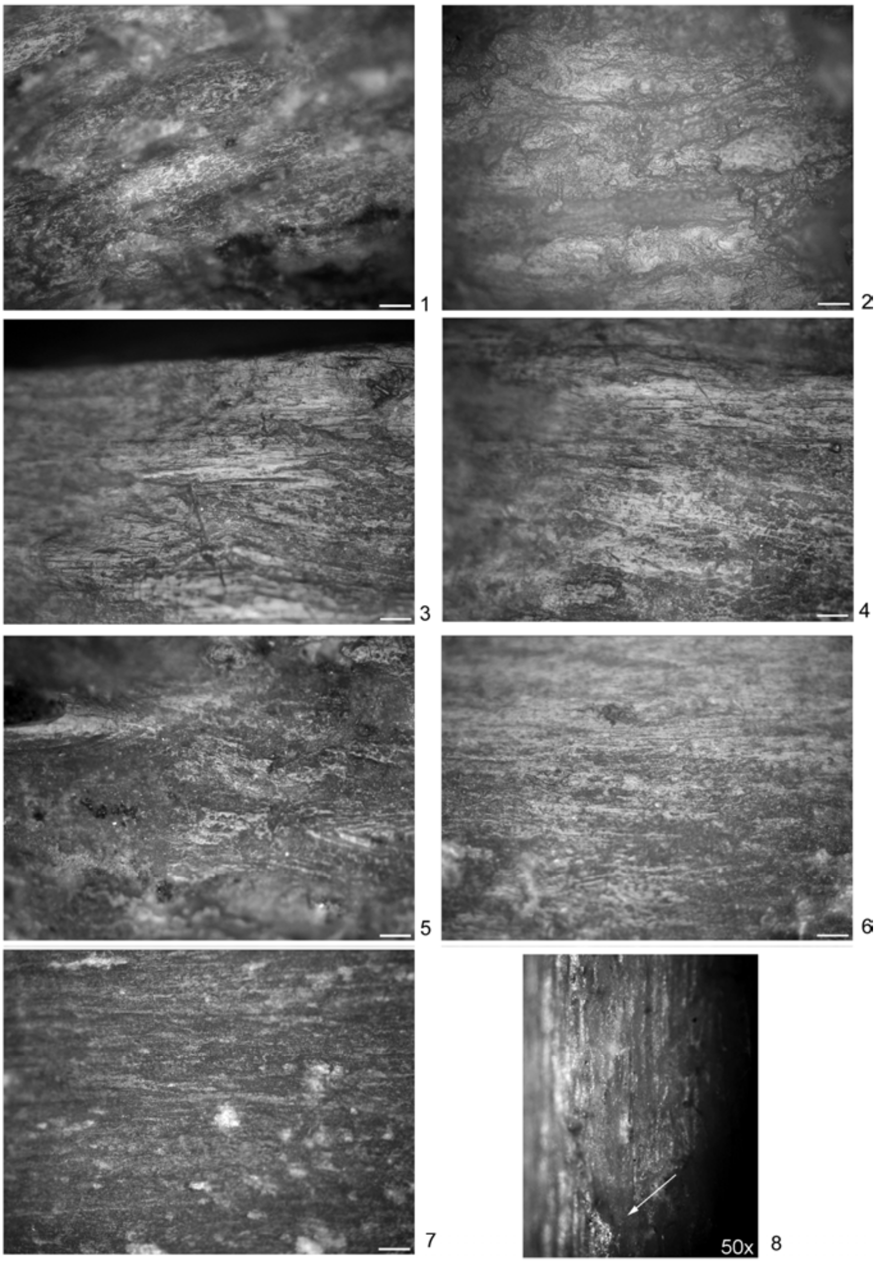

Fig. 5: Manufacture wear (1-2. Percussion, negatives of removals, experimental object, metallographic microscope, 200×, scale bar: 50 µm; 2-3. Outer zone of groove on the barbed point, metallographic microscope, 200×, scale bar: 50 µm; 4. Inner zone of groove on the barbed point, metallographic microscope, 200×, scale bar: 50 µm; 5. Experimental groove, transition from outer to inner zone, metallographic microscope, 200×, scale bar: 50 µm ; 6. Experimental groove, inner zone, metallographic microscope, 200×, scale bar: 50 µm; 7. Negative of thick shaving removed by pushing downwards and forwards the edge of a knife-blade. The arrow shows the notch at the launching point of the movement, experimental object, stereoscopic microscope, 50×)

away and at various parts of the surface, the polish can be described as linked or semi-linked. Polished elevations are completely or incompletely smoothed, levelled or slightly rounded; they bear tiny craters, superficial striations, which measure less than 2.5 µm in width, and sometimes transverse cuts. Polished areas tend to shrink toward the bottom of the groove, the inner part of which presents superficial polish with an open distribution network (Fig. 5.5). As the barbed point is made from deer antler, natural features appear regularly on the less polished zones. The wear pattern described above is very similar to that produced by metal knife-blades (Fig. 5.6-7).

Removal of thick shavings by pushing downwards and forwards the edge of the metal blade, as observed on the proximal end of the barbed point, creates elongated, slightly concave or flat facets, each corresponding to a single stroke (Fig. 5.8). The launching point of the movement is marked by a notch. Upon gross inspection, the facet is crossed by deep dark depressions resembling striations. Higher magnifications reveal the fibrous texture of the bone rather than a scratched surface. Elevations are levelled and polished and reveal topography similar to that created by percussion.

The outer zone of the grooved surfaces bears similarities to the scraped distal part of the point. Around the tip (Fig. 6.1), there is polish; longitudinal striations, craters, and transverse cuts are more or less affected by the polish; profiles are smoothed and rounded. The amount of polish diminishes toward the interior of the object. The polish on the tip is not due to grooving, or to use. It has been observed that, when a metal blade is used to scrape and the strokes are directed toward a pointed end or an edge, regular contact of the bone with the metal edge gradually polishes the tip and adjacent zones (Fig. 6.2-3). Overall, scraped bone surfaces exhibit smoothing and polishing, at various degrees, of the elevations and of the abrasion features on these surfaces (Christidou forthcoming). The wear observed on the metal-scraped pin from Sovjan (Fig. 6.4) is somewhat less developed than on the experimental surface shown in figure 6.5. It seems then that, unless one observes significant patterning in the succession of the use-worn zones from the tip to the inner part of an object, and within these zones (see also Christidou 1999), it is very difficult to recognize use wear.

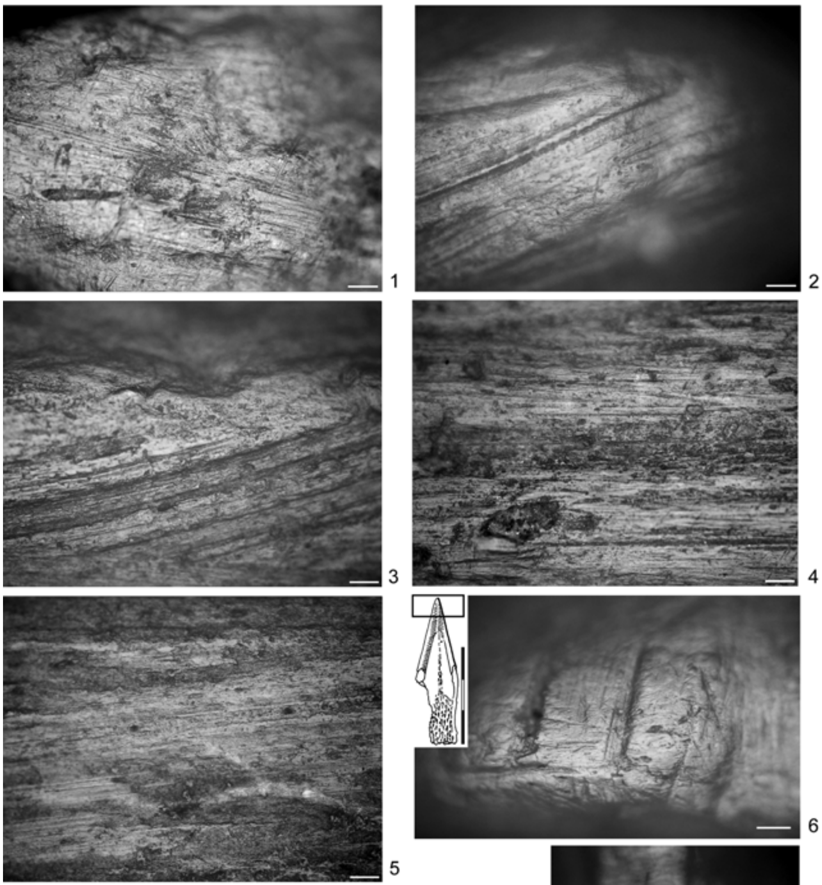

Fig. 6: Manufacture and use wear (1. Scraping traces around the distal tip of the barbed point; 2. Scraping traces around the distal tip of an experimental point; 3. Area just below the zone shown in figure 6.2; 4. Scraping traces on the Bronze Age pin from Sovjan; 5. Experimentally scraped surface; 6. Use wear on the distal part of archaeological point. The large transverse grooves are grinding (shaping) marks; 7. Use wear on experimental point used to perforate hide. The lower relief represents grinding (shaping) marks). Metallographic microscope, 200×, scale bar: 50 µm.

In sum, the majority of metal-worked artefacts represent division of the beam of the deer antler perpendicularly to its long axis and removal of tines using axes and chisels. With one exception, these elements date to the Late Bronze Age or to a later period and come, for the most part, from Angelohori. It can hardly be a coincidence that all of the specimens from this site indicate use of metal tools. Longitudinally cut or broken deer antler are only three in number and comprise the fragment from Angelohori, which had been worked on one side (supra), the barbed point and the pin from Sovjan. In only one instance (barbed point), the technique used to cut the bone longitudinally was recognized. The same tool, a knife-blade, could be used for both grooving and scraping. The number of scraped objects is two, and in one case the raw material worked is not deer antler but long bone.

What was the deer antler used for; and what does the use of metal tools for processing this material mean? At Angelohori, there is no evidence in the form of unfinished objects on which to conclude the manufacture of specific products. Combined evidence from this site and Kastanas (Hochstetter 1987, pp.66, 77-81) suggests that possible products would be pins, tablets with perforations, handles, and points. The latter two classes of objects were made from transversely cut or whole tines. A distal fragment of point based on a tine was found at Angelohori (Fig. 3.5). No debitage traces can be observed on this object but available evidence suggests that it had been cut using a metal tool. This fragment exhibits traces of grinding which was used to shape the point. In this respect, the point is not different from the rest of the tools found at Angelohori (Christidou 2005; 2006). This technique represents, both in the Neolithic in the study region (Christidou 1999) and in the Bronze Age, the most common shaping technique. The tablets and several pins from Kastanas were made from longitudinal fragments of deer antler, but techniques employed to make them have not been studied. At this site, no specific products have been associated to deer antler either.

When the limited range of deer antler finished products from the two Macedonian sites is considered in relation to the anatomical origin of the blanks of these objects, some inferences can be made. For pins and tablets, the beam, the large tines as well as the palmation of the antlers of fallow deer, which outnumber red deer in the Macedonian assemblages (Becker 1986, p.100 and *passim*; 1998; Stefani, Valamoti and Konstantinidou 2006), could be chosen. The burr and the many relatively short and/or twisted tines of fallow deer, as well as the middle bit and the crown of the red deer antlers would be of limited or no use at all. Selection of anatomical parts for processing would, then, explain- at least partly- the bulk of discards found at these sites. The scale of production of deer antler objects cannot be defined for the moment. Given these data, it is possible that traces of metal tools on deer antler from Angelohori reflect systematic use of metal axes and chisels. Some stone blades of axes have been found at this site; their use is not studied.

At Sovjan, use of metal tools is poorly documented. But contrary to the Macedonian sites, there is good evidence for standard use of deer antler in the production of axes, sleeves, and chisels. The former two types of tools were based on fragments of the lower beam which kept the burr as the butt of the tool (Fig. 3.1-3); tines were also used for axes of small size and chisels (Fig. 3.4). The manufacture of axes and sleeves was time intensive as it involved bevelling of the active end, opening of transverse holes, and finishing of the entire surface of the object. Stone tools were used for working, and ground and chipped stone tools as well as grinding stones are regularly found at Sovjan. Moreover, preliminary analysis of the use-wear on the chipped stone (Kourtessi-Philippakis and Astruc 2002, pp.78, 81-82) confirms bone-working. Processes and techniques employed to cut the deer antler and fashion the tools (heating-and-fracturing, transverse grooving, percussion, scraping, grinding) are well-known from Neolithic sites in Northern Greece and beyond (e.g. Christidou 1999; Maigrot 2003; Sidéra 1993) and will not be discussed here. Techniques of perforation probably varied at this site and research on this subject is ongoing.

Apart from the artefacts that demonstrate investment in manufacture, the production of the majority of tools found at both sites studied was based on gathering of fragments of shattered bones, usually long bones, of suitable shape and size, easy to fashion using grinding and sometimes scraping. Only long bones of large-sized animals (i.e. red deer-to-cattle) were grooved longitudinally at Sovjan in order to produce blanks for large awls (Fig. 2.4). Utilized ribs and long bones represent food remains (Christidou 2006; see also Gardeisen, Garcia Petit and Piques 2002; Stefani, Valamoti and Konstantinidou 2006). The morphological and technical features of these objects indicate a style of production known from the Neolithic sites of the study region (Christidou 1999, 2006). However, the specialized production processes, related to caprine metapodials and cattle ribs, are absent from the Bronze Age sites. Evidence of use of the tools from these sites suggests production for domestic or small-scale craft activities.

Tool use

Due to constraints of space in this publication, I shall be going over the main points of the use-wear analysis, without discussing individual traces, topographical details, or variations in wear features along the length of the used areas of the tools, although this information is very often important for the understanding of the nature and degree of the use wear (Christidou 1999).

The wear was more or less well-developed and could be characterized on twenty-seven out of a total of thirty-two pointed tools from the Bronze Age. Sixteen out of twenty-seven suggest contact with soft animal materials, like hide, and at least five out of sixteen, including two large awls from long bones, had served to perforate these materials using indirect percussion. Basic modifications on the active zones of the tools which suggest contact with animal tissue are: polish covering the entire surface, including the low points of the topography; abrasion features of varying dimensions and direction affecting both the elevations and the depressions; homogenization and complete or incomplete smoothing of the elevations, depending on distance from the tip and degree of wear (Fig. 6.6-7). Use abrasion features get rapidly worn, smoothed and polished, when the contact material is fresh or humid. It is of interest that small awls (Fig. 2.2) which do not measure more than 55 mm in length- probably a common occurrence at Angelohori (Christidou 2006) and Kastanas (Hochstetter 1987, p.62) –are associated with this type of wear. These tools have rounded distal cross-sections which at 10 mm from the tip measure less than 6 mm in width and 4.5 mm in thickness (Stordeur 1985, pp.19-20). Experiments have shown suitability of such tips for hide perforation (Christidou and Legrand 2005, p.390).

The remaining eleven points suggest work with or on vegetal fibers. A distinctive pattern associated with wear produced by vegetal fibres is shown in figure 7.1: rough-bottomed, long, and continuous striations, more or less affected by the polish, shape the topographic relief; fine-to-very fine (<2.5 μm) and long polished striations cross the flattened elevations; these latter can also be completely smoothed; transverse, fine, and short superficial striations as well as roundish craters are scattered on the worn surface. More developed wear (Fig. 7.2) is shown by the increase of the amount of polishing and smoothing. Basically, fine elongated points, including those separated from the shaft of the tool, which is based on a splintered (Fig. 7.1) or unbroken diaphysis (Fig. 2.3), and needles (Fig. 2.1) are associated to this type of wear. At Angelohori, the large point made from a deer antler tine (Fig. 3.5) exhibits the domed, smooth, and longitudinally oriented polish, observed on the elevations of the use-worn surface of the *ad hoc* axe (Fig. 7.3). This wear is attributed to contact with woody fibres (compare Fig. 7.4).

While prehension traces (Christidou 1999; D'Errico 1993; Stordeur and Christidou forthcoming) are also clear on the tools, suggesting rigorous use, evidence for curation is rather limited (8 specimens). This evidence includes reuse of broken tools (Fig. 2.4). Considering re-sharpening, this was perhaps of limited extent and masked by use wear. Whatever the case, short awls and points separated from the shaft of the tools cannot be continuously and extensively re-sharpened.

Thirty-one edged tools from the Bronze Age deposits, including deer antler axes and chisels, and the toothed pelvis fragments, were examined for use wear. On twenty-nine out of thirty one active zones, it has been possible to characterize the wear patterns.

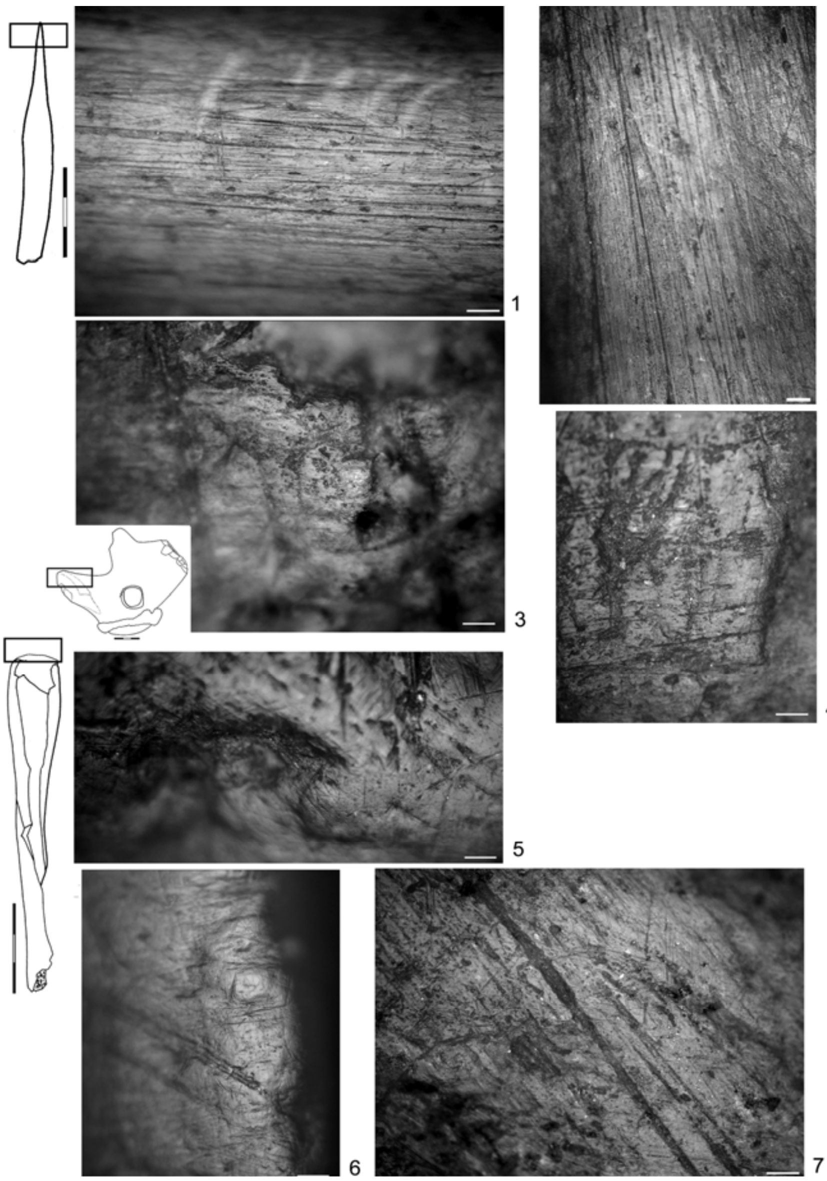

Fig. 7: Use wear (1. Archaeological point; 2. Experimental point used to work with straw; 3. Archaeological *ad hoc* axe; 4. Experimental axe; 5. Archaeological edged tool; 6. Experimental hide scraper; 7. Archaeological rib tool). Metallographic microscope, 200×, scale bar: 50 µm.

Another twelve edged tools, made from fragments of long bones, suggest work of wood and similar substances, using direct and indirect percussion; ten tools, including the toothed ones and an edged tool made from a rib have been associated with working of soft animal tissue (Fig. 7.5-6). The most characteristic traces of the wear associated with animal substances include: rounding of the working edge; irregular topographies along the edge formed by various craters and striations; polish with a distribution similar to that described for the points. Nine long bone tools were re-sharpened. These tools do not present a specific morphology or size of active end. Overall, there are no major variations in the length of the edge, which measures between 12 and 15.5 mm, with only a couple of narrower tools. Finally, an edged tool based on a rib fragment, showed highly abrasive wear (Fig. 7.7) and was thus connected to a group of three rib spatulae.

The polish observed on the *ad hoc* axe from Angelohori suggests use of rather short duration. The active edge of the tool exhibits, however, crushing and chipping, which could explain its abandonment. No attempt to repair the tool was made, suggesting expedient use. By contrast, four axes from Sovjan were re-sharpened. For that reason, the intensity of wear, probably due to wood-working, varies on these tools. Moreover, two axes bear battering marks on their base, suggesting change in use or different use modes of the axes, a problem that future analysis must account for. Only one chisel made from deer antler was examined, and this allowed substantiating its typological attribution, as an intermediate tool used for working with indirect percussion.

Discussion

This paper has relied principally on evidence for use of metal tools in bone working and on use wear observed on the bone tools from two Bronze Age sites of the Balkans. Interpretation of the metal-worked sample is complicated by its composition and rather small size. However, the available evidence suggests that at Angelohori metal axes and chisels could have replaced their stone counterparts in deer antler working, especially debitage using axes and chisels.

Use of these tools does not condition specialized production, unless it is connected to manufacture of particular products and/or deer antler processing is recognized as an independent craft. Evidence so far examined does not suggest specialization at Angelohori. More technological and, of course, contextual information is required in order to deal with this issue. Such data cannot be anticipated from analysis of metal tools. These finds are extremely rare, and preservation renders them unsuitable for use-wear analysis. As a matter of fact, traces on worked bone may be evidence for tools that do not survive in the archaeological contexts (see also Greenfield 1999); and, of course, these traces provide insights into the functions the metal tools served. Multiplication of the experiments with bronze tools and osseous raw materials will broaden our base of inference on tasks performed with metal tools.

Numerical decrease in chipped stone tools and waste in the Late Bronze Age sites of the Northern Aegean and in the Middle and Late Bronze Age at Sovjan has been observed (Kourtessi-Philippakis and Astruc 2002 with references). This does not result directly to increasing use of metal tools (Rosen 1996, p.145ff.). On the other hand, the frequency and function of the ground stone tools found in the Bronze Age sites have not been defined. However, replacement of these tools by metal ones is not excluded for Angelohori. On the contrary, reliance, at Bronze Age Sovjan, on various stone tools and technical processes practiced since the Neolithic period for working bone is certain. This result will not change, even if more metal-worked Bronze Age artefacts are recognized in the future. This difference between Sovjan and Angelohori must be explored in parallel with local exploitation of metal and also organization of the manufacturing activities both within and between sites and site networks (Andreou, Fotiadis and Kotsakis 1996, p.585 and *passim*).

At Sovjan, investment in the production of deer antler axes, coupled with functional data and indications of curation suggest the importance, probably economic, of the tasks into which these tools were involved, most probably wood-working. Indeed, architectural remains from this site demonstrate heavy reliance on wood for building (Lera and Touchais 2005, pp.32-35). Considering the rest of the tools, they could also be intensively used but, as at Angelohori, attention was paid mainly to suitability of the working points and edges for the task at hand. Little evidence of investment in acquisition of particular blanks that could support multiple cycles of reshaping suggests few constraints, temporal and/or functional, in blank procurement. Such data are useful as the scale of the exploitation of bone for tools in the Bronze Age sites also remains an issue to explore.

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Use-wear traces on bone remains from Later Prehistoric settlements

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Summary. *The present work illustrates the results of use-wear analysis undertaken on bone tools from Later Prehistoric sites in the northern Black Sea Region. At various settlement sites, different bones were turned into a wide range of tools: from everyday objects such as whistles, pipes, dice, to tools being used in the decoration of building material (e.g. soft stone) and for personal ornamentation (hair-curlers). On the basis of use-wear analysis and on the experimental data obtained by S.A. Semenov's comprehensive studies, we have been able to determine the functions of tools used in different activities, like skin-processing and stone-working. In addition, we have succeeded in the identification of some decorations and objects of everyday use.*

Key words: Black Sea, Late Prehistoric settlements, bone tools, use-wear traces

The present work is devoted to the study of a specific group of bone tools from Later Prehistoric settlements of Tiritaki, Mirmekij, Bezymyannoe, Volna, and Nimphei in the northern Black Sea region. These tools underwent no special treatment and have no clear typological characteristics. Sometimes it is impossible to identify them among numerous bone remains without the help of a paleo-zoologist, and in the present study, identification was carried out by A. Kasparov.

Just as stone tools of identical form served for different purposes, similar bone tools also could have had different functions (Korobkova, Sharovskaya 2001, pp.88-98). Here we group the analysed objects according to the types of bones.

Tubular bones were widely used and are represented by artefacts at different stages of preparation. They served as tools, utensils, decorations, etc., and in addition as a source of marrow (extracted from cattle and goat metapodia). The latter function was attested as far back as the Lower Palaeolithic and was described in detail by Semenov (1957, p.175).

During Later Prehistory, in the Greek-Scythian Black Sea region horse and bull bones were employed in building techniques. Firstly, diaphyses were whittled to become tetrahedral in shape. The smooth surface was then incised with a rasp file. These rasp files served to work both soft stone and marble, with constant addition of sand on the worked surfaces (i.e. rough polishing of cut stone). Incisions on the tools were necessary to prevent quartz sand from sliding off and thus to maintain the roughness of the working surface. During the working process the tool was gradually worn out, and the incisions had to be rejuvenated. When the tool was completely consumed it broke into halves (Semenov 1957, pp.200-223).

There is a fragment of such a tool made of a metapodial bone of a young bovine. Judging from the strong polish on its surface, it was secondarily used as a handle. There were also other types of rasp files, designed probably to work different surfaces. For example, there are tools with diagonal incisions on longitudinally split big bones. There are also files made out of tubular bones of small animals, like dogs or small cattle. Two slightly convex surfaces were incised with little inclined grooves.

Small tubular bones without epiphyses (which were removed in different ways) were used to make handles, whistles, pipes, implements that served to facilitate milking, and sticks for curling hair, which can probably be considered prototypes of the present-day hair-rollers. Judging by depictions of haircuts and hair styles found in contemporary artistic representations, such as those on preserved monuments in the northern Black Sea area, one may conclude that during Later Prehistory both men and women of this region used hair curling sticks. Some fragments of longitudinally split bones were sharpened by grinding and used as awls, perforators, pins. There is a perforator made out of a dog's ulna (Peters 1986, pp.48-77).

Tubular bones served also to manufacture pendants and beads, for which purpose they were cut with a circular sawing implement. Our collection includes a cat humerus with traces of initial sawing, and a large pendant made of a dog bone.

The collection includes numerous talus bones of young and adult cattle. Most of them should be considered dice. Various games in which bones were used had existed since Later Prehistory, and even the rules of some of them were reconstructed. Big bones (those of cattle and horses) served in outdoor games, while small ones were used in table games. Herodotus noticed that people amused themselves with table games when they had no strength for outdoor games. Many bones are intensely polished as a result of contact with hand skin and with leather bags in which they were carried. Some of the bones have small holes intended for putting through a string, used by some players to carry astragali. The most clear traces are those left by grinding with the use of an abrasive. Most often grinding was used to even the irregular sides. As a result of such smoothing bones became more stable (Peters 1986, pp.77-91).

Some bones are merely sawn into two parts. Cut surfaces almost invariably have a spongy structure and are smoothed by grinding. The surfaces bear traces of prolonged friction in the form of polish. Cells of spongy matter are good for holding the abrasive material. The same property is characteristic of pumice, which has a similar structure.

Some tools served probably as polishers. They could have been used to polish stone after it was roughly worked by a rasp file. Spongy cells of one of the polishers contain residues of metal oxide. It can be argued that this tool was used to clean metal objects.

All tools made using ribs are similar to each other (Korobkova 1965, pp.192-195). The concave edge is sharpened, the longitudinal convexities are cut off. Traces of whittling look like slightly waved parallel lines. Such traces form when a whittling knife is held almost at right angles to the working surface. The surface of the ribs is heavily polished. A microscope allows to see transverse striations, usually characteristic of end-scrapers on the concave working edge. These traces extend also to the adjacent lateral surfaces. These tools were used as scrapers to work raw hides. At least two heavily worn tools with especially deep striations and intensive gloss were definitely used for removing hair. One of them has traces of resharpening.

Deer antler was also used. In addition, animal teeth were used as amulets in many cultures. Our collection includes a cattle incisor with a sawn groove on its root neck, below the crown. Probably this groove served to tie the tooth to a string.

There is a bone plaque with remains of spongy mass made of a metapodial cattle bone. One of its ends is broken off. The surface of the bone is dark, smooth, glossy. The intact end is slightly rounded. Examination under a microscope shows that both sides of the plaque bear linear traces characteristic of hide burnishers. The striations are of nearly the same width. They go in different directions, touching even the very tip of the tool. Such a burnisher was designed for very delicate kinds of work due to its small size.

The burnishing of the front side of a hide piece is an important operation in skin-processing. Thanks to polishing, hides become more compact and watertight. Because of the strong pressure on burnishers, they often break during work (Semenov 1957, pp.210-212).

The present work has shown that some of the studied bone tools have traces of manufacture, some other have traces of use, and some have both the former and the latter. On the basis of our observations and experiments carried out by S.A. Semenov, we have been able to determine the functions of tools used in different operations, like skin-processing and stone-working. In addition, we have succeeded in the identification of some decorations and objects of everyday use.

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Towards a global functional analysis

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Summary. *Functional analysis of different kinds of materials together with studies on the exploitation of natural resources have reached a high level of reliability in the last years. They give us information about perishable elements in non-wet environments too, for example by means of the wear traces of them on lithic and horσbone tools and through the organic residues trapped in the vases. It seems to us that the principal aim now is the coordination of data that we can acquire from different fields of research in order to outline whole cycles of activity (pursued in discontinuous places and times too) and reconstruct complex patterns in the use of space. Just in this way we can gain a paleoeconomic view as complete as possible (including the social organisation of work), where production and use are not separate. As regards aspects with a high symbolic content too, bearing in mind a suggestion of C. Renfrew, we think it is important both the recognition of the activities and the decoding of their symbolic meaning.*
Authors deal with a discussion of these topics, also referring to a specific situation, a Bronze Age structure at Coppa Nevigata (south-eastern Italy).

Résumé. *Les analyses fonctionnelles de plusieurs classes d'objets manufacturés, associées à celles concernantes l'emploi des ressources naturelles, ont atteint un degré très élevé de crédibilité. A partir de ces analyses il a été possible tirer des informations concernantes les éléments périssables, par les traces reconnues sur les industries (lithique ou en matière dure animale) ou alors par les traces des restes organiques présents à l'intérieure des vases. Maintenant il faut coordonner de plus en plus les informations déduites de chaque domaine de recherche pour pouvoir reconstituer des cycles complets d'activité (même si ceux-ci sont réalisés dans des moments et des lieux divers), et les complexes modalités d'utilisation de l'espace. Il s'agit de la seule façon possible pour avoir un cadre paléo-économique complet (à cela on relie l'organisation sociale du travail), à l'intérieur duquel la production et l'utilisation ne sont pas séparées. Même en ce qui concerne les aspects dans lesquels le contenu idéologique est plus fort, en reprenant une proposition de C. Renfrew, il faut souligner non seulement l'importance de la reconstitution des activités diverses, mais aussi leur transformation symbolique.*
Les auteurs se proposent de discuter ces arguments aussi à l'aide d'une situation spécifique: une structure de l'habitat de l'âge du Bronze de Coppa Nevigata (Italie sud-orientale).

Key words: global analysis, functional analysis, spatial analysis.

It is a truism to say that archaeologists study just actions leaving physical traces, that most of them are produced by tools and that the analysis of technology is a central topic to understand the behaviour of prehistoric human groups. We would like to add to this obviousness that there are some differences between the study of production technology and that of use technology, but no clear-cut division, especially in prehistoric contexts where production and use processes are often contiguous (a different perspective in Mannoni and Giannichedda 1996). The principal difference lies in the prevailing perspectives: the study of production generally favours one class of artefacts at a time, even if other classes were included in the production process; the study of use generally regards whole cycles of activity implying several classes of artefacts and natural elements, even if often this does not happen because of scholars' specialization. Moreover the analysis of whole contexts can enable us to better understand both the functional role played by some classes of artefacts and how other elements were processed.

The aim at connecting the functional analyses of different elements seems to us near to the spirit of Semenov's proposal. The problem is not new, but worthy of more attention. Several years ago Binford (a synthesis in Binford 1983) asserted the importance to correlate the results of wear-traces analysis, oriented study of faunal remains and spatial analysis of finds in order to understand the activities carried out in well recorded Palaeolithic sites. As regards Italy, recently the approach to the study of the remains from Isernia La Pineta, integrating the results of different fields of research (origin and characterization of raw-materials; stone tools technology; wear-traces analysis; archaeozoology; taphonomy) was defined "holistic" (Longo and Iovino 2003). We think that we must develop this perspective *sensu* Binford, explicitly orienting the research to reconstruct cycles of activity, carried out in discontinuous places and times too. This theme is particularly important referring to Late Prehistory, when the technological elements implied are more complex and diversified than during the Palaeolithic. Just in this way we can give a paleoeconomic picture as complete as possible (including the social organization of work), where production and use are not separate.

A global functional analysis could have many advantages studying various contexts within the same site and various sites. The comparison between different contexts of the same site or different sites within the same cultural area enables us to understand the aspects socially accepted and those related to the individual variability. The comparison between sites that are distant in the space and/or time, but sharing some features, enables us to understand the specific situation of each of them, highlighting differences and similarities.

Settlements are generally the favoured contexts to make a functional analysis in order to outline cycles of activity.

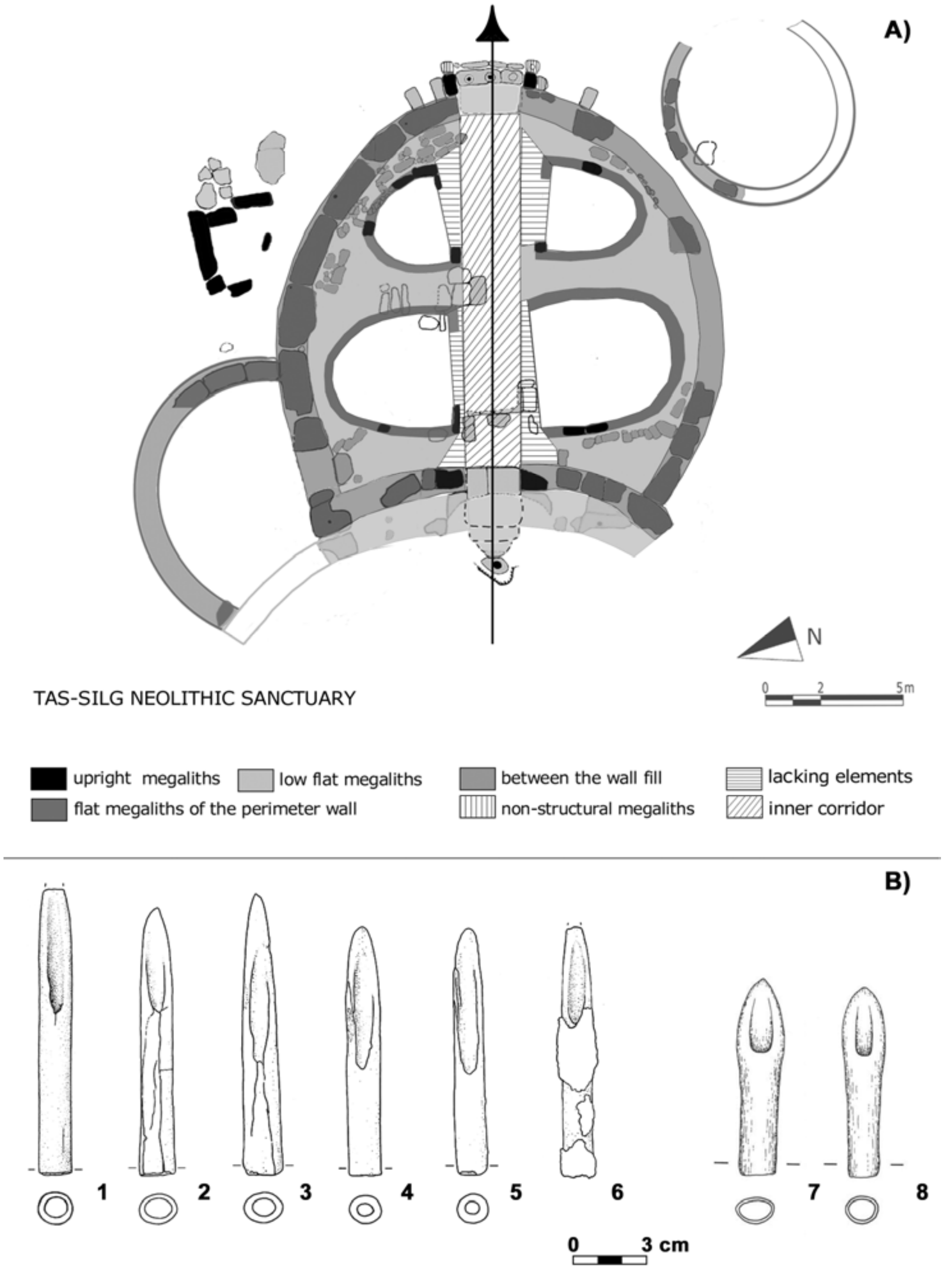

Fig. 1: A) hypothesis of path through the Neolithic Maltese temple of Tas-Silg. The discovery of accessory outside buildings (including a banked platform) by recent excavations complicates the picture of ritual actions; B) Bone spearheads from central Italy Copper Age cemeteries (1-6 Fontenoce di Recanati, 7-8 Camerano, Marche region). Use-wear analysis indicates that they were not used (they were probably produced as grave goods), but they were not symbolic imitations of stone weapons: similar used artefacts were found in contemporary settlements, as Conelle di Arcevia.

Nevertheless there are often many problems related to the location of the remains in their original spatial dimension, basic information to understand how the different activities were carried out. At the moment, in spite of Binford’s criticism against a Pompeii situation (Binford 1981), it seems to us that an experimental analysis starting from a case where a sudden destruction stopped ancient reality could be more successful. In this case, we can ask the data which picture the finds and their locations at the moment of destruction give us in comparison with the whole cycles of activities carried out, indirectly witnessed.

Studying contexts linked to highly symbolic activities, such as places of cult or cemeteries, could be of great interest too. Bearing in mind a Renfrew’s suggestion (1994), we think it is important both the recognition of highly ideological activities (also many symbolic behaviours product changes in the material context) and the basic decoding of their symbolic meaning, that could be supported by a better understanding of the practical function of artefacts and actions involved in their carrying out. For example, the excavations in progress of the third millennium BC megalithic sanctuary at Tas-Silg (Fig. 1A), Malta, the only one explored after forty years,

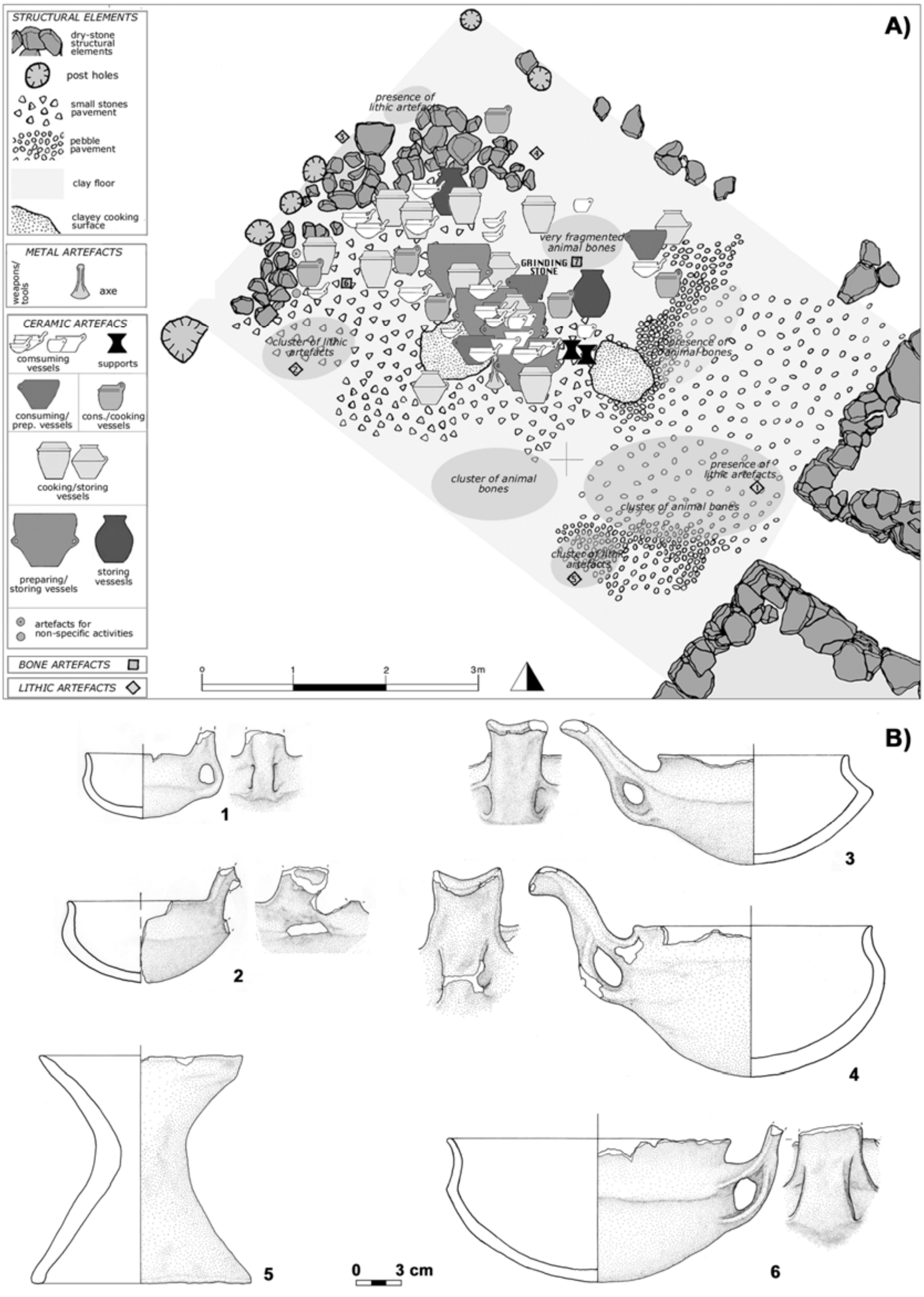

Fig. 2: A) Protoapennine (XVI c. BC) structure at Coppa Nevigata (south-eastern Italy) taken into consideration as a case study of global functional analysis: hypothetical areas of activity are indicated. The numbers inside the symbols of the lithic and bone artefacts in the map refer to fig. 4; B) Pottery from the structure: consuming vessels.

could give new data not only about the architectural structures, but especially about the use of sacred spaces, the ritual paths through them and the cult activities (Cazzella and Recchia in press). Moreover we can quote the research in progress on stone and bone artefacts (Fig. 1B) and pottery from some Copper Age tombs in central Italy, aimed at understanding which grave goods were inserted in the tomb after their use and which were made explicitly for the funerary ritual and for which categories of people (Lemorini 2004; Baroni and Recchia 2005; Cristiani 2005; Baroni *et al.* in press).

The example we are more widely dealing with refers to a structure of the Bronze Age settlement at Coppa Nevigata (south-eastern Italy), destroyed by a fire (Fig. 2). Several analyses were made, related to the use of artefacts, the treatment of parts of body as regards faunal finds, the spatial location of the remains. We would like to thank the colleagues of the research team: I. Baroni, V. Copat, E. Cristiani, C. Lemorini, G. Fiorentino, S.T. Levi, C. Minniti, M. Moscoloni, G. Siracusano. The gas-chromatography of the organic residues trapped in the vases is planned, but not still executed (some potsherds from Coppa Nevigata were recently examined, showing the use of olive oil starting from the XVIII c. BC: Evans and Recchia 2001-03)

Partial results of the analyses on this structure were previously discussed in other papers (Recchia 2001; Cazzella *et al.* 2002; Cristiani *et al.* 2003); here it seems to us useful to take it into consideration as a case study in order to highlight the informative potential of an integrate analysis on different classes of data.
A.C.

A case study: a Bronze Age structure at Coppa Nevigata (northern Apulia)

The structure dates back to the end of the sixteenth century BC (Late Protoapennine). It is located in a marginal area of the settlement (just outside the first walls fallen into disuse), dedicated to activities likely linked to the treatment of foodstuffs, especially by the use of fire in various ways. The concentration of several functional elements (two ovens; several circular cooking surfaces; a large structure to contain or process cereals) leads us to think that the area had a collective use, for example by members of a lineage.

The rectangular structure measures 7 by 5 meters circa, closed at least in the shorter sides and likely roofed. The internal space seems to be divided in different zones. The western part, paved by small calcareous stones, includes a platform of flat stones along the shorter side and two small circular clayey cooking surfaces. They were lacking of charcoal, so they were not heating up when the destruction happened. The eastern part, paved by pebbles, does not include fixed utilities.

The spatial distribution of the remains corresponds to this inner partition, suggesting a functional diversification of spaces. Some traces are likely due to the effects of activities carried out inside, while some elements, such as the pots, could not be linked to activities, but to storage. Fifty-three once intact pots were gathered in the western part, between the platform and the cooking surfaces. In the same place a grindstone, a bronze axe, two bone tools and a few small faunal remains were unearthed. Most of the flint elements and faunal remains were in the south-eastern area.

The functional study of pottery has dealt with different problems (Fig. 3). We aimed at understanding both how each pot was likely used in order to outline related activities and the functional meaning of the whole set of vases. We can formulate two hypotheses as regards the concentration of pottery: the pots were stacked on top of each other on the floor, so they and the whole area were not in use when the structure collapsed; they were both on a raised box-room and were hanged on the poles (as it happened in the Early Bronze Age huts at Nola, destroyed by a volcanic eruption: Albore Livadie and Vecchio 2005), so the area was free. We have to understand if either the pots constitute a functional set, to be used in the activities carried out inside the structure, or they were stored inside, but used outside, also separately. Wear traces on the rims and bases of the pots, corrosion of the inner surfaces and some cases of repairing drillings together with traces of resin indicate that they were not new pots waiting for their first use. Vases fit to store a large amount of goods are lacking. Cereals and legumes are gathered in the north-eastern corner; they were likely stored in the structure by perishable containers.

Almost half of the pots (22) are linked to the individual consumption both of small (1 to 3 decilitres) and middle (half to 1 litre) quantities of liquids or food. These vases, provided with high handles, can be used to draw from a large container. Two clepsydra supports to be used to put these pots on are related to the individual consumption too. Another set of six vases (1 and half litre) is fit for an individual use, referring both to consumption and cooking. The cooking of single portion is recorded in ethnographical contexts (for example from Peru: M. Ferrante pers. comm.). Twelve vases seem to be well suited both to storage and cooking of middle amounts (5 litres) of liquids or food, likely related to a small group of people. The remaining classes of vases are linked to the treatment of various substances. Their dimensions are variable, perhaps linked more to the quality than quantity of contents, not necessarily foodstuffs.

As regards the composition of the whole set of pottery, there are some anomalies both in comparison with the organization of the structure and with more clearly domestic contexts. The high percentage of pots fit for an individual consumption is not amazing, but there is no fire utility to use the cooking pots inside the structure. The cooking clayey surfaces, once they were heated, were well suited either to cook thin portions of food or to toast cereals by direct contact.

The flint elements (fig. 4) are not many (24), as it frequently occurs during the Bronze Age, when this raw material is prevailingly used to produce arrowheads. The technological study indicates that there is no trace of flint working on the spot. Flint artefacts were likely brought into the structure as tools to be used. Except for two blades, they are flakes (probably deriving from the production of arrowheads). Half of them are retouched and generally they are fit to cut in a longitudinal way.

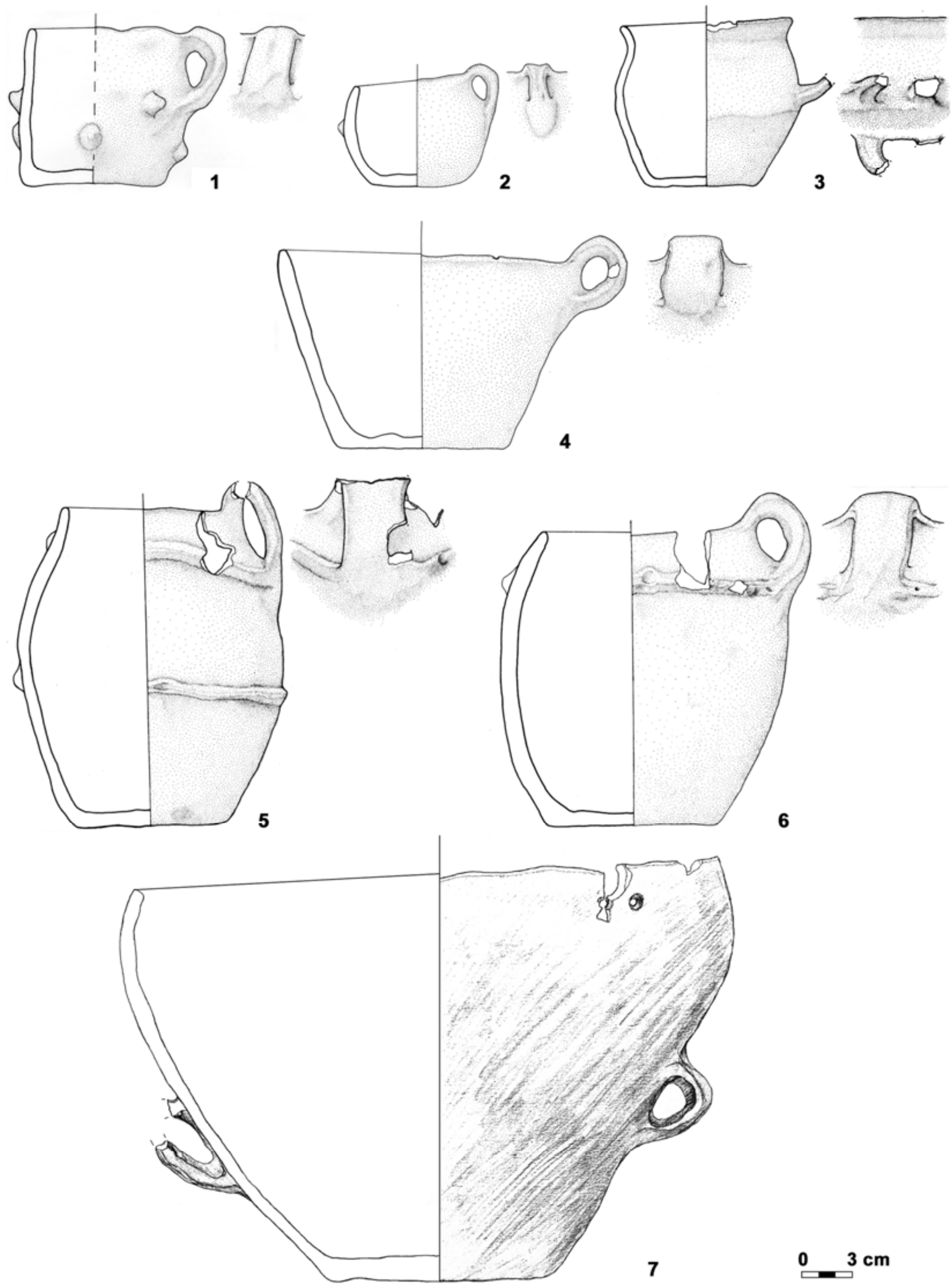

Fig. 3: Pottery from the Protoapennine structure taken into consideration: 1-4 consuming vessels; 5-6 consuming/ cooking vessels; 7 preparing/ storing vessel.

The analysis of wear traces, positive in five cases including blades, suggests activities linked to the treatment of soft materials. We can quote animal tissues, tanned hides, vegetal substances. As already mentioned, the dispersion area of the flint elements does not coincide with that of the vases. They are located in marginal zones, also beyond the platform. A primary refuse of abandoned tools and then a limited displacement of them by cleaning activities could cause this phenomenon. Also the location of a pestle is marginal: the analysis of wear traces indicates a long use to grind soft materials. Nevertheless these materials are different from the vegetal ones grinded by the grinding stone unearthed between the cooking surfaces. Also two bone tools (Fig. 4) were located in the central part of the structure, likely not far from the original place where they were used. They are a comb and a long awl: the wear traces on the first one are almost deleted by the fire effects, but the authors of the analysis hypothesize a use linked to textile activities (Cristiani and Lemorini in press). The long awl

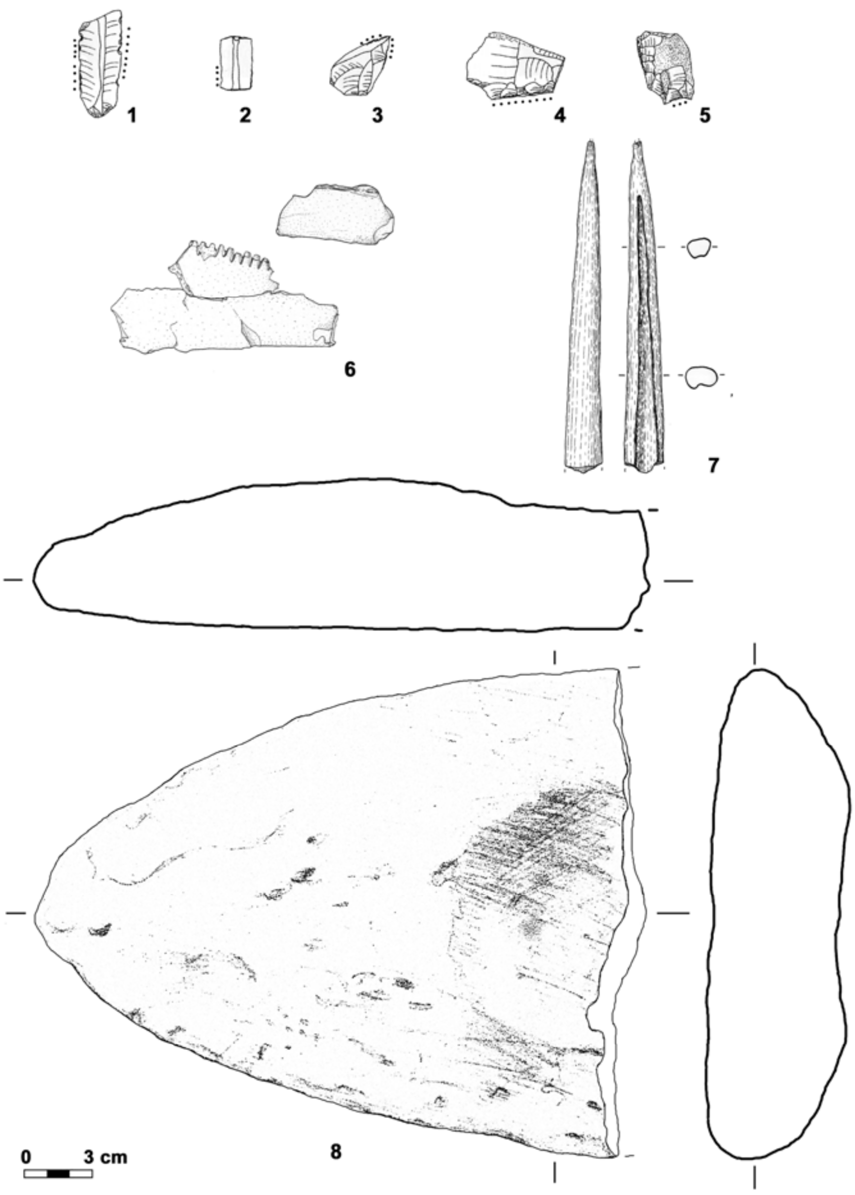

Fig. 4: Coppa Nevigata, stone (1-5, 8) and bone (6, 7) tools from the Protoapennine structure taken into consideration.

was used without handle to work vegetal soft materials (basketworks?). It was resharpened many times by a metallic tool.

The bronze axe in this kind of context leads us to interpret it as a tool more than a weapon. We can not know its specific function, but considering the prevailing ones of stone and bone tools we think it was used to cut flesh portions or vegetal elements.

The faunal remains show some difference in the percentage of the species in comparison with their means in the whole settlement in that period (Bökönyi and Siracusano 1987: sheep and goat are prevailing (70% in comparison with an average of 50%), followed by pig and cattle. Wild species are almost lacking. As regards sheep and goat the remains related to rich in flesh parts of the body are predominant; the contrary occurs as regards the pig; cattle is in the middle.

At the end we can observe that the central area of the structure, including still functionally active elements, was cleaned, removing the residues of the various activities. Part of the residues and tools not in use were shifted to marginal areas of the structure.

Concluding remarks

To conclude, a global contextual analysis leads us to think that the structure taken into consideration was not a hut, including daily domestic activities, such as preparing and cooking food, even if we do not rule out that there they had meals during activities of other kind. In any case, most of the vases were just stored inside the structure at the moment of destruction. We think it was a shelter within a wider area dedicated to various collective activities. We can quote:

- Toasting or cooking cereals and legumes or foods based on their flour. Some vases could be linked to prepare these foods. Intensive grinding was likely made in another place.
- Butchering prevailingly small and middle animals, at least including a first treatment of hides and tendons.
- Working various kinds of vegetal elements, perhaps preparing part of them by some pots among those stored inside.
- Specific domestic activities, as perhaps wool weaving.

G.R.

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Anchor axes: a case-study of wear traces analysis on ethno-archaeological stone tools from Brazil. An anthropological reflection on functional meaning

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Summary. *The anchor axes constitute a peculiar type of polished stone tool widely mentioned in the South-American scientific literature. From the ethnohistorical point of view, the half-moon axes are exclusively ascribed to Jê speaking people present in Brasilian territory and, in particular, in the Central Highplains.*
The Prehistoric and Ethnographic Museum "L. Pigorini" of Rome keeps the most remarkable collection of seventeen axes coming from this area.
The fact that the anchor axes are associated to both archaeological and ethnographic contexts stresses the exceptional nature of such objects thus motivating the techno-functional analysis of the Pigorini group of tools.
The analysis carried out on the anchor axes has allowed to distinguish two functional categories: used and unused axes. High power approach has permitted recognizing two categories of worked material on the basis of the analogy with the ethnographic tools: contact with animal tissues or contact with plants. These data have provided new elements in the interpretation of the anchor axes as cultural goods.

Résumé. *Les haches à ancre constituent un type particulier de pierre polie qui est très mentionnée dans la littérature scientifique du Sud de l'Amérique. D'un point de vue ethnohistorique, ces haches sont associées exclusivement aux populations Brésiliennes de langue Jê, répandues, en particulier, dans les Plateaux Centrals.*
Le Musée Préhistorique et Ethnographique «L.Pigorini» de Rome garde une exceptionnelle collection de haches à ancre du Brésil.
Le fait que ces pièces polies ont été retrouvées dans des contextes soit archéologiques soit ethnographiques souligne la particularité de ces objects qui, à son tour, a motivé leur analyse techno-fonctionnelle.
Cette analyse a permis de distinguer, au moyen de l'analogie avec des pièces ethnographiques de référence, deux catégories de pièces: celles utilisées et celles non utilisées. Grâce à l'approche à forts grossissements, on a réconnu deux grandes catégories de matières travaillées: les tissus charnus et les végétaux. Ces données ont apporté de nouvelles suggestions intérpretatives concernant le rôle de biens culturels des haches à ancore.

Key words: anchor Axes, ethno-archaeology, use-wear, fourier transform infrared spectroscopy (FTIR)

"Quando seguro a machadinha, seguro as duas metades juntas, então eu seguro a força inteira. Seguro os ventos. Os ventos que comandam nossa dança e nosso canto" (Pedro Penon, leader Krahò, personal communication).

Introduction

The anchor axes are artefacts widely mentioned in the South-American scientific literature (Nimuendajú 1939; Ryden 1937; Simons 1965-66, 1967). Their peculiar morphology distinguishes them from the rest of the Brazilian polished axes.

The Prehistoric and Ethnographic Museum "L. Pigorini" of Rome keeps the most remarkable collection of seventeen axes from the Central High plains of Brazil (Figs. 1, b-i). The anchor axes testify a long period – more than three centuries – from the first explorations of Brazil to those dating to the end of XIX century, in a time of colonization and ethnic massacre.

The most ancient specimen of the collection (n. Inv. 4210), was donated by Antonio Gigante, a student from Bologna, who had pointed it out since 1588, to Ulisse Aldrovandi. In 1648 it was published in *Musaeum Metallicum* as "*Securis Lapidea in sacrificiis Indorum usitata*" (Aldrovandi 1648, p.158; Pigorini 1881, p. 12).

With the exception of the two axes given in 1861 by Luigi Buscalioni (nn. Invv. 63028-29), the botanist who lived among the Apinayé of Goiás, the other axes are part of the collection of the naturalist Enrico Hillyer Giglioli. They come from the Pará, Maranhão, Tocantins, Goiás, Minas Gerais, Paraná and Amazonas states.

These peculiar specimens represent "… *la più bella caratteristica del Neolitico brasiliano*[1]" (Giglioli 1914, p.210) but their knowledge is insufficient and their classification engenders questions about their interpretation. Most of the axes show edges whose sharpness makes them efficient weapon while other

[1] "The most fascinating characteristic of the Brazilian Neolithic"

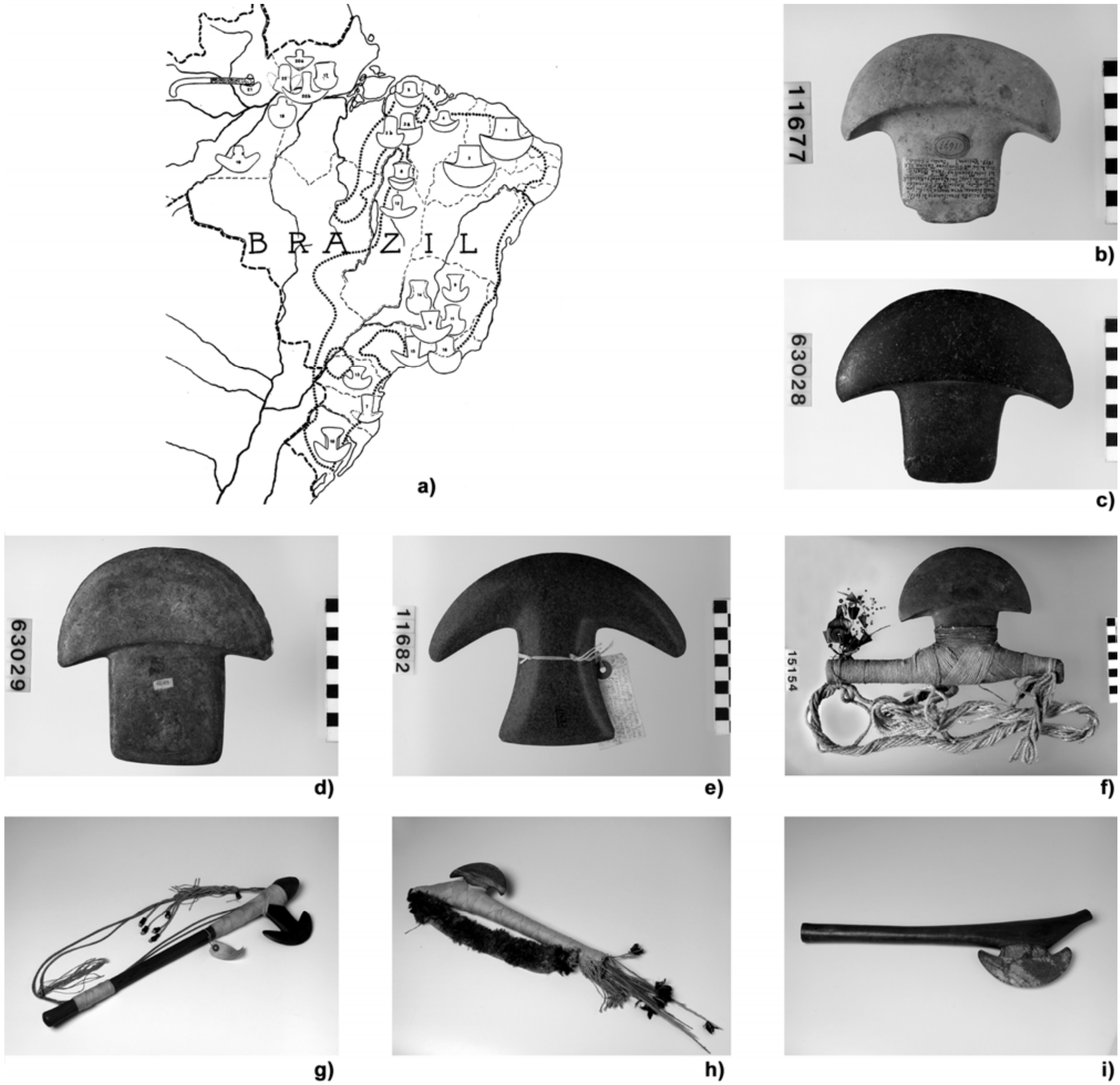

Fig. 1: a) Anchor axes distribution in the Brazilian territory (from Ryden 1937, p.79); b) Anchor axe n° Inv. 11677, E. H. Giglioli's Collection, L. Pigorini Museum, Rome; c) Anchor axe n° Inv. 63028, L. Buscalioni's Collection, L. Pigorini Museum, Rome; d) Anchor axe n° Inv. 63029, L. Buscalioni's Collection, L. Pigorini Museum, Rome; e) Anchor axe n° Inv. 11682, E. H. Giglioli's Collection, L. Pigorini Museum, Rome; f) Anchor axe n° Inv. 15154, E. H. Giglioli's Collection, L. Pigorini Museum, Rome; g) Anchor axe n° Inv. 15101, E. H. Giglioli's Collection, L. Pigorini Museum, Rome; h) Anchor axe n° Inv. 15102, E. H. Giglioli's Collection, L. Pigorini Museum, Rome; i) Anchor axe n° Inv. 4210, L. Pigorini Museum, Rome.

specimens, really light and fragile, could be probably interpreted as rank signs.

Their presence in the museums, where they are among the most ancient specimens, their finding in archaeological sites or on surface, stimulate reflections from the historical and archaeological sphere to that of myth and rite.

The latter considers both the analysis of the traditional narrative and the continuous mytho-poetical production on the axes found in surface.

The fact that the anchor axes are associated to both archaeological and ethnographic contexts stresses the exceptional nature of such objects thus motivating their techno-functional analysis.

Anchor axes: the ethnological and archaeological background

From the ethnohistorical point of view, the half-moon axes are typical artefacts exclusively ascribed to Jê speaking people (Nimuendajú 1939, p.126) and their distributional area would coincide with the cultural sphere of this linguistic family, present only in Brazilian territory and, in particular, in the Central High plains (Fig. 1a). These groups are known through their coastal enemies unpleasant reports (e.g. the famous Tupinambá - Tupí speaking peoples) who used the term "Tapuia" to denominate all their enemies "not-tupí" in the inland. No ethnographic documentation concerning the anchor axes is available with the exception of the report of Yves d'Evreux, a French Capuchin who resided among the Tupinambá of the Maranhão between 1613 and 1614. He related that the Tremembé, a Tapuia group, ritually manufactured axes in the full moon nights in order to give them the perfect shape to guarantee invincibility on the battlefield (d'Evreux 1864, pp.141-2).

The symbolic and ritual significance of the anchor axes as *weapons* is strengthen by mythology of the Apinayé, a Timbira speaking group (Jê linguistic family). They stole them from their enemies, the Bat People, which were mythical entities inhabiting caves and shelters. Bat People used to kill men breaking their skulls by means of anchor axes (Nimuendajú 1939, pp.179-80) that Apinayé people have always considered as cultural goods.

The Jê groups do not think themselves as the makers of the axes. This suggests an archaeological origin of these tools, collected and culturally assimilated by ethnographic Jê groups. The behaviour of contemporary Krahó, people of Timbira language (Jê family) that inhabited the Native Land of Kraolândia (north-eastern region of Tocantins state), is enlightening: *"O Koiré* – the singing axe – *foi uma conquista dos nossos antepassados"*, state the Ancient, dating its origin back to the age of myth (Dominques 1993).

They claim they cannot manufacture the anchor axes but they collect only the objects found in their territory. They parade them during ritual songs after having reshaped, re-handled and decorated them.

The Ancient state that in a very ancient time, Altan, the mythical hero, was wandering in the *cerrado* always carrying his Koiré with him. The sacred axe set the cultural rules which assure the life of the society with their ceremonies and everything concerning the process of becoming Krahò.

The case of *repatriation* (Nobili 1994, p.139) of one *koiré* kept in the museum of São Paulo to a krahó village in 1986, has renewed the ideology and knowledge connected to the half-moon axe concerning different issues such as the political.

A contemporaneous and enlightening example is the institution, in the same village, of a school named Koirè, as it is the Koiré that has taught to Altan, the great mythical and cultural hero, the power of singing and traditional knowledge.

After the studies of Ryden (1937), Nimuendajú (1939) and Simons (1965-66, 1967), issues related to the origin of the *anchor axes* have been underestimated in the recent development of the archaeological research.

According to Prous (1986-90, pp. 37, 65), most of the archaeological specimens come from funerary/cinerary urns of the so called "Aratu-Tradition". This cultural connotation identifies semi-sedentary communities of horticulturists distributed over a wide territory geographically localized in the central-east part of the Goiás State, in the Central Plateau of Brazil. Their sites are characterized by circular build-up areas/villages and are located in a chronological wide range, about the beginning of Common Era until 15th century, (Barbosa 1995, p.185; Fernandes 2001, p.29; Schmitz 1991, p.15). So far, the study of the "Arartu-Sapucaí" culture has been carried out by the analysis of pottery artefacts mostly and the lithic industry, among which the anchor axes, remain partially unknown.

The lack of ethnographic and archaeological information on so deeply culturally characterized artefacts have justified our techno-functional analysis (Keeley 1980; Mansur 1993; Mansur and Srehnisky 1996; Milles 1993; Semenov 1964; Thringam *et al.* 1974) carried out on the large collection of anchor axes belonging to L.Pigorini Prehistoric and Ethnographic Museum of Rome. The techno-functional analysis could provide implementing data to the ethnographic sources about the action related to the ethnographic manufacture, often absent in the anthropological literature.

The analysed sample

The whole set of anchor axes of L. Pigorini Museum has been observed, with the only exception of a specimen showing a completely different morphology compared to other axes which show homogeneous general characteristics.

Most of them are realized of diorite with the exception of few cases made out of gneiss or feldspat. Their morphological features allow us to propose a distinction in two types. Type 1 is characterized by oblique wings and by a trapezoidal tang (Fig. 2a). Type 2 has quite straight wings, a rectangular tang and two lines that divide tang from body and the bottom surface of the wings into two halves (Fig. 2b). Both groups of tools always have a bi-convex and symmetric profile of the edge.

From a morphometric point of view, these types are characterized by an analogous average length (type 1: 145mm; type 2: 144mm), a different whole width, largest in type 2 (type 1:114mm; type2: 160mm) and a dissimilar length of the tang which is shorter in type 2 (type 1:71mm; type 2:64mm)

a) b)

Fig. 2: a) Axe n° Inv. 11682, morphologically ascribed to “type 1”; b) Axe n° Inv. 63029, morphologically ascribed to “type 2”

Four cases of hafted axes are documented (Figs. 1f-i). They are two little anchor axes of type 1 transversally inserted at the end of a long wooden handle. In one case, cotton strings finish the artefacts and have been probably used as shoulder-belt and suspension (Fig. 1f). Other two large axes of type 2 are fitted in the middle of short wooden handles girded by cotton strings decorated with small herbivorous hooves (Figs. 1g-h). It is a very elaborated hafting with an evident aesthetic aim, which testify the ritual value of these two artefacts.

The reference collection

The great quantity of time consuming effort demanded for production and use of experimental anchor axes has justified the research of an alternative solution in order to acquire a reference collection.

Ethnographic axes belonging to L. Pigorini Museum coming from the same geographic contexts and used in daily activities have constituted a reference collection (Fig. 3a). The ethnographic sources document their use in plant and wood processing (Laming-Emperaire 1964). Their analysis has allowed a combined definition of diagnostic macro and micro-traces both for the technological and functional interpretation (Figs. 3, d-f).

In order to verify the connection between anchor axes and war waging, as suggested by Jê groups myths, polished stone wedges used to kill slaves during the Potlatch in the north-western North America have been chosen as a reference (Giglioli 1914, p.163) (Figs. 3b-c; g-h). On the active area of some anchor axes yellow and red residues have been observed. They have been analysed by Hemastix test, in order to evaluate traces of blood, and FTIR (InfraRed Fourier Spectroscopy) (Nunziante Cesaro *et al.* in press). No blood residues have been identified by both methods.

Techno-functional analysis

The artefacts surface shows a polished and reflecting characteristic that suggests aesthetic purposes (Figs. 1c; 4a). This technological choice seems to be absent on axes used in daily activities. In fact, traces of the *débitage* only partially erased by finishing are still visible on them.

The polished surface is always located in their active zone. Nevertheless, the most curated artefacts are also characterized by the polishing of the tangs (Fig. 4b).

Some anchor axes show reshaping traces that are meant for two different purposes. One for the maintenance of the morphometric variables that typify the artefacts (Figs. 4b, h) and the other for the preservation of the shape (Fig. 4l).

This second aspect is emphasized in a specimen on which the reshaping phase was performed just in order to maintain the general convexity of the profile without relation to the original morpho-functional feature of the tool (Figs. 1b, 4l).

The analysis carried out on the anchor axes has allowed to distinguish two functional categories: used and unused axes. This distinction does not seem related to the typological groups in which we have organized them.

In the first functional category (eight specimens) the active edges are potentially useful but no diagnostic traces have been identified on them. It can be only observed the invasive brightness produced during the activity of finishing. The anchor axe with the obtuse profile calls for the convexity of the original tool, is part of this category (Figs. 1b, 4l).

In the second category of artefacts (five pieces), a developed edge rounding is the most recurring type of macro-traces (Fig. 4e). Sometimes, functional traces are present on the wings too (Fig. 4i). Here, the higher presence of edge-removals as regards to the active edges could be connected to the protruding morphology of the wings, more subjected to secondary impacts during use.

High power approach applied to anchor axes has allowed distinguishing two categories of worked material on the base of the analogy with the ethnographic tools.

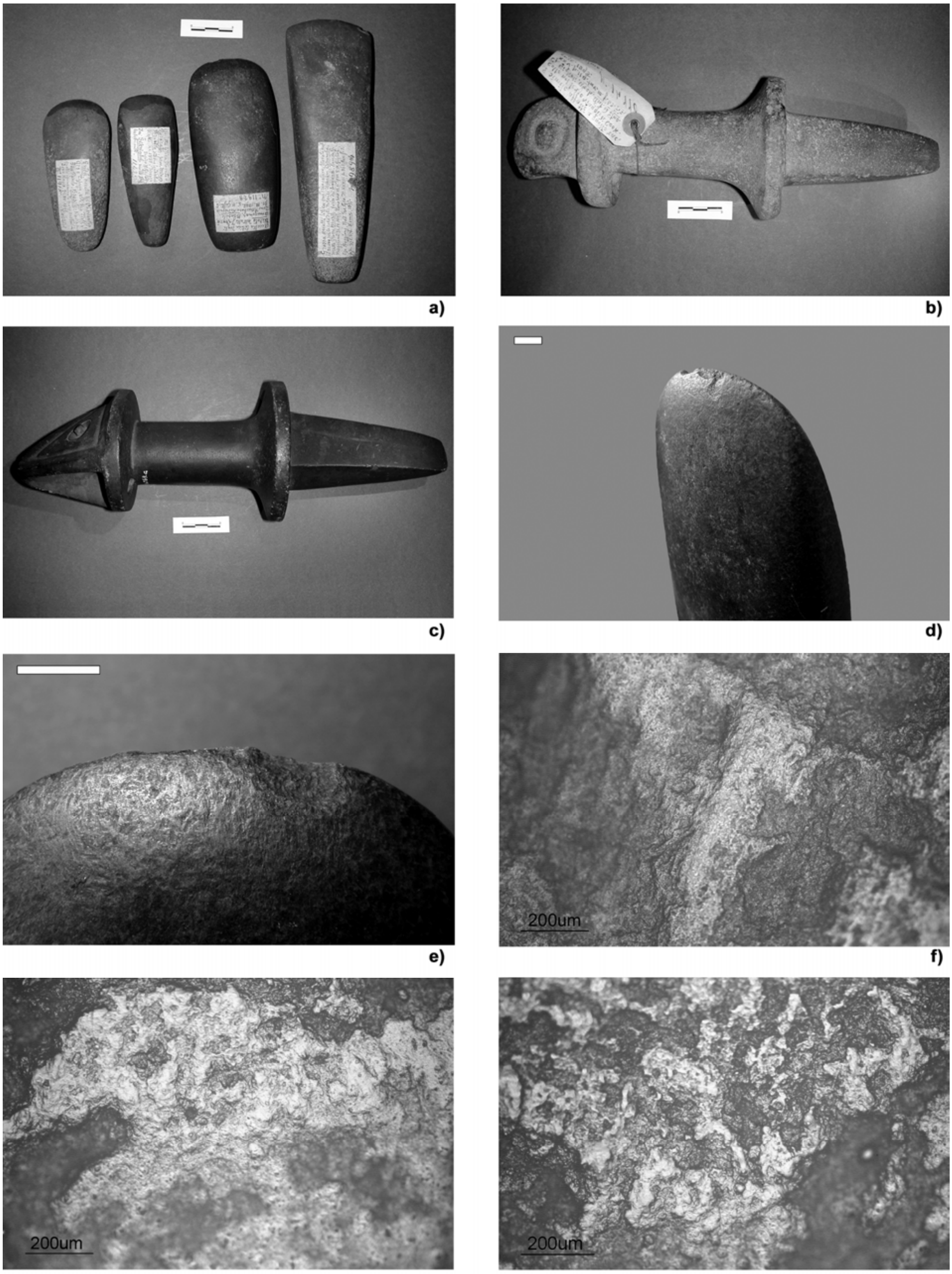

Fig. 3: a) Axes used in daily activities, E. H. Giglioli's Collection, L. Pigorini Museum, Rome; b,c) Polished stone wedges used to kill slaves during the Potlatch in the North Western North America, E. H. Giglioli's Collection, L. Pigorini Museum, Rome; d, e) Macro-traces identified on ethnographic axes used in daily life activities related to treatment of vegetal materials. The bars are 1mm; f) Micro-wear identified on ethnographic tool 11928 and connected with plants treatment; g, h) Micro-wear identified on ethnographic tool 14772 and connected with animal tissues

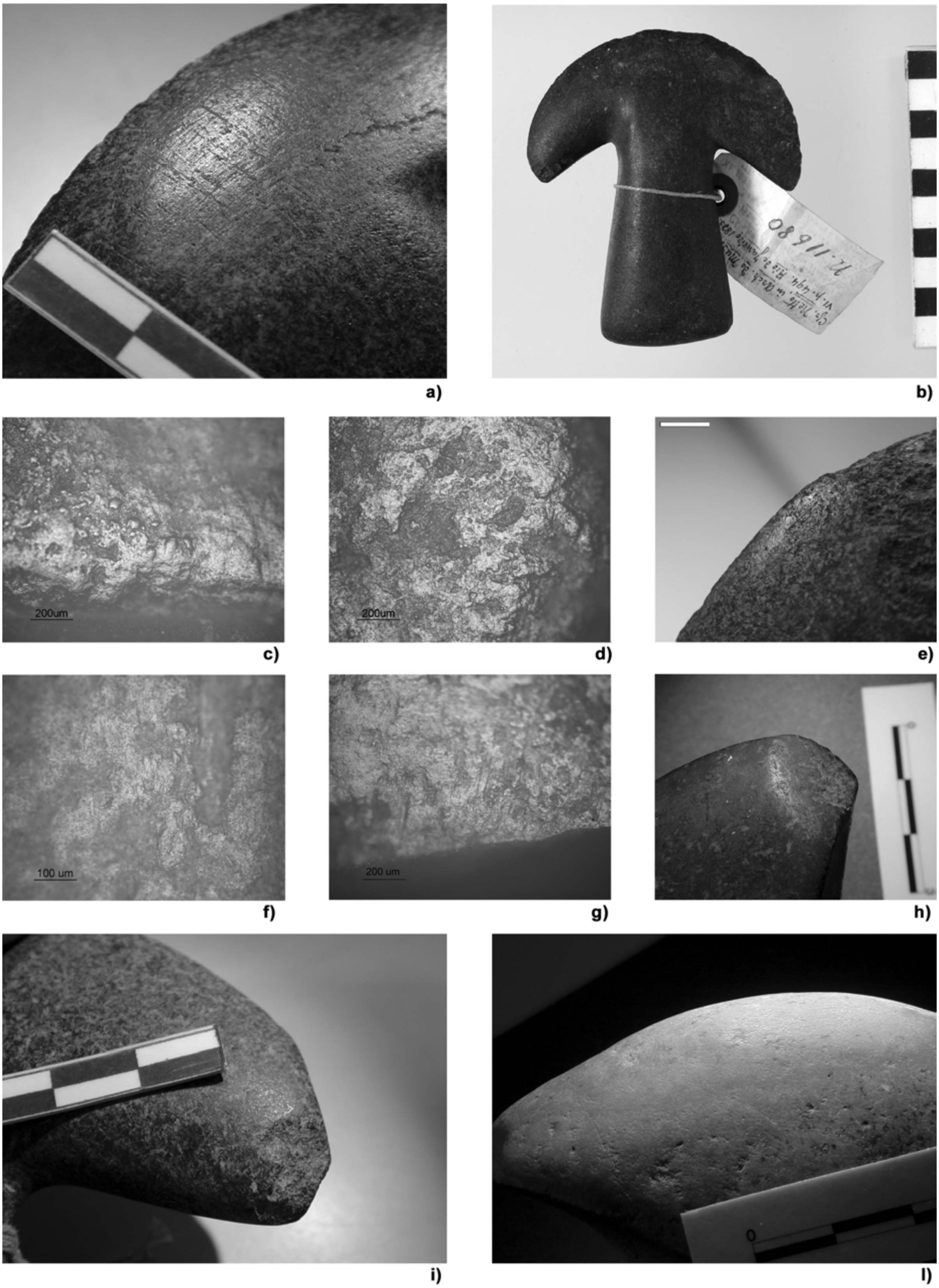

Fig. 4: a) Polished and reflecting characteristic that suggests aesthetic purposes on axe n° Inv. 11682; b) Reshaping traces on axe n° Inv. 11680. Note that the *refaçonnage* is meant for maintenance of the morphometric variables of the artifact; c) Micro-traces identified on axe n° Inv. 63028 and connected to a contact with animal tissues; d) Micro-traces identified on axe n° Inv. 11680 and connected to a contact with animal tissues; e) Macro-traces and developed edge rounding identified on axe n° Inv. 11687. The bar is 1mm; f) Micro-traces identified on axe n° Inv. 11683 and connected to a contact with plants treatment; g) Micro-traces identified on axe n° Inv. 11687 and connected to a contact with plants treatment; h) Reshaping traces on a wing of axe n° Inv. 63028; i) Macro-traces on the wing of axe n° Inv. 11683; l) Reshaping traces on axe n° Inv. 11677

Contact with animal tissues is characterized by smooth and greasy polishes that are patchily distributed on the surface (Figs. 3, g-h). These polishes are set down carefully and do not change the original topography of the tool. Traces of use on animal tissues has been recognized on three anchor axes (Figs. 4c-d).

On the contrary, contact with plants produces rough polishes modifying the original topography of the surface becoming flat when traces are developed (Fig. 3f). This kind of wear has been found on two axes.

Among the used tools, two anchor axes show specific techno-functional features as regards to other artefacts (Figs. 4f-g).

One axe (Fig. 5b), a type 2, has been used when already broken to perform two distinct activities. A thrusting percussion on hard material which has caused wide and invasive edge-removals and a longitudinal diffuse percussion on plants which has left a glossy band on the edge.

Yellow residues with a globular shape have been identified on the worn surface (Fig. 5c). Samples have been spectroscopically analysed without previous manipulation with an infrared microscope (IRscopeII, Bruker) in the 4000-600 cm^{-1} range. In addition, small amounts of all samples dispersed in KBr excess have been studied in Diffuse Reflectance (RD) with the Interferometre Equinox 55 (Bruker) in the 4000-400 cm^{-1} interval *to obtain more detailed spectra.* In both cases, the resolution was 1 cm^{-1} and 200 scans were cumulated.

Comparison with resin standards obtained in the same experimental conditions showed a perfect matching between spectroscopic features of the 11687 sample with the vegetable wax Carnauba extracted from the Carnauba palm (Fig. 5a). Carnaúba *Copernicia prunifera*, is a palm-tree traditionally employed by indigenous people in the North-East of Brazil for different purposes. Its fruits are used as food for both men and animals. The wood is utilized as building material and the leaves are utilized for manufacturing ropes, bags, fabrics and a special wax traditionally used as mastic.

The second axe, a type 1, has been partially reshaped by a curated retouch, which has maintained the morpho-functional characteristics of the original active edge. However, no finishing sequence has been carried out after the *façonnage* (Fig. 4b). This artefact, technologically incomplete, has been utilized for processing animal tissues in thrusting percussion (Fig. 4d).

On all the tangs of both used and unused axes heavy rounding due to the friction with a handle has been observed. Moreover, different patinas and residues localised on various areas of the tang testify the change of the handle system during the life of the axes suggesting, as a consequence, their antiquity (Figs. 5d-e).

Conclusions

In conclusion the techno-functional data provide new elements in the interpretation of the anchor axes as *cultural goods*.

The distinction between the anchor axes and other types of polished stone tools is already evident in the manufacture sequences clearly aimed at aesthetic purposes.

Generally, these technological characteristics are entirely maintained by reshaping. The curated aspect constitutes a cultural trait that has lasted for a long time. Sometimes, this continuity breaks up as for the rough reshaping of one axe that was just aimed at the maintenance of the whole convex shape. This exception could have been related to communities that thought the half-moon shape as the only significant cultural trait. As ethnographically documented, people of Jé language consider the half-moon as the "perfect shape" that synthesizes their symbolic, cognitive and social world. However in their tradition the production of the axes is associated to the mythical hero. This trait founds their cultural separation from the manufacturing sequences. Consequently, these groups were allowed by their myths to act in a different technological way from to the original makers of axes.

With reference to this issue, it can be mentioned that the Krahò consider the axes not only as an artefact but as a conquest. In the quarrel with University of São Paulo, for the returning of the axe kept in the museum of Sau Paulo, this institution endeavored to negotiate with the krahò the restitution of a copy of the axe. One of the ancient attending the krahò commission, while remarking the proposition's unacceptability verbatim stated that *"Branco fabrica muitas coisas! E, por isso, pensa que pode fabricar um machado-koiré. O koiré não foi fabricado. Nenhum povo, nenhuma fábrica do mundo, fabricou o koiré. O koiré veio da natureza*" (Domingues 1993).

In addition, functional data stimulate new clues for discussion.

The identification of traces of fleshy tissues agrees with the ethnohistoric sources that testify the ritual use of the axes for breaking skulls during war raids. The absence of traces on other objects does not contrast with the ritual function ethnographically documented for these tools. In this case the unused axes could be conceived as chief signs in an exchange network managing social relations among different communities as today among Krahó people.

These considerations reflect the habit peculiar to the Jé language family groups who have always practiced a "cultural predation" policy focused around rituals and songs that were acquired both from their neighbours and from "the spirits", thus allowing to increase their

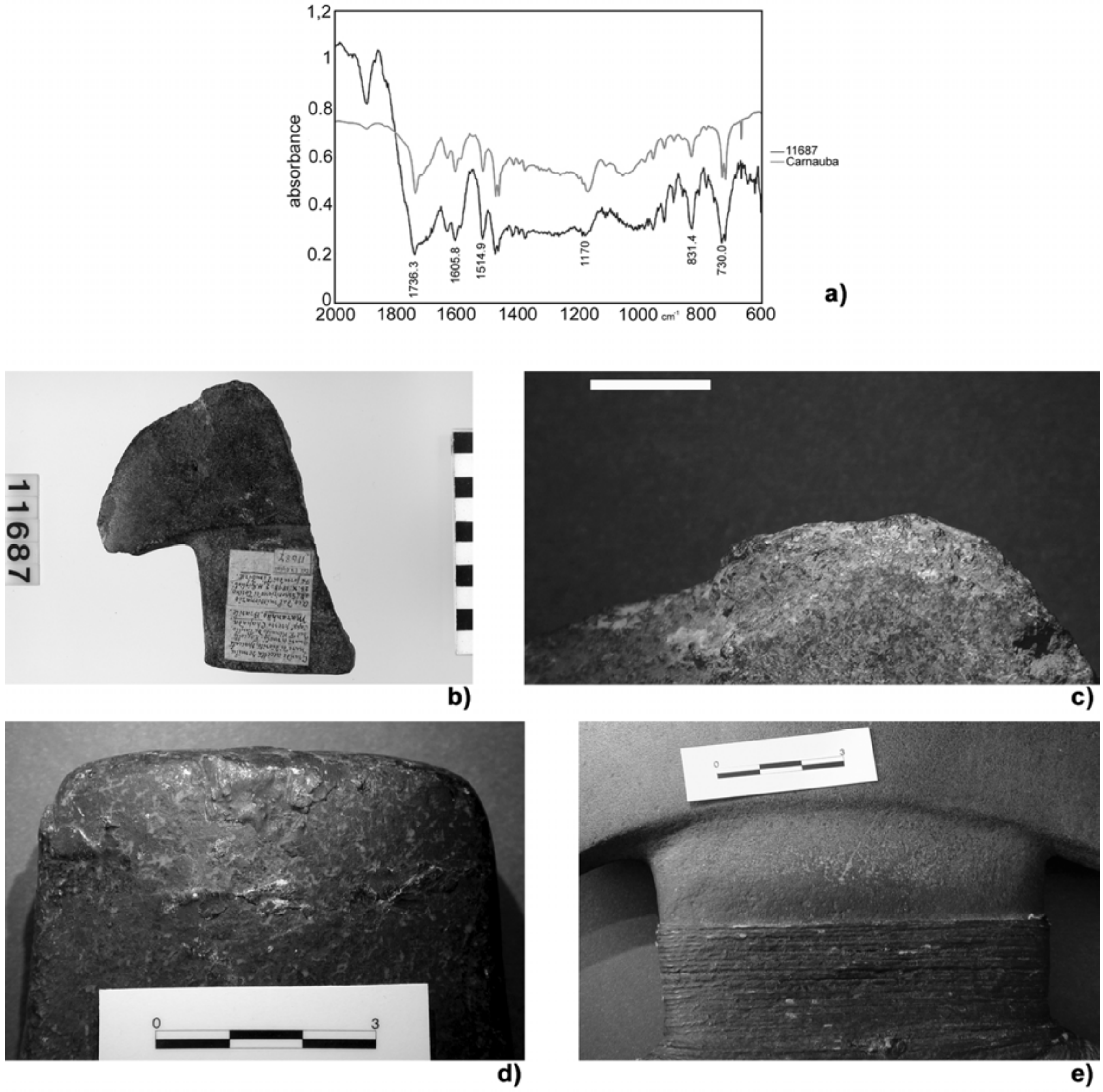

Fig. 5: a) Detailed FTIR Spectra which shows a perfect matching between spectroscopic features of the 11687 sample with the vegetable wax Carnauba extracted from the Carnauba palm; b) Anchor Axe n° Inv. 11687; c) Yellow residues with a globular shape identified on the worn surface of axe n° Inv. 11687. The bar is 1mm; d) Rounding and residues connected to grip system on axe n° Inv. 63028; e) Different patinas localised on the tang of axe n° Inv. 15154 testify a change of the handle system during the life of the axe.

endowment. Without losing the memory of their foreign origin, these cultural assets enter the circuit of exchange which sets their use (Carneiro da Cunha 1993, p.79). Therefore we are facing a situation which is marked by divisions, alliances formations and war creating altogether the cohabitation lifestyle of Timbira groups. One of the reasons for the drive to war waging consisted precisely in the conquest of ornaments and ritual axes as substitutes of revenge taken as motive of war waging (Melatti 1974, p.52). The recognition of vegetal traces on the anchor axes would suggest an unexpected connection of these objects to domestic fields, never associated to this type of polished stones by the ethnographic sources.

As far as the ethnographic sources are concerned, it is unusual that an artefact highly charged with a cultural significance would change its nature becoming a tool used in other social fields. It is more probable that these axes, also the broken one, would have been used in activities connected to the sphere of this cultural good as the production of its wood handle, its mastic and its vegetal strings that were a fundamental and highly symbolic part of the whole object.

The importance of the grip system is emphasized by well developed traces caused by prolonged insertion in wooden handles. Sometimes these use-wears testify a change in the grip system probably occurred after the cultural assimilation of the axes by different groups.

In conclusion, the techno-functional analysis has shed light on some of the aspects, which define the anchor axes as special objects.

The elements of continuity and change that we have recognized in the technological and functional choices related to the axes are well synthesized by the Krahó thought. They see in the ritual axes the central and living signs of their culture since their archaeological nature. For them, the findings of ancient stone tools testify the power of the stones and of the hearth. Consequently, they are dignified to be connected to a new network of social and symbolic exchanges.

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Manufacture and use of stone tools in the Caribbean Coast of Nicaragua. The analysis of the last phase of the shell midden KH-4 at Karoline (250-350 cal. AD)

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Summary. *This work presents the results of the technological and use-wear analyses carried out on the lithic material recovered during the 2002 and 2003 excavations at the site of Karoline, Kukra Hill, Caribbean coast of Nicaragua. Excavations unearthed a habitation unit linked to the shell midden No. 4 (KH-4), and provided a series of AMS dates ranging between 360 cal. BC and 350 cal. AD. Two trenches were opened within an area of 50 m^2. The first trench, in the north, is the shell midden, which is an area of garbage dumping as well as an activity area (with hearths and other structures related to cooking, fish smoking, etc.). The second trench occupied nearly 2/3 of the whole area. Here, many lithic artefacts were recovered. Chert (flint, chalcedony, etc.) was the material mostly used for chipped lithic production. Among the stone tools recovered, there is a vast amount of drills, mainly used on hard materials such as stone, bone and shell, often employed in the manufacture of necklace beads. In addition, tools were recovered that were linked to different stages of pottery production. This data suggest that the making of ceramics took place, at least partially at the site.*

Résumé. *Dans cet article nous présentons les résultats des analyses techniques et fonctionnelles réalisées avec le matériel lithique récupéré lors des fouilles de 2002 et de 2003 dans le site archéologique de Karoline, Kukra Hill, Côte Atlantique du Nicaragua. La zone fouillée est liée à une unité d'habitat en relation avec l'amas à coquillage numéro 4 (KH-4) qui a une datation au radiocarbone de 360 Cal. BC à 350 Cal. AD. La surface fouillée, de 50 m², comprend deux parties distinctes. La partie nord où se situe l'amas à coquillage qui est considérée aire de débris et lieu où se déroulèrent certaines activités (avec des foyers et d'autres structures en relation avec la préparation d'aliments, probablement avec le fumage de poissons, etc.) et une deuxième partie, qui occupe les 2/3 de la surface fouillée, où l'on a retrouvé la grande majorité de la production lithique. Parmi l'outillage lithique nous avons déterminé une série de perçoirs, utilisés en grande partie pour travailler des matière dures telles que des roches, des os ou des valves, cf. les parures; ainsi qu'une série d'instruments (outils) en relation avec différents stades de l'industrie céramique ce qui nous indique qu'une partie au moins de la céramique utilisée aurait été produite dans le site.*

Key words: Caribbean Archaeology, shell midden, lithic raw materials, use-wear analysis.

The archaeology of tropical lowlands in Caribbean Nicaragua

Over the last two decades a considerable amount of research has focused on the prehistory of tropical American lowlands. This can be explained by two facts. On the one hand, it has been proved that complex and unique social changes took place in some of these environments in the past. On the other, it has turned out that conventional theories on tropical American prehistory are not only too simple, but also wrong. These theories linked most of the American social and historical changes to two hypothetical focuses of evolution -the Andean and the Mesoamerican areas- from where two different waves would have spread towards the peripheries. A constant growth of empirical knowledge thanks to the discovery and detailed research of new sites has proved that some contexts usually linked to "complex-societies" were at least as old as those of the supposed nuclear areas.

Moreover, the investigation of some early sites with a long archaeological sequence in some areas of the tropical forests has contributed to gain a better understanding of the long term social evolution processes, and to refute the assumption that hunter-gatherer populations did not posses the necessary technology to colonise this kind of environments (Bailey *et al.* 1989). Some of these sites have also provided a good empirical basis in order to approach different exploitation and transformation strategies of wet tropical forests, such as deforestation and plant domestication. The development of a local archaeology with a high level of technical training has supposed, in some countries, an important encouragement of research.

In the Atlantic side of Nicaragua, which includes most of the country, this new phase of systematic research has only recently started to develop in a continuous way, due to the difficulty to develop fieldwork in places without infrastructures, as it is the case for most tropical lowlands. The problematic recent history of the country sometimes has also precluded such research efforts, as it has the lack of any "spectacular" remains that could have attracted international researchers, as it happened in Honduras.[1] Archaeological research in Nicaragua did not start until the beginning of the 1970s when the Nicaraguan researcher E. Espinosa excavated the Angi shell midden and documented occupations prior to 6000 BP. Unfortunately, the results of his works have never been published (Veloz 1991, p.33). At the beginning of

[1] An example are the archaeological teams from the Smithsonian Institution and Peabody Museum which were in Honduras during 1930s but did not cross to Nicaragua.

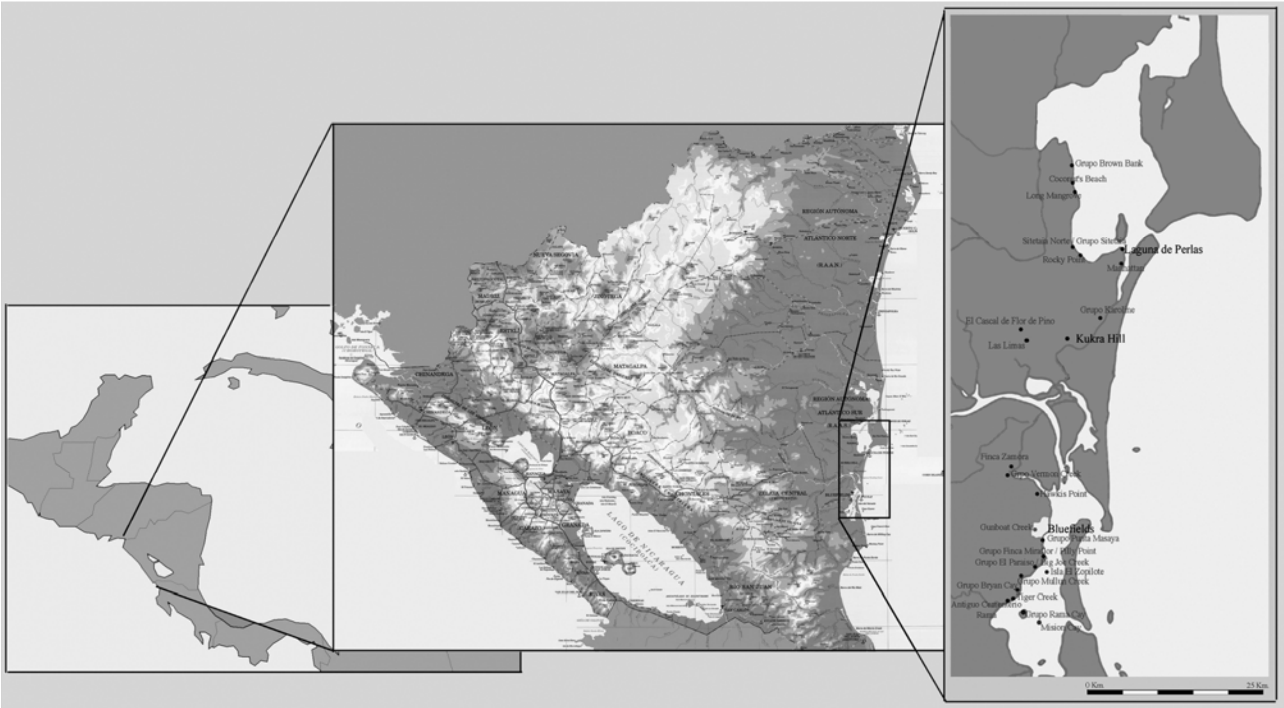

Fig. 1: Map of the research area.

1970s, R. Magnus, a disciple of I. Rouse, appealed by Espinosa's works, carried out a programme of site recording and excavated some of them (Magnus 1974, 1978). His excavations, that took place mainly in shell middens, involved test pits of a size of 4m^2 and followed arbitrary levels. The results allowed the author to establish a first archaeological sequence for the central coastal Caribbean of Nicaragua. The sequence, covering slightly more than 1000 years (from 100 BC to 1000-1100 AD) established a first phase of polychrome pottery followed by a second phase with monochrome vessels that had incised and impressed decoration. Some other excavations of shell middens completed these works, as the work carried out by the Nicaraguan researcher J. Matilló (1993) in Monkey Point, next to Angi. However, these excavations have not been carried out in a continuous way.

In 1998 the *Universidad Nacional Autónoma de Nicaragua* and the *Universitat Autònoma de Barcelona* undertook a long term research programme in the central Caribbean coast of Nicaragua, between Bluefields Bay and Pearl Lagoon (Fig. 1). The general aims of the project are focused on the definition of the exploitation of the tropical wet lowlands by prehistoric communities. The theoretical view point assumes that human societies established their objective life conditions through labour. This implies the acknowledgement that the environment, instead of being a restrictive element or offering a series of static possibilities in time, is just another social resource. The way in which a certain physical environment is integrated into social production depends on the characteristics of the society. Thus, the research project was planned considering the importance of recording specific productive processes in different places and periods as a starting point to approach social relations between the persons and communities, as well as the distinct processes of socialization of the territory. This implied moving away from an archaeological practice focused exclusively on the definition of ceramic sequences and, instead, to consider the different archaeological remains as a whole (Gassiot 2005; Gassiot and Palomar 2001; Gassiot *et al.* 2003 a, b and c; Gassiot and Estévez 2004).

Taking into account these aspects, the first phase of the research program took place between 1998 and 2001. It consisted in locating and recording archaeological sites for future more intensive studies. Surveys carried out during those years allowed to identify 21 archaeological sites, most of them placed next to the coast and containing more than 80 shell middens. Seventeen radiocarbon dates from 7 of the sites have contributed to document an archaeological sequence that starts around 1400-1250 cal. BC and ends around 800-1000 cal. AD. These dates allowed also to understand that the shell middens forming a site (as in Cukra Point, Karoline, Sitetaia and Brown Bank) are the product of synchronous occupations that represent, without doubt, real villages. This is evident from 450-400 cal. BC until the end of the sequence and contradicts most of the ethno-historical sources. Another interesting result is the location of El Cascal de Flor de Pino. This is a settlement of at least 21 mounds that surround a central open space or "*plaza*". Three of these mounds are big platforms, and can be considered evidence of monumental architecture.

According to two C^{14} dates, they can be dated from 700 cal. BC to 400/500 cal. AD, thereby overlapping in time with similar sites in southern Mesoamerica.

Karoline site

Karoline site was explored in 1999, on the shore of a silted coastal lagoon. It is located at the margins of a wide littoral plain with swamps, 4km inland from the current coast. The surveys recorded 12 shell middens, some of them being more than 2m high and most of them having an extension between 200 and $400m^2$. They are located on the slope of a small hill defining a U-shaped area. Radiocarbon dates shown that the chronology of the site ranges between 450 cal. BC and 350 cal. AD. In the central part of the site there is a rectangular platform that has not been excavated yet. It is built with stone walls containing an earth fill, which are more than 2m high. Although its use is still unknown it is remarkable that this is the only documented structure not related to large deposits of food waste.

During 2002 and 2003, the upper levels of shell midden number 4 (KH-4), were excavated. The extensive exploration included also the slope next to the midden. The excavation highlighted that the shell midden was associated to a domestic area, enclosed by a perishable architecture of which only the post holes survived. It was also clear that several productive activities were carried out on the surface of the shell midden, after and during its formation processes. These activities were mainly food processing, food cooking and, perhaps, fish processing (by smoking and/or drying). However, food use and manufacture of means of production were carried out outside the shell midden. In this study we focus on the results of the analysis of the lithic tools documented in the last occupation phase (between 250-350 cal. AD). We then proceed to discuss how these analyses throw some light on aspects of the social life, including other aspects of social production such as pottery manufacture.

Lithic raw materials used to manufacture labour instruments.

A large variety of mineral raw materials was used by the inhabitants of Karoline to manufacture goods. Different clays served to manufacture vessels, plates, *tamales*, etc. The functional analysis of lithics shows that pottery (or at least an important part of it) was manufactured on the site, as traces on tools used to scrape, smooth, decorate or polish pottery shows *(cf. infra)*.

Several types of rock were exploited to produce lithic tools. The most important group of rocks was “chert” (87%) (Fig. 2). Flint is the most common material (94%) among the different kinds of chert. It presents a wide variety of colours (mainly bright shades -white, grey-, brown colours, striped..., in some cases with marine fossils) and grain sizes. Corticality of fragments and flakes shows two important aspects. Firstly, several

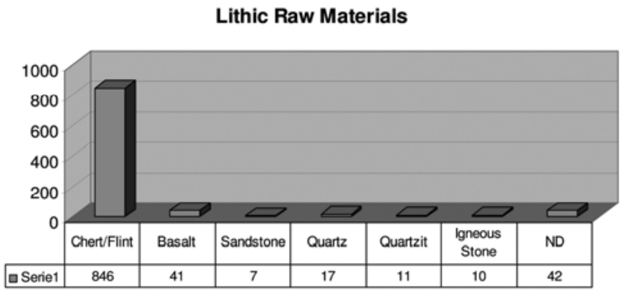

Fig. 2: Lithic raw materials identified in the shellmidden No. 4 at Karoline site.

sources of raw material existed. Secondly, knapping in order to obtain fragments and flakes took place on the site. Other varieties of siliceous rocks that have been identified are jasper (3%), usually with reddish shades, opal (2%) and chalcedony (1%).

Nodules of these raw materials are usually of different size and, considering the kinds of cortex observed, they seem to have different origins. Some fragments show a smooth and bright cortex as a result of natural transport (probably fluvial). This suggests that they were obtained from a secondary deposit. Other fragments have a rough, off-white and soft (plaster-like) cortex, with no evidence of any kind of movement or dragging. Macroscopically we have documented similar nodules in Sector No. 5 of the African palm fields that the Kukra Development Corporation cultivates 12km. from Karoline and 2km from Cascal de Flor de Pino site. We have also carried out surveys in the little creeks that run into Big Lagoon but none of this type of material was recorded. A couple of isolated nodules of rounded cortex have been located at some Caribbean beaches. Future surveys will be carried out to look for possible secondary sources of this kind of rocks in the marine littoral.

The source of the vesicular basalt used for manufacturing *“metates”*[2] and grinding stones (or *manos*) has not been located. Taking into account the ethno-historical descriptions, we assume that this basalt is the same raw material that the Misquitos people used in the Caribbean area and that Conzemius (1932, p.42) calls “tufflike”.

Manufacture of lithic labour instruments

Several techniques were used to produce diverse stone tools from different lithologies. Percussion was the most common technique for manufacturing cutting-tools, drills and side scrapers. Pebbles of different size, weight and raw material with characteristic marks on their surface have been used as hammerstones. Probably, many basalt pebbles recovered in the site were used as well. However, the damp and other climatic and/or sedimentary factors have altered the original surfaces of these tools.

[2] Latin-American word for grinding slabs.

We have been able to identify several ways of exploiting the cores: a unipolar and unidirectional method, a bipolar method with two striking platforms, centripetal and discoid exploitation and a bipolar method on an anvil**.** The last one is documented through small fragments and flakes, and reflects a wide range of exploitation of raw material. Bifacial reduction has been documented in just one case and probably the pressure technique was used.

Several raw materials as basalt, sandstone and non-defined igneous rock were used to manufacture polished artefacts as axes, hoes, adzes, etc. In some basalt and sandstone pieces, we have recorded the removal by percussion of some flakes and fragments. This allowed to obtain a base with a shape and size suitable to undergo a process of friction that permits to obtain polished products.

In shell midden KH-4 we have recovered only 13 "*metate*" fragments (from different grinding stones). However, it was possible to understand how these milling instruments looked like thanks to pieces recovered from other shell middens. Despite of their different sizes, they are generally made out of a block of basalt with a slightly convex surface, three legged sheets and a semicircular protuberance at one end, that sometimes represent an animal head (a feline), like in the "*metate*" from a house of Kukra Hill.

The presence of hammerstones and many cortical flakes shows that the production of lithic tools took place on the site. Reshaping of lithic debris from previous manufacture processes, which may be coming from earlier occupations of the site, has been documented too. The white patina on the surface of these pieces is removed by the new shaping process. Additionally, when they had micro use wears, these cover the old patina.

Functional analysis of the lithic remains

These results are based on the functional analysis to the 958 lithic remains from the field season of 2002 and 2003 at shell midden KH-4. The aim of this study was to obtain general information about the activities carried out using the stone tools.

As is generally the case, most of the lithic remains are waste materials or rejected products (Briz *et al.* 2002, p.16). In KH-4 rejected products represent 80% (776) of the material. From the remaining pieces, 64 (7%) could not be microscopically analyzed as they presented great alterations in their surfaces; 24 (3%) have been classified as possible labour instruments and 94 (10%) show probable or clear use wear traces (Clemente 1997, p.92). This last group provides information about the productive activities carried out at the site.

Apparently, there is a contradiction between the great quantity of faunal remains found at the site and the scarce number of instruments used to work animal materials. Only 4% of the used tools present such wear traces and none of them was used for cutting soft animal material (meat, fat, etc.) or butchering[3]. Although these butchering activities could have been carried out outside the excavated area, our hypothesis is that tools manufactured out of perishable materials such as wood, reed, shell and so on were used for these activities. Animal processing are activities that could be assumed in nearly all prehistoric sites. However, in this case, they are not represented in the stone tool assemblage. Working of bones has been documented in the form of scraping and drilling. A small elongated sandstone pebble shows several grooves that could have been used to sharpen bone awls. In fact, an awl of this material has been recovered from KH-4.

Apparently, modern communities that lived in this Caribbean area (e.g. Misquitos, Ramas and Sumus) widely used wood to produce goods. Indeed ethno-historical sources clearly mention the great importance of wood: *"...It would be nearer the truth to say that the Misquito and Sumu were living in the Wood age instead of the Stone Age. Stone objects are, of course, the ones which have been preserved mostly"* (Conzemius 1932, p.35).

In fact, 46% of the use-wear observed on the stone tools show work on plant resources while 29% were used to work mineral materials (pottery, rocks, shell, etc.). Further 21% of the tools were used on undefined material (9% corresponding to work on very hard material, 9% on medium-to-hard material and 3% on medium-to-soft material) (Fig. 3).

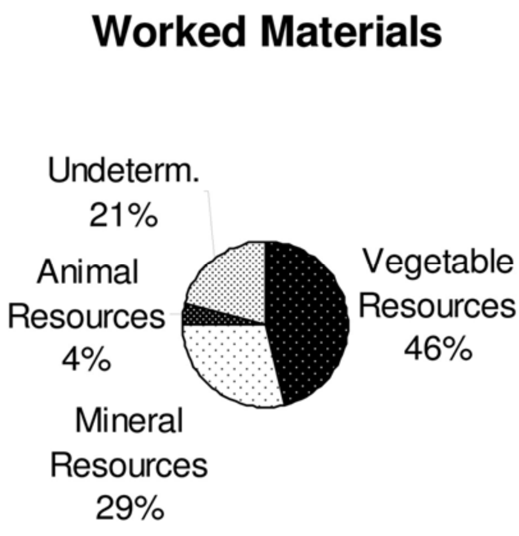

Fig. 3: The chart shows the different kind of materials worked by the lithic tools of the shellmidden No. 4 at the Karoline site.

[3] It must be noted that there is just a small piece that seems to have been used to cut soft material. Because of the type of rounding, it could be related to fresh skin. The rest of work on animal resources is related to transverse actions or scraping on hard animal matter and in one case to the drilling of bone.

Working of plant resources

Half of the instruments involved in the exploitation of plant resources are linked to wood working. They represent 23% of all the tools identified in KH-4. In this category we also include axes and adzes. Two of them, which are made of a reddish and probably igneous undetermined rock, show traces which can be attributed to work on wood. Both tools are fractured at the side of the handle, but the morphology of the edge and the distribution of the traces allows to classify the bigger one as an axe and the smaller as an adze. Also, two more polished elements of bigger size have been found. One of them is made of basalt and shows a symmetrical edge of great thickness with macro scars on both sides that show that it could have been in contact with a hard material (probably used as an axe or as a hoe for digging). Unfortunately, we have not been able to detect any micro-wear to clearly define its use. The other item seems to be made out of a compact sandstone. Its symmetrical edge has a semicircular shape and does not show any trace of having been used as an instrument.

Chert tools for working wood have showed evidence of both transversal actions, such as scraping and brushing (in a greater proportion), and longitudinal actions, such as cutting or sawing. The small proportion of retouching on these instruments is also remarkable, because these tools present natural abrupt angles that are usually used for working activities. Two pieces may have been used to drill wood. Surprisingly, these are the largest drills recovered from the site and they could have been used without handles. One of them shows a double use, probably on the same material: first, the distal end of the trihedral angle was used to drill with a bidirectional turn, and, second, the longest edge of the trihedral was used in a bidirectional and transverse action.

Among the instruments with traces that correspond to the work of plant materials, there are some pieces used to process herbaceous plants (11%). In one case it is only a little portion of the original instruments, a "flake of reshaping" (10×7×1 mm.) from a tool previously used in a transverse motion. Transverse actions on non-ligneous plants are the most represented. Non-modified flakes and fragments with angles between 60º and 75º are the most common artefacts used for these actions. One of these fragments displays a micro polish at the side of contact with worked material. It shows the usual characteristics of plant fibre contact (extension, location inside the flake, etc.) and, at the same time, the characteristics of contact with a more abrasive material (e.g. a mineral) that makes the micropolish less glossy and more matt and rough (González and Ibáñez 1994; Clemente 1997). We suggest that it could be used to clean some kind of tuber (similar to manioc), since this would imply both materials. However, a specific experimentation is necessary to support this hypothesis.

Lithic remains related to plants milling (that is, "*metate*" fragments and "*manos*" or grinding stones) represent 39% of the tools used in plant exploitation. Most of them are also fractured, as it is the case of grinding stones. They are mostly cylindrical with an oval section and made out of basalt. A siliceous pebble that shows wear from percussion in nearly all its perimeter as well as friction polishing and smoothing on both sides has also been recovered. Preliminary analyses of phytoliths and starch have been carried out on five "*metate*" fragments. The state of phytoliths and starch preservation is good and they do not seem to be fragmented or rounded, a fact which can be interpreted as sediment's stability and as a limitation in phytoliths vertical mobility. Some of the species that have been identified are: *Marantaceae, Palmae, Curcubitaceae and Burseraceae* (Zurro 2005).

Working of mineral resources

An important percentage of the stone tools (29%) were used to work mineral resources. Into this group fall the work of stone, pottery and shell. Shell is related to animal resources but we consider it as a mineral because of its composition. Use wear due to the working of shell has many characteristics in common with bone, such as the brightness and the typical cracks on the polished surface. However, other aspects such as volume, roughness of the surface or distribution of micropolish make them different.

One of the most common activities carried out on this kind of material was drilling. The drills identified in KH-4 represent 15% of all the instruments. Only two among them (the largest ones) seem to have drilled a material of medium hardness such as wood (*cf. supra*). The rest was used on different hard materials. In two cases, the material is undetermined, five tools show micro polishing corresponding to work on shell/bone and another five seem to have drilled some rock. In general, these instruments are flakes or fragments with a pointed area formed by a trihedral angle. Its small size suggests they were attached to handles.

During the excavations we found perforated necklace beads that were probably produced with this kind of instruments (Fig. 4). Most of the drilled beads are made of different rock types, although two were obtained from shell and one out of a peccary canine. The two largest polished stone beads are made out of some type of greenstone. The thickness of the drills and the distribution of the micro traces inside these stone tools suggest that none of them could have been used to make holes as deep as those of the beads.

Five more instruments were used to process shell in different ways. One of the instruments shows two active edges. One of them (the longest, sharpest and straightest) has been used for a cutting motion. The other one (shorter and more abrupt) has been used in a scraping activity. The remaining tools only show one active edge, three of

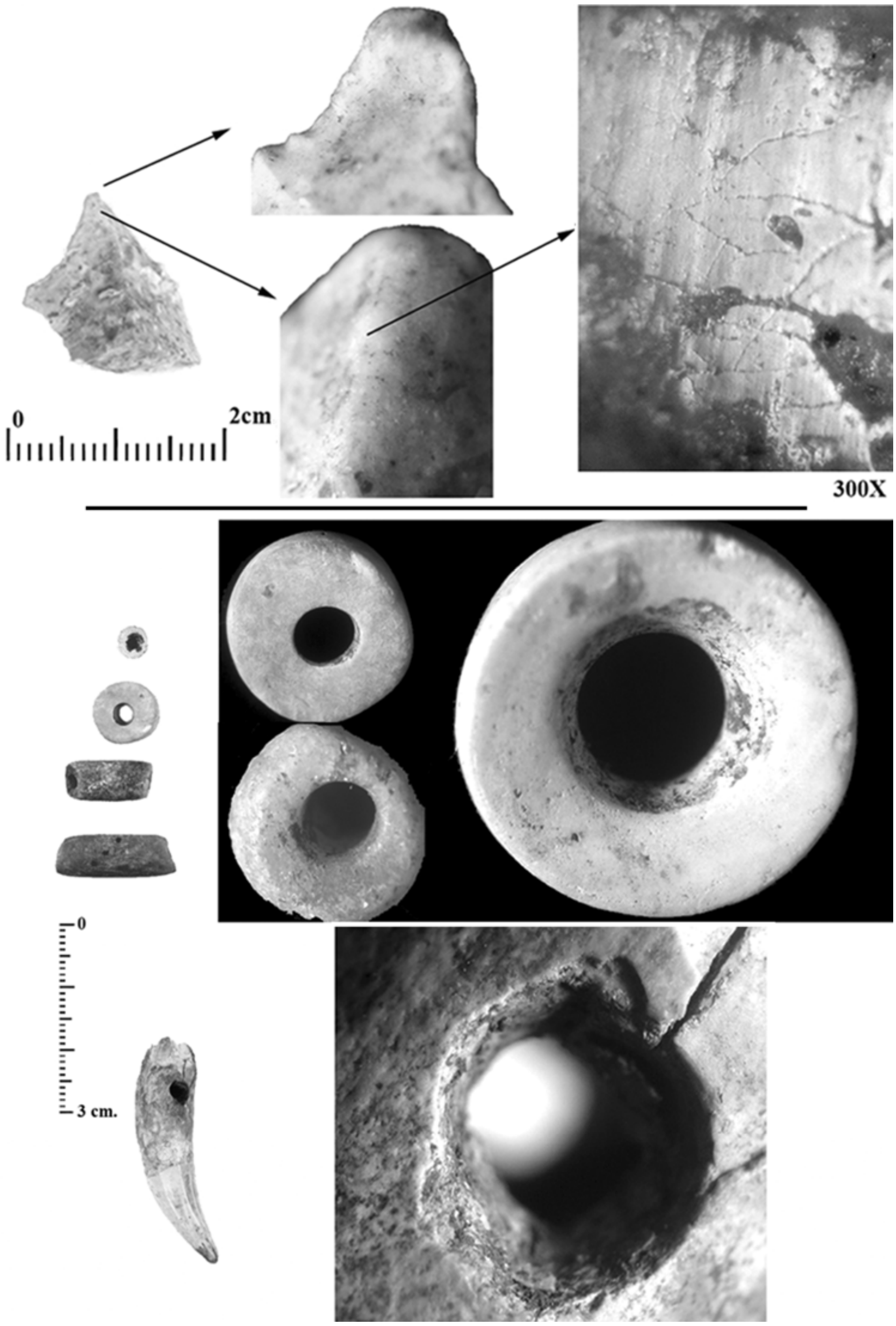

Fig. 4: Upper: a driller and the use wears of shell’s perforation. Lower: different cases of drilling in beads made on stone, shell and eye-tooth of peccary.

them were used for cutting (sawing) and the last one used for a transverse action. These tools could have been used in order to produce goods such as the beads that we have already mentioned, or to manufacture other artefacts as has been documented in other Caribbean areas (Jones and Keegan 2001; Lammers-Keijsers 2005).

Twelve pieces show use-wear that has been associated to pottery production (Gassin 1993). The observed variability suggests that they developed during different stage of the production process. Most of them were used before the firing of the pots, some on soft clay (cutting, punching, scraping and/or smoothing) and some on leather-hard clay after the vessel had been modelled (burnishing and/or incising). The pottery vessels were made with a coiling method. After the joining of coils and the thinning of the vessel walls by pinching, scraping and smoothing techniques, two types of lithic tools seem to

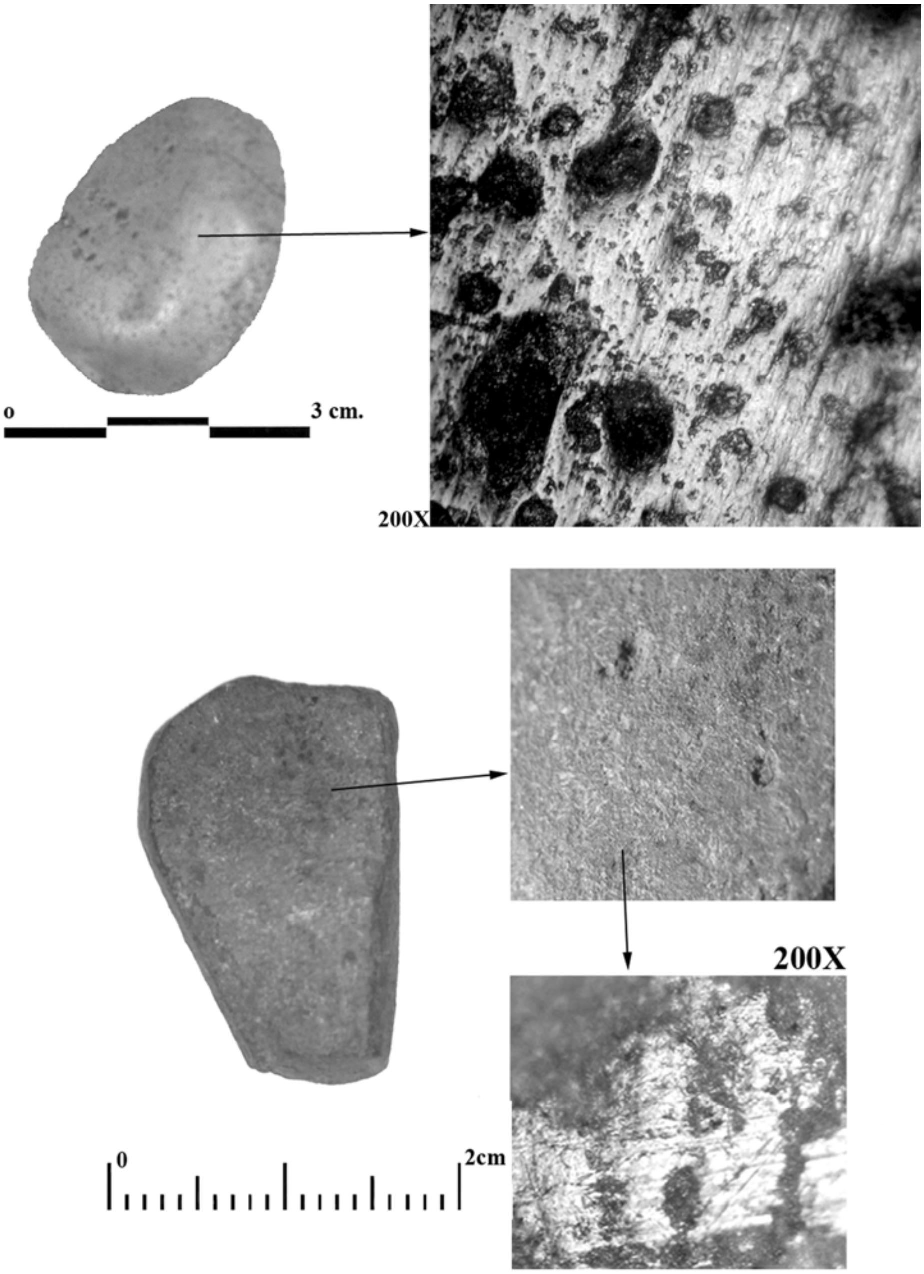

Fig. 5: Different tools used in the manufacture of pottery. The upper image displays a smoother and the lower a spatula.

have been used. The first implies the use of the arris and the abrupt edges of flakes in a transverse action. This has been documented in three pieces. The second kind of tool is probably a handled spatula, perhaps more effective for scraping and smoothing the inner surface of the vessel's walls (Fig. 4). In KH-4 one complete and well-preserved spatula and two fragments of other similar artefacts were recovered. All of them show the same kind of use wear and the same raw material (a rock still undetermined waiting for specific identification analysis). They are shaped in a similar way to the lithic artefacts recovered in K´abox (Belize) and published by S. López Varela. She compares them with metal spatulas used by present potters (López *et al.* 1999, p.233; López *et al.* 2001, p.187 and López *et al.* 2002, p.1136). The tools related to longitudinal actions on clay could be related to the cutting of clay in order to obtain clay coils or strips, or in order to pinch each coil to the one underneath and/or to carry out the deep incisions that decorate the necks of some vessels.

Finally, two pebbles have been identified that we have respectively classified as a sure and a probable pottery burnisher. The later one is an elongated pebble (100×72×38 mm) made out of basalt and which shows a smoothed side and a rounded lateral area as a consequence of friction on an abrasive material. These active areas also show a reddish colour and some clay remains of a different kind than the sedimentological matrix of the site. However, this basalt pebble could also have been used to tan or to dye leather. Both activities can produce similar traces, but without specific experimentation on this raw material, we cannot ascribe this tool to a specific production process. The tool that we have clearly identified as a pottery burnisher is a pebble, which is slightly smaller than the previous one (58×46×28 mm) and which is made out of an undetermined raw material. The active surface shows a specific brightness of the polished area (Fig. 5). On this tool percussion traces can also be identified on three lateral sides. They do not seem to be related to pottery production, and allows us to speak in this case of a multi-functional tool.

Conclusions

Functional analysis of the lithic remains of Karoline settlement site has allowed to infer a series of activities and production processes that were carried out at this settlement. It has permitted a description of some of the activities carried out in the domestic area formed by the shell midden KH-4 and its related dwelling. It is interesting to point out the almost total absence of instruments related to butchering and leather working. The presence of numerous faunal remains (mammals, reptiles, fishes...), especially in the shell midden area, suggests that at least one part of these activities could be carried out on the site. However, the absence of lithic artefacts usually employed in this production process suggests that these tools were made out of other materials, such as hard woods, bamboo, shells..., which remain "invisible" in the archaeological record. In these cases, the presence of perishable materials must be inferred from indirect traces (Mansur and Clemente in press).

The evidence of the last occupation phase in KH-4 shows the important role that lithic tools played in the processing of mineral and plant resources. In relation to the latter, woodworking is represented through both axes and adzes and through knapped flint tools that were used to cut, saw, scrape, etc. It can be expected that wood products (shafts or handles of hunting weapons, canoes for fishing and transport, timbers for building huts, etc.) were of vital importance for these groups, both in economic production and in social reproduction. Lithic tools also played a key role in the production of different types of flour, as is proofed by the presence of *metates* and grinding stone fragments. Use-wear traces observed on the active side of the *metate* fragments and thanks to the analysis of plant remains (phytoliths and starches) confirm the processing of different vegetable species. It is also remarkable that no lithic artefacts related to the manufacture of grinding stones have been found on the site. The absence of suitable raw materials in the area also suggests that they reached the site in an already finished state. This is not the case among the other instruments. In fact, evidence of different stages of the lithic production has been found, especially in relation to flint knapping.

Taking into account the observed use-wear traces, we can conclude that the use of lithics in the production of goods was very important. Drills were used to perforate hard materials such as rocks or shells, this allows us to link these instruments to the manufacture of several necklace beads found in Karoline. However, two of the necklace beads, made out of a "green stone", could not be drilled with any of the identified drills. Maybe these particular necklace beads were not produced on the site but brought in as an already finished product manufactured elsewhere.

Another important aspect revealed by the study of KH-4 is the local production of at least part of the pottery used in the settlement. Current data from excavations and surveys, including an important series of C^{14} datings (Gassiot 2005; Gassiot and Clemente 2004; Gassiot and Estévez 2004), seems to confirm that many coastal prehistoric "villages" were contemporary to El Cascal de Flor de Pino, at least between 450-400 cal. BC and nearly 400 cal. AD. During this period probably a dual settlement system emerged in the area, with small villages dispersed in lowlands surrounding a larger settlement located on the top of one of the highest elevation point of the coastal plain close to Kukra Hill. This central settlement, El Cascal de Flor de Pino, was composed, at that time, by more than 20 earth mounds surrounding a central open area or "*plaza*" and three large platforms. Both the monumental architecture of the site and the general structure of the settlement around the "*plaza*" reminds of some contemporary sites in southern Mesoamerica (Bove *et al.* 1993; Gassiot and Clemente 2004; Gassiot and Estévez 2004; Hammond 1991), where the so-called Mesoamerican proto-urban pattern began to develop at this time.

Despite the differences in the internal structure of El Cascal de Flor de Pino and Karoline, both settlements show close similarities in terms of lithic technology and pottery shapes and decoration. In consequence, initially we considered the possibility to consider the first site as a centre of craftwork production and distribution. An alternative hypothesis was that part of the manufactures, mainly the pottery of Mesoamerican style (e.g., polychromy over a white slipped surface), was imported from the north. However, once the lithic artefacts of Karoline have been analysed, we are now able to identify a local production of pottery in the domestic area close to the shell midden KH-4. This interrogates the first hypotheses and obliges us to consider a third possibility in relation to two observations. The first is the lack of clear evidence for differences between both settlements in terms of craftworks (lithic and pottery making). The second is provided by the pottery production in Karoline, which rises the question about the origin of polychrome decoration in the Caribbean Coast of Nicaragua. If no evidence exists that this pottery was imported, how the similarities of some of the pottery types and decorations with southern Mesoamerican products can be explained? How the similarities between central settlements should be interpreted? One possibility is that the Caribbean Coast of Nicaragua and some areas of the southern Mesoamerica underwent similar social and economic development during the centuries around the change of era.

The actual stage of research raises many questions and offers, up to now, few solutions. Nevertheless, the identification of a series of production processes in Karoline sets the basis for future research. Traces of plant processing are coherent with the preliminary identification of corn phytoliths and starches on many grinding stones. This suggests that agriculture was present close to Karoline as, may be, in El Cascal de Flor de Pino, where pollen analyses describe an artificial clearing of the forest landscape (J. A. López pers. comm.). Meanwhile, the relation between the little coastal villages and the central settlement of El Cascal de Flor de Pino remains unclear.

Acknowledgements

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5.5 Burial Context

From traces to function of ornaments: some Neolithic examples

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Abstract. *Very little attention has been paid to ornaments, a special category of object in the material culture of ancient societies. For a long time, use-wear analysis was not applied to Neolithic ornaments, examined merely in terms of typology and chronology. The results presented here are a description of the traces of wear observed on objects from graves in the Paris and Rhine basins and a demonstration of the method used for the reconstruction of ornaments worn in Neolithic times.*

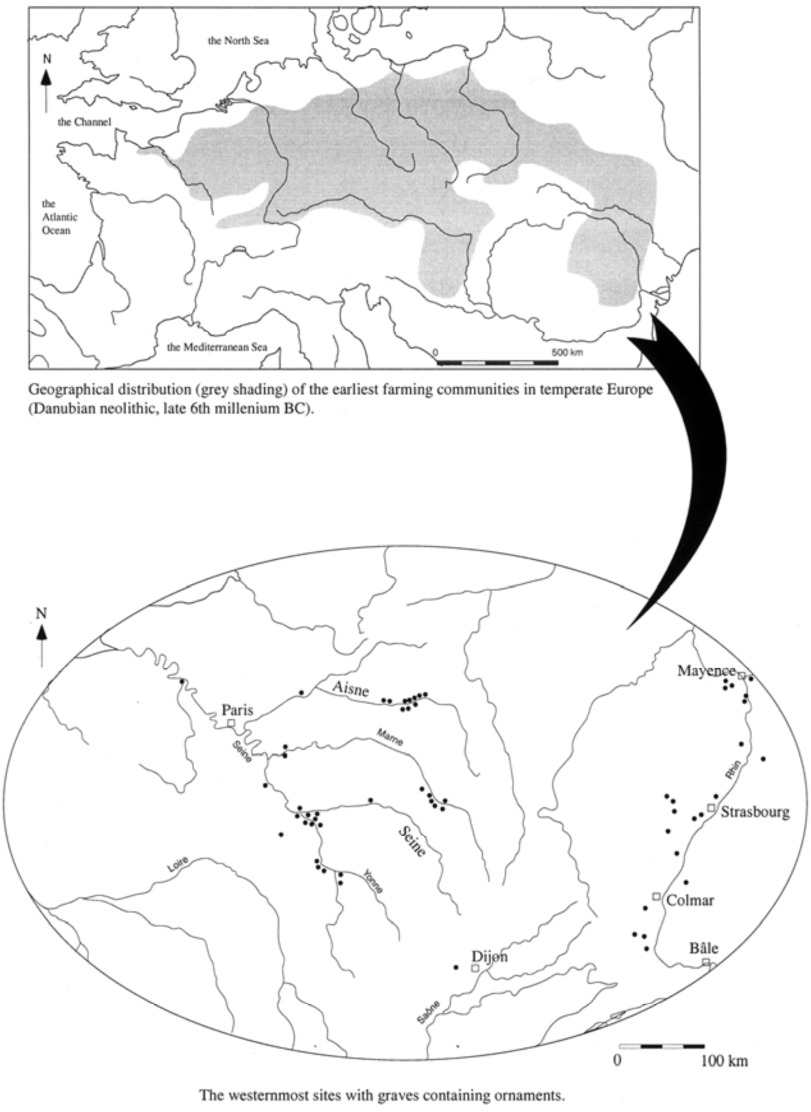

Fig. 1: Regional context of the data.

Ever since the fundamental studies by S.A. Semenov (1964), the working and function of artefacts have been analysed through traces of manufacture and use. Recent research employing this method has mainly involved stone tools (Keeley 1980; Anderson-Gerfaud 1981; Vaughan 1985; Plisson 1985; Mansur-Franchomme 1986; Beyries 1987; Caspar 1988; Van Gijn 1989; Astruc 2002; Dubreuil 2002; Hamon 2004) and more rarely bone artefacts (Christidou 1999; Maigrot 2003). For reasons which we will not examine here, very little attention has been paid to ornaments, a special category of object in the material culture of ancient societies. The earliest work in this field was carried out on Palaeolithic material. Thus Y. Taborin (1974, 1993) was the first to undertake a broad study of manufacture and wear on shell ornaments in France. This was followed by a number of technical and use-wear studies (White 1993; D'Errico 1993; Vanhaeren and D'Errico 2001, 2002).

For a long time, use-wear analysis was not applied to Neolithic ornaments, examined merely in terms of typology and chronology. This was not due to the scarcity of finds, since from the 1970s onwards, thousands of ornaments have been uncovered in graves as well as settlements. The ornaments of the earliest Neolithic farming communities in temperate Europe, dating to the second half of the 6th millennium BC, are exemplary here. In the Paris and Rhine basins alone, a recent count (2000) listed a total of over 12,400 items from 204 graves (Fig. 1). These numbers would increase significantly if sites further east were included (eastern Germany, Bavaria, Austria, Slovakia, Moravia).

The typology shows shells and perforated teeth, shaped beads, rings, pendants and appliqués (Fig. 2).

Do such ornaments found in graves show traces of wear which reveal that they had actually been worn by living people? What information is provided by Neolithic technical practices? Using various lines of evidence discussed further below, is it possible to reconstruct the original appearance of the ornaments and thus examine the diversity of body decoration in the Neolithic? These are the questions that we intended to address by examining for the first time macroscopic deformations due to wear on objects from graves in the Paris and Rhine basins. The scale of observation was 6 to 40x, using a Nikon SMZ800

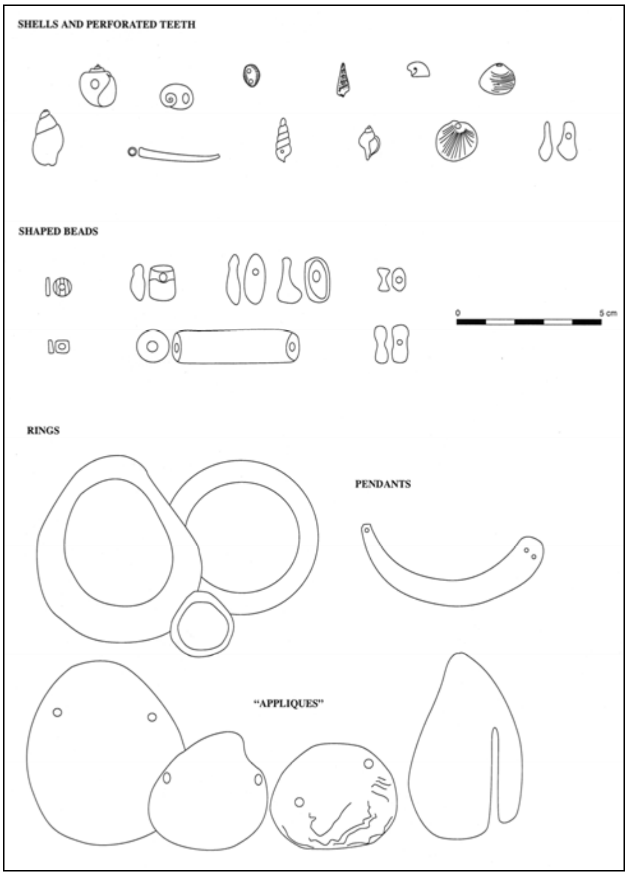

Fig. 2: Ornament typology.

microscope. Ethnographic data were also included, as a source of complementary evidence rather than for direct comparison.

The results presented here are a description of the traces of wear observed and a demonstration of the method used for the reconstruction of ornaments worn in Neolithic times.

Traces of wear on ornaments

Macroscopic observation revealed several main types of wear (Fig. 3):

Polish
Although they can occasionally result from natural or taphonomic alteration, or quite simply from the manufacture of the object, the polish observed on several ornaments does seem to have been caused by wear, since it occurs on areas already smoothed by wear. The polish is characterised by shiny flat surfaces. It was mainly identified on bone objects such as a small ring made from a caprovine long bone (Fig. 3, No.1), and more rarely on shell objects (tubular beads and rings in *Spondylus*, circular beads in *Cardiidae*) which deteriorate to a greater extent in the soil. We have not included here ornaments in lithic materials because they were intentionally polished as part of the manufacturing process, in the same way as axes and adzes (Praud 1993; Pétrequin, Jeunesse 1995). At a maximum scale of observation, multi-directional micro-marks appeared and could be considered as an additional identification criteria as mentioned by D'Errico for bone artefacts (D'Errico 1993). Further microscopic analysis is necessary to clarify these observations.

Colouring

Following experimental work which has shown that the wearing of an object can change its colour (Rodière 1996), it seems likely that the yellow colour observed on normally white shell beads results from wear. The fact that this characteristic is limited to the most highly smoothed and polished zones of the beads would appear to confirm this interpretation.

The same colour appears on the contours of shell edges (Fig. 3, No.2), along the line where a strap was attached, on the abrasion marks or on the voluminous parts of certain objects.

The nature of the material against which the beads rubbed could be the cause. According to the experimental work quoted above, steatite beads worn on bare skin change colour, unlike beads worn over tanned calf leather. It is thus possible that the shell beads affected by colouring were worn in a particular manner.

While polish and colouring are wear-traces limited to the surface of the objects, other marks have affected the volume of objects, to such an extent that the original appearance is altered. Such marks are considered to be the most advanced stages of wear. They include various kinds of smoothing:

Erased natural decoration
Similarly, rubbing can also remove the natural ridged decoration (Fig. 3, No.3) present on many shell species (ribs on *Trivia monacha* type cowries, sides *Cardiidae* shells, growth layers on *Spondylus* shells), as has already been noted by Y. Taborin for *Cardium* shell beads (Taborin 1984).

Erased manufacturing traces
Wearing causes rubbing which can erase manufacturing traces still present on the objects. The manufacturing traces which have been smoothed out are abrasion marks or perforation marks. These occur on small shells, as well as on geometrical shaped beads. Partial obliteration of abrasion marks can be seen on the internal edge of the schist ring presented in Figure 3 (No.4).

Facets flattening out round, convex or protruding parts
In certain cases smoothing produces a facet already observed by Y. Taborin on prehistoric cowries and termed “ *zone d’aplatissement* ” (Taborin 1993b). This is a small area, either flat or concave, located on the convex part of an object. We have observed this not only on the dorsal or ventral parts of Neolithic cowries (Fig. 3, No.5),

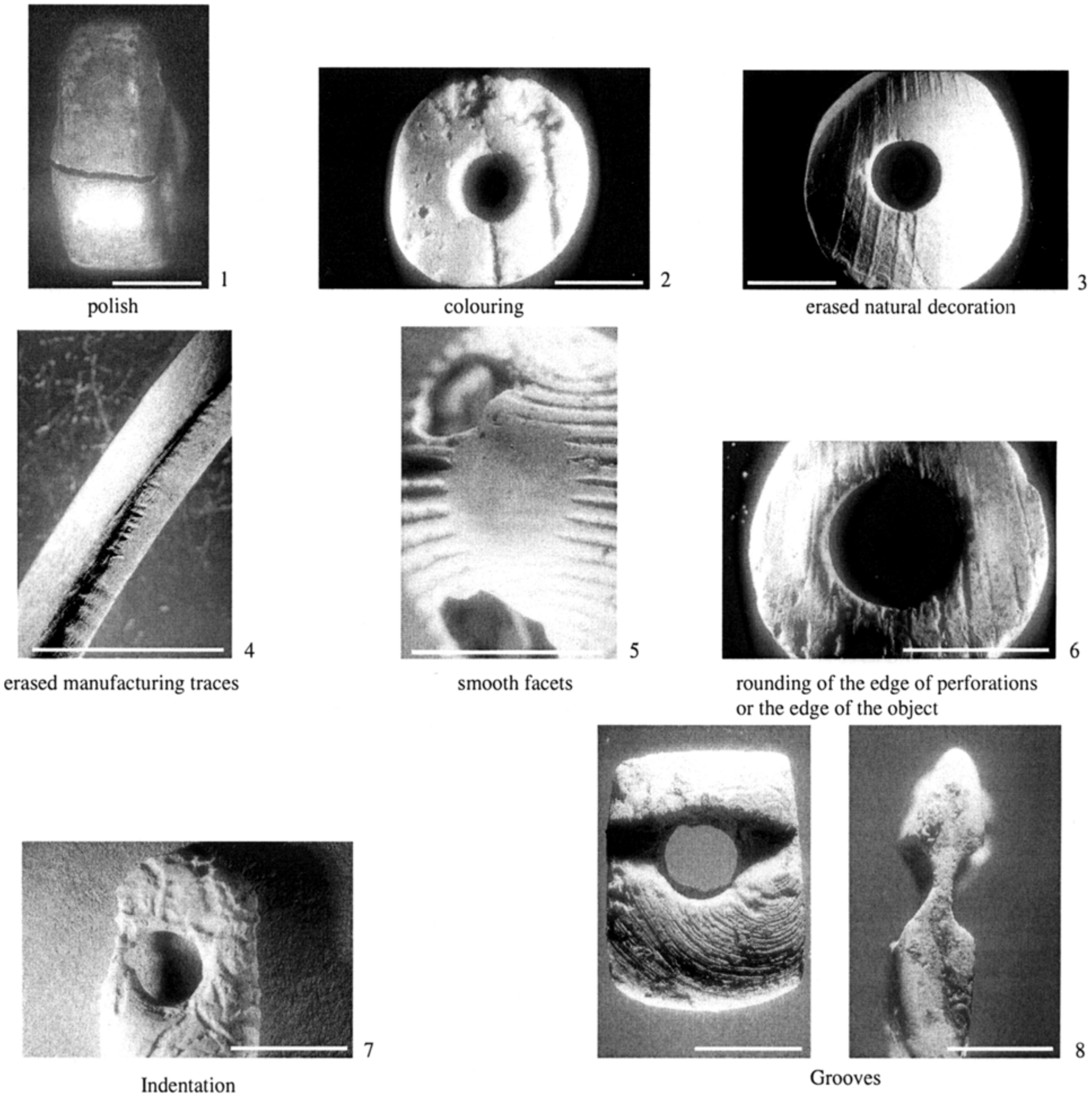

Fig. 3: Traces of wear observed on ornaments.

but also on the base of perforated red deer canines, on the rounded ends of bone beads, and on the long tubular bodies of *Dentalium* shells.

Rounding of the edge of perforations or the edge of the object
The edge of perforations and the external contours of objects are prone to rubbing when the object is worn. They are smoothed out or even become very rounded. This is visible for example on a circular *Cardiidae* shell bead, where the whole edge of the perforation is rounded by wear (Fig. 3, No.6).

Indentation
The tension of a fastening strap passing through the perforation has sometimes created an indentation reaching the external edges of the object. The perforation thus becomes slightly out of line. This is especially clear on a red deer canine (Fig. 3, No.7). Trapezoidal beads on *Cardiidae* shells are also affected.

Grooves
The tension of a fastening strap passing through the perforation has sometimes created distinct grooves which, like the indentation, reach the outside of the object. These are elongated depressions with a widening out, U shaped profile. They have been observed on different materials like limestone, shell and bone. Grooves can be multiple. The pattern of grooves indicates how ornaments were fastened. Thus, due to such marks on small shell plaques (Fig. 3, No.8) on both edges of the perforation and on both sides, it could be shown that ornaments were fixed by interlacing threads.

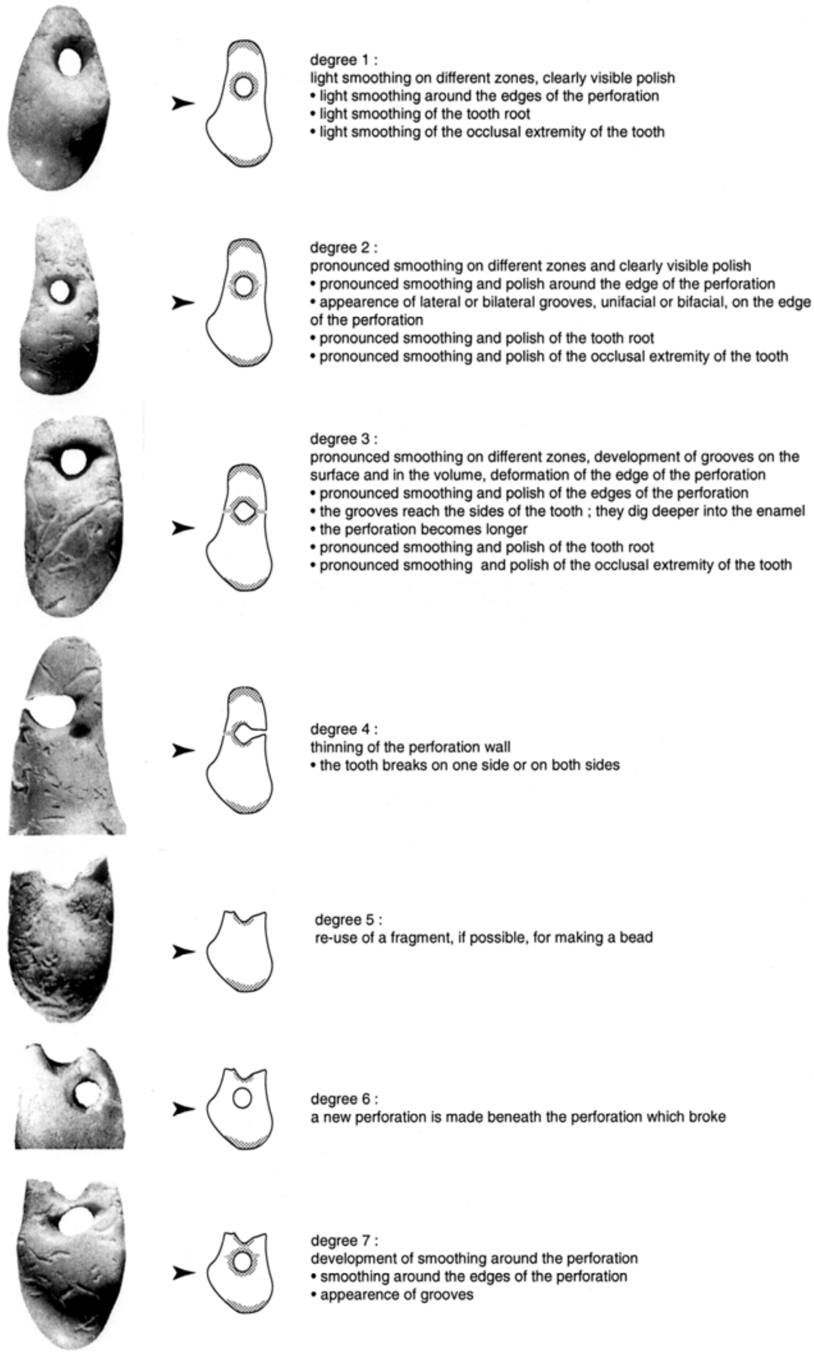

Fig. 4: Sequence of wear on perforated red deer canines.

Nicks and breaks
Pronounced wear sometimes produces nicks or even breakage of the object.

Varied degrees of wear

Variable intensity of wear has been defined in terms of "states of wear" (Taborin 1993b; Mansur-Franchomme 1986), "stages of wear" (Sidéra 1993, 2001), or "states of development of wear" (D'Errico 1993). This is an important aspect because it provides a means of addressing the question of how long an object was used. With ornaments, variation can be identified in the wear visible on a set of beads belonging to a necklace or a bib, for example. This implies, as I. Sidéra has already suggested for red deer canines (Sidéra 2002), that ornaments were altered during the time they were worn, with new pieces replacing broken pieces or completing the set. Degrees of wear thus provide a previously unexploited line of evidence for Neolithic behaviour and customs. Just like adze blades, bone tools and querns, ornaments were maintained through time and this reflects their importance in the Neolithic economic and social system.

Due to the large numbers of objects available for analysis, it was possible to reconstruct the wear sequences for almost all the ornaments, providing a new heuristic approach to the study of Neolithic ornaments. Here are some of the reconstructed wear sequences.

Red-deer canines (Fig. 4):
Degree 1: slight wear only visible as polish on protuberances of the tooth
Degree 2: polish and first grooves on either side of the perforation
Degree 3: the grooves are deeper
Degree 4: these grooves result in a break on one side
Degree 5: the object breaks completely at the perforation
Degree 6: if possible, the object is repaired by making a new perforation
Degree 7: new grooves appear.

Small cowries (*Trivia monacha*) (Fig.5):
Degree 1: partial erasing of the natural ribs on the dorsal part of the shell
Degree 2: total erasing of the ribs, leaving a surface which is smooth but still convex
Degree 3: the convexity disappears and the smoothed area becomes a flat facet
Degree 4: the facet becomes so flat that the shell loses its thickness and a hole appears
Degree 5: the facet gradually becomes deeper and the hole is enlarged

Another sequence of wear can be reconstructed with double perforated pendants (Fig. 6).

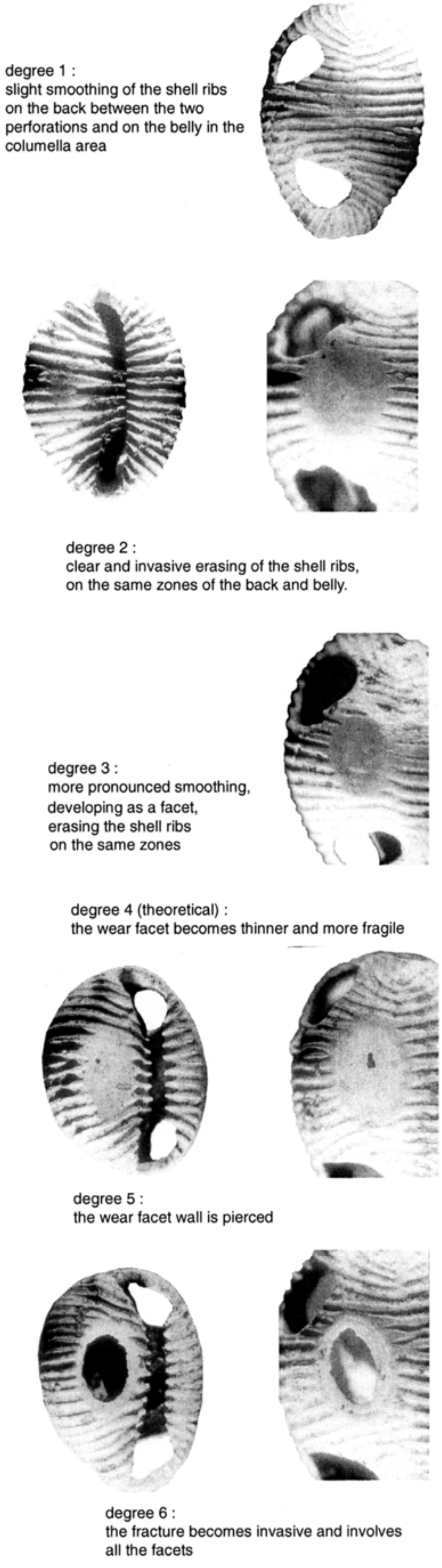

Fig. 5: Sequence of wear on perforated *Trivia* (cowrie) shells

Parameters of wear of Neolithic technical practices

The causes of wear need to be sought with various parameters which clearly reveal Neolithic technical practices. These parameters are as follows:

- Care applied to perforation or know-how, because making the hole very near the edge of the bead made it fragile and resulted in breakage.
- Length and frequency of wearing, which are difficult to evaluate but the series of degrees visible on these objects show that they had been worn for a long time and/or frequently.
- Strapping of the object.
- Fastening system. Although animal or plant fibres have long since disappeared, the type of wear traces reveal the Neolithic fastening system (Fig. 7). A single smoothed area on the edge of the perforation suggests the object was simply suspended on a string. Grooves on both sides of the perforation and both faces of the object suggest it was held in place by lacing. Grooves on one side of the object suggest it was sown on. Thus, suspension, lacing and sewing are the three main ways of attaching ornaments used in the Early Neolithic. This shows that ornaments were not just portable elements; they were also embroided onto clothing.
- The place of an object in a set; important factors here are the placing of a bead in relation to other beads, its exact position, flat or on the edge, and the nature of the underlying material with which it is in contact. The position of ornaments on the body must therefore be considered. Luckily in Neolithic burials, objects are often still in position on the body. There are fine examples showing a row of beads around the head, around the neck (Fig. 8). Objects decorate several body zones and highlight them: the head, the bust, the arms, the hands and the waist, which suggests that these objects must have formed a diverse range of ornaments.

Yet in previous archaeological studies they have never been treated as such. For a long time, in fact, ornaments of these early farming populations were just treated from a typological point of view. For example “bead ornaments” and “bracelet ornaments” are mentioned (Bailloud 1974). It was often supposed that, since ornaments were usually found in the bust area, they were necklaces. Thus there was no attempt to identify other forms of ornament. Due to the minor attention paid to ornaments until recently and in the absence of broader studies, the image that has been conveyed is of ornaments which are unvaried and unchanging, implying that these populations invested little effort in body decoration. Yet this is not the case.

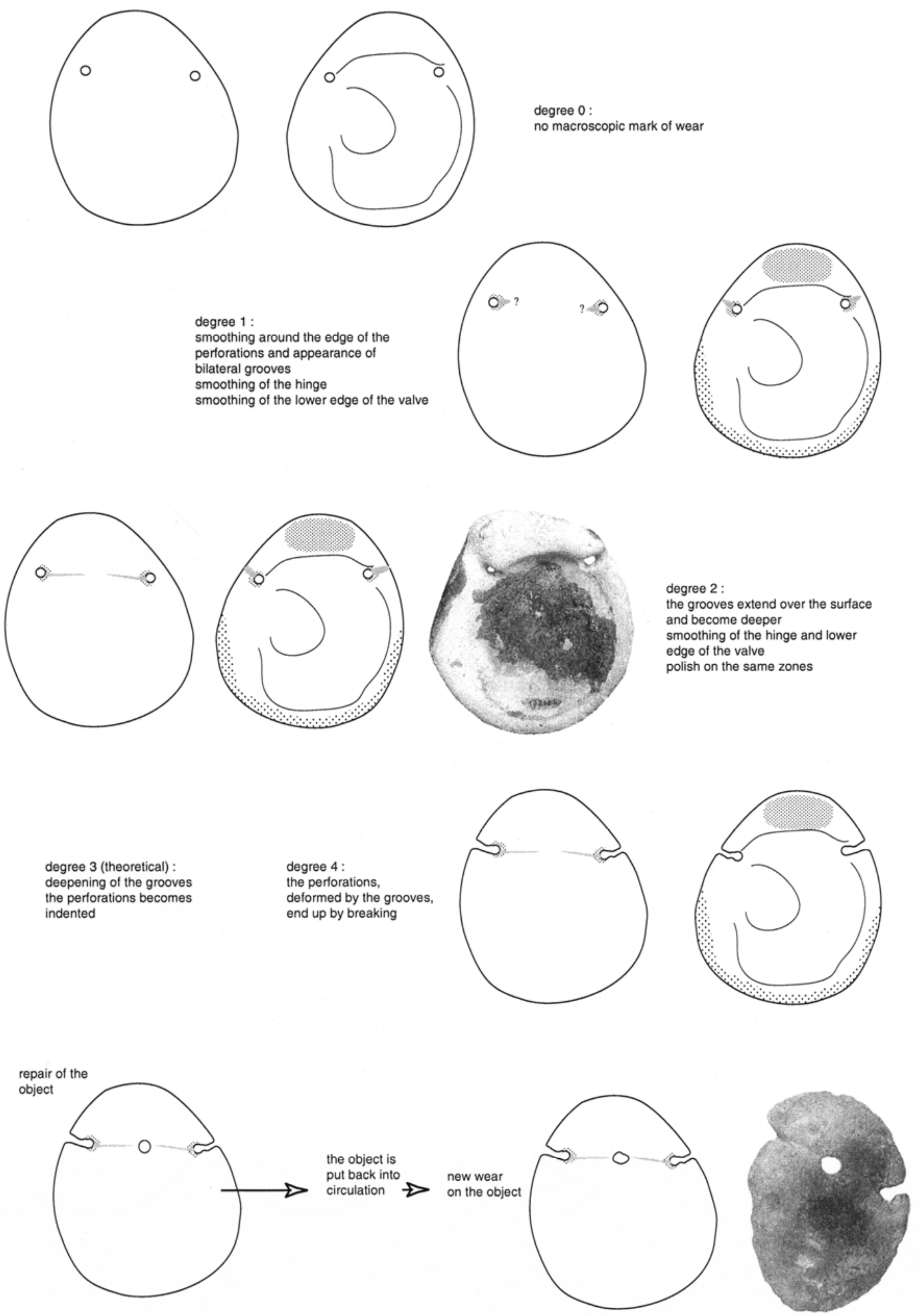

Fig. 6: Sequence of wear of double perforated appliques in *Spondylus* shell.

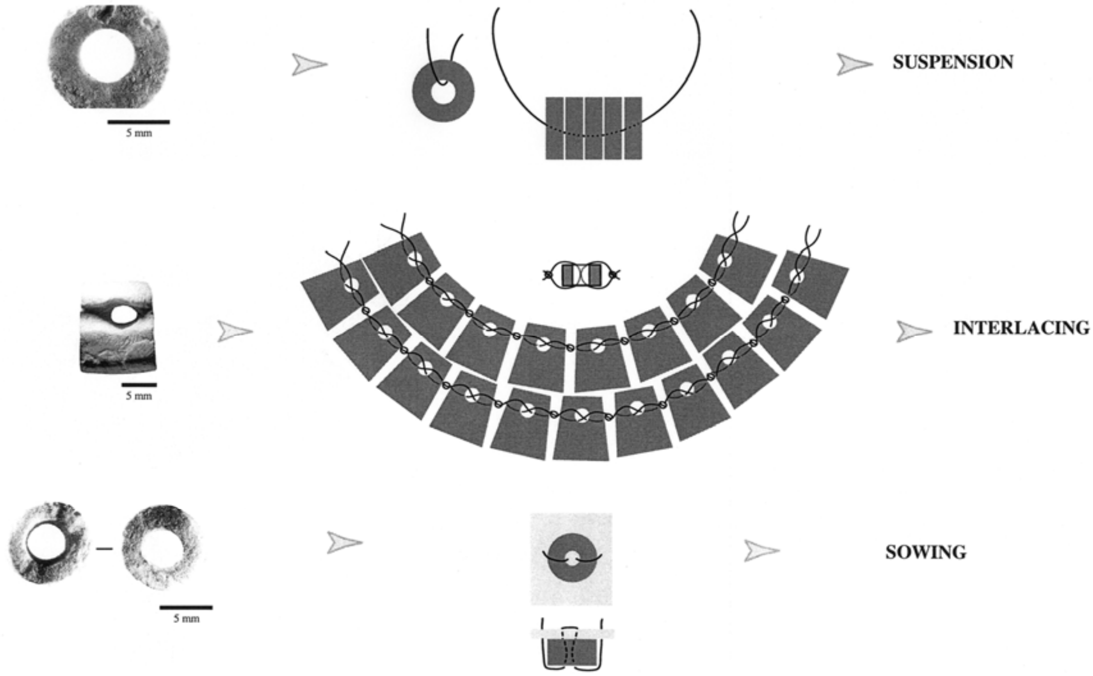

Fig. 7: Proposed Neolithic fastening systems used for fixing ornaments on the body, based on traces of wear.

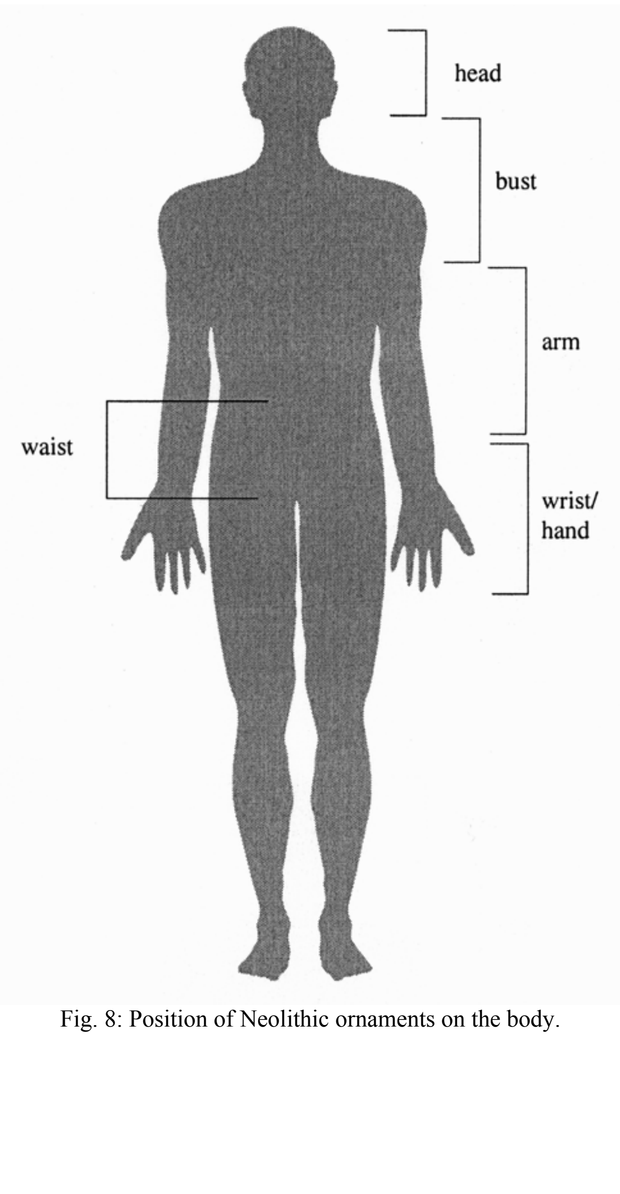

Fig. 8: Position of Neolithic ornaments on the body.

From wear to reconstruction of ornaments

By combining the different kinds of information which include the objects' position, arrangement, morphology, perforation, use-wear traces, (especially wear in relation to the fastening system) and quantity, as well as excavation evidence and ethnographic data, a considerable variety of prehistoric ornaments emerges (Fig. 9): necklaces, bib, composite bracelets, single-piece bracelets, rings, embroideries, composite belt ornaments, single-piece belt ornaments. Some of the ornaments reconstructed using this approach will now be presented.

The first example shows 52 circular beads spread around the neck (Fig. 10). Wear on the beads consists of smoothing around the edge of the perforation and on the circumference of the object. This kind of wear suggests that the beads hung loosely next to one another, with no constraint on the movement of the thread. The beads were probably strung together as a necklace, as it is still the practice today. This can be visualised with the help of a picture of a young Indian woman (Brafford and Thom 1992) and a schematic drawing.

The second example presents 82 red deer canines still in position around the skull, lying flat and in a single row (Fig. 11). Wear on most of the teeth consists of a groove on either side of the perforation which indicates that the elements were sewn. Given their position on the skeleton, the teeth were probably sewn flat on to the edge of a hood and thus formed a sort of embroidery, as in the picture of a child (Taylor 1995).

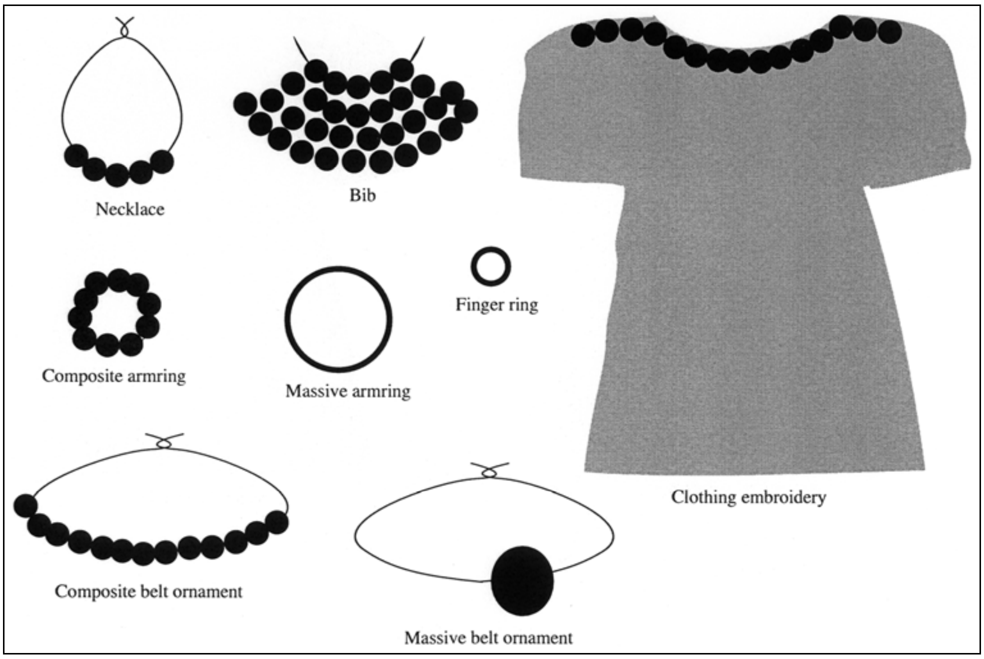

Fig. 9: Typological proposition for Neolithic ornaments.

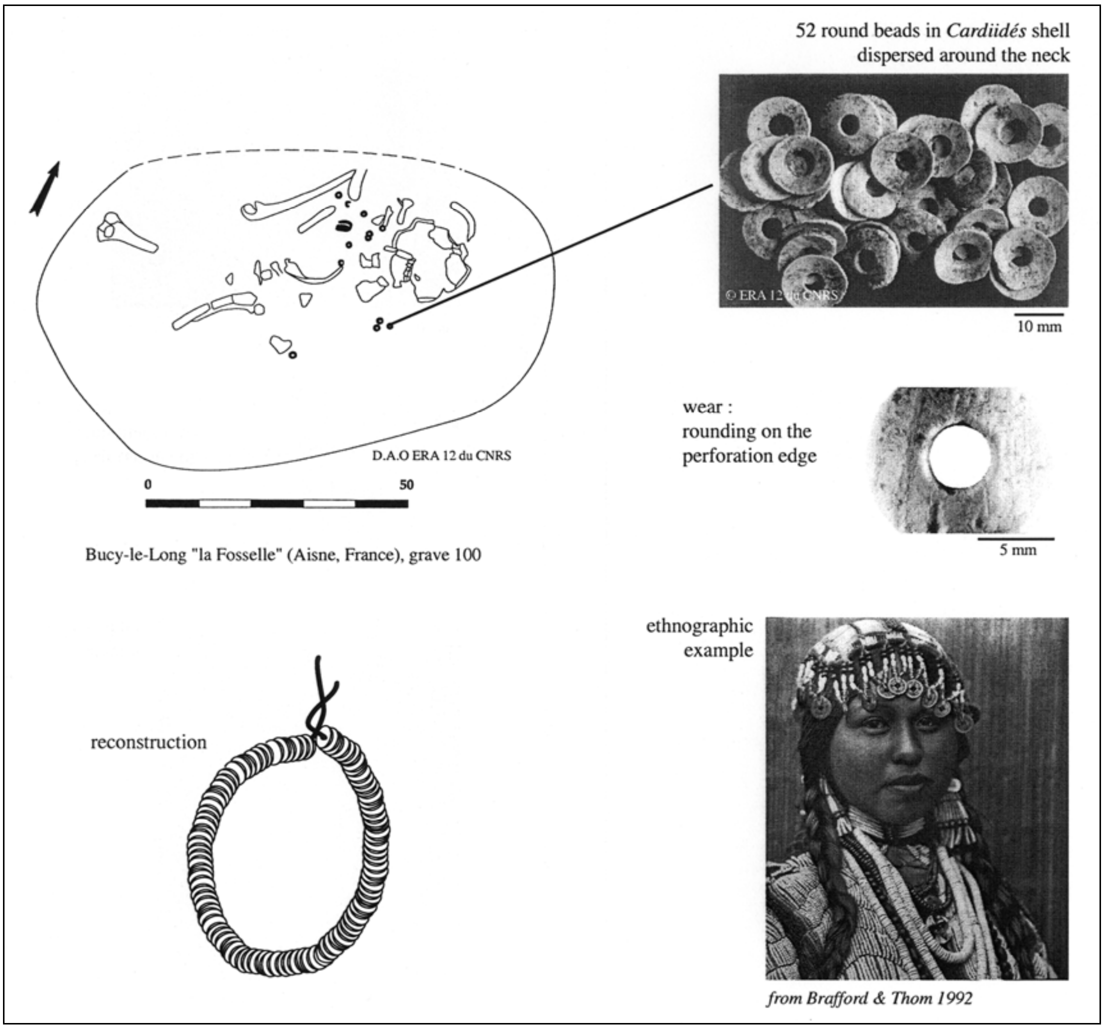

Fig. 10: Neolithic bead necklace.

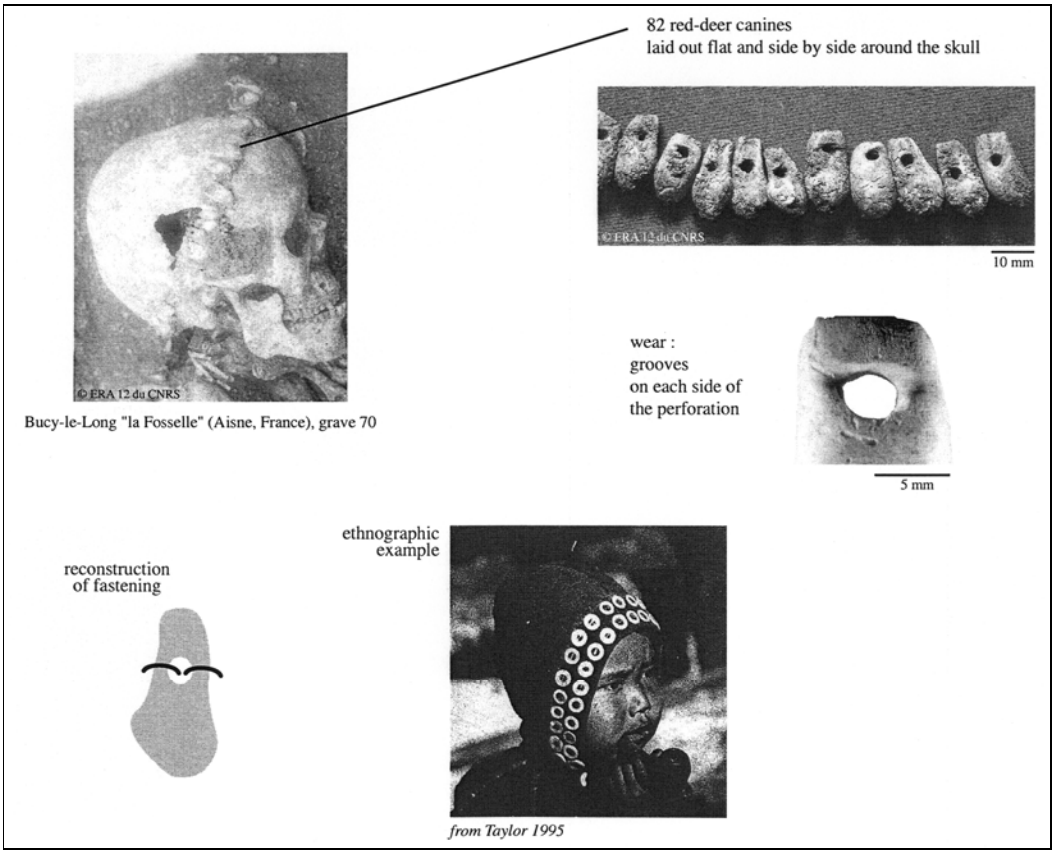

Fig. 11: Hood with red deer canines sewn on.

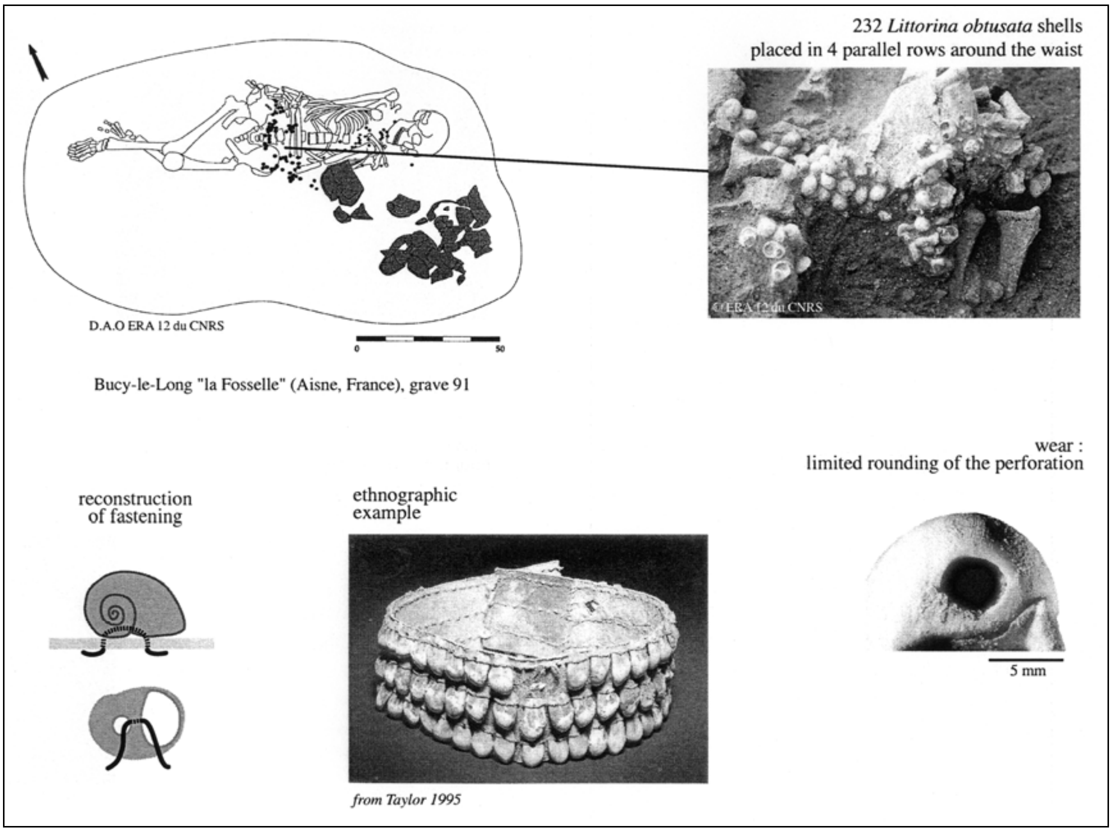

Fig. 12: Embroidery on Neolithic belt.

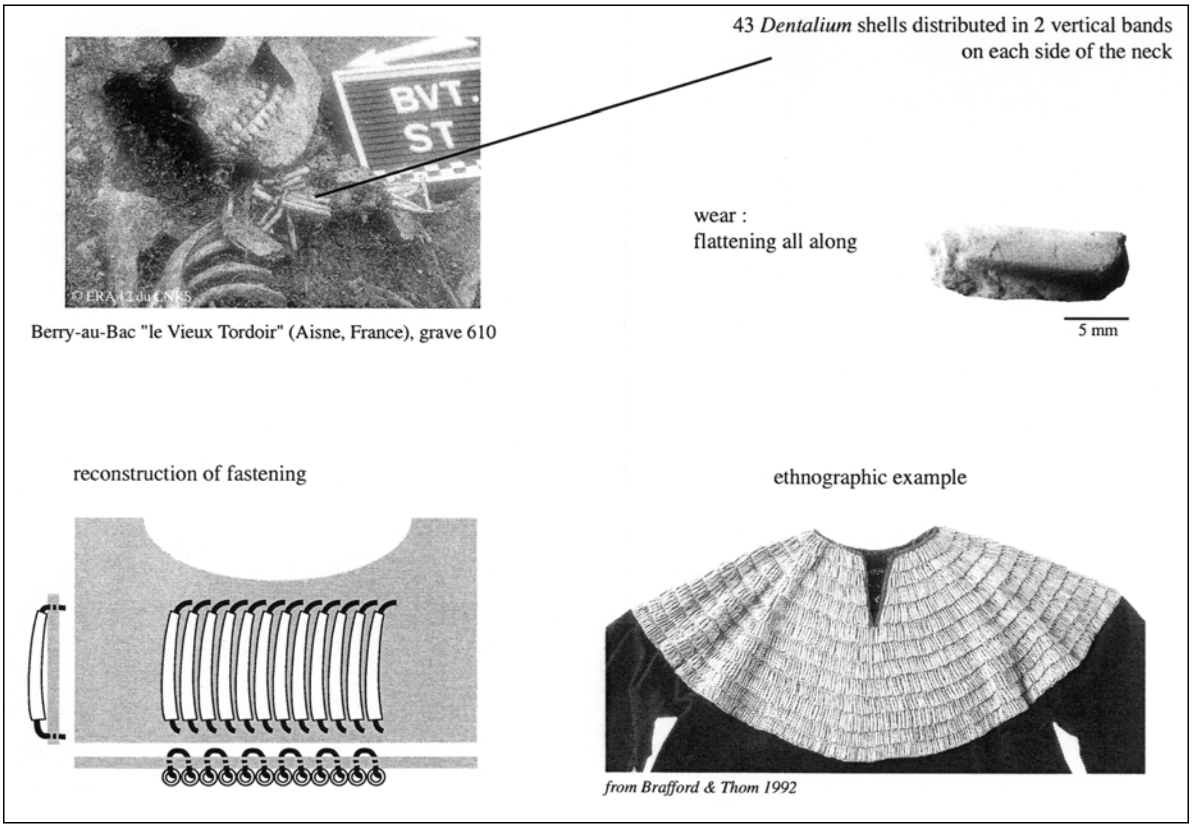

Fig. 13: Neck embroidery on Neolithic clothing.

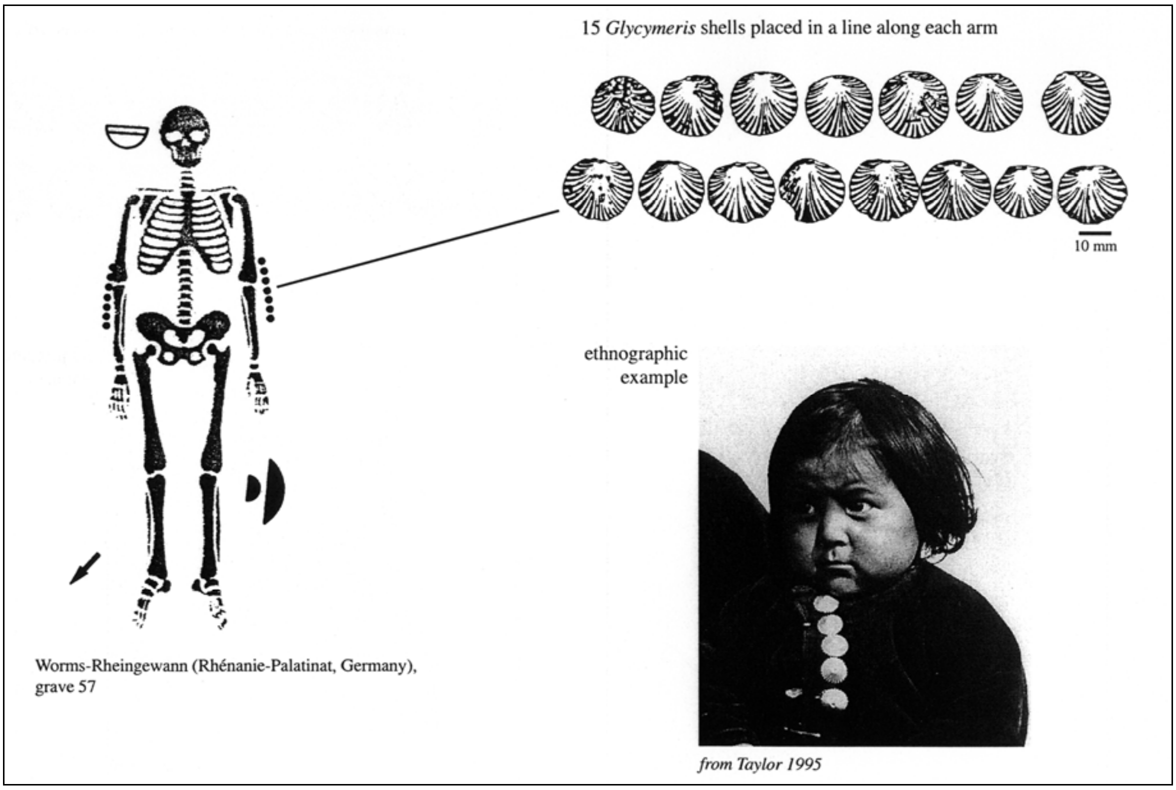

Fig. 14: Sleeve embroidered with shells.

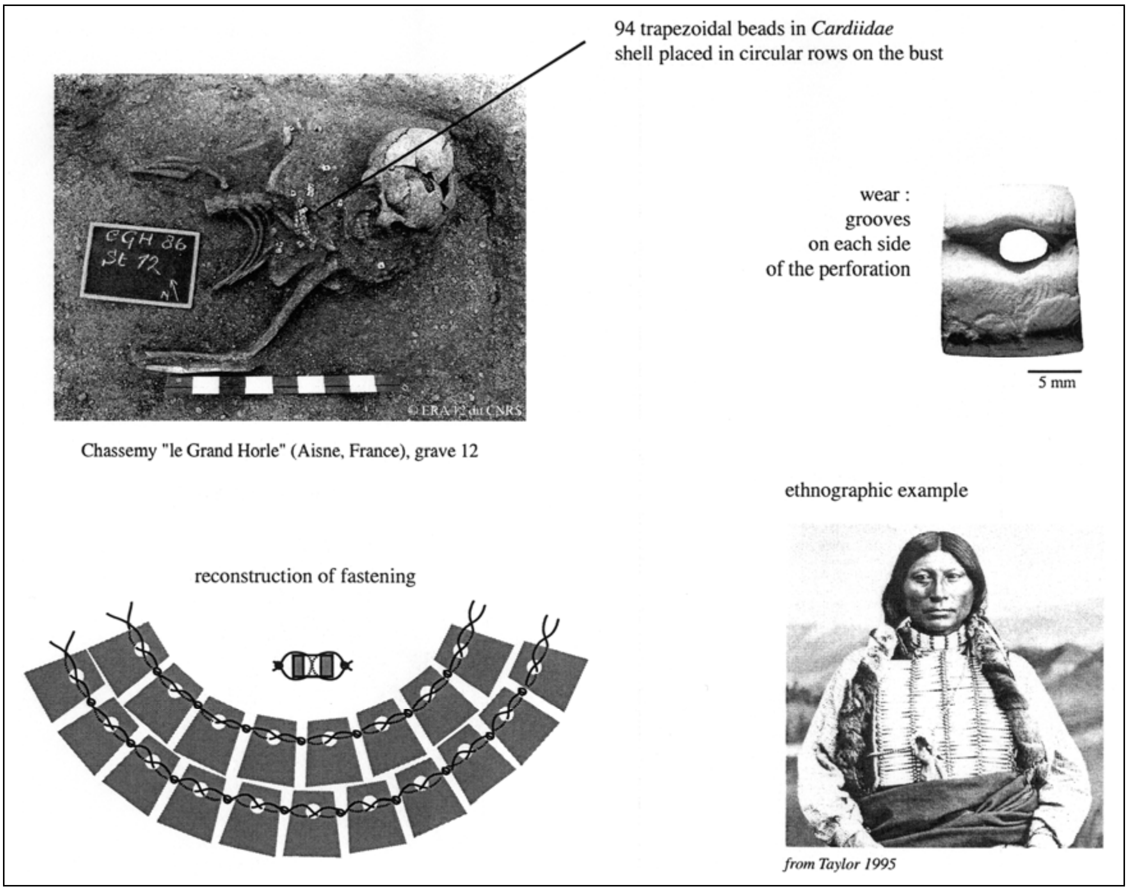

Fig. 15: Neolithic bead bib.

In another quite similar example, 235 *Littorina* shells were flattened by abrasion, then perforated and fixed flat on to a backing (Fig. 12). Wear shows the passage of a strap through the object. Set out in four parallel rows around the waist, they must have formed a kind of embroidered belt similar to this Indian one (Taylor 1995).

Another example of sewn beads shows 43 *Dentalia* shells forming two parallel vertical bands on either side of the neck (Fig. 13). Examination of the beads showed that shells, originally round in section, presented long facets caused by wear, which had flattened the whole length of the shell. This wear suggests that *Dentalia* were sewn on a backing and probably decorated the neck opening of a garment like an embroidered shoulder braid. The decoration may well have looked like an Indian garment (Brafford and Thom 1992), although it is more elaborate.

The last example of sewn beads consists of about 15 small bivalve shell (*Glycymeris pulvinatus*), found along the arms (Fig. 14). Wear was difficult to identify, but by comparison with the child's garment shown in the photograph here (Taylor 1995), one could suggest that the shells were sewn flat in a row on a jacket sleeve.

Several graves present, in the bust area, rows of trapezoidal beads which are placed flat and side by side, forming parallel curves (Fig. 15). Study of wear on the beads revealed grooves on either side of the perforation and systematically on both faces of the objects. This kind of wear indicates that the objects were held in position by lacing. Attached in parallel lines, they formed a kind of bib like ornaments worn by Hopi chiefs (Taylor 1995).

Conclusion

Burials form a particular category of material remains of ancient societies, since they result from symbolic and ideological gestures which are difficult for archaeologists to apprehend. The presence of ornaments in graves raises the question of their actual role as grave goods, as well as that of the gestures involved in their deposition with the body. Were these ornaments made specially for the deceased or were they previously worn by living people? Our research was designed to address these questions, using a macroscopic study of traces of wear on the ornaments. By identifying various marks of wear, it could be shown that ornaments found in the graves of these early farmers had indeed been worn in the course of their lifetimes.

Yet it was not sufficient just to study the traces of wear. The preservation of ornaments on skeletons offered the chance to identify the types of ornaments made at the time, despite decomposition of the fibres and bodies. By combining information on the exact position of objects on the skeletons with the technical, typological and use-wear data, this research was successfully undertaken, leading to the identification of Neolithic necklaces, bib and embroidery on clothing.

Results obtained shed new light on Neolithic behaviour, techniques and aesthetic practices.

* I warmly thank M. Ilett for the English translation.

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Use-wear analysis of long blades. Funeral contexts of the Neolithic-Chalcolithic in North-East Iberia

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Summary. *In this work, we present the first results obtained from the use-wear analysis carried out on a set of long flint blades found in funerary contexts in North-East Iberia. This undertaking has been developed within the framework of a number of international research projects.*
Between 3500 and 1500 cal. BC, human communities in the North-East of the Iberian Peninsula suffered various changes in their social, economic and ideological organisation. As far as the ideological aspects are concerned, we have noted various funeral habits characterised by collective inhumations in different forms of burial that were accompanied by several types of objects such as pottery, ornaments, stone tools, etc.
In this perspective, our work has been focused on the analysis of certain tools: long flint blades. This choice was made because these tools are one of the most representative witnesses of the existence of extensive communication networks among human groups. The interdisciplinary study of these blades allow us to present our first hypothesis about their origin, the technical procedures applied to their production and the objectives of their manufacture.
The first data obtained shows that long blades are tools made from several types of flint, probably of foreign origin, elaborated by specialists. Use-wear results show that these tools were destined to different activities among which cereal harvesting and, eventually, the treatment of skins stand out. The tools have also been used for butchery and to work hard materials of animal and mineral nature. It is clear that tools of this type were not goods exclusively endowed with an ideological character. However, these tools acquired a new and final function when they were used as funeral tributes.

Résumé. *Ce travail présente les premiers résultats des analyses tracéologiques menées sur une série de grandes lames en silex trouvées en contexte funéraire dans le Nord-Est de l'Espagne. Cette étude a été menée dans le cadre de plusieurs projets de recherche internationaux.*
Entre 3500 et 1500 avant J.-C., les communautés humaines du Nord-Est de la péninsule ibérienne subirent des transformations variées relatives à leur organisation sociale, économique et idéologique. Concernant les aspects idéologiques, nous avons relevé différentes coutumes funéraires caractérisées par des inhumations collectives, sous différentes formes, qui étaient accompagnées par plusieurs types d'objets comme la poterie, la parure, le matériel lithique, etc.
Dans cette perspective, notre travail s'est concentré sur l'analyse de certains objets : les grandes lames en silex. Ce choix s'explique par le fait que ces objets sont un des témoignages les plus représentatifs de l'existence de réseaux de communication extensifs entre les groupes humains. L'étude interdisciplinaire de ces lames nous permet de présenter nos premières hypothèses sur leur origine, les procédés techniques appliqués pour leur production et les objectifs de leur manufacture. Les premières données obtenues montrent que les longues lames sont des outils réalisés à partir de plusieurs types de silex, probablement d'origine lointaine, élaborés par des spécialistes. Les résultats tracéologiques montrent que ces objets étaient destinés à différentes activités parmi lesquelles ressortent la récolte de céréales et le traitement des peaux. Les outils ont aussi été utilisés pour la boucherie et pour le travail de matériaux durs de nature animale et minérale. Il apparaît clairement que les outils de ce type n'étaient pas des biens exclusivement investis d'un caractère idéologique. Cependant, ces outils prennent une fonction nouvelle et ultime lorsqu'ils deviennent des attributs funéraires.

Key words: long blades, burial, North-East Iberia

Introduction

Between 3500 and 1500 cal. BC, the communities of North-East Iberian Peninsula were affected by a series of gradual and profound changes that had repercussions on their social, economic and ideological structures. For this period, it has been possible to document in the archaeological record a series of artefacts common to all of the western Mediterranean and that are representative of the existence of wide spread communication networks among groups. The fact that the majority of these new material goods have been recovered within funeral contexts allows us to suggest from the beginning the hypothesis that the property and use of these goods could have been restricted to certain individuals and/or groups as a result of social inequalities.

Although certain objects and materials such as the bell-beaker ceramics or the first metal products have received enormous attention from the scientific community, others, on the other hand, have hardly been dealt with. This is the case we tackle in this work: stone tools, and

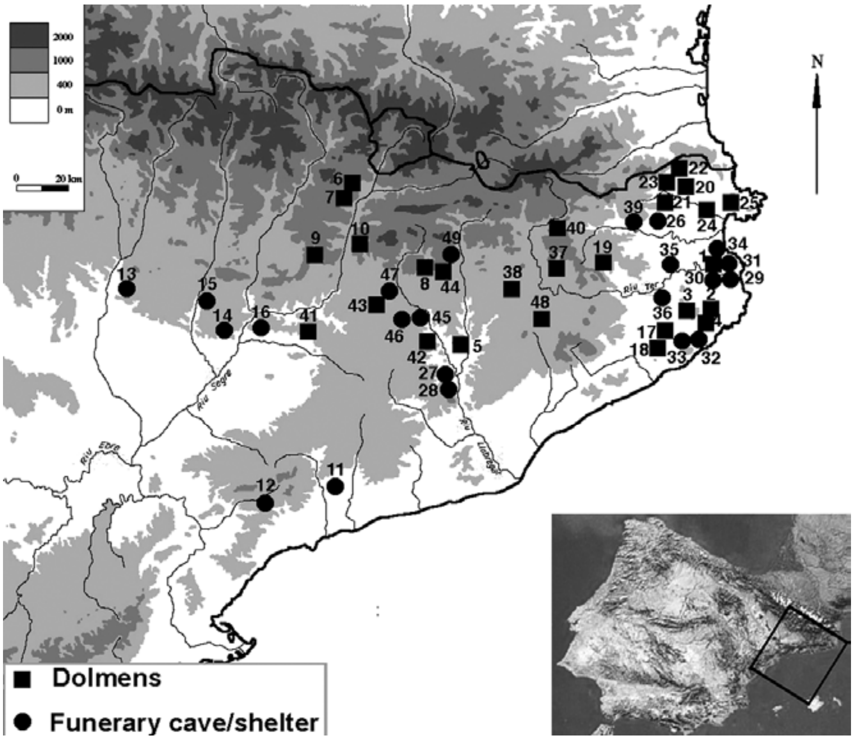


Fig. 1: Funeral contexts of the Northeast of the Peninsula in which the long flint blades have been found.

more exactly, the production of flint blades. In fact, the so-called "long blades", "knife blades" or "daggers" have as their principal characteristics: their size (although the majority are between 10-20 cm., some are as long as 35 cm.), the excellent flint used and the context, usually funerary, in which they appear (Fig. 1).

As of the end of the 19th century and throughout the 20th century, archaeological investigations undertaken in the NE of the Iberian Peninsula have ascertained the presence of long blades in an important number of burial contexts that are situated chronologically between the final stages of the Neolithic and the beginning of the Metal Age (Pericot 1950; Tarradell 1962; Martín *et al.* 2002; Tarrús 2002).

Although stone tools from this period have received little study until now, we think that their analysis could provide us with information of an inestimable value about the social and economic structure of human communities of the past.

In the framework of two research projects,[1] our objectives should be to deal with various questions:

1. The study of the origins of the raw material used in the manufacture of the blades and an analysis of whether they are local productions or products from other areas. In the latter case, we should establish how they were circulated, whether in the form of raw materials, in different stages of elaboration or as completely finished products. In order to do this, it is indispensable to characterize, under petrological and geochemical parameters, the lithologies exploited and to determine their geological and geographical origins (Terradas 1995; Bressy in press).
2. The particularities of the production process should allow us to tackle the question of the degree of technical specialization required for the manufacturing process. The technological analysis will facilitate the reconstruction of the production processes involved in the elaboration of the utensils.
3. To know what activities were carried out with the blades and what necessities they covered. We will also analyze if they are utensils used at times for a particular activity or if they have been used in a variety of work processes.
4. To evaluate the contexts of social uses these blades may have had and to pose the questions as to whether we are looking at goods that represented prestige, if they were conceived as offerings, etc. In this respect, it is fundamental to analyse if these long blades had been used and what their presence in the funerary contexts of the NE Peninsula means.

Archaeological Context

An exhaustive revision of existing documentation in various museums[2] as well as the published bibliography has enabled us to register that, up until now, there have been a total of 49 findings in which 218 long blades have been found to which almost a hundred more should be added among complete or fragmented examples discovered at only one cave site: the cave of Les Encantades de Martís (Esponellà, Girona). As a result, the information in our hands, at the moment, is the existence of approximately 300 long blades.

Of this group, 173 have been documented as being from caves or shelters and 45 from megalithic burial mounds. It is significant that of the 173 blades belonging to

[1] This work is part of the studies carried out in two research projects: «Producció i circulació de béns de prestigi elaborats amb matèries primeres d'origen mineral durant el Calcolític i les primeres etapes de l'Edat del Bronze» (2003/XT/00033) and «Estudi de la disponibilitat de roques silícies per a la producció de l'instrumental lític a la Prehistòria» (2002/XT/00112).

[2] Museu d'Arqueologia de Catalunya (centres in Barcelona and Girona), Museu Episcopal de Vic (Barcelona) or the museums of Sant Feliu de Guíxols and the Museu Arqueològic Comarcal de Banyoles in Girona.

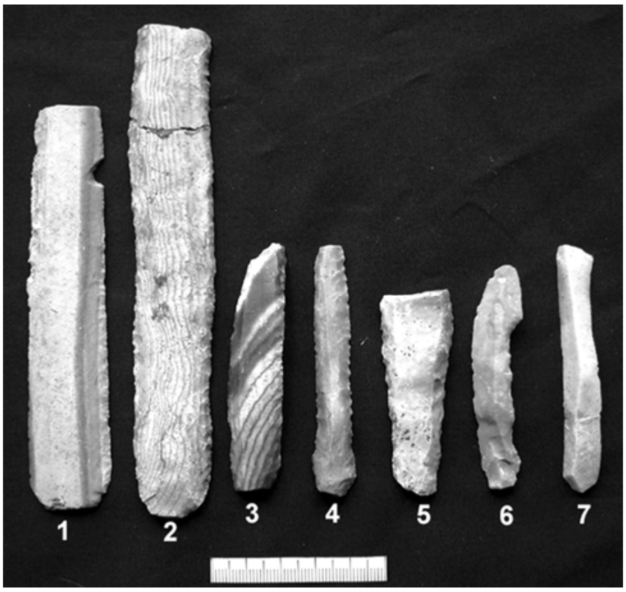


Fig. 2: Documented long blades from the dolmen of Mas Bousarenys.

cave/shelter contexts, 126 are from just seven of the findings: Cova Negra (Tragó de Noguera, Lleida), Cova del Tabac (Camarassa, Lleida), Cova Gran (Collbató, Barcelona), Cova de Can Sant Vicens (Sant Julià de Ramis, Girona), Cova d'en Pere (Sant Feliu de Guíxols, Girona), Cau d'en Serra (Picamoixons, Tarragona), and especially, the aforementioned group of Les Encantades de Martís.

As far as the megalithic burial mounds are concerned, the presence of a single blade is common, with the exception of some cases in which there were two to four blades: Bressol de la Mare de Déu (Correà-Espunyola, Barcelona), Cementiri dels Moros de Puig Roig (Torrent, Girona), Fontanilles (Sant Climent Sescebes, Girona) and Turó de l'Home (Roses, Girona). An exceptional situation is represented by the megalithic burial of Mas Bousarenys (Santa Cristina d'Aro, Girona) in which ten long blades were found (Fig. 2).

This information should be taken with certain reservations, however, as we cannot discount the fact that an exhaustive search of museums and other collections may offer new information. To summarize, we have noted that:

- All of these archaeological contexts are probably situated between 3500 and 1500 cal. BC, taking into account, therefore, the catalogued periods of the end of the Neolithic, Chalcolithic and the first phases of the Bronze Age.
- These findings correspond to collective funeral contexts.
- At settlement sites, long blades do not tend to be found (such as at Riera Masarac, Pont de Molins, Girona).
- Most of the existing documentation comes from old archaeological excavations.

Lithologies used and technical exploitation systems

Our study of the long blades is in its initial phase. It is for this reason that, up until now, we have analysed a group of 30 complete or fragmented blades from the excavations of Mas Bousarenys, Llobinar, Dolmen de Pericot, Cabana Arqueta, Cementiri dels Moros, Vinya del Rei, Fontanilles and Les Encantades de Martís.

One of the questions that will be tackled in depth within the framework of the two projects in which we are working is the source of the raw materials used to make long blades. The first surveys carried out and the preliminary macroscopic analyses have allowed us to distinguish between two groups of blades:

1. Blades knapped in chalcedony and other silica stones with megacrystalline granular textures. The presence in Catalonia of some outcrops of similar silica stone that belong to the formations of the Eocene and Lower Oligocene, leads us to suggest that this type of flint is possibly coming form local outcrops.
2. Blades knapped in flint of a basically granular micro or cryptocrystalline texture. Most of these blades display banded structures of brown coloration. Differently from the previous case, we consider that this type of flint comes from far afield as there are no similar silica deposits in the local geological context. With respect to this, our research into the source-areas should be directed in two ways:

   - Towards the North-East, in the depressions filled with continental and marine material from the Paleogene Age (Oligocene) and Neogene Age (Mio-Pliocene) which are found along south-east France: Roussillon (Grégoire 2000), Languedoc (Briois 1997) and Provence (Renault 1998).
   - Towards the continental sedimentary lacustrine facies evaporated basins, of the Oligocene and Miocene, which can be found in the Ebro basin (Ortí *et al.* 1997).

As far as this is concerned, the morpho-technological study allows us to characterize the exploitation systems used and the consequent products generated. As a result, we have recognized two different knapping strategies used to obtain these large blades (Clop *et al.* 2001; Palomo *et al.* 2004; Clop *et al.* in press; Terradas *et al.* in press):

1) Knapping by means of indirect percussion with a punch. This technique favours precision in the transmission of energy without the necessity of complicated preparations and facilitates the combination between the route of the striking instrument and the position of the chisel to the carver (Baena 1998).
2) Knapping by means of reinforced pressure a with lever. The force exerted by means of pressure, with the help of a lever, leads to a production of longer

blades with respect to those obtained by use of indirect percussion. With respect to the blades studied from the different funeral contexts, it can be said that information available to date indicates a dominance of indirect percussion over reinforced pressure. Frequently, the blades obtained by both methods were finished through a series of abrupt, deep, direct and continuous retouching along the edges. However, we have also observed in some blades, such as the case of Cabana Arqueta, the practice of deep, flat retouching in the pointed extreme which gives the blades the form of a dagger.

The existence at the sites analysed of only complete or fragmented blades and no lithic waste generated during the formation and exploitation of the volumes of raw materials prevents us, for the time being, from establishing whether these two techniques for knapping blades are related to different knapping methods. Whatever the case may be, it is evident that these are very sophisticated knapping methods that would entail a costly apprenticeship which undoubtedly reflects a highly disciplined craft specialization. This allows us to consider the possibility of restricted access to certain raw materials and the existence of individuals with the necessary technical knowledge to obtain these blades of lengthy dimensions. Should this hypothesis prove to be true, it will be necessary to assume a presence of possible mechanisms of social control over the production of these long blades as well as to evaluate the forms of accessibility to the possession and use of these goods as far as the population is concerned.

The use of long blades as harvesting tools

The traditional concept that the long blades were prestigious possessions deposited during burial without having previously been used was one of the questions to be confirmed through functional analysis. By means of this study, our intention was to demonstrate, effectively, if we were dealing with artefacts expressly made to be left in the burial with the deceased, in way of an offering, or, if on the other hand, they had previously been used in particular productive processes.

Until recently, due to classical proposals, it has been difficult to consider that instruments found in a tomb had not been used. However, the latest information we have completely denies this proposal. Although we have registered pieces in funeral contexts that were perhaps not used, we have also found tools with marks of use. The use made of these blades should help us to become familiar with different aspects related to the technical processes used in the transformation of different materials worked as well as the role that these instruments played in the productive activities carried out by human groups.

Before the possibilities that use-wear analysis can offer us, there are the impediments and problems that have been caused by alterations. It should therefore be noted that it has not been possible to analyse an important number of blades because of the alterations they have suffered (polishing, thermal alteration, alterations due to storing and restoration).

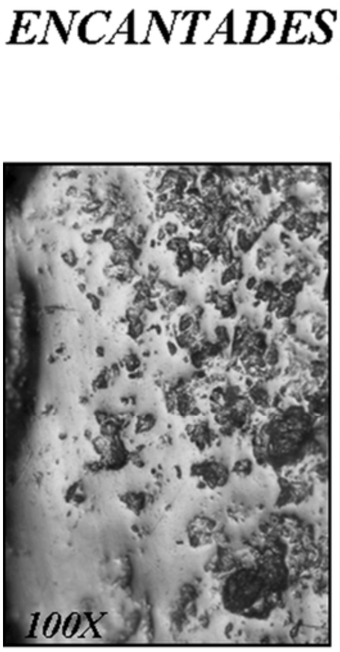
Precisely, on certain blades deposited in museums, we have noticed that, as a result of various being stored together, small breakages have been brought about. In addition, blades that were broken were repaired with sticking agents that were later mechanically abraded. This activity has surely taken away possible marks of use on the edges near the repaired zone.

In spite of these adverse factors, the study of the long blades has allowed us to find traces of use related to a wide range of activities such as cutting non-woody plants, scraping animal flesh and treating skins. Nevertheless, of this group of activities, it is harvesting that especially stands out as being representative of the use long blades were put to. With the exception of Cabana Arqueta, on all of the sites, one or various blades presented signs of use associated with the cutting of non-woody plants, probably cereals.

Blades used for harvesting

Based on traces left by use, we have established three groups of blades related to non-woody plants:

- Blades used to cut cereals at mid-height of the stems. This attribution has been made due to the scarcity of marks observed on the surfaces of the blades (Fig. 3). This supposes that the finality of this form of harvesting was preferably to obtain the ears (grain). On some of these blades, the high intensity of the use-wear traces, particularly the micropolish, show that they were sickles used during long periods of time and not just for a particular task carried out previous to their deposit in burial chambers. Such is time that it has provoked a rounding off of the cutting edges. This rounding off was often rectified by sharpening the active zones.
- Blades for cutting stems close to the ground or even to cut stems at ground level. This is reflected in the strong abrasive component that these blades present in the way of abundant scratches, numerous pecks and very rounded off cutting edges (Fig. 4). If we suppose that this low cut is to obtain grain and to make the maximum use of the length of the stems, this cut at ground level could be related with the separation of the ear from the straw or with the consecution of a particular length of cut. Whatever the case may be, these processes have as their objective the consumption of the grain and the use of the stems for a diversity of purposes: to thatch houses, elaborate baskets, fabrics, etc. (Clemente and Gibaja 1998; Gibaja 2003). These intense abrasions associated with working cereals have also been acknowledged by H. Plisson in long blades and daggers from sites pertaining to the end of the Neolithic period in the east of France and in the west of Switzerland (for



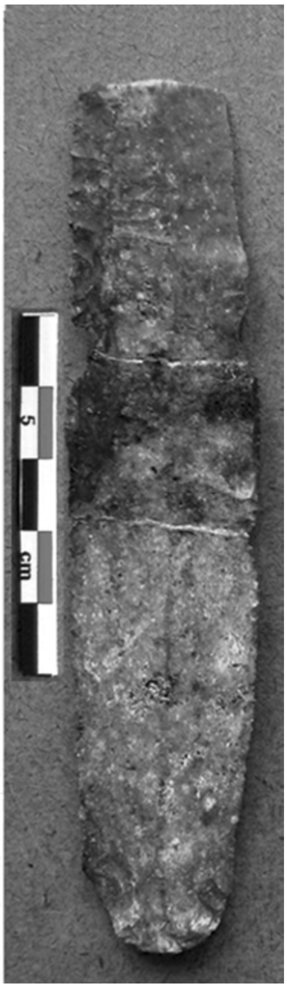
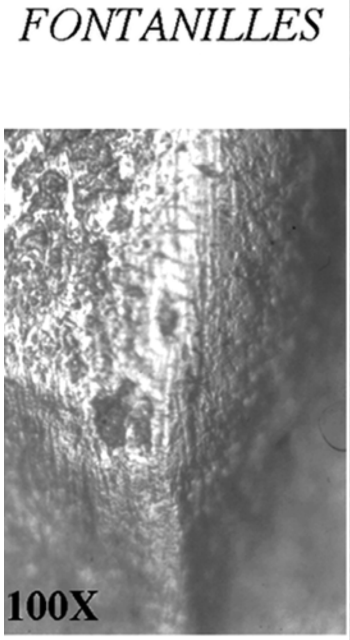


Fig. 3: Flint blade from Les Encantades de Martís used for harvesting. Micropolish highly developed by cereals with few abrasive components.



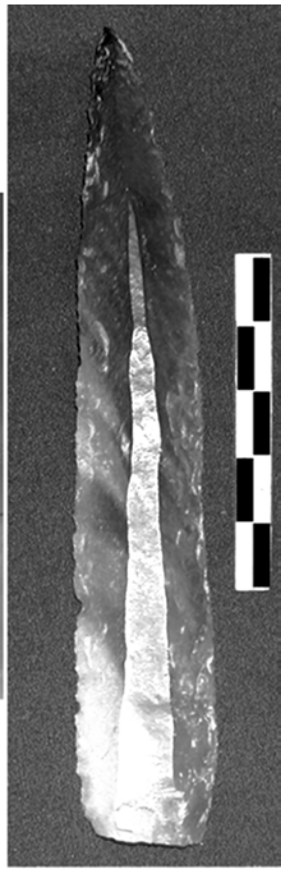


Fig. 4: Flint blade from Fontanilles used for cutting plants near to or at ground level. A micropolish associated with a strong abrasive component can be appreciated (scratches and nibbling).

example in Charavines and Portalban) (Plisson *et al.* 2002).

In the last group, we have included those blades which, as far as we have been able to determine, have been used to cut some kind of non-woody plant, but we have not been able to define if this was a cereal or a type of wild plant. This indetermination is due to a number of factors among which the following stand out: the little development of use-wear traces, the little time of utilization, the effect of the sharpening of the cutting edge and particular alterations suffered by the blade.

In many cases, we have observed that many of the blades have been used and sharpened on both sides. The degree of sharpening of some of the active zones has been so intense on occasions that it has provoked a loss of a good part of the cutting edge in some blades and has even led to very abrupt angles in some of the active zones, at times of around 80º. If we understand that the acute cutting edges are enormously effective, it is probable that these blades were initially used without being retouched. However, continuous work and the gradual rounding off of the edges led to obligatory sharpening so as to lengthen the lives of the sickles. The practice of sharpening harvesting tools is not exclusive to this period of history. It has been documented on Early and Middle Neolithic sites in the North-East of the Peninsula: La Draga, Sant Pau del Camp, La Bòbila Madurell, Camí de Can Grau or Ca n'Isach (Gibaja 2003).

What the useful life of these blades was is a difficult question to answer. The main reason is that we do not know if the cutting of cereals was the only task performed with them or the last of a series of activities carried out. There are various factors that prevent us from knowing if these instruments were initially used on other materials:

- The intensive and extensive marks produced as a consequence of cutting cereals cover traces previously created by the transformation of other materials.
- Obtaining or treating certain materials such as meat or skins leads to no more than slightly developed use-wear traces that are difficult to discern for archaeological purposes. The re-use of the tool on other material could easily cover them.
- The sharpening of the cutting edge leads to the disappearance of a good part of the surface of the blades in which perhaps marks from previous tasks were developed.

In spite of these problems, we should not discard that these blades may have originally been employed in other activities as not only have we observed that there are blades which have not been sharpened and that have been used to cut meat or skins, but that on some of these we have also found marks created by working with various materials (especially plants, skin and meat). These types of multipurpose blades have been registered on sites such as Mas Bousarenys, Llobinar, Dolmen de Pericot or Cabana Arqueta.

This type of blade for harvesting contrasts with the material found on some contemporary settlements in which the sickles were made of small teeth-shaped stone flakes set in a curved shaft. This is the case, for example, of the sickles coming from the non-funeral contexts of Les Roques del Sarró, Minferri or Genó (Ollé and Vergès 1998; Alonso 1999; Alonso *et al*. 2000). As opposed to the long blades from the funeral contexts analyzed, the sickles recorded at these settlements are not only morphologically different, but in addition, they tend to present only one used cutting edge. With the objective of fixing these stone chips or the blade to the handle, the sides of the pieces were often reshaped or broken.

Blades used for butchery
The long blade in the shape of a dagger from the megalithic burial of Cabana Arqueta (Espolla, Alt Empordà) presents various zones which have been used with different materials. While its two cutting edges have been used for boning meat, in the middle zone of the right side, traces created by cutting vegetable matter can be appreciated and in the distal part of the same edge a strong abrasion produced by its use on undetermined material has also been found.

We consider that this blade was used for scraping and not so much for simply cutting meat because along the edges points of micropolish with bone can be observed especially in the most elevated parts of the surface. This is a tool that must have been quite effective if we bear in mind the angle of its sharpening (20º), its straightness and its length: 232 mm (Fig. 5).

On the other hand, the invading sharpening carried out on the entire blade has led to the disappearance of a good part of the original cutting edge and perhaps traces of use created by other activities previous to this sharpening. The materials worked as described in the previous paragraph are those observed in the present state of the blade. What we do not know is if it had been used on other materials before being sharpened.

Blades used for treating hides
Three blades belonging to the funeral contexts of Mas Bousarenys, Llobinar and Vinya de Rei show active zones employed in the scraping, possibly, of dry hide.

In the case of the blade from Mas Bousarenys, on its left side, we have seen as much marks from cutting cereals as an intense rounding accompanied by a micropolish of a

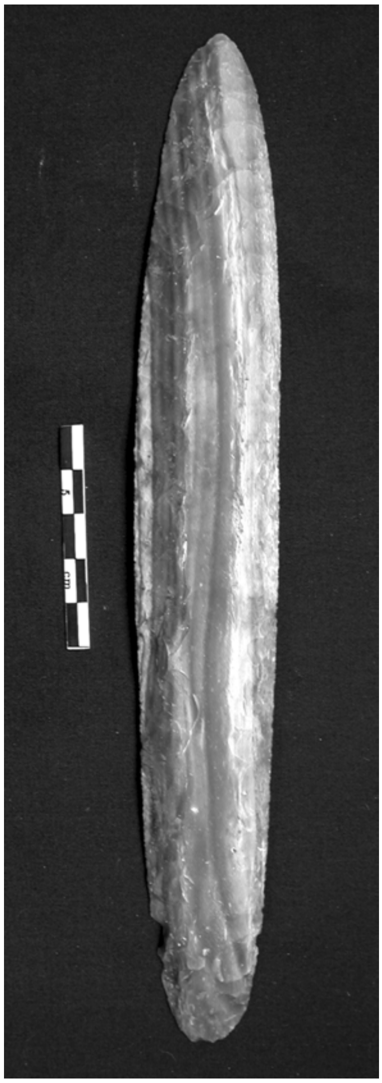


Fig. 5: Flint blade from Cabana Arqueta.

semi-closed nature that we have associated with the working of dry hides. However, this is an attribution that is difficult to verify given that such traces have been covered by those created by the cutting of cereals.

The fact that the active zone has been sharpened by means of deep and abrupt extractions has led to a cutting edge of a very high angle (80º) and a high degree of resistance.

As far as the blade from Llobinar is concerned, the situation is very different given that the traces of hide can be appreciated in two small zones whose edges have also been used for cutting cereals. The overlapping of the marks of both substances prevents us from determining with clarity what length of the cutting edge of the blade would have been used during the treatment of dry skin. Precisely the fact of this being dry hide leads us to tasks that are not related to the first phases of the hide preparation when the fat and adipose tissue is taken away, but with technical processes related to its thinning and finishing (Fig. 6).

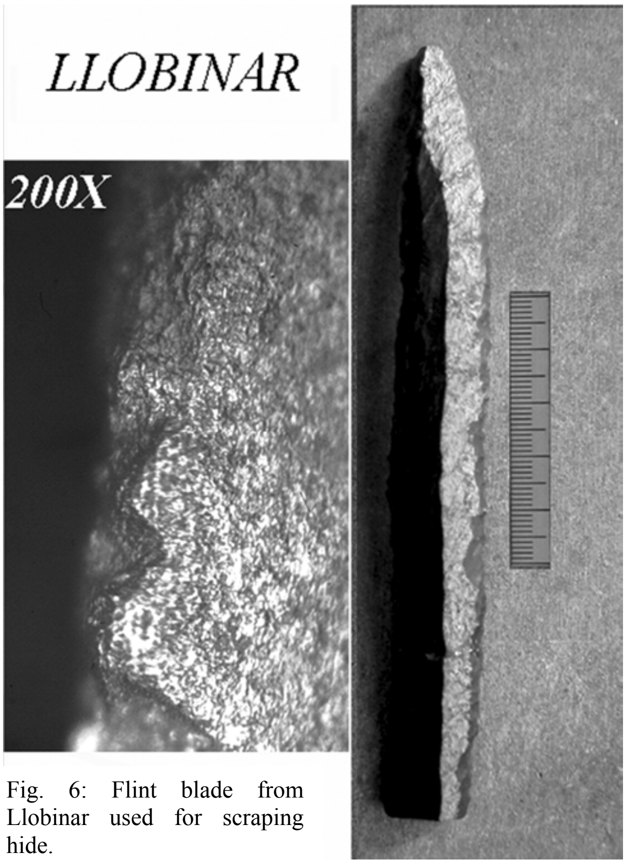


Fig. 6: Flint blade from Llobinar used for scraping hide.

In the same way as the blade from the megalithic burial mound of Mas Boussarenys, this one from Llobinar has also been sharpened. This gives the zones used on skin active cutting edges with very high angles (between 40º-80º).

Lastly, in the burial of Vinya del Rei, we have found another retouched blade that presents a rounded cutting edge and a highly abrasion micropolish that reminds us of dry hide processing. Nevertheless, we should take this with many reserves because marks of this kind are very similar to those produced by cutting cereals very close to the ground or at ground level. Again, sharpening has created an abrupt cutting edge (50º).

Conclusions

Between 3500 and 1500 cal. BC, profound socio-economic transformations took place in the North-East of the Iberian Peninsula that are reflected in the archaeological record. Among the artefacts found in the funerary contexts of this period, long flint blades of non-local origins stand out.

Although we are at a preliminary stage of analysis, it seems that apart from their possible symbolic significance held up by the fact of being tools localized exclusively in funerary contexts, these long blades intervened in different work processes related as much to subsistence activities as to processes concerning the elaboration and preparation of other instruments and objects. It is therefore clear that we are not before something given exclusively an ideological character.

As we have outlined, these blades require a highly complex technical process for their production which is surely associated with the presence of specialists. In this sense, the morphology of the blades and their technological stigmas have shown us that there was no single way of exploiting the groups and knapping the blades. We have also registered blades extracted by means of indirect percussion and by pressure (reinforced with levers). It is important to emphasize, according to the register and the archaeological information available up to now, that these processes were not undertaken *in situ.* The blades arrived to the North-East of the Peninsula in the form of finished objects.

The functional analysis carried out on the long blades from some of the funeral contexts studied have shown that we are dealing with tools destined to different activities among which harvesting and processing cereals stand out. Some of these blades have been used on both sides for the same material (plant or meat), others are multipurpose instruments. The multipurpose character is often difficult to define given that the reuse usually leads to the destruction or covering over of the marks previously produced. Nevertheless, it is possible that the re-use of the blades was an habitual practice if we take into account that it has also been documented concerning blades from funeral and settlement contexts in Switzerland and eastern France (Plisson *et al*. 2002).

The line of work and the results that we have presented here make up the first results obtained from the application of the proposed methodology for our projects. Without doubt, in the coming future our research will allow us to complete the information presented and contrast and discuss the hypothesis of the work proposed here.

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Signs of deliberate damage on the weapons from Altay Neolithic burials

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Summary. *The article presents the signs of deliberate damage on the daggers from Neolithic burials. The author pays attention to the leading tendency of weapon breakages. The carried-out deformation analysis suggests that the greater part of damages are not occasional but the result of ritual activities in burial practice.*

Résumé. *L'article présente les traces d'endommagement délibérés de dagues retrouvées dans des cimétières néolithiques. L'auteur porte attention à la tendance dominante de leur fractures, dont l'analyse suggère que les dommages résultent pour la plupart non pas de causes accidentelles mais d'activités rituelles funéraires.*

Key words: Altai Culture, experimental archaeology, use-wear analysis, Neolithic burials, daggers, arrowheads.

This research covers the burials of the Kuznetsk-Altay culture found in the northern foothills of Salair-Altay in Siberia. According to radiocarbon dating burials date to the beginning/middle 4th millennium BC. The local culture was connected to the Neolithic cultures of the Cis-Baikal region of Siberia and was formed under the influence of migration of its population to the West (Okladnikov and Molodin 1978; Dryomov 1980; Kungurova 2005). Grave goods, according to their technological and morphological characteristics, are more similar to those from the burials of the Cis-Baikal area. The burials were left by hunters who lived in the Altay low mountains territory during the Neolithic. Hunting weapons have been found in male graves and even with 1.5-2 year-old boys. Stone daggers, composite blade-daggers, arrowheads were compulsory items in the burials. In one of the burials a man was accompanied by flakes and various types of hunting and fishing equipment.

Our attention has been focused on studying deliberate damages left on weapons. The act of damaging weapons took place in funerary rites and was connected with the ideology and ritual practices of hunters and warriors. Daggers represent the most remarkable and characteristic items of the funerary goods assemblage. Eight stone daggers and ten bone composite blade-daggers were found at two Altai burial grounds: Ust-Isha and Solontsy-5 (Kirushin *et al*. 2000) (Fig. 1). Stone daggers have an average length from 29 up to 36 cm. They are made either of thin flint blanks or long straight flakes. The daggers are narrow in section, both of the surfaces are processed by bi-directional shallow removals. On the areas which were subject to enhanced pressure (handle and sharp point) there is a double retouch, making the edges blunt. Thin lines of abrasive edge grinding has been discovered by use-wear analysis on the edges (Fig. 2). Experimental modelling of the abrasive grinding process of retouched edges has shown that micro-crystallised sandstone abrasive leaves analogous signs. It is possible to suggest that grinding was carried out during surface preparation for removal of retouching flakes and of thin, long and narrow flakes from thin edges in the process of large bifacial daggers manufacturing. The

Fig. 1: Daggers from graves in the Altai region.

same technique was used for preparing a core platform for the removal of blades. This fact was noticed by Giria E.Yu. and investigated by him through experimentation (Giria 1997, p.161). There are areas where the edge is ground, which may suggest the occurrence of that technique. However, on the studied daggers the thin lines of grinding also covered the facets borders and ran along

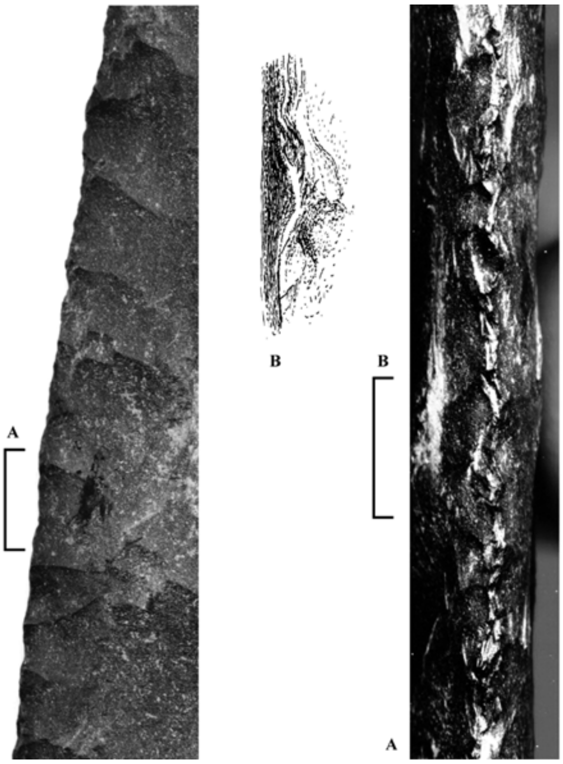

Fig. 2: The spreading of polish on the blades of stone daggers.

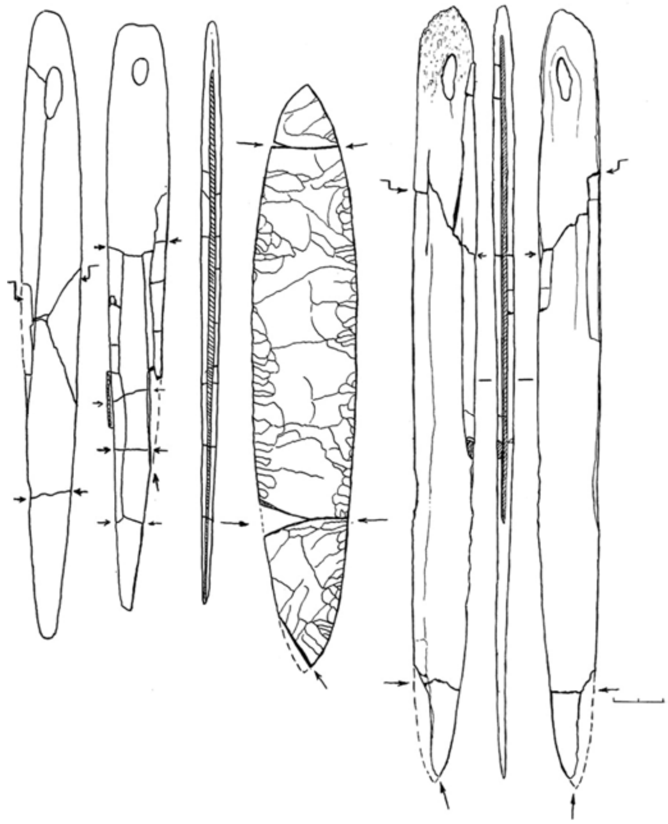

Fig. 3: Deliberate damage of the daggers. Tools are split along the sides and across the body in 2 places across the edge and across the middle place-near the hilt.

the daggers edges forming a narrow strip. A similar strip can be seen on the external edges of the blades in composite daggers. There is no sign of grinding on the edges inserted into the grooves. Whereas microanalysis of knives and spears from a burial ground further north, on the river Tom named the Staroye Musulmanskoye Kladbishche (Old Muslim Cemetery), showed signs of utilitarian use on the edges of knives blades (Kiryushin and Kungurova 1996), the same were not identified in the study presented here. The daggers cutting edges may have been ground slightly during the final production stage with the purpose of smoothing sharp toothed corners and margins (Fig. 3). A similar method was revealed for the arrowheads from a later settlement, dated to the Early Bronze Age – the Beryozovaya Luka, culturally connected to the Altai Neolithic culture. The surface of Neolithic bone-flint composite daggers received the finishing touch through lengthwise abrasive grinding and blade insertion.

There are three categories of deliberate daggers and arrowheads damage: breaking of sharp points, blades coming loose and falling out of composite weapons hafting shafts, breaking of weapons up to complete destruction of daggers.

The first two categories of damages can be called passive. In those cases the "dangerous" part of the weapon was broken or removed.

The third category, in our opinion, is connected with the consequences of active actions. Blade daggers with identical etymology of damages were found in two graves at both burial grounds: weapons were split along the edges and across. A long longitudinal fracture stretched from the end of the sharp point. Blades of one of the weapons remained intact but they were highly fragmented. We have been able to replicate them in succession. On the blades that were closer to the weapon sharp point, transversal slanted facets similar to burin spalls were noticed. Several facets were identifiable on one fragment.

In general, one can see breakage of the tools as a result of a clash with some hard material caused by a powerful blow on the sharp point which runs down the tool itself. A longitudinally slanted facet was chipped off the end of the sharp point. Splits and breaks appeared along the edge area. The main load was on the first blades (Fig. 4). They were mostly fragmented and as a result of the pressure from the previous blades there appeared spalls similar to those proper of burins. A similar dagger splitting technique was found in the assemblage from the Staroye Musulmanskoye Kladbishche burial ground (Kiryushin and Kungurova 1996). A long stone head of a spear, or a dagger was split into three parts. Its end was split transversally and lengthwise. The burin facet, similar to the burin spall, was 3 cm in length. On the edge of the point area there were micro-damages from the impact.

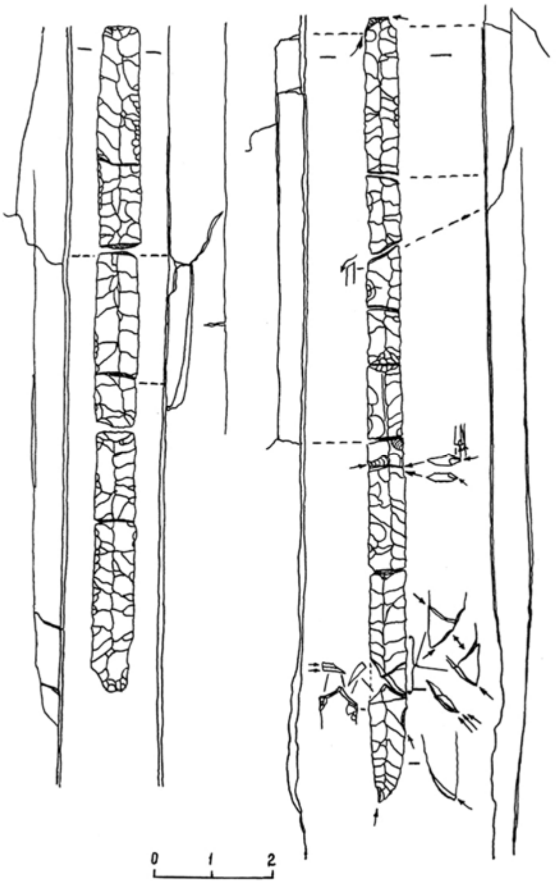

Fig. 4: Deliberate breaking up and difragmentation of the blades in the bone composite dagger.

Cross-fractures were found in the point and handle parts, which could have resulted from a heavy blow.

Deliberate splitting of the weapons as a result of purposeful blows was marked by A.P. Okladnikov in the burials of the Verkholenskii burial ground (Fig. 5). Arrowheads with longitudinal facets 2-3 cm long produced from sharp points were placed in different parts of one of the burials (Okladnikov 1978, p.41).

Many scientists have conducted researches on damages of composite weapons and arrow heads, among them there are invaluable works by A. Fischer, H. Plisson, G.H. Odell, by Russian specialists, such as D. Nuzhnyi, A. Philippov (Nuzhnii 1992; Odell and Cowan 1986). A similar etymology of spalls was created as a result of weapon throwing with great power at short distance into some hard material (but not stone). The character of complex splitting of stone and bone daggers from Altay burial grounds shows that throwing them into hard material at short distance was deliberate. In Altay funerary practices there could have been a ritual connected with the "killing" of weapons, i.e. with destruction of their active elements: blades, points. In addition it seems likely that, a part of the ritual was consisted in thrusting of daggers into objects, resulting in weapon destruction.

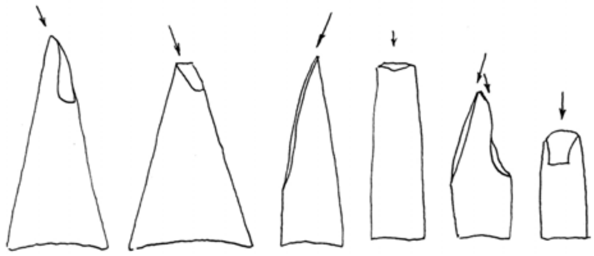

Fig. 5: Deliberate damage of the arrowheads.

A similar ritual, the shooting of an arrow into hard material to break the arrow, was in use among hunters of the river Lena. Rites using spears are ethnographically attested among the Ulchi people: to clear the way for the soul of a dead man to another world and prevent aggressive actions of "gal'ambani" a relative shoots a spear, and subsequently plunges it into the ground near the fire (Smolyak 1974, pp.333-334). Rites of plunging spears into the burial area or platform have been recorded in different societies. It has also been documented that the Kazakhs used to set the spear of a dead man vertically in his yurta (Kazakh dwelling). After one year the spear was broken, and its fragment were deposited on the grave of the dead man. Ancient authors mentioned the existence of cult weapons for the Sarmatians and the Scythians that found confirmation from archaeological findings, e.g. spears thrust into the ground and swords deposited in funerary contexts (Bessonova 1984, pp.7-8; Maksimenko 1984, p.167).

In the Early Bronze Age burial ground at Rostovka on the river Om, a concentration of spearheads thrust in the ground were unearthed (Matyushchenko and Sinitsyna 1988, p.40).

As a result of the analyses carried out we have come to the following conclusions.

Weapons laid in hunters' burials were not used for household purposes. There are no traces of such use. Traces evidencing deliberate damage of weapons suggest the existence of a ritual symbolism referring to the significance of the interrelation between a warrior's death and his weapon. The weapon used for killing animals or for warfare was made safe by breaking off the dangerous parts. The cutting edges of daggers could have been blunted by grinding. Destructions of piercing weapons show that before their placement in the grave there was a ritual consisting in throwing arrows or thrusting daggers into some target, which resulted in "killing" the weapons.

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Projectile points as signs of violence in collective burials during the 4th and the 3rd millennia cal. BC in the North-East of the Iberian peninsula

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Summary. *During the Late Neolithic and the Chalcolithic in the NE of the Iberian Peninsula two main changes in the burials take place with respect to the previous period: the appearance of collective burials and the high proportion of projectile points among the tools recovered inside the monuments. What is the meaning of these projectile points? Without ruling out the possibility that some of these points were intentionally deposited, stressing the symbolic relevance of these hunting/war tools, we think that many of them must have entered the burial place inside the bodies of the deceased people, indicating human violence. We analyse three collective burials showing many signs of violence: some points inserted in the human bones, other points broken by impact, some traumatic fractures in skulls, etc. We think that the violence observed in these burials can be characterised as systematic and organised, showing the social importance of war in this period.*

Résumé. *Pendant le Néolithique supérieur et le Calcolithique au NE de la Péninsule Ibérique les sépultures ont expérimentée deux changements principales en rapport avec la période précédente: l'apparittion des sépultures colléctives et la proportion elévée des pointes de projectiles parmi les outils récupérés à l'intérieur de ces monuments. Quel est la signification de ces pointes de projectiles? Sans exclure la possibilité de qu'une partie des pointes furent déposés intentionellement, en souslignant le simbolisme de ces outils de chasse ou de guèrre, nous pensons que la plupart d'elles ont du être introduites dans les sépultures à l'interieur des corps des morts, en indicant violence humaine. Nous analysons trois sépultures collectives qui montrent quelques évidences de violence: des pointes insérées dans les os humaines, des autres cassées par impact, quelques fractures traumatiques aux crânes, etc. Nous pensons que les évidences de violence observées à ces sépultures peuvent être caractérisées comme systématiques et organisées, en montrant l'importance sociale de la guèrre à cette période.*

Key words: Neolithic, Chalcolithic, Iberian Peninsula, arrowheads, violence.

Introduction

At the end of the 5th millennium cal. BC, in the NE of the Iberian Peninsula, people were buried in individual graves and offering deposits accompanied the bodies (i.e. sites of Los Cascajos, in Navarre or Bobila Madurell, in Catalonia). Among these offerings we can find several types of tools (sickle elements, blades for working hide, wood, butchery, etc., microliths used as projectile tips, endscrapers for softening hides, etc.). The correlation between the activities represented in the tools and the individuals in the graves showed the existence of a certain division of labour by age and gender. During the 4th millennium cal. BC, at the Late Neolithic and Chalcolithic, two main changes in funerary practices took place: individuals were buried in collective graves (hypogea, artificial caves, megaliths) and arrowheads became the most common tools recovered in these contexts. What is the meaning of the prevalence of arrowheads among the tools deposited in the graves?

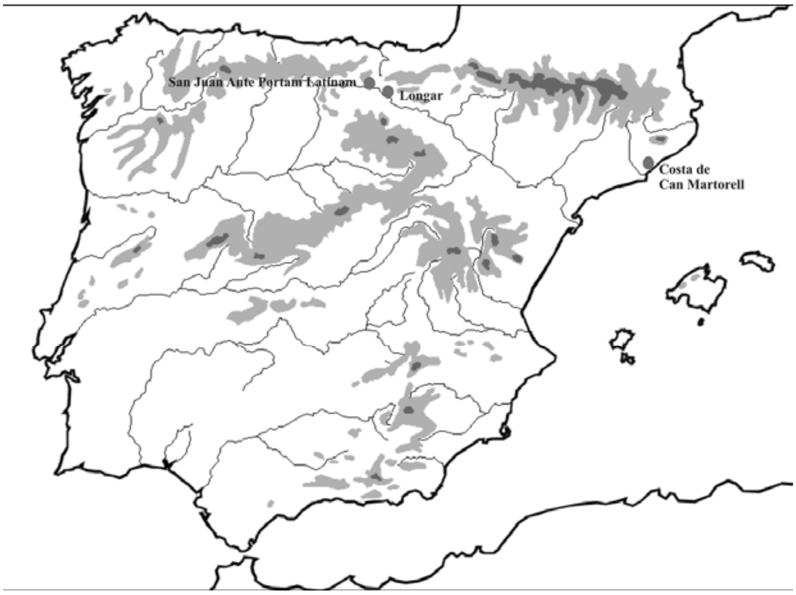

Fig. 1: Location map.

We have carried out analysis on the arrowheads recovered at three collective graves located in the NE of the Iberian Peninsula (Fig. 1): 1) the hypogeum of Longar, located in Navarre and dated to 2500 BC; 2) the approximately contemporary rockshelter of San Juan Ante Portam Latinam, located in Alava (Vegas 1999, p.3) The megalith of Can Martorell, in Catalonia, dated to 2500 cal. BC (Mestres i Torres 2003).

Fig. 2: The site after the removal of the roof (after Armendáriz e Irigaray 1995).

Longar (Armendáriz e Irigaray 1995)

The hypogeum of Longar is located in Navarre (North Spain). This region offered in the past a perfect natural environment to develop the first productive economies in the northern Peninsula. The density of sites with collective burials is very high.

Longar was discovered in 1989 and excavated from 1991 to 1994. Today, the preserved remains can be visited.

The roof of the chamber collapsed on the inner deposits (Fig. 2). The structure was filled with human remains. The NMI is 112, and all the ages and sex are represented. Some of the corpses were in anatomic position and were deposited through time. There are no elements of personal adornment. Only a small vessel, some flakes, blades and arrowheads have been recovered.

All the arrows are of the leaf type with invasive retouch on one or both faces. 4 of them are directly related to skeletal parts (Fig. 3), and so, the authors consider that they came into the chamber inside the corpses of four adult males.

San Juan Ante Portam Latinam (Vegas 1999)

The archaeological site of San Juan Ante Portam Latinam (SJAPL) is located at Alava, North Spain. It was discovered in 1985 during the works of enlargement of a path, when a singular deposit of human remains was affected by the machines. The deposit, located into a little shelter, was sealed by the roof collapse. Once the slab was removed, the deposit was excavated in 1985 and then in 1990 and 1991.

The remains of SJAPL have been dated to the end of the 4th IV millennium cal. BC. More than 300 individuals were buried (Fig. 4). All the ages and sex are represented, although males are over represented. The study of pathologies shows some wounds surely produced by arrows. Other are not so clear but probably have been caused by the same agent.

One-hundred-and thirty-one lithic object has been recovered. There are 61 arrow points, and some pieces of worked bone (ornaments and tools). There are only a few fragments of ceramics. From a typological point of view the sample of arrow points from San Juan can be grouped into leaf points and barbed-and-tanged points. The latter group has scarcely developed barbs. None of them are heavier than 5 gr.

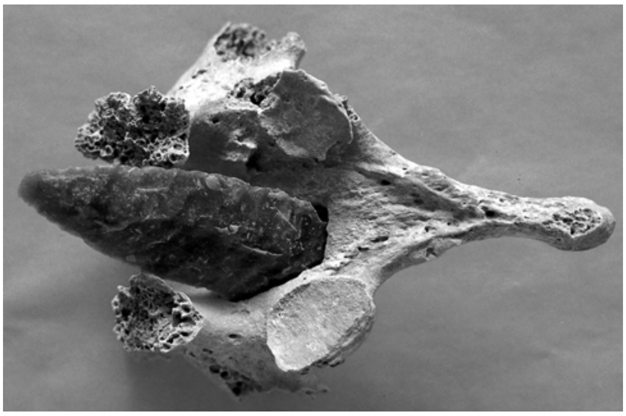

Fig. 3: Vertebra with flint arrow-point attached (after Armendáriz e Irigaray 1995).

Fig. 4: Detail of the deposit of San Juan Ante Portam Latinam (Photo. J.I. Vegas).

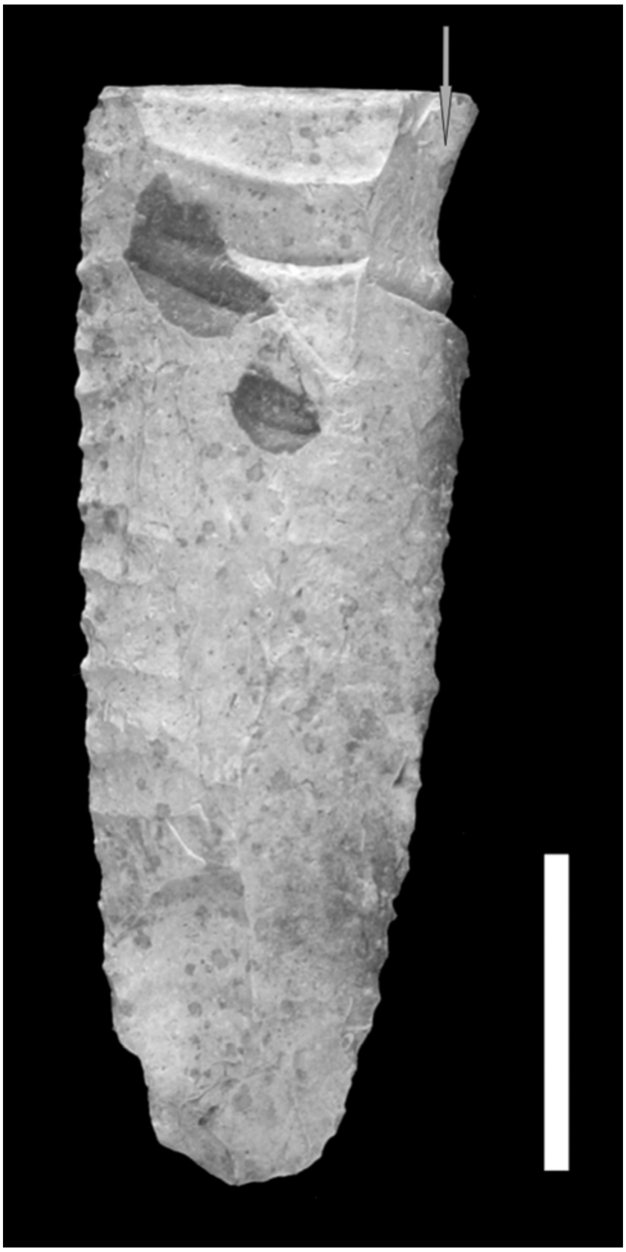

Fig. 5: Broken arrow by impact. It can be seen a burination in the right distal part of the arrow.

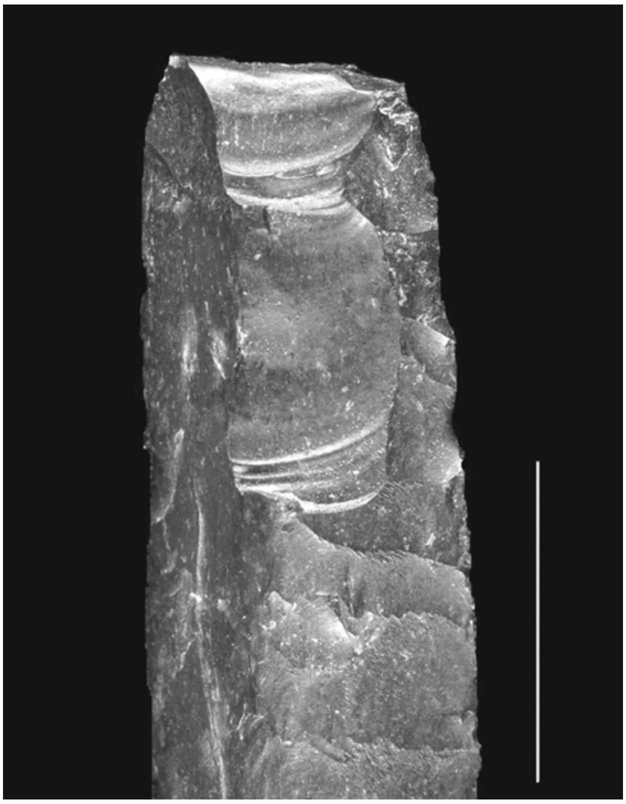

Fig. 6: Detail of a “flute-like” fracture.

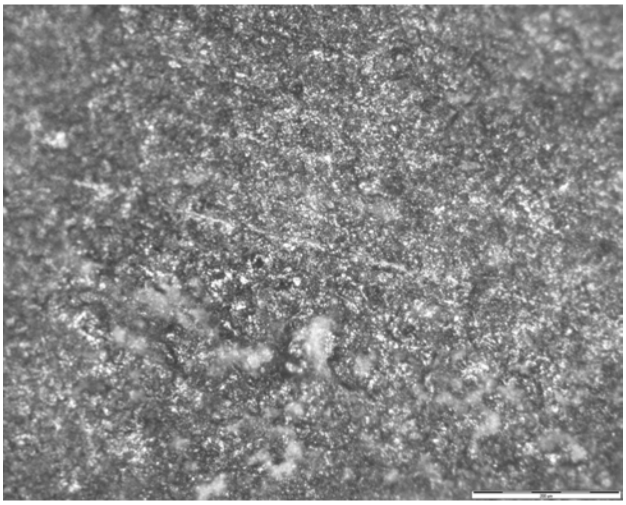

Fig. 7: Striation due to impact.

The hypothesis to the formation of SJAPL sample, points to a deposition in a short period of time. The objects recovered by the corpses did not correspond to ritual offerings but belongings or were included inside the bodies (e.g. some of the arrows) (Vegas 1999).

After the use-wear analysis of the arrows, we can say that apparently most of their fractures are due to their use (Márquez in press). In fact, we can distinguish some of the type of fractures due to impact showed at the performed experimental programs with arrow points. For example, “burin” (Fig. 5), “flute-like” (Fig. 6) and bending fractures are frequent. “Right” fractures do not mean impact breakage but can be produced by trampling or other non-use processes. Impact striations are also found in 9 of the 37 studied pieces (Fig. 7). They are in fact bright lines generally oriented following the long axis of the arrow and so the direction of motion. Use polish is generally hidden by patination and then we can ensure only that few spots of polish are due to impact.

Among the sample there are two apical parts of an arrow and two medial fragments. Nevertheless proximal parts of the arrows are lacking. These parts normally remain attached to the shafts, which used to be recovered by the hunters. And so, it’s easier to find the arrow tips and their medial parts which use to be attached to the game.

Fig. 8: General view of the entrance to the megalithic structure.

Can Martorell (Mercadal 2003)

This site is located in a mountainous region in Dosrius, Barcelona (North-East Spain). It was discovered in 1995 by a member of the Archaeology Section of Mataró Museum, when some slabs of stone could be observed emerging from the ground. A rescue excavation campaign determined that this was a multiple inhumation structure, with a megalithic entrance (Fig. 8). From a topographic point of view, this site is located in an excellent place, at 205m a.s.l., above two water sources.

The chamber is a semicircular space of about 7 m² excavated into the granite substrate.

There are three archaeological levels. The lower one corresponds to the burial where all the arrow points were found. Four C^{14} dates have been obtained yielding 3rd millennium cal. BC dates for the human bones. The osteological study points to the presence of 161 individuals (Fig. 9). Adults are the group best represented followed by youngsters and children (Mercadal and Agustí 2003).

There is no proportion between the lithic material, 68 arrow points, and the scarce fragments of pottery.

The lithic elements found are barbed-and-tanged points made of flint (Palomo and Gibaja 2003). Two types of arrows can be recognised: arrows with well developed barbs and short stems, and arrows with scarcely developed barbs and long stems. A different use for the two types can be supposed. More of the 80% of the arrows show fractures. The same kind of fractures owe to impact are recognised. Only 19 are complete or with little microscopic fractures which cannot be produced by the use. On the other hand, in most of the pieces (33%) we have recorded *striae* due to impact (Fig. 10) or contact with a hard material. Also, intense roundings have been found at the external edges of the barbs which can be produced by the contact with the leather of the quiver (45% of the pieces) (Fig. 11).

The first conclusion after the study of the pieces of Can Martorell is that most of them were used as projectiles. The fractures recorded at the point, barbs and stems, can only be caused by impact towards a hard object. Most of the pieces could come to the site included in the corpses. As it occurs in SJAPL, neither barbs nor stems have been found at the burial, perhaps because they were recovered together with the shafts. Contrary to what happen in Longar and SJAPL, we have no direct proof of death by an arrow point. Neverthless, the paleopathological study suggest that some traumatic lesions could have been caused by violent attack.

Fig. 9: Detail of the deposit of Can Martorell.

Finally, in relation to those unbroken points, we can say that they can be part of the offerings, although our experiments show that not all the arrows which have been thrown, broke.

Conclusions

The quantity of individuals buried varies from around one hundred at Longar (Armendáriz and Irigaray 1995), to near two hundreds at Can Martorell and three hundreds at San Juan (Vegas 1999). All segments of the population (gender and age) are represented in the graves. Some of the bodies are in anatomic position, while other human remains have been removed and concentrated at the sides

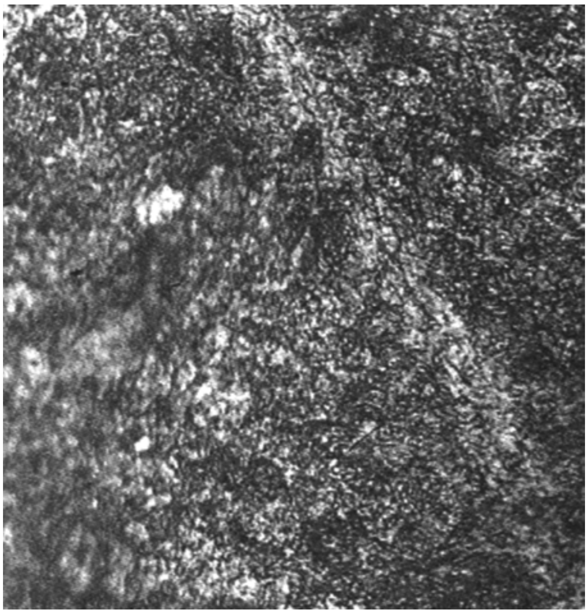

Fig. 10: Striation due to impact.

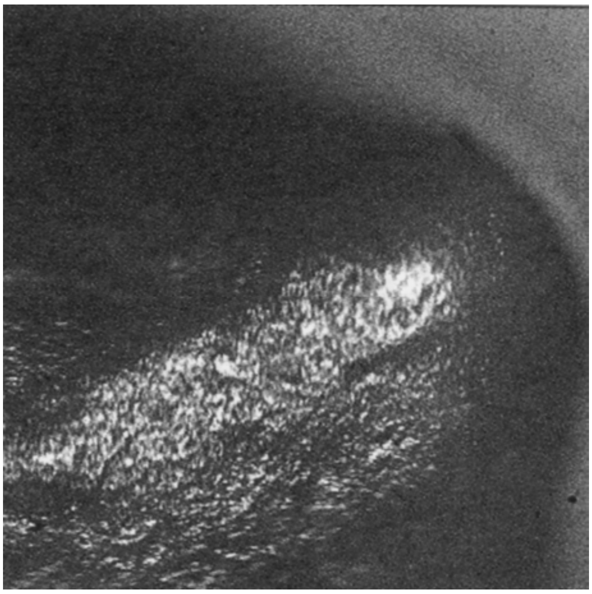

Fig. 11: Rounded edge.

of the grave, in groups of skulls, or long bones. All this indicates that the graves were used to bury all the individuals of prehistoric communities during a certain period of time, when the grave was in use.

The human remains showed abundant signs of violence. Several individuals bear arrowheads inserted in the bones, 9 cases at San Juan and 4 cases at Longar. Some of the individuals survived the wounds while others seem to have died because of the injury. Fractures in the skull, some of them incising, and in the forearms are also common. All these signs of violence affect young males. Use-wear analysis of the arrowheads shows that most of them had been shot (Márquez in press; Palomo and Gibaja 2003), so these tools were not elaborated specifically for ritual offerings. A certain proportion of arrowheads were inserted in the bones. Some others were broken by impact and were not functional any more. As the custom of offering tools that were potentially functional in the graves is well established we think that these arrowheads entered the grave inside some of the bodies. In conclusion, many of the arrowheads were not part of the offerings, although we cannot rule out this possibility for some of them.

We think that the violence observed in these burials can be characterised as systematic (recurrent in time and space) and organised (affecting young males), so the existence of war can be suggested. There seems to be an increase of systematic violence in these area and at this time, when compared to previous periods. The arrowheads inserted in the bodies are a direct sign of this violence, while the arrowheads deposited as offerings speak about the symbolic relevance of violence. Social and economic factors could explain the importance of war in this period, as the need of new territories in a moment when population seem to be stressing their attachment to land (megalithic phenomenon) or the need of prestige in a context of social ranking that was beginning to develop.

Acknowledgements
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Sacrificial stone knives from Abusir

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Summary. *An examination of the Pyramid of Neferefre (Raneferef, the 5th dynasty - 25th century BC), long known as the Unfinished Pyramid in the pyramid field of Abusir, revealed considerable insight into Egyptian life. The Sanctuary of the Knife located South-East of the temple, was the oldest and most unique part of the temple complex. It served the needs of the temple personnel and according to the preserved iconographic and written evidence, a long-term slaughtering of animal sacrifices was practiced there. During the excavation, over five hundred pieces of knives and blades were found. A sample of 26 knives and 33 blades were selected for the use-wear analysis to gain complementary information about processes and activities performed in the sanctuary. The results bring an interesting insight into the usage of the stone knives during ritual slaughters in Old Egypt.*

Résumé. *L'exploration de la pyramide de Neferefre (Raneferef, la Ve dynastie - 25e siècle A.J.CH.), longtemps connue comme pyramide Inachevé dans le site d'Abousir, a révélé une vue considérable dans la vie égyptienne. Le Sanctuaire du Couteau situé au sud-east du temple, était la partie la plus ancienne et la plus unique du complexe de temple. Il a servi les besoins du personnel de temple et selon l'évidence iconographique et écrite préservée, un abattage à long terme des sacrifices animaux a été pratiqué là. Pendant l'excavation, plus de cinq cents morceaux de couteaux et de lames ont été trouvés. Un échantillon de 26 couteaux et 33 lames ont été choisis pour l'analyse de la tracéologie pour obtenir des informations complémentaires sur des processus et des activités exécutés dans le sanctuaire. Les résultats introduisent une perspicacité intéressante dans l'utilisation des couteaux en pierre pendant des abattages rituels en vieille Egypte.*

Key words: Old Egypt, use-wear analysis, ritual lithic knives.

An examination of the Pyramid of Neferefre (Raneferef, the 5th dynasty - 25th century BC), long known as the Unfinished Pyramid in the pyramid field of Abusir, revealed considerable insight into Egyptian life. The pyramid was examined by a number of early explorers, but its purpose was not clarified until the 1970s when the Czech Institute of Egyptology of the Charles University in Prague did a systematic investigation by piecing together various clues. The research, directed by Professor Miroslav Verner, followed up the references in the important collection of papyrus documents (Abusir Papyri of Neferirkare) that have been found at Abusir and which gave information about Neferefre's pyramid.

During the excavations of 1984-86 performed by the Czech Institute of Egyptology, the Sanctuary of the Knife (Verner 1986) was uncovered in the Neferefre's temple complex. At first, the sanctuary had been known only from a newly uncovered collection of 2,000 rare papyrus fragments found in the North store rooms of the temple. The documents have been very useful as they not only deal with the structural and functional aspects of this temple, but also with the Abusir necropolis as a whole.

The Sanctuary of the Knife (a name found in texts), located south-east of the temple, was the oldest and most unique part of the temple complex. It served the needs of the temple personnel and according to the preserved iconographic and written evidence, a long-term slaughtering of animal sacrifices was practiced there. By the 6th dynasty, the slaughter yard only functioned for storage, and was soon closed. The sanctuary consisted of a slaughter yard where mainly cattle were butchered and of another three rooms with a well-preserved butchery table. According to the papyri, animals were ritually slaughtered by a stone knife and then quartered and skinned. The butchers cut the meat into smaller portions that were further cooked and baked. Some selected pieces were dried under the sanctuary roof.

The numerous artefacts found during the excavations of the Sanctuary of the Knife corresponded with its anticipated purpose of a place where ritual slaughters were carried out. Animal bones, stone knives and blades, pottery (vessels with a spout for blood, granary, beer mugs, and clay casts of clerk seals) were all found (Svoboda and Vachala 1989). Although ritual slaughter in Old Egypt was well documented by paintings and reliefs on the tomb walls since the 3rd millennium BC, often accompanied by explanatory hieroglyphic texts (for example the relief from Ptahshepses' tomb, Verner 1977), the results of micro-wear analysis are very scarce. Therefore, a sample of 26 knives and 33 blades were selected for the use-wear analysis.

Although use-wear traces from butchering are among the most difficult traces to interpret (Van Gijn 1990), we believed that some traces could be detected, as ritual butchering is likely to be more intense and invasive than a standard procedure. According to the original sources of information, we would have a quite clear understanding of how the cattle were butchered – first of all the left foreleg was cut (the most valuable part sacrificed for the deads' soul) then the heart was taken, etc... (Vachala 1987). Considering such scenario, the knife is likely to have been in intensive contact with bones and tendons, but the butchers were probably experienced enough to be able to carve the selected parts with a minimum of both vigour and tool damage.

The relief also shows the butcher having re-sharpened the knife with a, possibly wooden, retoucher (Fig. 9). Some reliefs even recorded microchips flying away from the knife, which had previously been misinterpreted as blood or sparks. But the depicted retouchers have yet to be excavated in Egypt. Comparison of different stages of the excavated ritual knives shows that the re-sharpening/reshaping retouch was made on the whole outline, not only on the knife blade edge. That might be significant as to why the retouch was made. The intensive re-sharpening of all the edges significantly lowered the possibility of development and preservation of the use-wear traces.

At the very beginning, Egyptologists were not too much interested in an ordinary lithic industry, but the excavation of the Sanctuary of the Knife provided a great opportunity to compare the archaeological findings with the papyri records. Hence the additional collection of a lithic industry in all pyramidal complexes and a general lithic analysis was made in 1989 (Svoboda 1993). During the excavation, over five hundred pieces of knives and blades were found. Most of them are deposited in the Kahira's museum, but about one third can be found in a collection in the Náprstek Museum of Asian, African and American cultures in Prague. The sample was made from the Náprstek Museum collection only. Unfortunately, the knives are mostly in fragments so the blades of the knives were preferred. A supplementary sample of 26 simple blades was created to gain complementary information about other processes and activities performed in the sanctuary.

All analysed pieces were made from tabular chert but of different qualities, imported from an unknown place (about 40-50 km far) to Abusir Necropolis as probably already finished pieces because no chipping debitage was found there. At least two types/variations of chert can be recognised – a fine chert with a colour strips (Fig. 1) and a coarse or middle coarse chert containing visible silica and calcite crystals which may influence the edge use-features. For example the sharpness of the edges could be more effective and durable for cutting due to the micro-saw created by the crystals. However, no differences in using of the two variations for knives and blades were observed. In some cases the calcified casts of micro-organisms were observed. As the calcite crystals crop up the silica binder, the cleaning must be carried out with the closest attention. Unfortunately, the use of hydrochloric acid could not have been avoided due to some resistant dirt that was irremovable by detergent or ethanol. Therefore, the tools were only immersed in a low concentration HCl (about 1%) for a short time so as not to remove the calcite crystals and irreversibly damage the tool surface.

The shape of knives was stable within the whole 5th dynasty; a straight blade with a relatively short handle. There are no historical records about possible hafting in this period but we have some for much later time, the 12th dynasty, when the handles were wrapped with organic fibres. All inspected handles were more likely right

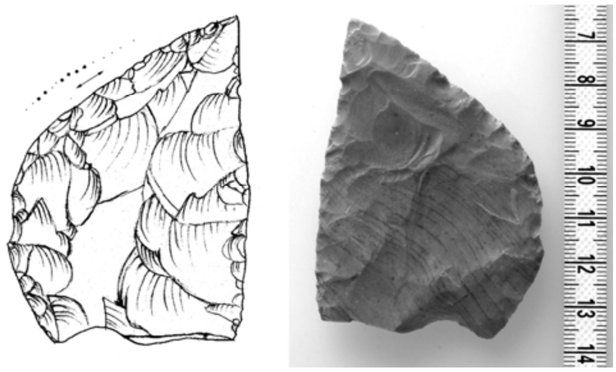

Fig. 1: Knife P6552a 172/I/82 a-g (a) – photo and drawing of the interpreted use-wear traces (cutting soft animal tissues).

Fig. 2: Knife P6575a 601/I/82 – photo and drawing of the interpreted use-wear traces (cutting soft animal tissues).

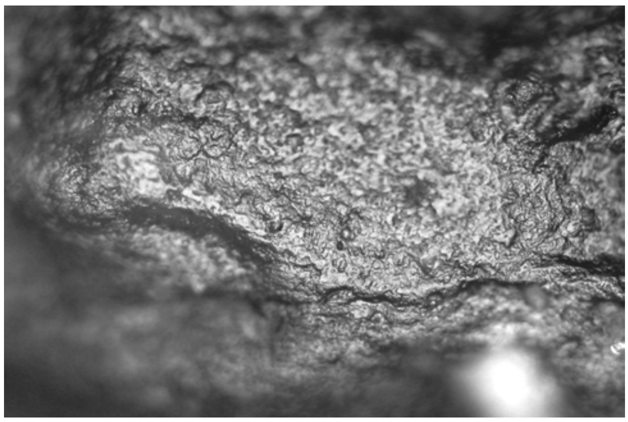

Fig. 3: Knife P6575a 601/I/82 – micro-photo of the interpreted use-wear traces (cutting soft animal tissues) mag. 200x.

handed but this fact refers more to the outside manufacture knife production than to an actual handedness of the butchers.

The surfaces of most analysed pieces were affected by a very light abrasion. Unfortunately, all knives were intensively re-sharpened and most of them seemed to be in a final stage of their functional life, on some pieces signs of burning were observed (7 pieces). The majority of the analysed pieces had no use-wear traces at all

(78%). Only two blades carried clear interpretable use-wear traces. They were covered with an intense (visible to the eye) sickle gloss (Figs. 4-7). The other 8 pieces (4 knives, 4 blades) showed weak use-wear traces but of a rather unsure interpretation. The 4 knives displayed undeveloped soft-animal-tissue-like traces with a longitudinal orientation (Figs. 1-3). Surprisingly, no animal tissue traces were found on blades although they were not retouched or re-sharpened. It may indicate that the blades were either not employed intensively in butchering, or possibly only for a short time or occasionally. The blade traces were of a mixed nature: 2 with undeveloped traces with an edge rounding and 2 with traces of a material of a medium hardness, possibly vegetal (Fig. 8). The above mentioned 8 pieces with unsure traces could be a result of possible short-time usage, but a post-depositional origin cannot be disregarded either. And finally, 3 pieces (blades) displayed traces that could be most probably of a post-depositional origin. No specific hafting traces were recognised on the analysed handles.

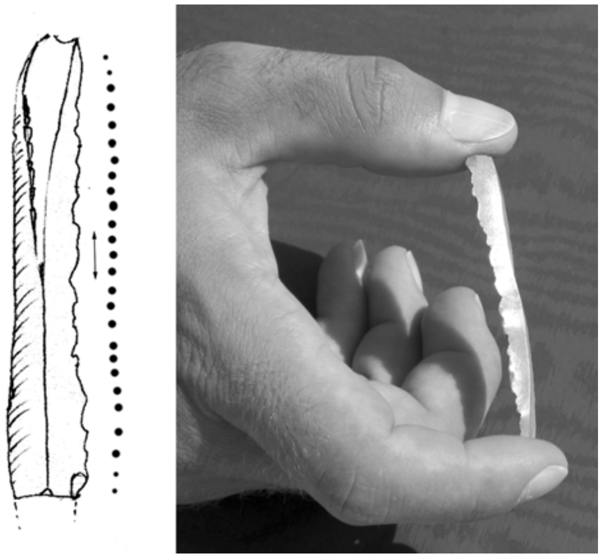

Fig. 4: Blade P6558d 277/I/82 – drawing of the interpreted use-wear traces (sickle gloss) and photo of the macroscopically observed polish.

It is very unlikely that the remaining unanalysed pieces in the Náprstek Museum collection would reveal any use-wear traces as all the pieces with an indication of possible usage (micro-scaring, regular long edge or the other proper shapes, the blade edge parts of knives) were selected for the analysis. To compare the surface preservation and the activity pattern, a complete unbroken knife from another site (Chentkaus) was analysed as there was a macroscopic rounding on its edges. However, the analysis showed only extensive post-depositional abrasion on the whole surface, removing all possible traces. If we are to compare their preservation, the knives from the Raneferef's sepulchral complex were in much better condition.

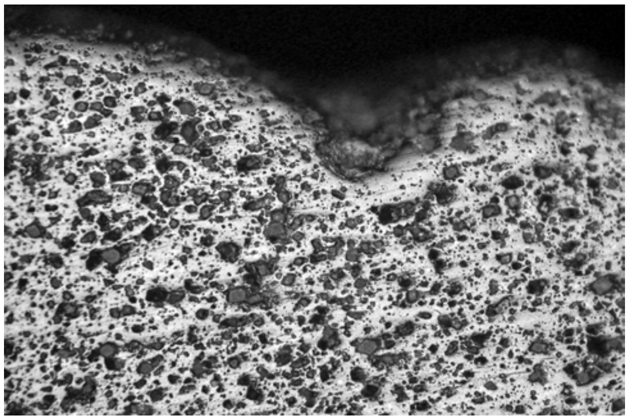

Fig. 5: Blade P6558d 277/I/82 – micro-photo of the interpreted use-wear traces (sickle gloss) mag. 100x.

The lack of use-wear traces on both the knives and blades suggests several hypotheses. It is obvious that the knives were intensively retouched although the reason was rather ritual or religious than functional. The intense retouch observed on sacrificial knives led to the change of their shape which was in the end far from the original. Bearing in mind the experiments with butchering and Egyptian butchers' long-term experience, the edge removals/rounding/scaring should not be so intensive to require such a massive edge retouch in the range of the whole knife verge, including the back side and the handle. The experiment with a similar tool was performed and the results further discussed with a contemporary butcher. The result did not prove the edge would get round so quickly to need such a frequent and intensive retouch. Moreover, the above described edge reduction seems to be incongruous if we suppose that the knives were meant solely for the particular ritual slaughter. Unfortunately, we do not have records about the time aspect using of the knives – if they were used on cattle only or for one sacrifice event or more. The experiment suggested that the reason for reshapening could be more ritual than functional as the edge angle was rising quickly

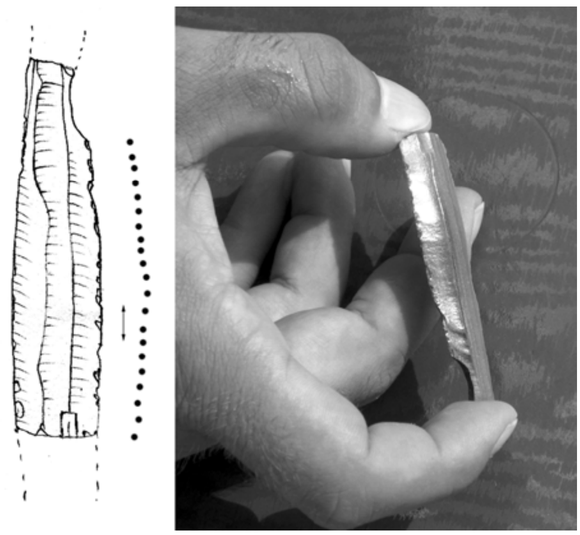

Fig. 6: Blade P6571d 466/I/82 – drawing of the interpreted use-wear traces (sickle gloss) and photo of the macroscopically observed polish.

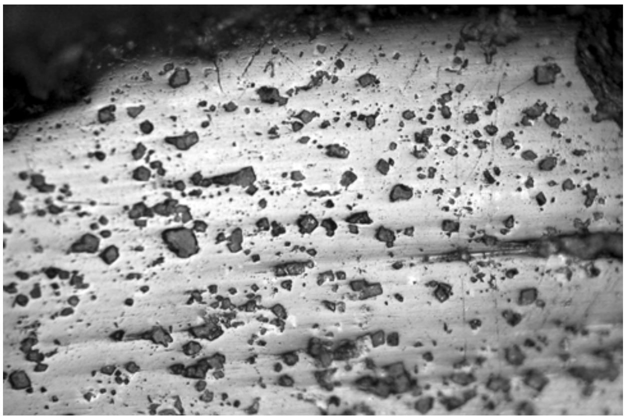

Fig. 7: Blade P6571d 466/I/82 – micro-photo of the interpreted use-wear traces (sickle gloss) mag. 100x.

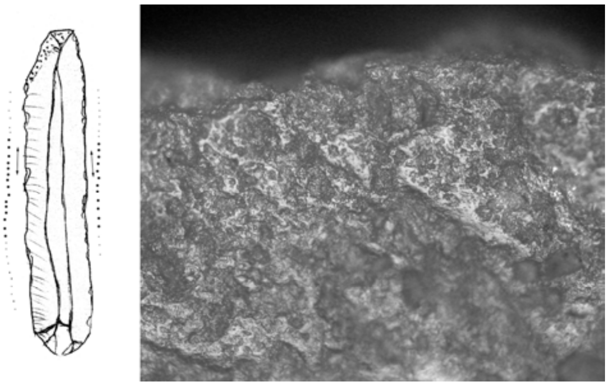

Fig. 8: Blade P7165a 938/I/84a-e – drawing of the interpreted use-wear traces (sickle gloss) and micro-photo of the interpreted use-wear traces (middle hard vegetal material) mag. 200x.

Fig. 9: Butchering and re-sharpening scene (Plate 12, Mastaba of Ptahshepses, Verner 1977).

from 30° to 80°/90° and such an angle is actually too steep to be efficient for butchering. Having considered that the frequency of butchering and re-sharpening scenes on reliefs is almost equal, it implies that the re-sharpening activity might have had a special meaning although not mentioned in the hieroglyphic texts.

In conclusion, it is without any doubts that the knives were used for either actual butchering in the slaughterhouse or for some ritual purpose. Although only few traces were found, the intense retouch can be considered an indirect evidence of the use. But the results of the micro-wear analysis can neither prove nor disprove the activity displayed on the reliefs. The numerous blades found in the Neferefre complex having minimum use-wear traces support the idea that they might have been used only for a short term, for unspecific auxiliary works (except for the two sickle blades), not specifically for butchering.

The results, although rather negative, bring an interesting insight into the usage of the stone knives during ritual slaughters in Old Egypt and may imply that further researches be conducted on it, to look for more explanatory answers.

Acknowledgements
We would like to thank to the Náprstek Museum of Asian, African and American cultures in Prague for providing us with the documentation of the original excavation and for their overall assistance.

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Functional analysis as a tool for the interpretation of mortuary practices. A case-study from the Corded Ware Culture graves at Zielona, southern Poland

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Summary. *Excavations of the Late Neolithic Corded Ware Culture cemetery brought to light 3 inhumations dated around the mid of 3rd millennium BC. Grave No. 3 – due to numerous goods and body position was the object of detailed studies including technological, typological and functional ones. Six categories of flint objects were identified, based on different location and function. Results point towards a complicated mortuary practices that existed in the Corded Ware Culture, a possible way in which local groups particularly honoured their leaders.*

Résumé. *La fouille d'un cimétière de la Corded Ware culture du Néolithique finale mis au jour 3 inhumations datées du milieu du 3éme millénaire BC. La tombe n°3, en raison d'un mobilier important et de la position des corps fut l'objet d'études détaillées incluant typologie, technologie et tracéologie. Six catégories d'objets de silex furent identifiées à partir de localisations et de fonctions différentes. Les résultats pointent une pratique mortuaire compliquée qui existait dans la Corded Ware culture, une voie possible par laquelle les groupes locaux honoraient particulièrement leurs leaders.*

Key words: functional analysis, mortuary practices, Corded Ware Culture, lithic tools.

The paper presents the results of functional analysis of the artefacts from a grave of the Neolithic Corded Ware Culture cemetery in Zielona. Analysis was undertaken to address the issue whether traceological analysis would, and if so, to what extent, increase our knowledge of the burial and the related funerary rites.

The cemetery in question is located in the vicinity of Cracow, in southern Poland (Fig. 1). It covers a pronounced loess peninsula where remnants of a circular mound were discovered. Fieldwork was carried out in 1999-2000 by Piotr Włodarczak (Włodarczak 2004).

Excavations yielded 3 graves, dated to the period before the 1st half of the 3rd millennium BC and associated to the earlier stage of the Cracow-Sandomierz group of the Corded Ware Culture.

One of them, grave no. 3, stood out against the others in terms of the inventory and the arrangement of the burial. The excavated grave goods belonged to the richest grave inventories recognised for the Corded Ware Culture in Małopolska
The deceased man was placed along North-South axis on his back in anatomic position with the face heading South (Fig. 2). He was accompanied by two vessels (a beaker and an "amphora"), found in the northern corner of the grave, a grinding stone found by the chamber wall and a flint axe over the head. Just behind the head a stone battle-axe was found and west of the body two flint artefacts and a cluster of stone and flint artefacts comprising a small flint axe, a stone tool and a deposit of flint half processed material (Fig. 2).

Behind the back of the inhumed man, there was a cluster of seven flint arrowheads. Two more arrowheads were found among the bones of the rib cage and the abdominal cavity of the body, and one near the head (Fig. 3). An isolated copper awl lay north of the cluster of arrowheads. Between the cluster and the skeleton, there was a deposit of yellow substance, contained within a poorly preserved vessel made of organic material. The vessel also contained a flint blade tool. Several other flint tools were found above the skeleton.

It was relatively typical for the numerous graves of the Corded Ware Culture from the region to contain single flint artefacts. It was the first time, however, that a grave with such a rich and typologically varied flint assemblage had been excavated.

To address the issue of the character of the inventory, it was decided that the technological and typological analysis would be supported by traceological analysis. It must be emphasised that, undoubtedly, all excavated grave goods were intentionally placed in the grave between the body and the entrance.

The grave goods analysed, 32 artefacts in total, can be divided into several groups regarding their placement in the grave as well as different functions they performed.

The first group comprises a dozen of artefacts placed in close proximity to the skeleton, some of them bearing clear traces of wear (Fig. 2).

Four tools from this group may be identified as knifes used for cutting various raw materials, both soft and hard, as well as hide. Their strongly deformed edges suggest intensive use. Three of them had the same characteristic retouch and were probably hafted (Fig. 1:2, 4, 29; Fig. 2). The above mentioned tools in some aspects remind artefacts known from the Portalban site (Anderson *et al.* 1992). Tools from that site were found with preserved

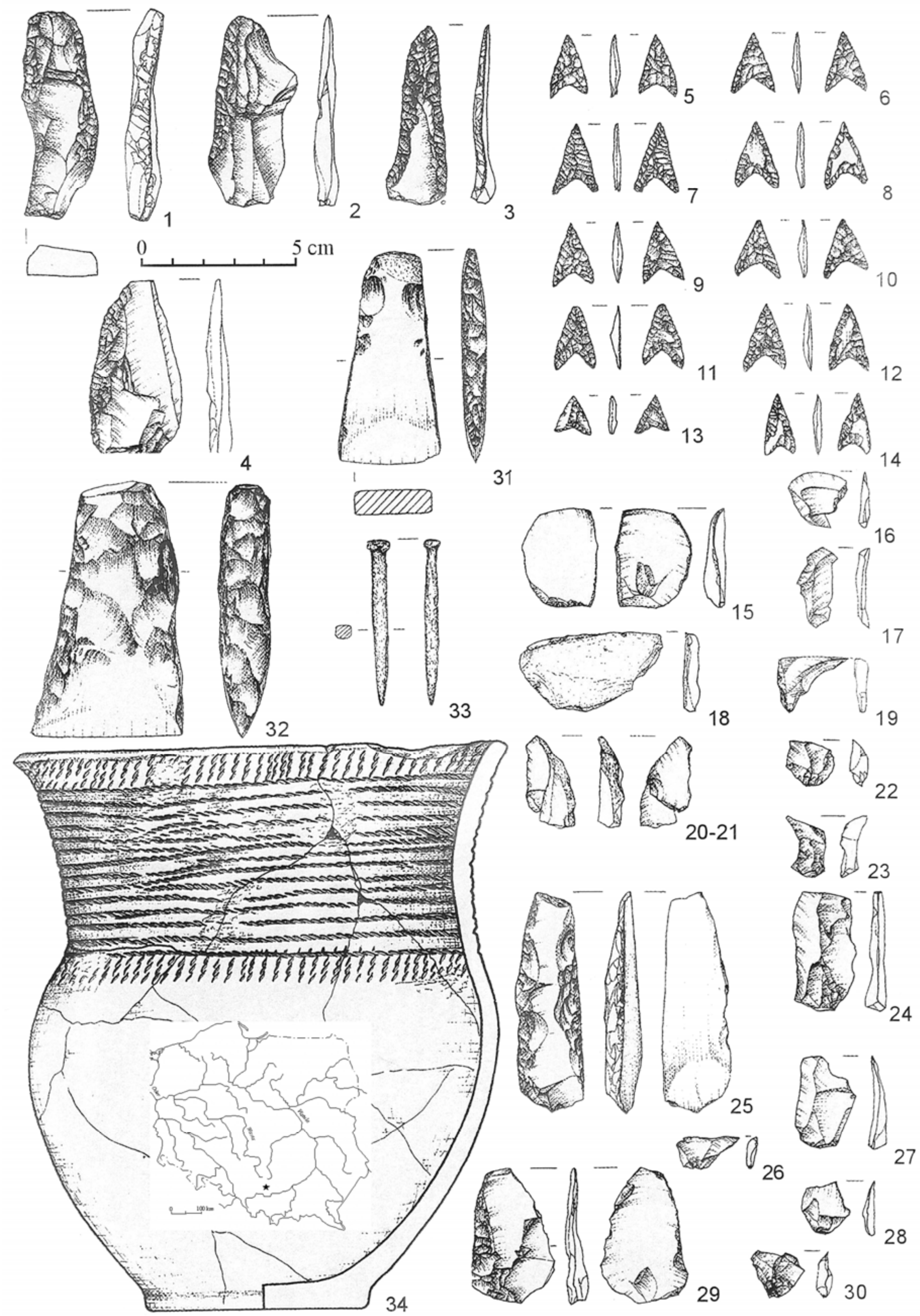

Fig. 1: Zielona, site 3, grave 3. Artefacts from the grave.

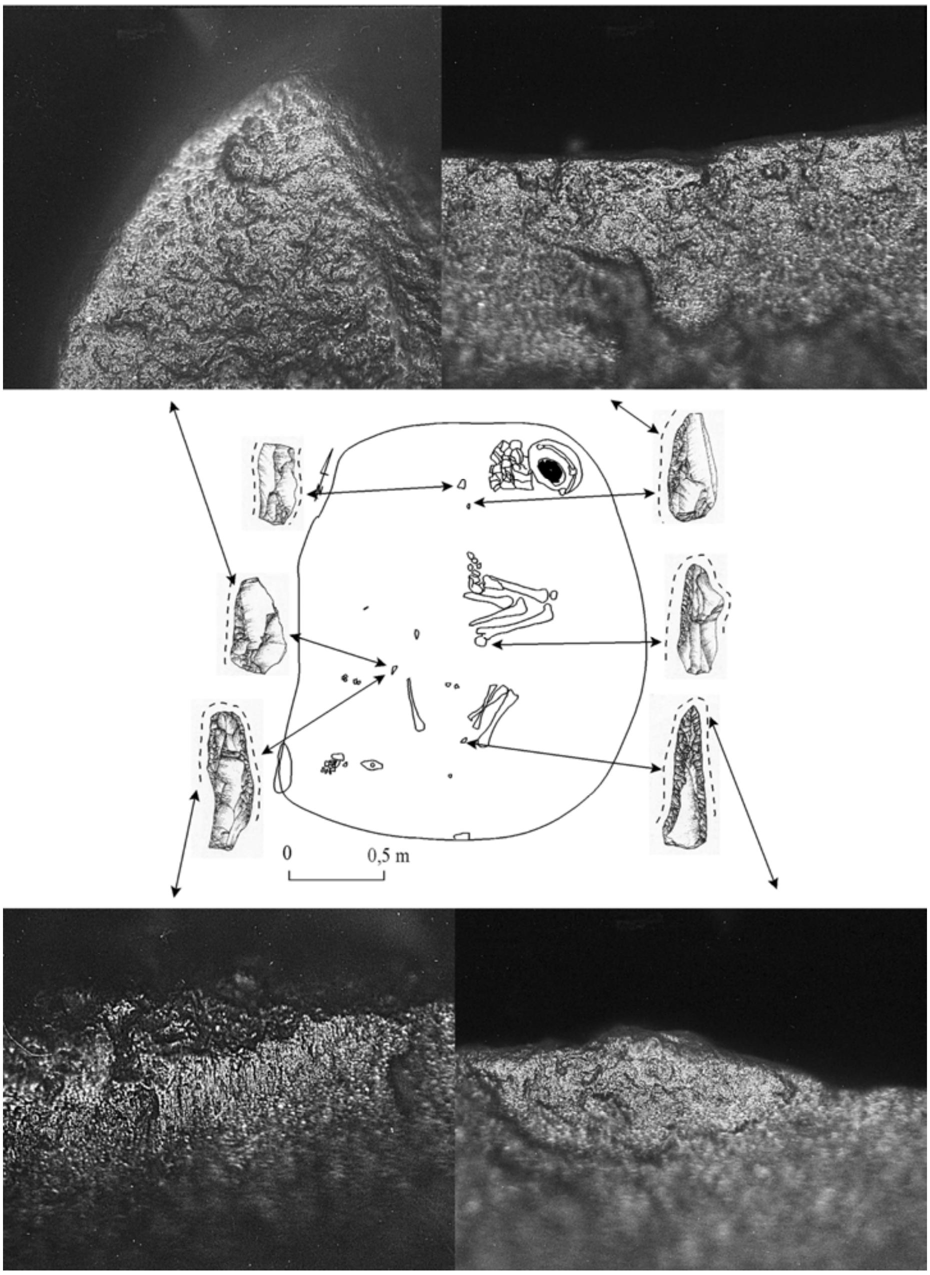

Fig. 2: Zielona, site 3. Map of grave no. 3 with some of used tools and microscopic photographs of use-wear traces; magnification 200x.

wooden hafts (Ramseyer 1987; Anderson *et al*. 1992). Most probably knives from the Zielona site were hafted in a similar way.

Another chocolate flint tool in the form of a blade is similar to the above-mentioned tools in terms of the type of retouch (Fig. 1:3). However, its determined function is different. Intensive deformations at the side edges and the tip suggest that the tool was multifunctional, used for different activities from drilling to smoothing (hide?) (Fig. 2).

A tool made on a Jurassic flint blade found inside the vessel made of organic material performed a different function (Fig. 1:1; Fig. 2). The type of traces identified suggests that it was used for smoothing or probably as a fire-lighter. Some change of colour was recorded on its edges, resembling the colour of the substance filling the vessel made of organic material, where the tool was found. That is the first container made of organic material found in southern Poland in the context of the Corded Ware Culture, whereas examples of the presence of a similar yellowish substance are known from other CWC graves of neighboring sites (Budziszewski and Tunia 2000:128). Two explanations have been provided for the substance's function: it was either a dye or a material for making fire.

The second group of tools comprises 10 arrowheads made of various kinds of flint (Fig. 3). Three of them

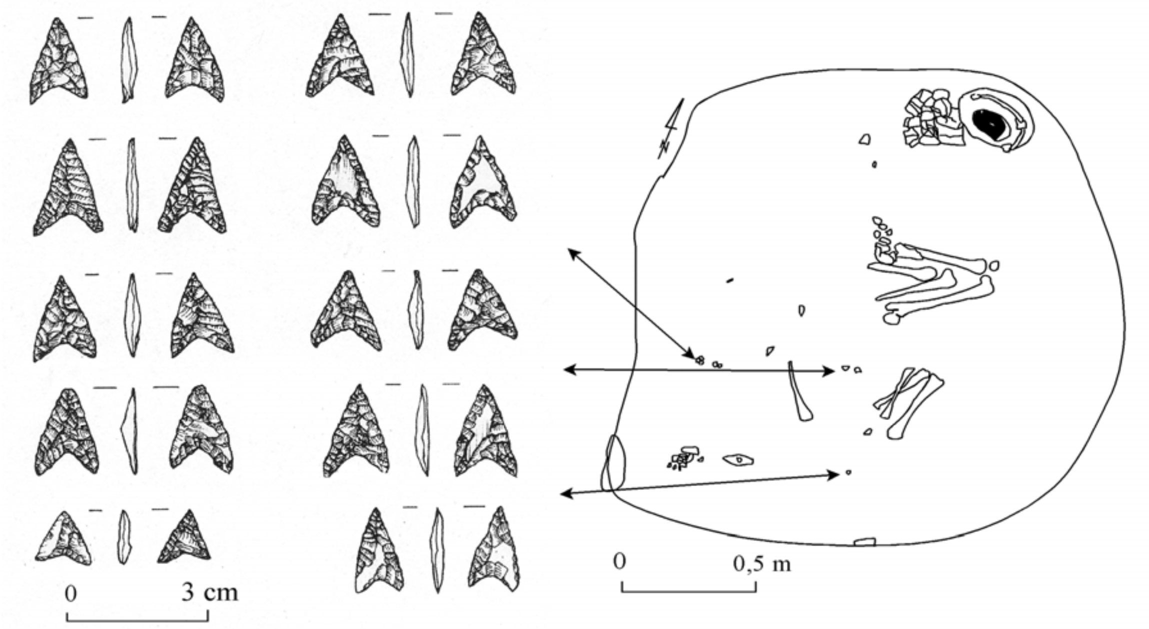

Fig. 3: Zielona, site 3. Map of grave no. 3 with arrowheads.

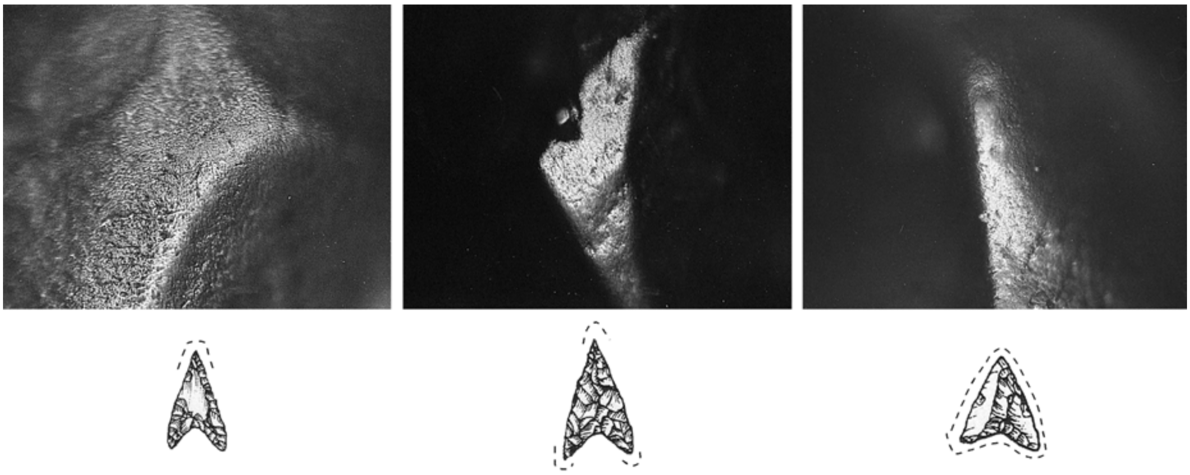

Fig. 4: Zielona, site 3, grave no. 3. Examples of arrowheads and microscopic photographs of wear traces recorded on them; magnification 200x.

were placed within the bones of the skeleton: two near the rib cage, one at some distance from the others in the place where the unpreserved skull must have lain. They show no traces of wear (Fig. 5).

The remaining seven arrowheads were found in the cluster behind the back of the deceased (Fig. 1: 7-13). All of them show traces of wear. Their tips are smoothed, just as are the upper parts of the lateral edges as well as the flat surfaces near the tips (lower and upper). In two cases similar traces are visible on the notches of the arrowheads (Fig. 4).

The type of traces on the arrowheads points to their contact with hide. The question is what function these arrowheads performed. One of possible hypothesis is that the traces result from carrying the arrows in a leather quiver. However, the type and localisation of the traces suggest different hypothesis: that the arrowheads were, at least occasionally, used for hide processing, namely for perforation. Hafting of the arrowheads is another open issue. There is a lack of evident hafting traces and in the cases where location of traces suggests hafting, identical traces were observed on tips of tools.

Another group of tools is a cluster of 12 flint artefacts, comprising one tool, flakes and their fragments. No artefact from this deposit showed any traces of wear. Most of the artefacts (Fig. 1:15-23, 26-28, 30) are small amorphous waste products. They could not serve as material for arrowheads or other flint tools.

Another category of artefacts comprises two flint axes (Fig. 1:31-32), both with traces of wear. Tools like these

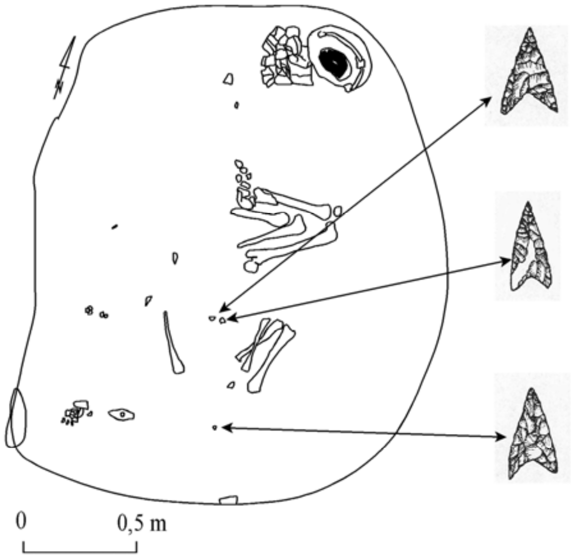

Fig. 5: Zielona, site 3, grave no. 3. Map of the grave with unused arrowheads.

are typical items in the inventories of the Corded Ware Culture male graves. In use was also a stone chisel – a tool rarely found in the CWC graves (Fig. 1:25).

To sum up, the grave goods included a number of different categories of flint artefacts, with different function and localisation:

- a cluster of flint tools, placed in close proximity to the skeleton, used predominately as knifes and in most cases hafted;
- flint arrowheads placed among the bones of the skeleton and showing no traces of wear;
- a cluster of flint arrowheads placed behind the back of the deceased, showing traces of wear from contact with hide (resulting perhaps from carrying them in a quiver and/or using for perforating ?);
- a strike-a-light (?);
- a deposit of waste products showing no traces of wear;
- 2 utilised flint axes;
- a used stone chisel.

Traceological analysis is not intended to directly answer the question about the meaning of particular groups of artefacts. However, equipping the body with such a number of so varied artefacts, namely clay vessels, weapon elements, flint, stone and copper tools as well as flint debitage suggests that the people of the Corded Ware Culture performed sophisticated funerary rites aimed at emphasising the role of the deceased in the local community. It is particularly evident when we compare other numerous graves of the Corded Ware Culture from southern Poland, usually containing poor grave goods.

Distinguishing male graves through their rich inventory, and at the same time lack of differentiation of the grave structure, resulted from the institutionalised diversification of the population, namely in the formation of a separate group of particularly important men, i.e. leaders. The man buried in grave 3 was probably one of them.

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6.1. Methodology

Identification of anthropic and non-anthropic traces on the osteological remains of Contrada Stretto-Partanna (Trapani, western Sicily, Italy): layers 1-16

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Summary. *Different categories of traces can usually be identified on archaeozoological remains, but too often they are simply classified as cutmarks without a thorough analysis of their actual nature. Only detailed analysis of bone surfaces can avoid misunderstandings, involving wrong hypothesis concerning economic, social and/or ritual behaviours of human groups.*
Marks on osteological remains coming from layers 1-16 of the excavation carried out on some levels of the neolithic ditch in Contrada Stretto-Partanna were examined.
A first list of marks was made using only the naked eye, then they were organised by taxon and anatomical part and classified by their shape and position. Further analysis were carried out identifying different kinds of marks and traces, using both binocular and Scanning Electron Microscope. Their characteristics were registered and used in order to identify diagnostic features that could confirm or deny their anthropic origin. This method enabled us to highlight non-alimentary exploitation of animals and to clarify the actual cause of marks observed on a human humerus that seemed to be related to some peculiar mortuary ritual.

Résumé. *Les vestiges osseux portent fréquemment sur leur surface différentes traces, mais trop souvent on les attribue à l'activité humaine sans essayer de mieux comprendre leur vraie origine. Pour cela il faut analyser de façon détaillée les surfaces des ossements, notamment pour corriger de fausses hypothèses concernant les habitudes sociales ou rituelles d'un group humain.*
Cette étude a été conduite sur les restes osseux des niveaux 1-16 de la fouille du fossé néolithique de Stretto Partanna. Il a débuté par le relevé des traces à l'oeil nu et s'est poursuit en les classifiant par taxon, anatomie et en registrant leur position et forme. De nouvelles observations ont été conduites à l'aide du microscope optique et du microscope électronique à balayage et toutes caractéristiques des traces ont été enregistrées pour confirmer ou nier leur origine anthropique. Cette méthode nous a permis de mettre au jour l'exploitation non alimentaire des animaux et éclairer l'origine des traces observées sur un fragment distale d'humérus humain qui semblait se rapporter à quelque sorte de rituel funéraire.

Key words: cutmarks, pseudo- cutmarks, osteology, SEM.

Many subsistence practices of human groups generate visible traces on skeletal remains of the animals involved in these processes both in archaeological and contemporary cultures. Ethnographic descriptions of butchering, carried out among modern groups of hunters have analyzes techniques and patterns of dismembering, filleting and skinning processes. Even if there is some variability in procedures, it is possible to elaborate reference models of actions generating similar typologies of traces on skeletal remains. Cutmarks are one of these traces that could be observed on archaeological remains. They were often used to describe also behavioural, social and economic aspects of past cultures, but only after several ethnographic researches their actual meaning has been understood.

Modern standards of cutmarks studies are focused on location, orientation and morphology of the cuts found on bone surfaces and these data are always crossed with those recorded for contemporary societies in order to provide an interpretative framework. Binford's field-work carried out among the Nunamiut of Alaska (Binford 1978; 1981) and the Bushmen of Kalahari shows that is possible to infer the human behaviour reflected on the bones, but, more important, that the assumption that all marks occurring on archaeological bones are the result of human activity must be seriously reconsidered. As a matter of fact several non-human agents can produce marks on bones, such as sedimentary clasts, animal actions or even biostratinomic phenomena.

Non-anthropic agents could be responsible of the production of pseudo-cutmarks even on human bones, and this could generate frequent misunderstandings about the correct reconstruction of peculiar burial practices or rituals. Moreover, even when humans could be identified as the only responsible of the observed modifications on bone surfaces, ethnography has demonstrated that the paradigm that cutmarks on human remains are the result of cannibalism must be reconsidered.

In fact, dismembering and/or defleshing of bodies could be often related to secondary burial practices or complex rituals not necessarily involving meat consumption. This kind of behaviour is more widespread than we could expect, so it is very important to consider a large set of data about differential patterns of skeletal elements frequencies, traces distribution, and, in order to rule out pseudo-cutmarks and non-human agents, traces morphology and location.

For instance, studies carried out on Fijian archaeological and contemporary burial contexts have shown that in the site of Vunda (AD 800-1600) cannibalism hypothesis is

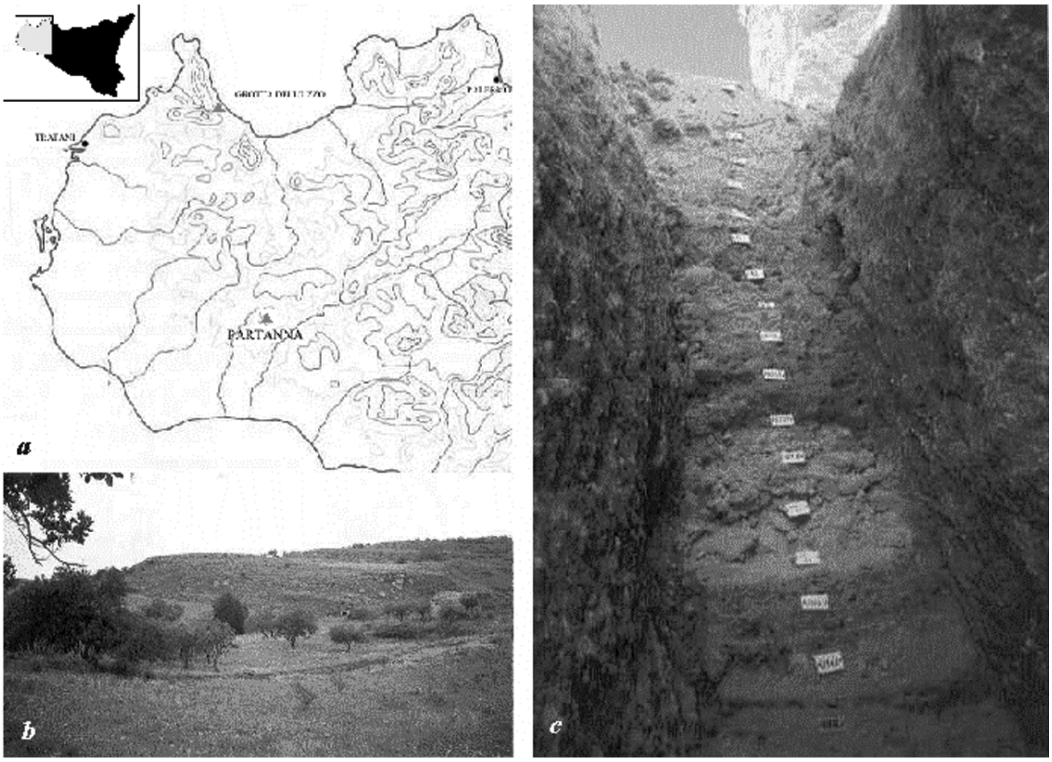

Fig. 1: a, Map of western Sicily showing location of Partanna site; b, Panoramic view of the Contrada Stretto area; c, Partila view of the stratigraphy of the ditch.

not supported (Degusta 2000) and that the modifications of the skeletal sample could be referred to peculiar mortuary rituals.

The Contrada Stretto-Partanna ditch

The so-called Contrada Stretto-Partanna is located in the south-western part of Sicily in the administrative province of Trapani (Fig. 1a;1b). During the seventies a Neolithic site was discovered (Fig. 1b) by S. Tusa and I. Valente as a consequence of some observations that they carried out on some outcropping lens high in ash content and with fictile remains and lithic tools (Tusa and Valente 1994).

The excavations, carried out in two different campaigns (1988/89 and 1994), brought to light a ditch up to 13 m deep. The function of this imposing structure is unknown so far. Its complex stratigraphy (Fig. 1c) starts with some levels referred to Middle Neolithic and containing pottery remains typologically related to the end of the so called *facies* of Stentinello and ends with stratigraphical units containing typical materials of the end of the Upper Neolithic assigned to the *facies* of Diana (Nicoletti 1999).

The impressiveness of the ditch induces us to think about the complexity of the relative human group. The functional interpretation of the ditch is made more difficult by the presence of some human skeletal remains whose occurrence has been explained as a consequence of secondary lying (Di Salvo 1999).

Radiocarbon dating, carried out by the Laboratorio del Centro di Studio per il Quaternario e l'Evoluzione Ambientale of the University "La Sapienza" of Rome, allowed us to propose for the whole stratigraphic sequence a time range between the VIth millennium BC (cal.) and the Vth millennium BC (cal.).

The osteological assemblage (layers 1-16)

Since human and non-human modifications of bones have a very different value in archaeology, it is an important topic to work out a methodology that allows us to distinguish the actual nature of the modifications agent.

The analyzed faunal assemblage, coming from the upper units (layers 1-16) of the ditch and consisting of 1247 remains, includes most domestic animals, as ovicaprines, swine and bovines; but, the presence of wild animals too, as deer and, probably, wild boar and aurochs, attests the weight of hunting practices for the studied human group.

According to the Number of Identified Specimens and Minimum Number of Individuals (Fig. 2), ovicaprines prevail over all species. The presence of bones coming from the whole skeleton and, moreover, of neonatal or infantile individuals is a sign of their breeding within the village.

Deer follows statistically the ovicaprines, a demonstration of the important economic role played by hunting in such settlement. The age at death calculated for this *taxon* was

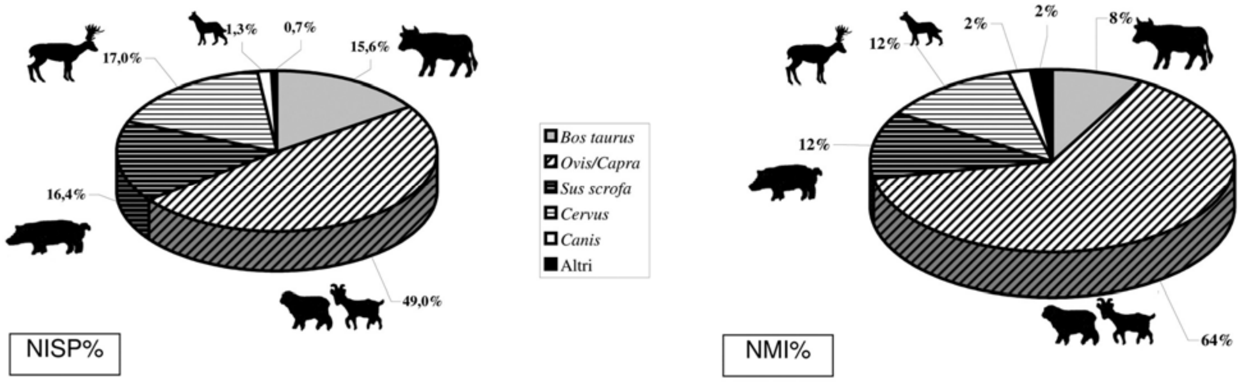

Fig. 2: Composition of the faunal assemblage calculated both in terms of NISP% and NMI%.

about 2-3 years, and more probably it could even goes over.

Pig's remains point out an interesting interpretation. Distribution of anatomic parts suggests that they are wastes of a primary butchering occurred into the village because of the absence of limbs and the high number of cranial elements, as teeth. The animals were killed at young age, they don't go over one year of age; then, the exploitation of these animals is essentially related with meat consumption.

Remains of *Bos* are less frequent: all anatomical parts are well represented and most of the individuals are adult, probably utilized for traction in the fields and then butchered to exploit primary products, as meat.

The faunal assemblage includes some sporadic dog remain (1,3 % in terms of NISP) and bones of others *taxa*, as *Micromammalia* and *Aves*, but they appear of little importance.

Marks on bones: testing their origin

Butchery and skinning marks are definitely the result of a human action. This kind of traces is easily recognizable because of the V-shaped outline of the produced grooves and the presence of secondary striae visible inside or outside the primary groove often as a consequence of instruments retouched edges (Lyman 1994). These features are difficult to see and use of both optical and scanning electron microscopes is recommended when examining doubtful traces. Moreover SEM images could add several data when examining details of butchery and skinning marks like the sequence and the direction of movements made during the process of transformation of the carcass (Fig. 3).

Animal modifications related to carnivores teeth and rodents incisors (gnaw marks) distinguish their selves from butchery marks by the rounded section of furrows and, when occurring, by the appearance of coupled grooves corresponding to the cusps of two adjacent teeth (Fig 4). Another way to discriminate this kind of traces is to examine their arrangement normally following the coarse state of bones surface.

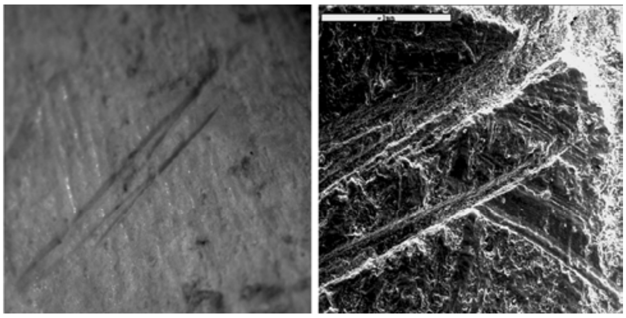

Fig. 3: *Cervus elaphus* radius showing cutmarks: on the left OM 10x; on the right SEM microphotography showing stratification and secondary striae.

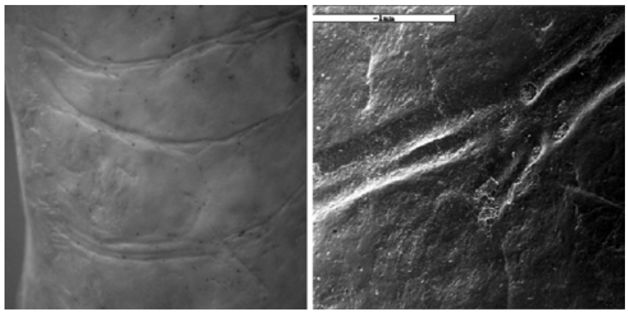

Fig. 4: *Cervus elaphus* radius with gnaw marks: on the left OM 10x; on the right SEM microphotography showing U section of the grooves.

Vascular grooves are sometimes very similar to preceding categories of marks, in some cases even using scanning electron microscopy. When they did not occur in group, these grooves are often hard to discriminate, but some of their morphological features, as trade and lamellar morphology of groove bottom, can be used in order to be sure of their physiological nature (Fig. 5).

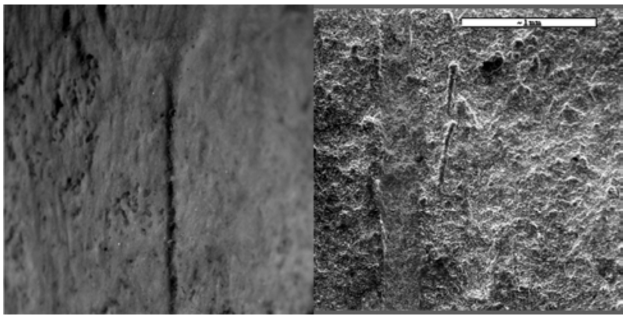

Fig. 5: *Ovis* tibia with vascular groove: on the left OM 10x; on the right SEM microphotography showing lamellar morphology of the groove.

Marks produced by sedimentary particles are related to trampling events and then these modifications are assigned to taphonomic processes. Generated grooves are very irregular in shape because of the particles heterogeneity. Even though sometimes they could appear straight and well defined so they could be confused with butchery marks, SEM images show often discontinuous marks with coarse bottom and U-shaped sections with rough margins.

Different kinds of marks on osteological remains coming from the upper units (layers 1-16) of the ditch were examined. A first list of marks was made using only the naked eye, and then they were organized by *taxon* and anatomical part and classified by their shape and position. Then the analyses were carried out using both binocular and scanning electron microscope in order to identify diagnostic features that could confirm or deny their anthropic origin.

Particularly, the use of SEM provides us a useful instrument in order to assess patterns of distinctive morphologies concerning butchery marks, animal modifications as gnaw marks, abrasion by sedimentary particles, or even peculiar physiological features as vascular grooves (Malerba *et al.* 2000). Our study was carried out with a Nikon optical microscope SMZ 800 and a Cambridge Stereoscan 240 scanning electron microscope. SEM observations of doubtful traces permitted to discriminate anthropic against non-anthropic marks on bones and only definite anthropic marks were listed and arranged using Binford’s inventory of skinning and butchering marks (Binford 1981). After this testing procedure we were able to advance some hypothesis about the exploitation of animal resources.

Meat was not the only purpose for animal breeding. Skinning occurred on sheep and goats individuals and on *Bos* as well, as demonstrated by the presence of cutmarks on metapodials (Fig. 6).

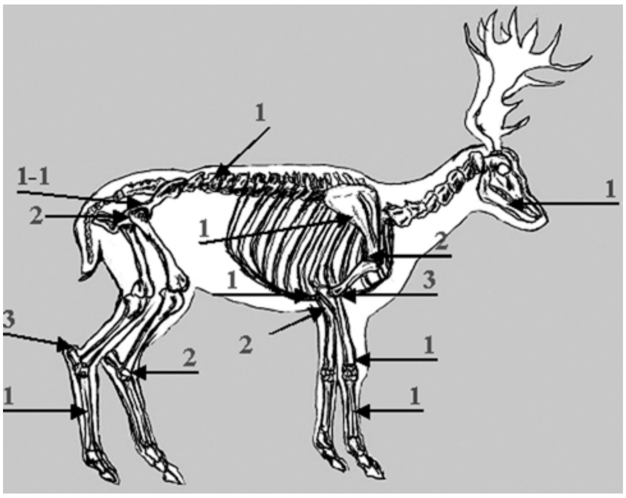

Fig. 7: Map of cutmarks identified on *Cervus elaphus* bones.

On the other hand, deer remains represent only some portions of the whole skeleton; part of the limbs are definitely related with the exploitation of meat, but their distal segments (metapodials and phalanges) and the skull, were introduced in the village with skins. Cutmarks distribution on such anatomical elements confirm the hypothesis (Fig. 7).

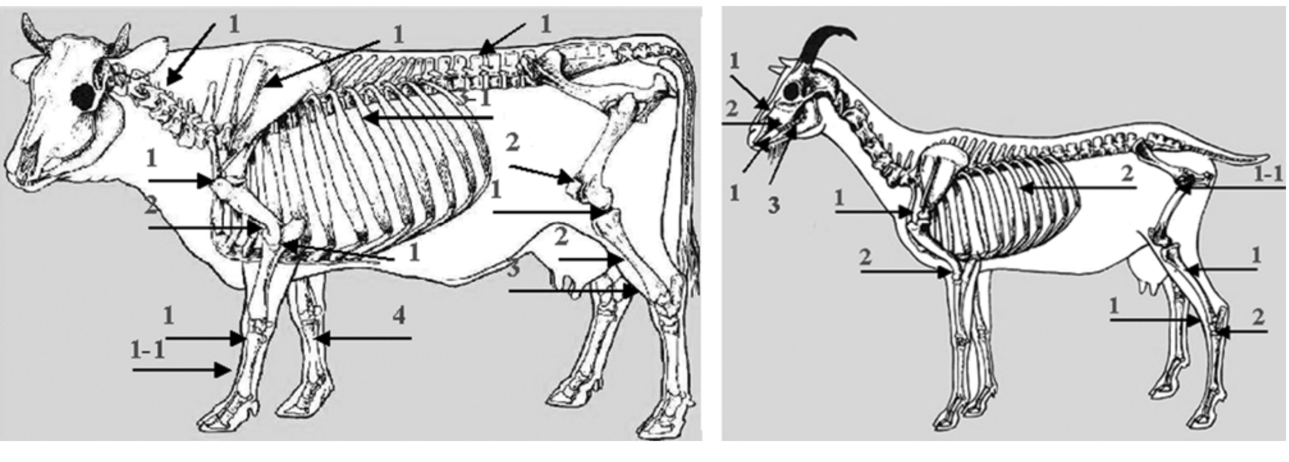

Fig. 6: Map of cutmarks identified on *Bos* and *Sheep/Goat* bones.

A peculiar case-study: human humerus ST A2 147.

The examined osteological sample contained some human bones mixed to the animal remains. As said before, human bones were brought to light during the excavation of the ditch and interpreted as secondary burials.

The naked eye observation of a fragment of human humerus (labelled as ST A2 147) set an interpretation problem. Because of its orientation and position a doubtful trace, located on the lateral side of the distal third of the diaphysis, could be related to the disarticulation of the elbow joint (Fig. 8).

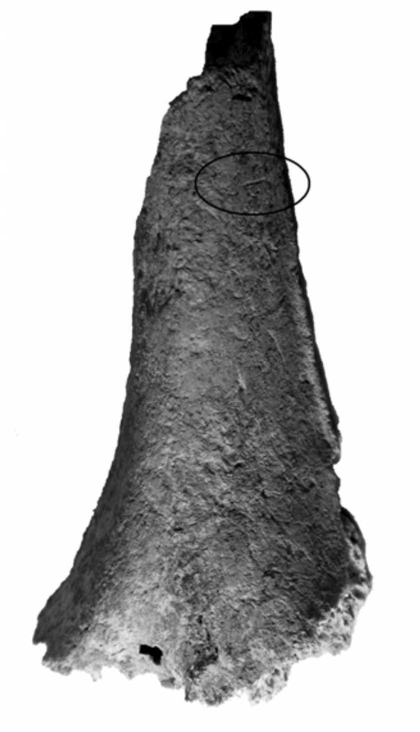

Fig. 8: Human humerus ST A2 147. Circle shows the location of the doubtful mark.

As demonstrated by several authors, rituals involving practices of manipulation of human bodies that could produce cutmarks are recorded in the Mediterranean Neolithic burial contexts. For instance body defleshing and disarticulation was practised in Algeria by Capsian nomads whose mortuary rituals involved secondary re-burial of the bodies (Haverkort and Lubell 1999). Our first hypothesis was that, during the Neolithic in the Stretto Partanna area, bodies were temporarily disposed in some kind of collective grave and later the bones were collected after the disarticulation of residual joints. The ditch will be then used as a collector for the removed bones and this could explain the presence of secondary-laying human bones mixed to the faunal remains.

We applied the testing procedure to the observed mark in order to confirm or reject this hypothesis. First observations made by means of optical microscope did

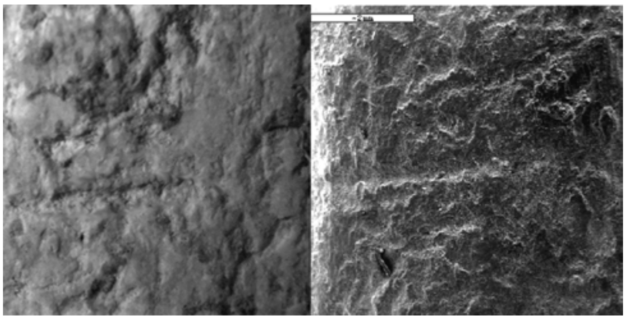

Fig. 9: Particular of the mark observed on human humerus ST A2 147: on the left OM 10x; on the right SEM microphotography showing irregular shape of the edges and the coarse aspect of the bottom.

not exclude an anthropic origin of the groove, but SEM images highlight the irregular edges of the groove and the coarse aspect of its bottom (Fig. 9).

According to this features, the U shape of the groove section and the loss of secondary striae, the trace must be related to non-anthropic agents, particularly to abrasion by some sedimentary particle and no clarifying hypothesis can be made about human bones presence in the ditch.

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Cooking and firing, on heated sandstone: an experimental approach by SEM

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Summary. *Macroscopic and microscopic alterations in function of various heating process and transfer phenomena of cooking residues were observed on stones. An experimental approach and microscopic analysis by SEM. were applied to observe these phenomena and to determine identification criteria adapted to archaeological context. So we have been able to characterize the stone boiling technique by the detection of particular stone alterations during re-utilization. Moreover, among the different types of residues present on stones, it seems possible to discriminate cooking residues from those of animal or vegetable origin.*

Résumé. *Des altérations macroscopiques et microscopiques ont été observées sur des roches en fonction de différents processus de chauffe ainsi que des phénomènes de transfert de résidus de cuisson. Une approche expérimentale et l'analyse microscopique au M.E.B. ont été appliquées pour étudier ces phénomènes et pour déterminer des critères d'identification adaptés au contexte archéologique. Nous avons ainsi pu caractériser la technique de cuisson de bouilli par pierres chauffantes par l'apparition d'altérations particulières sur les roches lors de la réutilisation. De plus, il semble possible de discriminer dans les roches entre des résidus de cuisine d'une origine animale ou végétale.*

Key words*:* heated rocks, experimentation, SEM, stone boiling, macroscopic and microscopic alterations, cooking residues*.*

Introduction

Heated rock utilization as element of cooking is spread worldwide and well testified ethnographically. Prehistorians have tried to identify these practices in the archaelogical record. However, the main difficulty is to differentiate between the utilization of a stone as a structural part, e.g. of a hearth, from its use as a cooking element (e.g. stone boiling, grilling, earth oven) (Carlier 1992, Julien 1985, Thoms 2003, Wandsinner 1997). Generally, the hypothesis of stone utilization came from particular associations of different kinds of archaeological remains (empty areas, particular forms of fire structure or association with faunal remains) (Julien 1984, Leroi-Gourhan and Brezillon 1966, 1972, March 1996, Perles 1977). Considering this, developing methods and tools, which can help in the reconstitution of stone cooking history, or more globally of cooking process, is a big challenge for archaeological research.

Heated stones are artefacts which attest this practice more directly: we have tried to bring to the fore specific anthropological alteration. Previous studies showed that the transfer of cooking residues, absorbed by the stone during cooking, can be used for taxonomy purposes and to identify cooking techniques (March and Soler Mayor 1999, March and Lucquin 2005, Quigg *et al.* 2001).

We can consider two other kinds of transformations due to cooking process. The first one is a physical alteration of the cooking stone. The rock undergoes thermal alterations of several sorts: colour, cracks and breaks. Some studies based notably on analysis of stone boiling technique have sought to characterize these alterations that appear during cooking (Batchelor 1979, Pagoulatos 1992)

The second one is the absorption of food material, linked to the appearance of blackening. Blackening of a rock is the result of diverse cooking residue deposited on a cook stone: tars, soot, charcoals, ashes, and so on. The nature of cooking residues depends on the use of the stone as a hearth structuring element or participating in the culinary activities. Of course, we are aware of the possible taphonomical origins of stone's blackening, but confusion is limited to a macroscopic level of analysis.

In fire structure studies, the experimental approach is unavoidable (March 1996, March and Wünsch 2003, O'Kelly 1954). The reproduction of the cooking process and the constitution of comparative corpus, coupled with an analytical perspective can allow us to approach these problems.

Several previous research showed different aspects and interest in the use of SEM, in particular with regard to the understanding of functioning and functions of fire structures. Purdy (1982) studied thermal transformations of metamorphic stones related to flint stone technology. Bazile (1987, 1989) studied transformations under fire effect of the molasses of Fontgrasse (France). Another example is provided by the study led by March and Soler-Mayor (1999) concerning sandstones coming from Marolles-sur-Seine (France), in order to understand the use of these rocks. They were able to suppose that sandstones were utilized for indirect meat cooking. Lastly, remain the study concerning Le Closeau (France), or at Cova negra (Spain) for calcareous ones always in order to know the chemical composition of the samples, and then to see the morpho-structural changes due to thermal alterations (March, B. Soler Mayor 1999; March, B. Soler Mayor, S. Vertongen 2003; Purdy 1982; Soler Mayor 2003).

So we developed an experimental approach linked to SEM analysis to study firing and cooking practice following three axes:
- Show stones' alterations during their utilization as element of cooking, (e.g. stone boiling).
- Understand to what extent SEM allowed us to study the different aspects of mineral element of cooking residues.
- Try to distinguish the origin of residue left on stones (e.g. animal, vegetal,etc.) with SEM.

Experimental phase

We carried out different experiments in realistic and in laboratory context.

Experiment 1: From the same stone (a yellow sandstone), we cut two fragments with a planar surface (cut surface). The fragments are heated in an electric oven at 600°C for one hour. Subsequently, one of them is put in water (150ml of distillate water) at room temperature (nearly 18°C) and the other one is left for air-cooling at room temperature. When the stones are cooled and dried. We start the operation all over again until one of them breaks (the stone, which was cooled in water, was broken during the eighth reuse). The stones are scanned before each use.

Experiment 2: It is a laboratory cooking experiment. We use sandstone to cook green leafy vegetable (*spinacea oleracea*) in water. In the first experiment, the stone was used one time and in the other the stone was reused. The two stones are coming from the same sandstone block (as an unheated sample and a simply heated one). In the first experiment, the sandstone was heated in an electric oven (600°C) for two hours. Then it was placed in hot water (92°C) to simulate a pre-cooking. The ebullition was immediate and started to decrease after 43 seconds. Macroscopic activity (boiling and simmering) finished totally after two minutes. The stone was maintained in the water for five minutes more, and subsequently removed to dry.

In the second experiment, the water was not preheated. The stone was heated and used as the first one, but when water started to cool, the stone was heated again: firstly for 25 minutes, and then heated eight times during 10min. During this experimentation water didn't boiled, the maximal temperature was 84°C, but we noticed a local ebullition (around stone surface). Total experimental cooking time was 139minutes but the stone was in water for only 28.5 minutes (immersion cumulative time). In the final immersion, the stone was maintained in the water for five minutes more, and next removed to dry.

Experiment 3: We created a real hearth. The fire structure consisted in a flat hearth crowned by stones. Two samples were taken, sandstone blackened by smoke and another one blackened when it was deposited on the grassy ground still hot.

Experiment 4: It is a laboratory cooking experiment. The sandstone was heated in an oven at 600°C for 3 hours. Next, we cooked a piece of beef directly on this hot stone (grilling).

Materials and methods

Scanning: Stone scanning is carried out with a scanner with a 2400 dpi definition. Estimated porosity percentage is established by a count of black pixel by binary white/black analysis in function of total image pixel after image treatment (blackening holes and cracks).

SEM: Samples were analysed by a JEOL-JSM-6400 scanning microscope coupled with an X-probe for EDS (Energy Dispersive Spectrometry) analysis from Oxford Isis. The surface is scanned with secondary and retro-diffused electron beam, and several elements are quantified (Element are expressed in atomic percentage). We observed systematically the internal surface at four levels (0 to 1mm, 1 to 2mm, and 2 to 5mm) in order to appreciate depth of penetration and/or some phenomenon's graduation at systematic enlargements and the cortex or external surface. We fixed five scales of analysis: x10 and x30 for a general view, x100 for cartography, x1000 as scale of study, x5000 for detail.

Stone alteration during stone boiling process

Macroscopic view
As we observed in previous experimental studies (Lucquin, R.J. March 2003), the alterations between stones cooled in water and in air are not possible to differentiate after one utilization. Nevertheless, some authors as Batchelor (1979) or Pagoulatos (1992) showed that macroscopic thermal alterations produced by stone boiling (cracks and breaks) become more and more marked with the reutilization of stone. In experiment No. 1, we characterized the specific alteration between these two kinds of cooling and their increase with the reutilization (Fig. 1).

After the first use, we could not notice real differences between the two stones. However, the stone which was cooled in water seems to have had an increase in porosity represented by a light increase of holes covering its surface. When stones are reused the one cooled in air does not seem to have new alterations whereas the other is more and more altered.

So the estimated porosity (Fig. 2) seems to be more or less constant for the stone cooled in air while we note a large increase, proportional to the number of reutilization, for the other one. We can explain it by an increase of the space between the quartz grains and by losses of theses grains, creating holes in the surface or enlarging the existing ones.

Consequently the stone surface is being covered by a grid of cracks following the porosity holes, which makes it

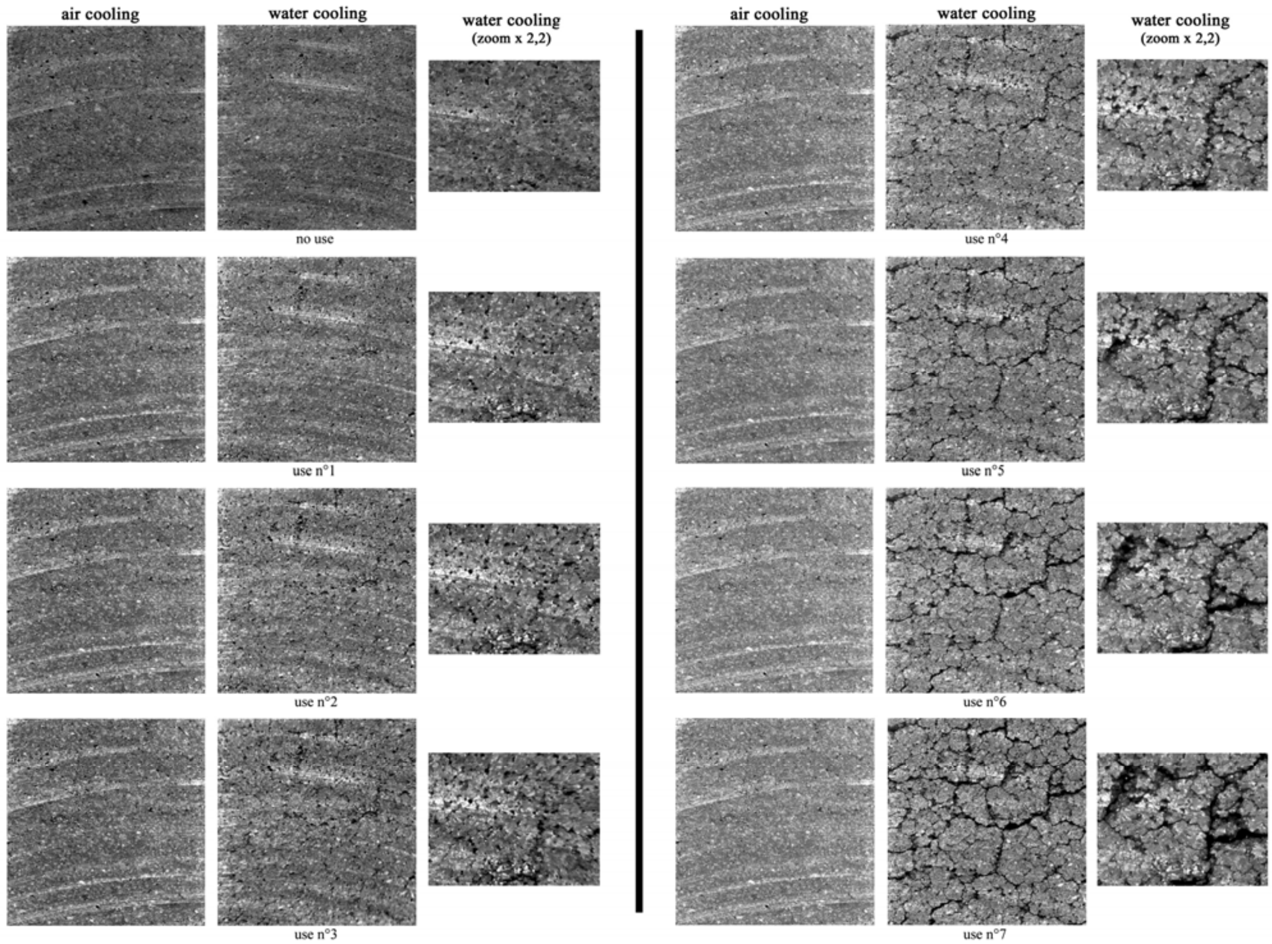

Fig. 1: Scanned surface of experimental stones, exp. 1.

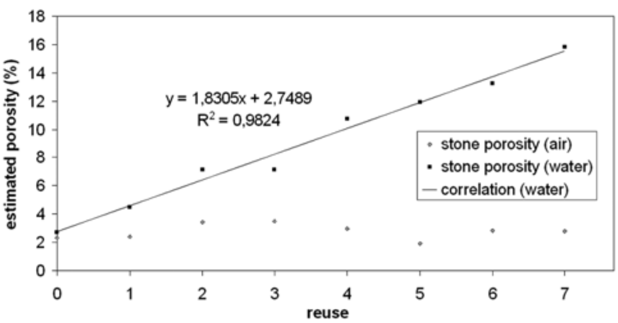

Fig. 2: Sandstone porosity in function of reuse, exp. 1 (image analysis process with Photoshop).

weaker. So during the eighth utilization, it broke following the line cracks. Moreover, this kind of cracks and breakages are quite different from those forming during heating in a hearth. These latter ones are more conchoidal than those produced by stone boiling which are more irregular. These phenomena induce a change in stone density.

Microscopic view

To explain the macroscopically observed phenomena, four samples were analysed in MEB, two stones coming from experiment No. 2, another one unheated and the last one heated in the same condition but which was cooled in air. We were particularly interested in the transformation of the sandstone cement during cooking practice.

For the unheated sandstone, we can characterize this cement as a thin and homogeneous paste rich in iron. This cement fills the intergranular space, recovering and hiding the quartz grain surface in a coating form (Fig.3).

The study of the heated stone cooled in air brought to the fore the alteration due to the heating process. We could note an alteration of the cement, represented by a decrease of its quantity in intergranular space and in some part it became pulverulent too. Concerning the recovering of grain surfaces, these were still present, but their aspect was crackled (Fig. 3).

For the stone cooled in water, the alterations were much more important. We observed the cement disappearing from the intergranular spaces and from the grain surfaces. When this cement was still present, we could not describe it as a homogeneous thin paste but as an aggregate of microgranular quartz (Fig. 3).

Therefore, we could observe that the use of this technique really spoils the cement of the rock. These alterations are going to be more marked when the rock is reused. The

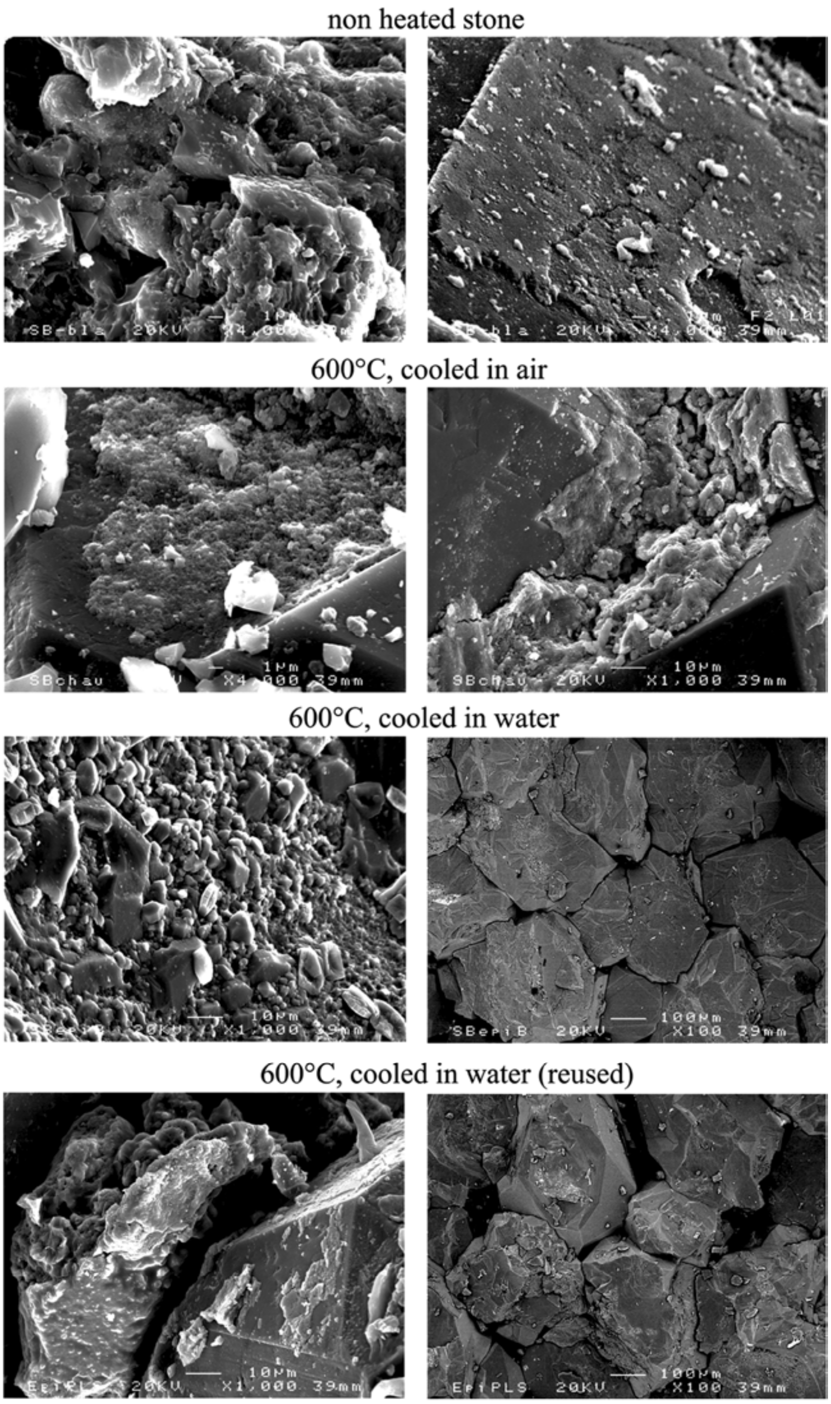

Fig. 3: S.E.M. pictures of experimental stones, exp. 2.

cement is disorganised and dissociated, and there are few shreds of recovering in the surface grain. More generally, grains seem to be dissociated with important intergranular spaces often empty of cement. Quartz grains are also altered; they seem chipped and present important cracks (Fig. 3). This marked alteration of the cement explains the alterations that we observe macroscopically (increase of porosity, cracks).

Differences in the alteration, between stones cooled in air and in water, seem to be due to a leaching of the stone during the boiling process which removes the dissociated parts of the cement and which can be recovered as a stone dust in the container after the experiment. So a particular stone alteration exists for this cooking techniques (cracking and breaking linked to cement degradation) and increases with the reutilization of the stone.

A preliminary approach to the problem of residue origin

Several processes can produce stone blackening or organic adherences during cooking and firing. We employed the SEM and inorganic element analysis to differentiate them.

Non heated sandstone, experiment 2 (Fig.3)

The external zone or "cortex" has got a planed and worn aspect but seems to have homogenous cement constituted by iron, titanium, silica and aluminium. Iron is under the form of veneer on quartz grains. In natural conditions, apart from silica (26.13%), we can observe carbon (13.43%), iron (0.17%), calcium (1.14%), sodium (0.10%), sulphur (0.13%) magnesium (0.07%) and titanium (0.03%) (Fig. 4). At 1mm, we can note the increase of iron (0,5%) and titanium (0,06%), and the decrease of others elements (silica 26.77%; carbon 11.28%; magnesium 0%; sulphur 0.09%; and calcium 0.11%), only sodium stay on the same percentage (Fig. 4). At 2mm, we can note the increase of iron (0.98%), sulphur (0.18%), sodium (0.17%) and a best representation of silica (28.14%). On the other hand, we can see the decrease of carbon (7.8%), calcium (0.03%), magnesium (0.05%) and titanium (0.04%) (Fig. 4). By imaging, it seems to have calcium inside cement, and iron looks more diffused. At 5mm, most of the element are decreasing (carbon, 4.22%; iron 0.37%, others tend to zero), that allows a best visibility of silica (30.09%) (Fig. 4).

After this first presentation we know to what extent sandstone is not only composed of silica. So we can see that without cooking residues, we can already find

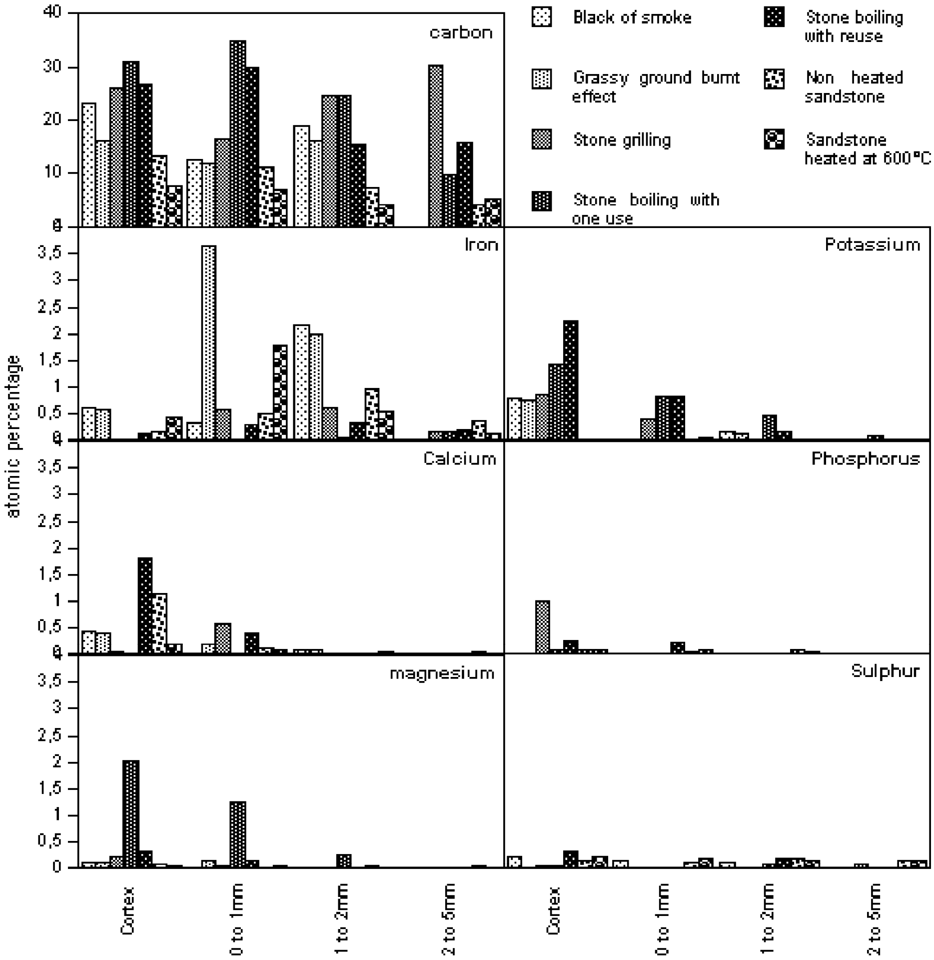

Fig. 4: Main characteristic elements of cooking and burnt residues.

heating effect. Moreover, they are only present in little quantities. It is the same case with calcium which decreases under heating. So, carbon and calcium can be considered as discriminatory.

Concerning partial higher iron representation in heated stone, it can be explained by the conjunction of three phenomena (March, B. Soler Mayor 1999):

- Quartz grain alteration due to heating and disappearance of the cement homogeneity.
- Disappearance of certain minerals under heating allowing a best representation of iron.
- During heat transfer, heat will be diffused by decreasing way from the outside of the rock to the inside; converting goethite (iron hydroxide) in hematite (iron oxide) due to water loss and change of crystalline system under increase of temperature inherent in exposition to radiations of a heat centre.

carbon, magnesium and calcium, but not really phosphorus that always tends to zero.

Sandstone heated at 600°C, experiment 2 (Fig. 3)
Concerning the cortex, except for the silica (28.86%), we can find Carbon (7.58%), iron (0.43%), aluminium (0.39%), calcium (0.18%), sulphur (0.20%), others elements tending to zero (Fig. 4). At 1mm, except a best visibility of silica (30.14%) and iron (1.78%), all elements are decreasing, such as carbon (6.81%), aluminium (0.27%), calcium (0.09%), others tending to zero (Fig. 4). At 2mm, silica is more and more visible due to continual decreasing of other elements, like carbon (4.28%), iron (0.55%), others elements tending to zero (Fig. 4). Lastly; at 5mm, except a non-significant increase of carbon (5.09%), only silica has been clearly observed (Fig. 4). Imaging allows to see that cement is eroded and iron veneer seems to have disappeared and tends to be a "background noise".

After this two studied samples, we can admit that the initial presence of carbon and associated elements is not problematic, given that they tend to disappear under

Black of smoke, experiment 3
The cortex shows a washed and eroded aspect (Fig. 6.1). It is possible to note the presence of iron on the surface (0.61%), associated with calcium (0.43%), and potassium (0.78%) and aluminium (1.09%). Carbon is well represented (23.25%) but difficult to be positioned. This may be explained by the fact that cooking residues film is far from thick. This allows the electron beams to transpierce it and reach the lower silica. The presence of iron before the patina, seems to be more a deposit formation than a transformation of inner stone iron. The percentage of aluminium increases clearly by places and can dissimulate carbon somewhat. Other elements are fleeting (Fig. 4). At 1mm of surface, carbon is very difficult to be seen, even if it represents 12.56% of the components of the rock, and iron represent 0.33% of the sample. At 2mm of surface, there is not great change, but we can observe an increase in carbon percentages (18.96%) that followed those of iron (2.17%). This increment takes a "crust" layers appearance. Although it appears more present according to the analyses, carbon

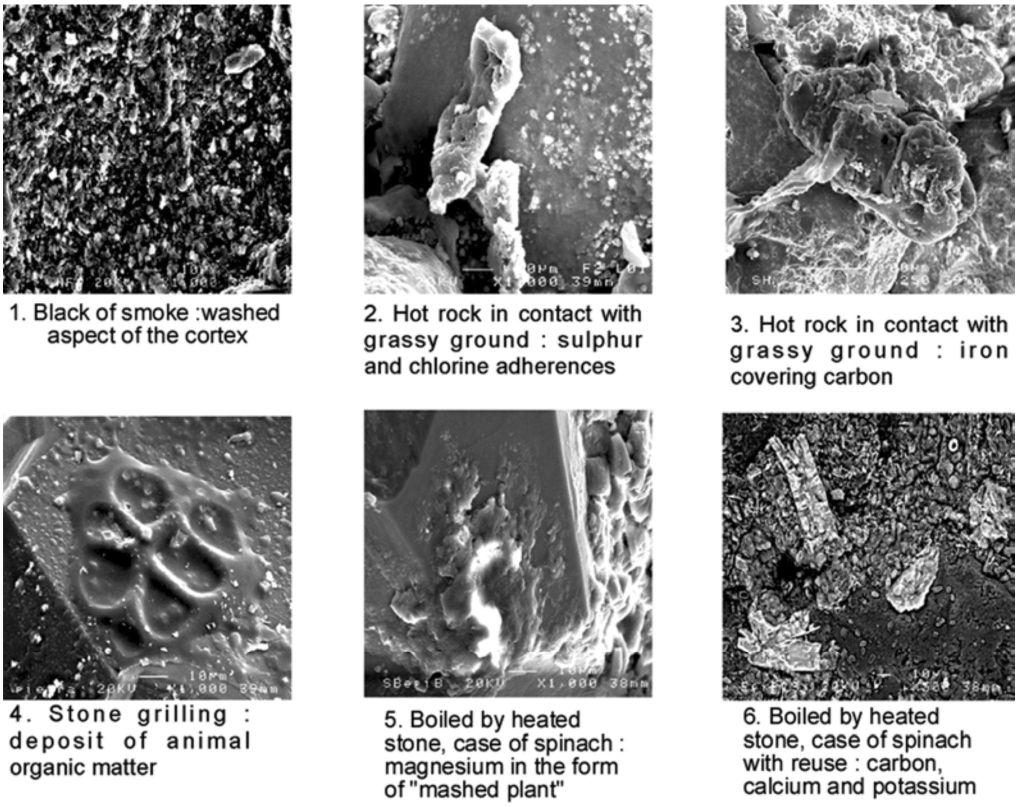

Fig. 5: Several aspects of the study of cooking residues by the way of S.E.M.

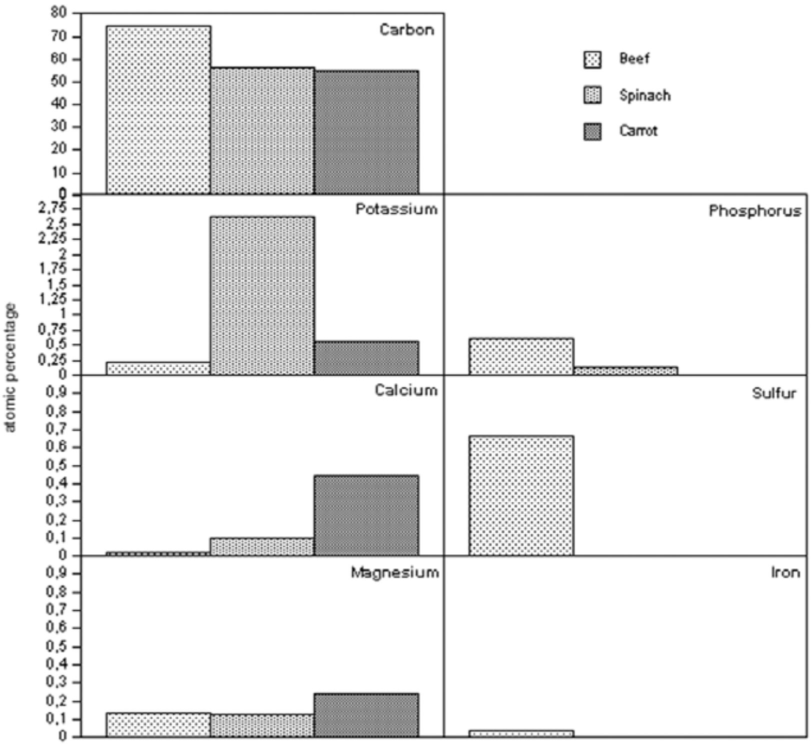

Fig. 6: Percentage repartition of the main elements characterising beef, spinach and carrot.

remains always difficult to be positioned by imaging analysis. At 5 mm, the rock is a little richer in silica and carbon somewhat decreases.

Burnt grassy ground effect, experiment 3
The general aspect of the cortex seems to be rough, and presents marks of iron (0.58%) and carbon (16.27%), always in small quantity. This is related to an important porosity. Carbon seems to be present in the form of a fine film and has a "powdery" aspect. At 1mm from the surface the presence of carbon (11.94%), although obvious with the naked eye, is almost unperceivable, even after several enlargements. It results in very rare adherences, sometimes also made up of sulphur and chlorine only visible by imaging (Fig. 6.2 and Fig. 6.3). At 2mm of depth, carbon is a little more present (15.97%), and is sometimes covered with iron (2%) (Fig. 6.3). Other elements are very little fleeting (Fig.4). At 5mm of depth, we observe a larger porosity, which could allow the carbon penetration within the rock. We can also note the presence of calcium carbonate in the form of tubes.

Stone grilling, experiment 4

Macroscopically, the cooking residues are perfectly visible; they result not only in their black colour; but also by some calcinated meat residues and a black and shining deposit, consequence of the heating of the "liquid losses" of the meat. The cortex contains above all carbon (25.99%) phosphorus (0.99%), potassium (0.86%), and calcium (0.47%), which seem significant of meat cooking. This raw material is present in a diffuse way. At 1mm, it is possible to observe cooking residues deposits above all consisting of carbon (16.48%), potassium (0.39%), iron (0.58%) calcium (0.58%), somewhat presenting a velvety aspect at the surface of the quartz grains (Fig. 6.4). The rock is rather friable subsequently to heating, which reveals not very dense cement, porous, favouring cooking residues penetration. At 2mm, cooking residues almost disappear, but there remain still carbon (24.69%) and iron (0.63%) (Fig. 4). Cement always presents a faded aspect, which may allow cooking residue penetration. At 5mm, carbon (30.24%) is punctually present into pores of cement deterioration. Cooking residues always presents the "run-out" aspect mentioned above.

Then in this case, the double source of information delivered by SEM allows a detailed observation of the cooking residues, which is more concentrated in the cortex; and not only an observation almost reduced to the only limits of the presence and absence, the images being almost unusable.

Stone boiling, experiment 2

Cooking residues are represented by the images as well as by the analyses. They are noticeable in the form of spots, of mashed plants stuck to the surface of quartz (Fig. 6.5). The cortex presents potassium (1.43%) concentrated in places in the form of white deposits, while magnesium (2.01%), calcium (0.02%), potassium (1.43%) and carbon (30.99%) are present in a more diffuse way, in the case of images. Iron tends to zero. At 1 mm, the organic proportion of matter clearly decreases; in particular with magnesium at 1.24%, and 0.83% for potassium. Iron tends to zero. At 2mm this trend is confirmed, given that magnesium is at 0.27%, potassium at 0.46% and carbon decreases too with 24.56%. Lastly, at 5mm, it is possible to observe that cooking residues tend to completely disappear (Fig. 4), except a few potassium chloride projections because of the pores and the cracks. With imagery, carbon seems to have disappeared, as a matter of fact, it is still present with 9.67%.

Stone boiling with reutilization, experiment 2

This time, cooking residues seem to be more diffuse, and only in asperities, cracks of the grains and intergranular spaces; but that is not very well represented by the imagery. That is why we resorted to analyses, which show in the cortex the presence of carbon (26.86%), the reduction in magnesium (0.34%) and potassium (2.23%), as well as the more visible presence of calcium (1.82%) and iron (0.13%); comparing with the sample with one use. The legibility of cooking residues image at 1mm is similar to the one use example; the recourse to the analyses is thus once again essential to detect the presence of carbon. This one represents 29.91% whereas there is 0.15% of magnesium, 0.81% of potassium, 0.28% of iron and 0.39 % of calcium. At 2 mm, only the analyses allow to observe the presence of the cooking residues by the way of carbon (15.27%), iron (0.33%) and potassium (0.16%). At 5mm, only carbon (15.91%) is observable by the way of analyses, the other elements having percentages tending towards 0% (Fig. 4). Even if carbon is difficult to be seen and positioned, the representation of the cooking or burned residues is however observable by means of imagery and analyses for magnesium, potassium and calcium. (Fig. 6.6).

Following these observations, it is possible for us to note the effectiveness of this technique for the study of the cooking or combustion residues, although the imagery is sometimes insufficient when the elements to be observed are too slightly present and/or too diffuse. The probe analysis makes it possible to mitigate this difficulty from a distribution point of view on a given surface and from an identification point of view of the elements. But it does not replace the data of the aspect of each phenomenon. That teaches us that a few cooking residues are enough to mark and black-colour the stone. Thus in the case of the black of smoke, the observable phenomenon on the rock required only few quantity of carbon.

The analysis is effective even if it returns account only of the quantity and the nature of the elements to be observed for a given surface. Within the framework of our work where it is a question of observing the gradation or the penetration of certain surface phenomena within the first 5mm of depth (after the quantities are too fugacious) this problem does not affect us.

Certain elements can typically be brought by the way of cooking, in particular carbon, iron and calcium. Nevertheless they already exist in natural constitution of sandstone. Our studies clearly show that this fact is not detrimental to an approach of cooking residues by SEM given that initial constitution tends to be lightened under a simple heat effect. Then percentages of elements in case of cooking really reflect acquisition of cooking residues during cookery. For example, calcium is a sign of calcinations.

It is however necessary to note two parameters which it is necessary to keep in mind; some atomic elements that are not very abundant and mostly diffuse are over represented by SEM in order to be able to be visible in analysis; more points are solicited. In addition, it is necessary to handle the samples carefully in order to avoid any deposit of pollution coming from the manipulation of stone, which skew the representativity of carbon. The presence of calcite coming from taphonomic processes must be also avoided, and particular treatment must be developed while sandstones are calcified.

These results prompt us to believe that the use of this technique in order to discriminate the origin of the cooking residues would be possible provided that the samples contain sufficient cooking residues.

Considering the corpus we have and the synthetic presentation that we made, the samples ready to be used in this step are the two samples resulting from the experiment of stone boiling and the sample coming from the experimenta of the stone grilling. In order to carry out this study as well as possible, we somewhat increased the variety of our samples. For that, we used a sample resulting from experiment of boiling again a heated stone but with carrots. Then, we used SEM in order to observe a sample with crude beef, spinach and carrots. At first these samples have been placed in an oven and smoothed down in order to offer a plane surface for studying.

Test of discrimination between the cooking residues of animal and vegetal origin

The first exeperiment regarded a sample of dried beef, whose principal components, are proteins, lipids and sugar that give us 74.28% carbon, for this muscle (Figs. 5 and 6.7). Potassium results in 0.23%, along with sulphur 0.66%), phosphorus (0.61%) and a little of magnesium (0.14%). The second sample is a dried sample of spinach. The imagery enables us to observe small crystalline formations on its surface, probably inherent in an insufficient washing which made stay negligible quantities of ground. The observed components are carbon (56.37%), phosphorus (0.15%), magnesium (0.13%)and calcium (0.10%). We can also observe the veins of the sample which present potassium (2.62%) and oxalates of calcium (Figs.5 and 6.8). The last sample is a dried sample of carrot (Figs.5 and 6.9). In addition to carbon (54.63%), components observed are potassium (0.57%), calcium (0.44%) and in a specific way sodium (0.29%).

If we synthesise the elements contained within these three new samples, seven of them seem relevant so that one can proceed to an attempt at discriminating between the animal and vegetable cooking residues. These are: carbon, calcium, magnesium, phosphorus, sulphur, iron and potassium (Fig. 7).

If we considered the whole data illustrated in our charts, the first approach that seems to be necessary is thinking in terms of presence/absence. Carbon is obviously present inside all stones. In fact it is especially the elements that are associated with carbon, which are able to determine the origin of the cooking residues. Iron can principally be observed in the two first millimetres of the stone, because of the high exposure of cortex to thermoalterations that will entail its almost full dispersion. Iron exists in all samples, but principally for stone grilling. Sulphur is rather little represented on the whole of experimental sampling, except in the case of the re-use for the cooking of spinach. It seems more constant within the framework of the cooking of carrot, but in a fugacious way at all events. Potassium, present in the form of potassium chloride, is almost non-existent in the case of carrot; it is undoubtedly inherent with the constitution even of carrot. On the other hand, it is well represented in the three other cases. Two facts are observable; this element is more present in the samples having been used in the cooking of vegetable matter, and if those are compared, its representation is better without re-use until the report/ratio is reversed between 1 and 2mm. Magnesium is not very present in the experiments of stone grilling, re-use and cooking of carrot. On the other hand it is almost ten times more present in the case of the single spinach cooking. Except the cortex, this element is slightly represented. Calcium is present in low values in the sample of stone grilling, and the ratio previously observed with magnesium for the two experiments of cooking spinach is reversed here. For the remainder of the experimental data, its representation within the samples is better than magnesium between 0 and 1mm of surface, and disappears thereafter. Phosphorus, finally, is primarily present in the case of stone grilling, and represents also one of the strongest percentages of carrot. It misses completely beyond a millimetre of surface, and is present at this distance only for the stone grilling and the re-use.

Behind those observations, several sides seem to be evident for sandstone. At first, carrot is less rich than others types of food tested, that is why it is less represented on graphics. Some differences with spinach can be assessed, it contains more phosphorus, but less of all other elements, even in the case of carbon. The most notable divergence between the two types of cooking is the apparition of calcium for the re-use, to the detriment of magnesium, because of the accumulation of ashy elements due to successive calcination of plant residues for stone boiling. A light reduction in carbon for stone boiling and a light increase in carbon for grilling are also to note. Lastly, the more discriminating aspect between the meat and the plants are the strong percentage observed with phosphorus for the first one. On the level of the cortex, it is present in the four samples, but almost four times more in the sample of stone grilling that for the most percentage in the plants. Between 0 and 1mm, it continues in the sample of stone grilling and similar re-use of way; then disappears in the other cases.

Thus, it appears that cortical surface is the best testimony of the various cooking residues which settles and penetrates in the rock. It is there that discrimination can take place.

As for the elements previously studied, four are really relevant in this step of discrimination between the cooking residues of animal and vegetable origin:

magnesium, potassium and calcium for the plants, and phosphorus for the meat.

The imagery is also a good support because the form of the deposit within the rock diverges according to whether it acts of animal or vegetable matter. In the case of the cooking residues resulting from the meat, it acts of 'velvety' and 'oily' deposit; in the case of spinach, the deposit resembles to mashed plants, and in the case of carrot, the cooking residues takes a "sparkling" aspect (Figs. 6.4, 6.5 and 6.6). Certain plants less lends them to this step of the fact theirs low content of each one of these elements; it is what we could note with carrot.

With regard to the identification of the modes of cooking, it was already shown the relevance of this technique with regard to the stone boiling and its various methods.

It is interesting up to what point to ask for this technique of study which is the SEM would be ready to discriminate of other modes of cooking, and other raw material origins.

This method seems relatively well adapted to this type of approach, with the condition of being aware of these limits. It is also effective as preliminary to a study of organic chemistry because it allows a first sorting of the samples with or without cooking residues and probably between certain cooking residues origins. It also makes it possible to know if there is enough matter within a sample so that this one can be studied by the means of the organic chemistry.

Conclusion

This experimental approach has allowed us to bring to the fore several transformations of sandstones due to cooking practices. A specific increase of cracks and breaks has been observed with reuse during the stone boiling process. On the other hand, this study has allowed us to observe in which extent stones blackening were different in function of their origin, and in the same time, to test the limits of SEM in this kind of approach.

It is attested that the penetration processes observed while heating are not the same that the ones we can observed in natural conditions because dilatations and contractions processes at low temperatures are not similar with those presented here. But we must assumed that deposit of inorganic matter in natural low temperatures conditions exists and must be excluded before that cooking hypothesis was affirmed. Furthermore, we think that we have been able to start discrimination between animal and vegetal cooking residues.

Of course, laboratory experimentation is a partial view of real cooking and firing practice, generally bringing to the fore an aspect of the process in certain conditions. Thus a stone that has been used in stone boiling, suffer the cooking alterations but also those happening during fire heating. Or a grilling stone will be blackened by the meat but also by the smoke, and so on.

So theses approaches are being extended to as well realistic experiment to estimate the degree of each kind of alteration, as other cooking practices, and more globally others stones functions.

Then we show the SEM significance as an analytical tool for the study of cooking and firing aspects in archaeological material. Theses analytical tools (SEM, organic chemistry…) as well as descriptive methods (thermoalteration…) linked to an experimental approach in order to have a better understanding of technical processes, improve our vision of firing processes and culinary activities in the past societies.

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An experimental approach to formation of use-wear traces on quartzite tools

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Summary. *Non-flint raw materials played an important role in Bohemia where the glaciations or the Cretaceous sediments were present in a very limited extent as a natural source of flints. Therefore, the alternative raw materials were exploited from the Lower Paleolithic to the Neolithic period. The frequently used materials were quartzite and chert. The selection of the raw material differed not only by the proximity of the possible natural resources but also by the specific chipping qualities of the available raw materials.*
Several quartzite varieties were used in almost all cultures although fashionable trends in the selection of a specific variety are apparent in every culture. This study tried to experimentally verify different development of use-wear traces and functional qualities of each frequently used raw material.

Résumé. *Les matières premières alternatives autres que le silex ont joué un rôle important en Bohême où les glaciations et les sédiments Crétacés étaient présents dans une ampleur très limitée comme source normale de silex. Par conséquent, les matières premières alternatives ont été exploitées du Paléolithique inférieur jusqu 'à la période Néolithique. Les matériaux fréquemment utilisés étaient le quartzite et le silex corné. Le choix de la matière première a différé non seulement selon la proximité des ressources naturelles possibles mais également selon les qualités spécifiques disponibles des matières premières pour la taille de la pierre.*
Plusieurs variétés de quartzite ont été employées dans presque toutes les cultures bien que les tendances à la mode dans le choix d'une variété spécifique soient évidentes dans chaque culture. Cette étude a pour but de vérifier expérimentalement la formation des traces d'utilisation et différentes qualités fonctionnelles des diverses matières premières les plus utilisées.

Key words: non-flint raw materials, functional analysis, Bohemia, lithic, quartzite

The use-wear methodology has not so far been limited only to flint tools, but many other materials, like obsidian, wood, bones, etc. have been experimentally studied and thus contributed not only to a comprehension of the prehistoric cultures, that used the materials for tool making, but also to the understanding of the origin and development of the use-wear traces as a phenomenon. Quartzite is also one of the raw materials, used for chipped industries since the Paleolithic era that, due to its structure, has its own specific formation of the use-wear traces.

Quartzite, as a raw material frequently used in the chipped industry, played an important role at all sites where neither glaciations nor the Cretaceous sea were present as a natural source of flints, i.e. in the whole of central Europe (Czech Republic, Germany, Slovakia, Hungary, Austria). The quartzite used for chipping mainly originates from the tertiary quartz sandstone/sands sediments that were not later metamorphosed. It generally consists of quartz crystals (of variable sizes) and a silica binder. Quartzite has a very good chipping quality and also allows a shell break. The archaeologists supposed that some of its features could prove to be more useful for chipped tools than those of the flint; for example the sharpness of the edges could be more efficient and durable for cutting due to the micro-saw created by the quartz crystals. A series of experiments were conducted to prove this idea.

The Czech Republic is rich in natural sources of quartzite that were used for chipped industries since the early Homo societies in the Old Palaeolithic era by the Neolithic and even younger cultures (Halstatt). The quartzite was extensively exploited and also transported to distant areas. Moreover, this raw material is very similar to the one used in the Old Palaeolithic African Acheulean industry. The Czech quartzite has several varieties but the best known and the most used are: Bečov and Skršín. The Bečov variety consists of very fine quartz sand and even pure SiO4 bulbs that were often used in the Czech Magdalenian industry occur. The Bečov quartzite was preferred mainly by the Old and Middle Palaeolithic cultures. On the other hand, the Skršín variety comprises of clay particles, so its structure seems more homogenous in comparison with the Bečov variety. The Skršín quartzite was used mainly in later periods; since the Neolithic era till the Iron Age, when mining pits were documented (C^{14}).

Experimental research of the general formation of use-wear traces on the Bečov and Skršín quartzite tools was initiated to create a comprehensive collection for the excavated quartzite industries. The aim was also to compare its use value and convenience with other raw materials (flint and chert) used in the Upper Paleolithic cultures on the territory of the Czech Republic. As the quartzite use-wear formation has not been thoroughly studied yet, only the sickle gloss traces have been reported on the excavated tools. The other use-wear traces seem to be difficult for analysis. Therefore, the possibility to interpret the other prehistoric activities on this common raw material would be very helpful not only for the Czech archeologists.

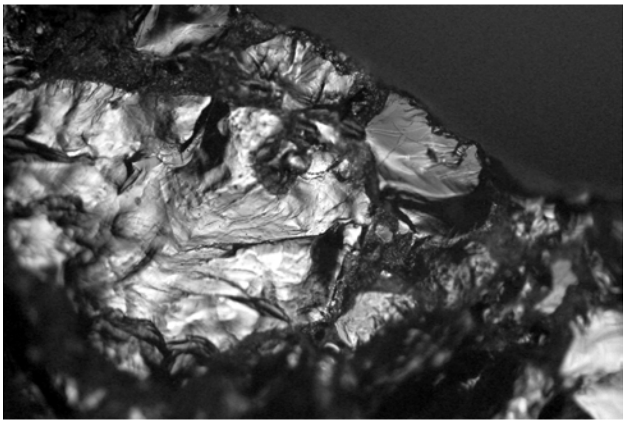

Fig. 1: Bečov white variety quartzite, mag. 100x

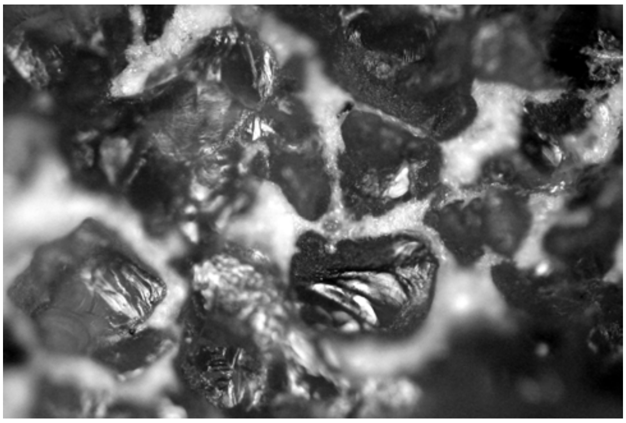

Fig. 2: Bečov yellow variety quartzite, the white filling appearing after the usage, mag. 100x

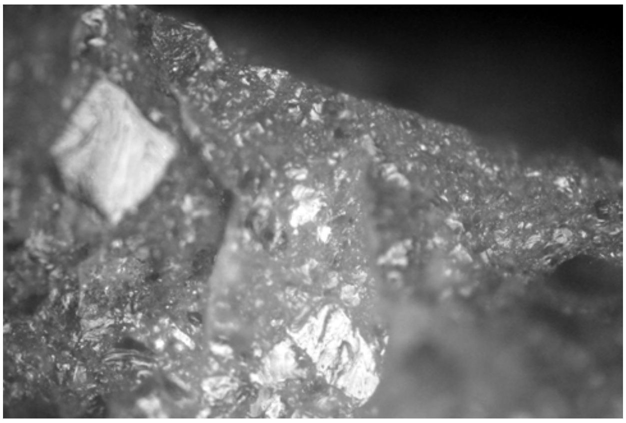

Fig. 3: Skršín variety quartzite, mag. 100x

Four raw materials known from the old Palaeolithic industry collections were chosen for the experiments: quartzite Bečov "white" (Fig. 1), quartzite Bečov "yellow" (Fig. 2), quartzite Skršín (Fig. 3) and Palaeozoic chert Klobuky (Fig. 4). The micro-photos of the intact surfaces are attached to the respective photos of the raw materials. The experiments were conducted on wood working: cutting and shaving. The experimental tools made from the selected raw materials (plus flint for comparison) were used for one hour activity - each used for the same activity, for the same time period, by the same person. The efficiency of the used quartzite varieties and chert were compared mutually and also with the steal blades.

The use-wear trace formation on quartzite surfaces is connected with the crystals and their binder. We were not able to recognize a polish formation on any of the experimental tools made from the quartzite although we had high expectations for the Skršín variety, where the homogeneity and fine clay crystals resemble the flint or chert structure. We noticed a different surface and material features between the yellow and white variety of the Bečov quartzite although the origin should be the same for both.

The yellow variety has a greater soaking up ability, probably due to the microspaces in its structure. That would correspond with the easier release of the crystals during the usage, i.e. faster edge rounding. Such a result supports the archaeological findings that the white and yellow varieties were used for different purposes/tool types. The yellow variety was used in Acheulean for anvils or palettes, further for tools denoted as hammer stones or pestles, indicating the activities connected more with grinding or sanding. After the usage, we found a strange white filling that appeared on the used areas only (Fig.2). This should not be from the wood residuum as the tools were carefully cleaned with HCl solution.

On the contrary, the white Bečov variety was used more for the "cutting" tool types, with sharp edges. The white variety seems to be harder than the yellow and more compact (considering the low soaking ability in comparison with the yellow var.) Although, the sickle gloss has often been reported on quartzite tools, we observed only use-damage traces on the edges (Fig.1). Probably, the quartzite tools, in general, need at least double the time than flint/chert to develop the polish on its surface.

On the other hand, the chert Klobuky showed a very similar use-wear formation as the flint. The polish development and appearance were almost identical to those developed on the comparative flint experimental tools (Fig.4).

We decided to compare the efficiency of the different varieties of the quartzite tools, chert and flint (Fig. 5). Further, we compared them with the recent kitchen steel knives with different cutting edge shapes. We tested the efficiency of the cutting edges when cutting off a regular wooden stick. During the test we found that the efficiency was influenced by the edge angle and the edge shape. We found the steel knife with big jags (Steel 3) the most efficient. Its result was taken as 100% to express other efficiencies. As we expected, the quartzite tools were slightly more efficient than the flint/chart tools, except for the yellow variety. The higher efficiency of the quartzite tools is related to the micro-saw edge shape, similar to the

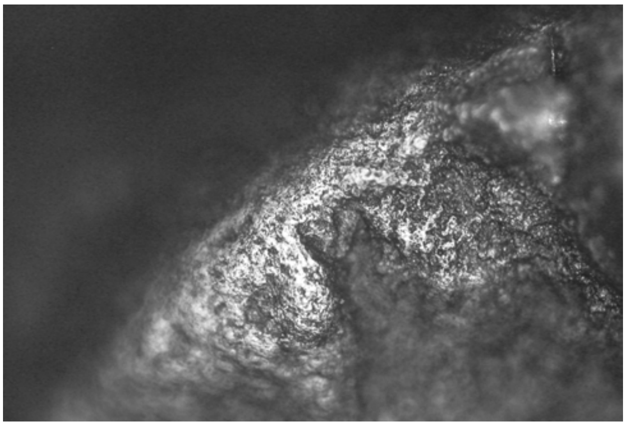

Fig. 4: Klobuky variety chert, wood cutting polish, mag. 200x

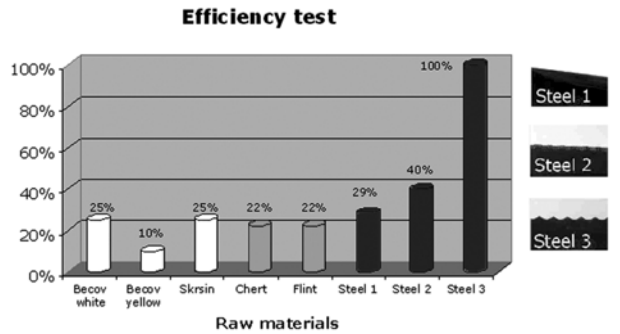

Fig. 5: Efficiency test of cutting abilities of the respective quartzite varieties in comparison to chert, flint and steel blades.

Steel 2 sample. However, the difference from the flint/chert tools was not as big as the archaeologists had anticipated. We suppose that the low efficiency of the yellow variety is caused by the soft raw material consistence which is heavily reduced during the usage and therefore the edge becomes round.

We would also like to mention that the efficiency of the stone tools in general was quite close to the one of a straight steel edge (Steel 1); although the edge angle of the stone tools was three times bigger than the of the recent steel knifes. It is possible, that had we used better experimental tools with a lower edge angle, their efficiency results would be even better.

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The bone mattock from the Mesolithic site of Plawienko 31 (Pomerania, Poland). Use-wear analysis and experimental method for determination of function and manufacturing processes

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Summary. *This paper concerns technological and functional aspect of Mesolithic bone tools (mattocks, axes, chisels). We describe the assumptive process of manufacture and usage of the bone mattock from Plawienko 31, Pomerania, Poland. Our researches are based on the experimental method and use-wear analysis. The schema created by David (1999, 2003) was used to draw the general sequence. Comparison of the technological and use-wear traces on the Mesolithic tool and experimental replicas let us to construct chaîne opératoire for the implement under study. Three digging experiments were performed in respect to different soil condition during the Mesolithic in Poland. Use-wear traces are very similar to those observed on the Mesolithic implement. However more experiments are going to be done in the frame of this research project.*

Resumé. *L'article traite de l'aspect technologique et fonctionnel des outils mésolithiques en os (mattocks, haches, ciseaux). Il s'agit de la fabrication et usage d'un mattock en os de Plawienko 31 en Poméranie (Pologne). Nos recherches sont basées sur la méthode experimentale et l'analyse des microtraces d'utilisation. Le schéma créé par David (1999, 2003) a été usé pour esquisser la séquence générale. La comparaison des traces technologiques et des microtraces d'utilisation sur un outil mésolithique et sur les répliques experimentales nous laissaient construire une chaîne opératoire pour un objet en matière. Les trois experiments ont été réalisés en respectant les différentes conditions géologiques de sol de Mésolithique en Pologne. Les microtraces d'utilisation ressemblent à celles d'un objet mésolitique. On prévoit cependant les experiments suivants dans le cadre de même programme des recherches.*

Key words: bone mattock, experimental archaeology, use wear analysis, Mesolithic.

The experimental research project concerning the Mesolithic bone and antler industry in Poland started for a series of reasons. Excavations of the Mesolithic sites revealed types of tools for which the process of manufacture and function were unknown or not certain. Functional determination of bone tools described as mattocks, axes or chisels are mostly based on morphological features and no other research methods are applied. Moreover such artefacts are very rare in Polish archaeological collections and they come from excavations of several peat-bog sites, like Orle, Niezbyszewo (Kobusiewicz 1999), Szczepanki 8 (Gumiński 2005), Biskupin (Jasnosz 1949).

The aim of the project is to identify the "*chaîne opératoire*" (Grace 1997) at work for Mesolithic mattocks. This means to establish the series of manufacturing sequences and function(s) characterising the artefact's life: from the selection of the raw material to the abandonment or final use and deposition of the artefact, but also those events which took place after the item was discarded into the archaeological context, where various post-depositional processes could modify its surface, shape and properties.

The bone mattock from the Mesolithic site of Plawienko 31, was carefully investigated (Fig. 1). The tool is made of a metacarpal bone of female aurochs. It shows an asymmetrical one-sided working edge on the distal part and a hole bored on the opposite proximal part (on the articular facet) of the bone. The hole is parallel to the mattock axis and probably was made for hafting. The tool is 14.3 cm long and 5.4-3.1 cm wide. The mattock was discovered in the peat-bog layer with radiocarbon dating 8920±90 BP (Gd-7432) (Bagniewski, 1995). Similar mattocks made of radial bones of big mammals are known from Maglemose culture sites located in northwestern Germany (Schuldt 1961), Sweden (Larsson 1978) and Zeeland (Mathiassen 1948).

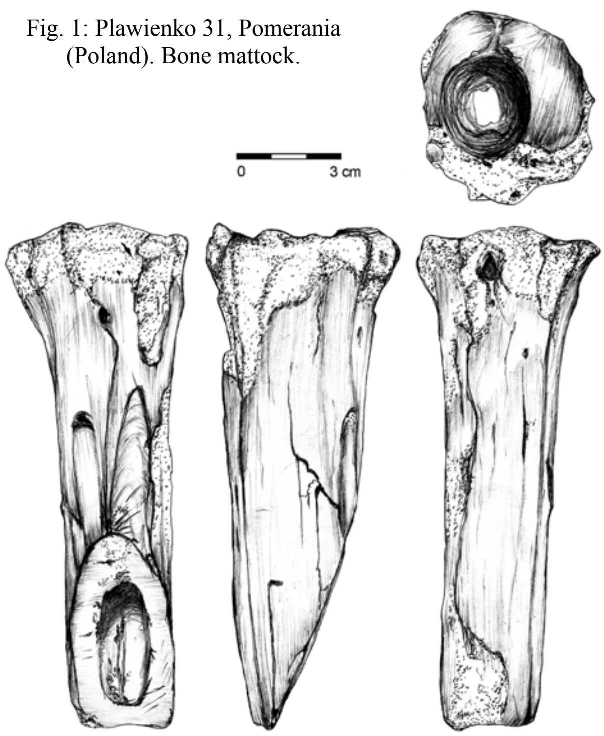


Fig. 1: Plawienko 31, Pomerania (Poland). Bone mattock.

Three research methods were employed in the project. Experiments were used to make replicas of the mattock, for which raw-material were metacarpal bones of a modern cow. A series of experiments were conducted to obtain a similar final product, identical manufacture and use-wear traces. In order to obtain the latter, various activities and gestures were carried out which required different types of flint and antler tools. Microscopic analysis of manufacture and use-wear traces on the Mesolithic implement and on the replicas were made using Stereo Microscope Olympus SZX9 with reflected light illuminator. Observations in "low-power" mode (with magnification range between 6.3x and 57x) are the most appropriate for identifying wear traces on bone artefacts. Photomicrographs were taken with an Olympus Camedia 5060 camera attached to the microscope. Comparative methods were useful to analyse wear traces on the tool from the Mesolithic site and on replicas manufactured by authors and used for various tasks.

Microscopic analysis of manufacturing traces on the original tool allowed to draw some preliminary conclusions concerning the different activities and gestures taking place during production. Such traces are however incomplete, because they represent only the final stages of manufacture. In addition, byproduct waste or semi-finished products from Polish Mesolithic sites are rare. These types of artefacts are very useful for understanding manufacture processes. By using the experimental method, the whole process of mattock manufacture, including the initial preparation of the metacarpal bone, was reconstructed. The aim of the experiments was to gain the same traces (which can be observed on the Mesolithic implement) on the surfaces of the replica mattocks, as well as to find the most efficient and the less time-consuming manufacture process. Since bone is a very hard material to process, several methods of softening it, like soaking and boiling in water or soaking in sorrel acid, were also used (Drzewicz 2004).

The operational sequence scheme created by David (1999, 2003) was used to re-construct the general sequence. However, microscopic observations and experiments showed that some more stages must have been present on the Polish implement. The following sequence shows a series of operations in the manufacture of the Mesolithic mattock .

In the first stage the raw material (a metacarpal bone) is selected and prepared. Flint flakes with sharp, unretouched cutting edges were used as knives for cutting skin, cutting out meat, sinews, cartilage, etc. Flakes were wrapped in leather pad. Subsequently, some of the unnecessary fragments of the bone proximal part were removed. This made the shape more regular and rounded. Such activity is quite simple and takes only a few minutes. A craftsman would need only a large blade or a flake with unretouched edges and a wide butt, to use as a chisel. This activity causes partial exposure of the bone internal structure in some points (Figs. 2-3). A hole for

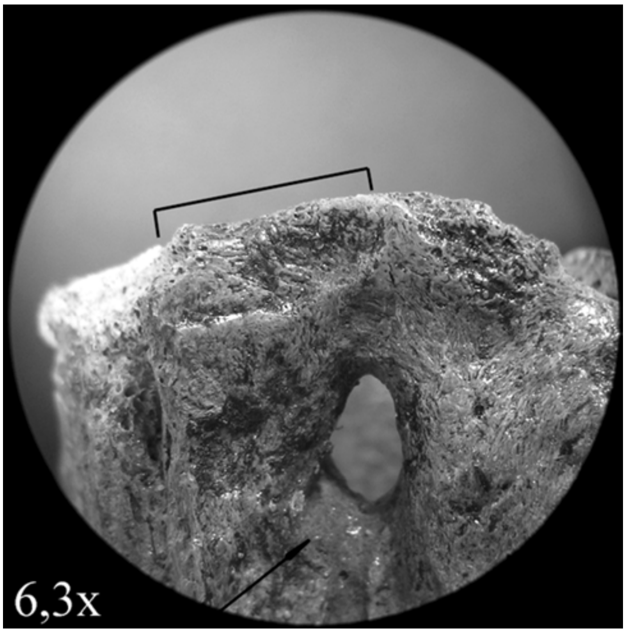


Fig. 2: Plawienko 31. Manufacture traces.

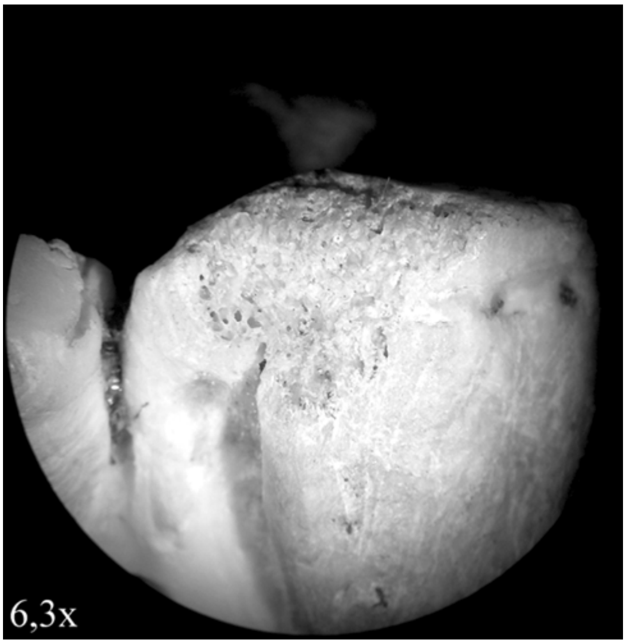


Fig. 3: Experimental mattocks. Manufacture traces.

hafting was made in the proximal extremity prior to the shaping taking place. After a few minutes of scraping, the surface was flatter and thinner. Activities like boring, puncturing and scraping occurred. Subsequently the wall of the marrow cavity was removed with an antler tool. Part of the distal part of the bone was removed by sawing. One flint saw lasted for almost half an hour. The bone was cut up to 4-5 mm deep, then split broken by hitting with the help of a stone. As a result of this stage, waste products similar to those from the archaeological site were obtained. Both experimental waste products and semi-finished products displayed linear traces left by sawing. These are long parallel scratches, sometimes

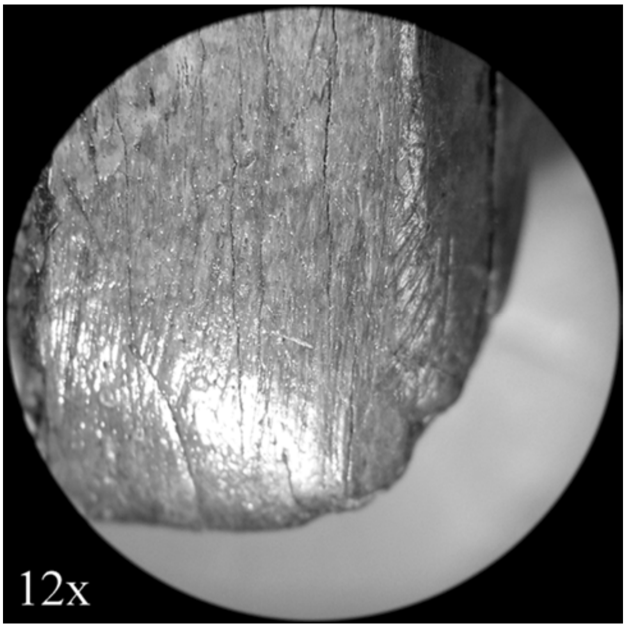


Fig. 4: Plawienko 31. Manufacture traces.

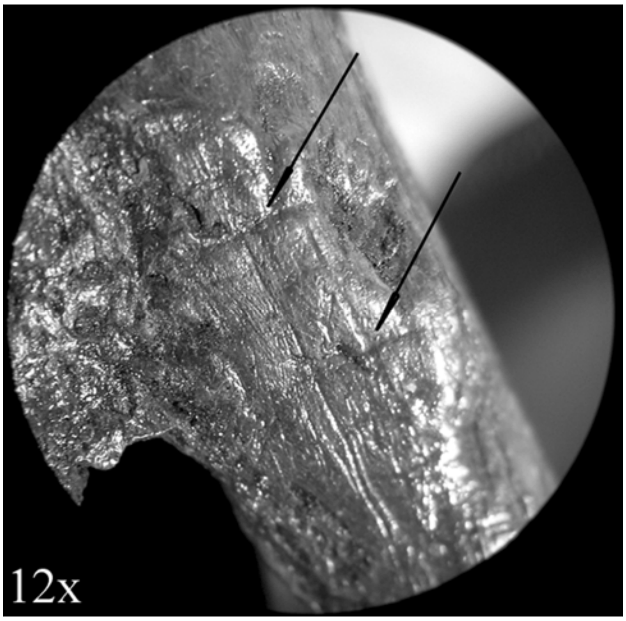


Fig. 6: Plawienko 31. Manufacture traces.

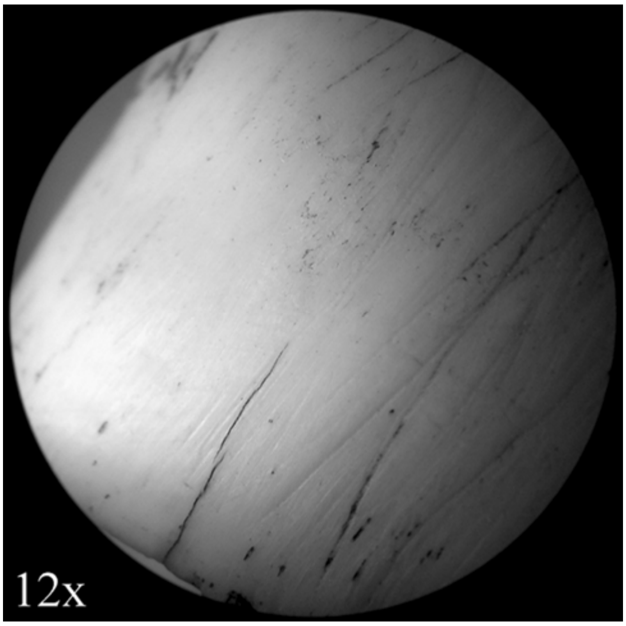


Fig. 5: Experimental mattocks. Manufacture traces.

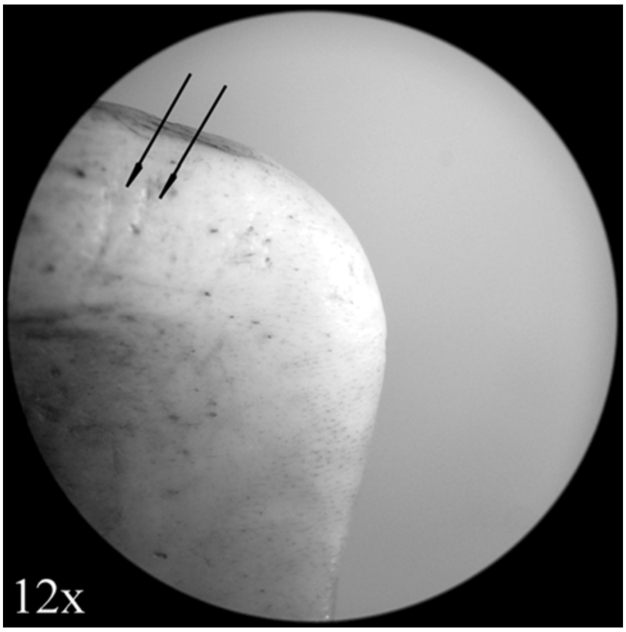


Fig. 7: Experimental mattocks. Manufacture traces.

overlapping. One surface of the bone shaft was scraped in order to form a general shape of a one-sided blade. Some of the wear traces present on the Mesolithic mattock, probably some striations on the blade surface and certainly striations on the opposite side (Figs. 4-5) are connected with this manufacture stage. They are rather long scratches, perpendicular to the cutting edge. Flakes and chunks with big angles of cutting edge were used for scraping. Bone scraping is a very time consuming task and requires previous softening. One side of the blade was finally shaped by adzing using the flint pick. The traces occurred on the surface of the artefact after this stage of manufacture are very clearly visible. They are represented by short scratches parallel to the cutting edge. Edges of the scratches are shallow on one side and steep on the opposite. They are observable at a low magnification of around 12× (Figs. 6-7). Scratches are slightly rounded and are covered by traces of subsequent activities – final scraping (Fig. 6). Such scratches could be confused with traces of unidirectional scraping, pushing the flint tool forward. However scratches created by adze use are deeper and uneven in cross-section with one very steep side. Scratches after scraping are regular and U-shaped in cross-section (Fig. 8). The surface of the mattock-head was rough after cutting with an adze and required smoothing after the final scraping. Traces left after final scraping are visible very clearly on both sides of the Mesolithic tool (Figs. 9-10). A metacarpal bone has

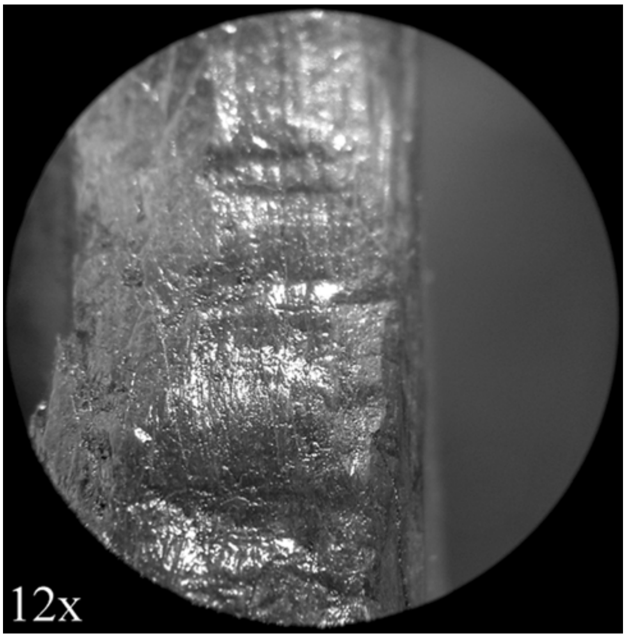


Fig. 8: Plawienko 31. Manufacture traces.

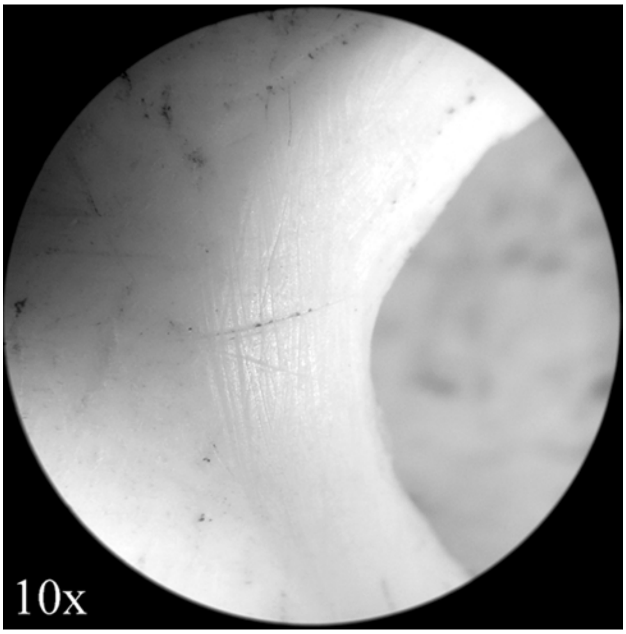


Fig. 10: Experimental mattocks. Manufacture traces.

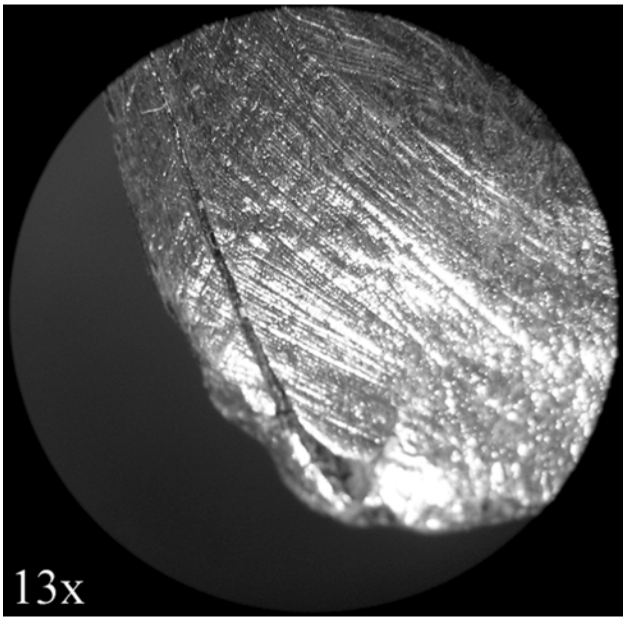


Fig. 9: Plawienko 31. Manufacture traces.

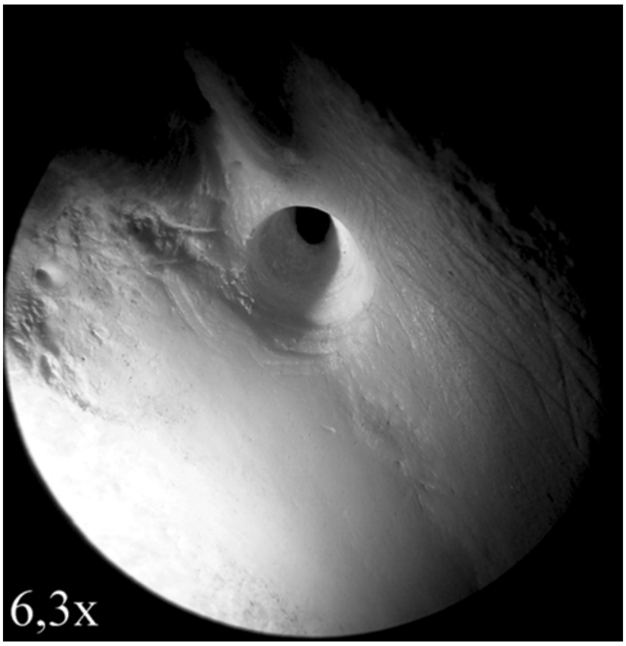


Fig. 11: Experimental mattocks. Manufacture traces.

a foramen on the proximal part. During detailed investigations of the implement it was noticed that this hole was in fact wider than usual and had an irregular shape (Figs. 2; 11). Certainly, it was bored for some functional purpose. A possible explanation is that the mattock was carried tied with straps to a belt. Probably this type of tool was used also unhafted, with bare hands and was hafted occasionally. Since bone mattocks are long-life tools, they could be used for a very long time and for different tasks. A handle could be fixed temporarily and removed during transportation.

There are some suggestions made by other scholars, concerning function of such bone tools (Louve Kooijmans 1971; Korobkova 1999). Korobkova (1999) described use-wear traces present on such bone tools and determine them as traces caused by digging (pits, traps, roots collecting, raw material extraction). The Mesolithic implement is slightly damaged on one surface. Moreover it was covered with gloss paint, therefore possible polishes are also hidden by such gloss. Despite this, some use-wear traces are present and visible on the working edge. Breakages and fractures are present on the dorsal side. Micro-chippings are visible under higher magnification 57× and on the ventral side of the working edge (Fig. 12). They are accompanied by striations on the very edge of the working surface (Fig. 13). Short, deep

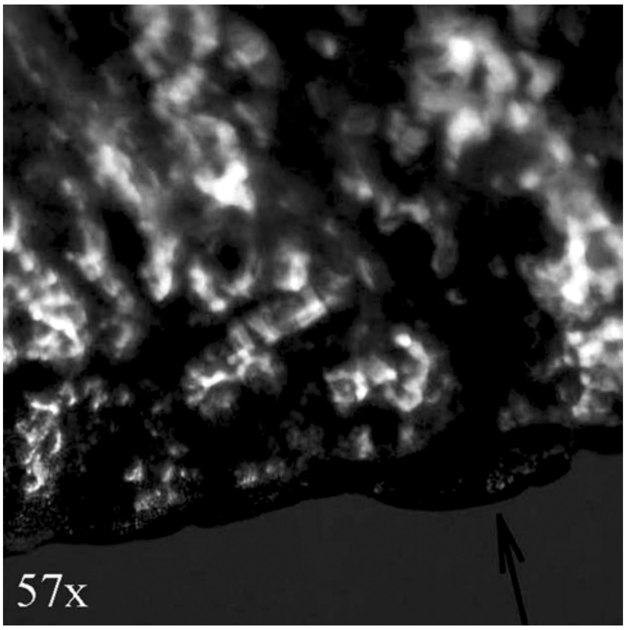


Fig. 12: Plawienko 31. Use-wear traces.

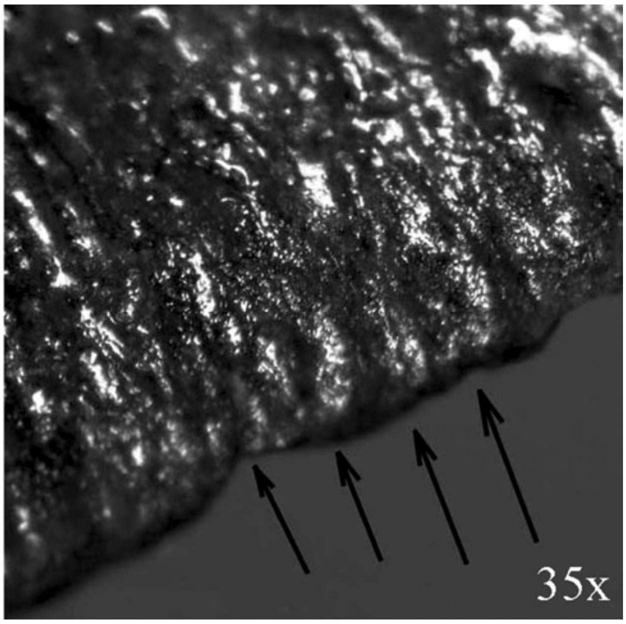
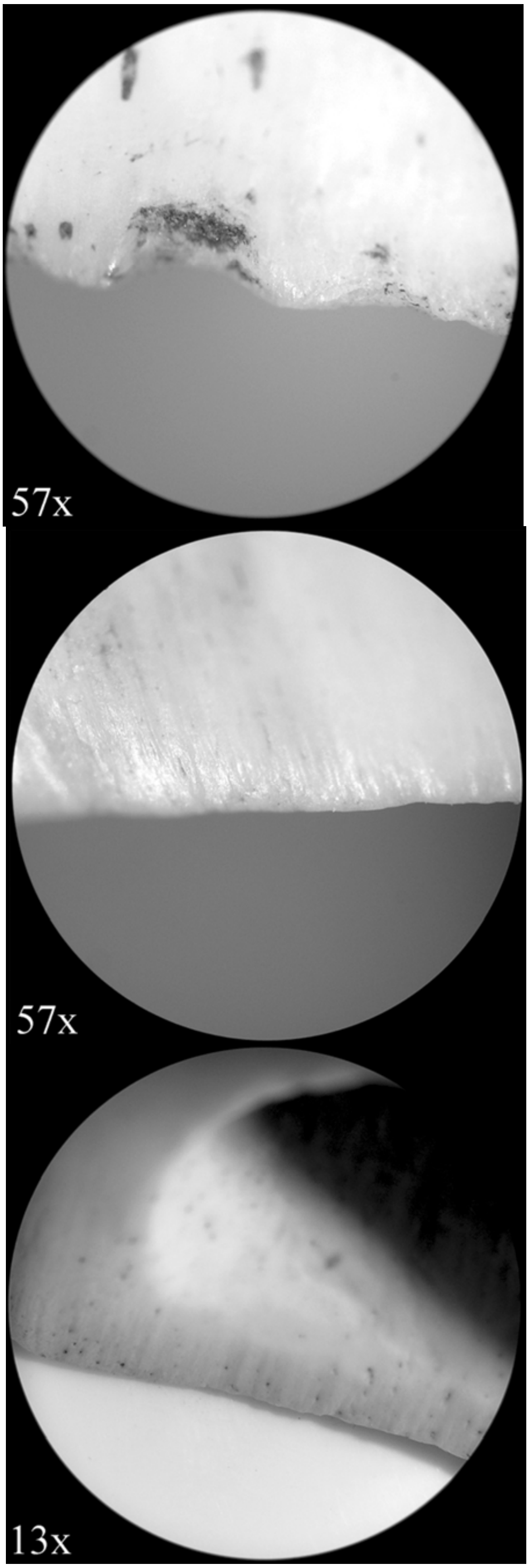


Fig. 13: Plawienko 31. Use-wear traces.



Figs. 14-16: Experimental mattocks. Use-wear traces.

furrows and scars caused the corrugation effect (Fig. 13). The working edge is also rounded.

Three experiments were conducted with respect to different soil conditions during the Mesolithic in Poland. One tool was used for digging out and cutting some roots for a relatively short time. There were some small stones in the soil. Micro-chippings (Fig. 14) and poorly visible linear traces were observed under low magnification. The same replica mattock was used for digging a posthole in clay, which took 11 hours. There are very strong use-wear traces on the surface, but the tool is still effective. The cutting edge became shorter, sharper and thinner. Use-wear traces were observed during work, once every hour and after specific events, e.g. if the cutting edge hit the stone pebble, this caused breakages. Some of the breakages vanished due to following work undertaken, some of them became rounded, other stayed fresh. Abrasion is seen on a wide area, because the tool went very deep into the soil. There are two long fractures parallel to the bone axis. They appeared after the bone interior was filled with clay. Linear traces on both sides of the cutting edge are long and short, deep and wide, perpendicular to the cutting edge and caused corrugation effect (Fig. 15). Another mattock was used for digging the hole in sand. After one hour, use-wear traces were visible under low magnification. Breakages were crescent-shaped and very rounded. There were many spots on the blade surface. These spots are rather small, microscopic holes, which appeared as a result of contact with little quartzite grains. Striations were very clearly visible. Short, deep, wide scratches, parallel to the bone axis caused a corrugation effect on the cutting edge (Fig. 16).

The above described traces obtained through experiments are typical of digging activities and similar to those traces observed on the original tool. Differences between those patterns (small spots, two long fractures, etc.) depend on soil conditions and working time. However, they all represent characteristic digging traces: micro-chippings, different-sized scratches perpendicular to the working edge, and the corrugation effect (Korobkowa, 1999). They entirely differ from use-wear traces formed as a result of other tasks, which were possibly undertaken in the context of everyday life in the Mesolithic (Diakowski and Kufel in press).

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Tracing traces from present to past. The use of shell, flint and stone artefacts on Morel and Anse à la Gourde, Guadeloupe, FWI

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Abstract. *Nicely preserved examples of ornaments and tools made from shell, coral, flint and stone were unearthed during excavations at the pre-Columbian sites of Morel and Anse à la Gourde, Guadeloupe (FWI, 400-1200 AD). Research on these artefact types in Caribbean Archaeology has been limited to typological and technological studies. The research presented here applied a more functional approach, through use-wear analysis, to investigate the range of possible domestic activities taking place at the site.*

On the pre-Columbian sites of Morel and Anse à la Gourde, Guadeloupe (FWI, 400-1200 AD) nicely preserved examples of ornaments and tools made from shell, coral, flint and stone were found. Research on these kind of artefacts in Caribbean Archaeology has been limited to typological studies into the sequence of tool production (e.g. Serrand 2002), and technological studies which are generally used as a relative dating method. The presented research yielded a more functional approach, submitting tools made from shell, flint and stone to use wear analysis. Different sources of information were used to broaden the concept of the range of possible domestic activities.

Methodology

Caribbean archaeology provides the unique opportunity to combine archaeological, ethno historical and ethno graphical data to reconstruct past domestic activities. Paleo botanical and paleo zoological data from the region is used to reconstruct the environment; the source for food and raw materials (Newsom 1993; Stokes 1998). Ethno- historical sources, written in the first centuries after the arrival of Columbus (e.g. Breton 1978,1998; Labat 1931) provide insight in the way of life of the original inhabitants. Although one should be aware of the possibly biased backgrounds of the authors (religion, purpose of visit), the relative neutral character of domestic activities makes these manuscripts valuable as a source of information. Ethnographic studies deliver important information on daily practices as well, since some of the modern inhabitants of the island of Dominica and the mainland are descendants of the indigenous people (e.g. Steward 1948; Roth 1929; Taylor 1938).

The information derived from the different sources mentioned above was used to create an experimental reference collection for use wear analysis. Shell celts were used to cut trees, bivalves were used to clean fish, scrape branches and roots, flint was used in a grater board and to work shell, calabashes and wood, stone was used to polish shell and bone for example. Finally, the archaeological artefacts were submitted to use wear analysis. Especially for the shell tools this was an innovative process, since the experience with this type of material within the field of wear trace analysis is very limited.

Example 1: Preparation of Manioc

Bitter manioc (*Manihot esculenta*) is one of the most important food products of the Meso-American region. It is generally assumed that it was introduced on a modest scale in the pre-ceramic period before it eventually became the most important staple crop (Keegan 2000; Newsom 1993). Nowadays, it still forms an important part of the diet and the method of preparation is virtually unchanged (Fig. 1). The appearance of manioc in archaeological context is however difficult to prove: it produces hardly any pollen, it leaves no phytoliths and it does not carbonize when it burns. The possibility of research on starches in this case is under debate (Piperno 1998). The only archaeological evidence therefore is the occurrence of numerous griddles, nowadays still used for the baking of cassava bread. Another indication for the use of manioc is the presence of wear traces on flint flakes, resulting from scraping manioc. Experiments with a replicated grater board (Figs. 2, 3) show that manioc causes a bright, rough polish and rounded edges, occasionally with striations. The same polish was encountered on small flint flakes from Anse à la Gourde (Figs., 4-6). The combination of the traces, their directionality and the artefact type makes the

Fig.1. Scraping manioc, Surinam 2000 (photo A. Vredenbregt)

Fig.2. Scraping manioc, experiment (photo I. Briels)

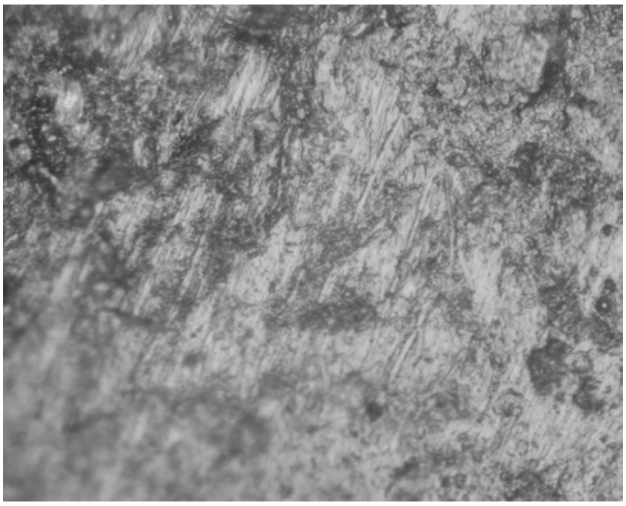


Fig 3. Scraping manioc, experimental use wear traces, orig. magn. 200x (photo Y. Lammers)

interpretation of these artefacts as pieces from a manioc grater board highly likely.

Example 2: Canoe building

Shell celts form an important artefact category in both sites and throughout the Lesser Antilles in general. It is assumed that they were used mainly in the production of

Fig.4. Anse à la Gourde: Flint artefact 64.44/F2185, scraping plant/manioc (drawing K. Wentink)

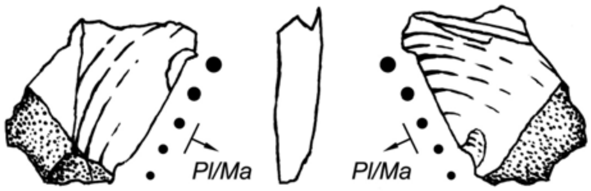


Fig.5. Anse à la Gourde: Flint artefact 73.19.01/07/01, scraping plant/manioc (drawing K. Wentink)

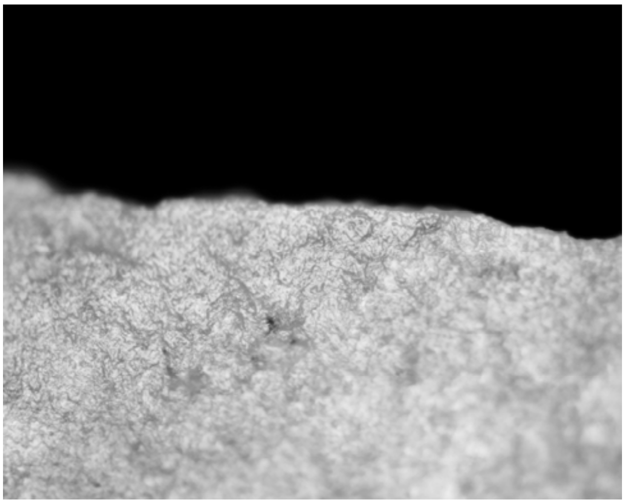


Fig.6. Scraping plant/manioc (64.44/F2185), orig.magn. 200x (photo Y. Lammers)

canoes and posts. So far, it was unclear how and if the celts were hafted and whether they were used on fresh or burned wood. Ethno historic pictures show the use of hafted celts and fire to remove the inside of a log (Fig. 7). This image is affirmed by the use of fire in modern canoe building on the mainland in Surinam, where it is used both to remove wood and to widen the canoe (Fig. 8). Paleo botanical studies reveal that several species of trees suitable for canoe building like Silk Cotton Tree *(Ceiba pentandra)* and Bullet wood *(Manilkara nitada)*, were introduced to the islands during the time of colonisation to make houses and dugout canoes.

Experiments reveal remarkable differences between traces resulting from fresh and burned wood. Tools used on fresh wood loose their sharpened edge in the first couple of blows and then seem to stabilize into a useful, but heavily damaged edge. Polish develops in the

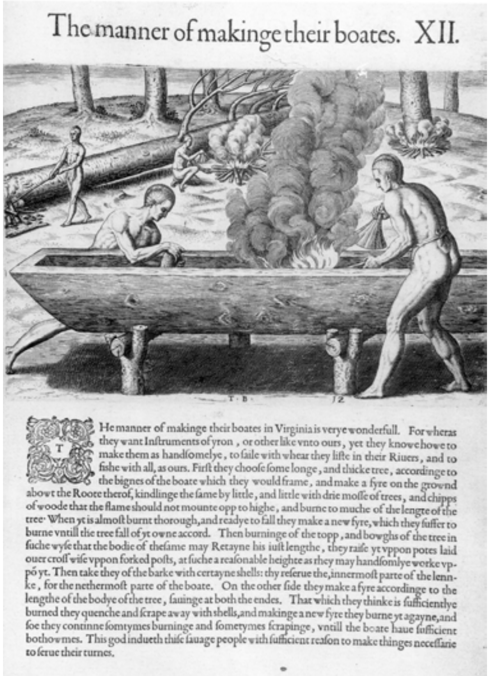


Fig. 7. "Indians making canoes" engraving by Theodore de Bry 1590, after an illustration by John White, 1585

Fig. 8. Using fire to widen a dugout canoe, Surinam 2000 (photo A. Vredenbregt)

Fig. 9. Felling dead burned oak, shell axe in replicated shaft (photo Y. Lammers)

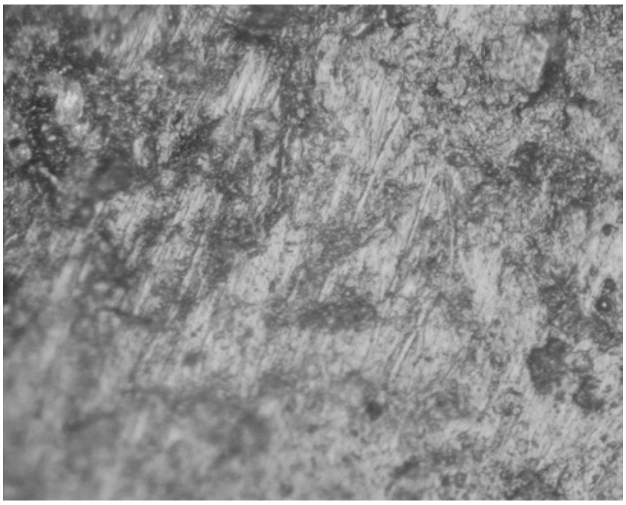


Fig. 10. Felling dead burned oak, experimental use wear traces, orig. magn. 200x (photo Y. Lammers)

retouches in this stage. The gloss is spread, with streaks of a duller polish.

When used on burned wood, the edges of the celts are not or a little retouched but heavily rounded. A celt hafted like an adze shows lots of high gloss on the contact surface and a heavily abraded edge, but not on the opposite side. An axe used on burned wood did not show this highly developed gloss, although the edge was very rounded (Figs., 9, 10). This might well be explained by the fact that using these axes involves a different way of cutting: it is recorded by Yde (1965) that the Waiwai use small blows that do not enter the wood deeply, in order to protect the axe from breaking and deteriorating fast. The wood is in fact not cut but more or less shattered. In this way it takes much more time to fell a tree, but the axe can be used much longer. Burning of the post speeds up the process considerably. The artefact displayed here might be interpreted as a celt that was hafted as an axe and used on burned wood (Figs., 10, 11).

Results

Plant material appears to have been the main worked material, which was anticipated based on the study of the afore mentioned sources of information.

Stone tools were used for rubbing, hammering, polishing, grinding and wedging and have served as axes, net weights and ornaments. Many stone tools have been used for multiple activities. Flint tools were in grater boards and used to cut plants, saw shell and scrape calabashes.

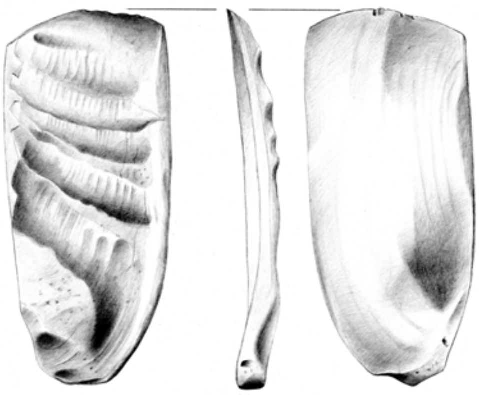
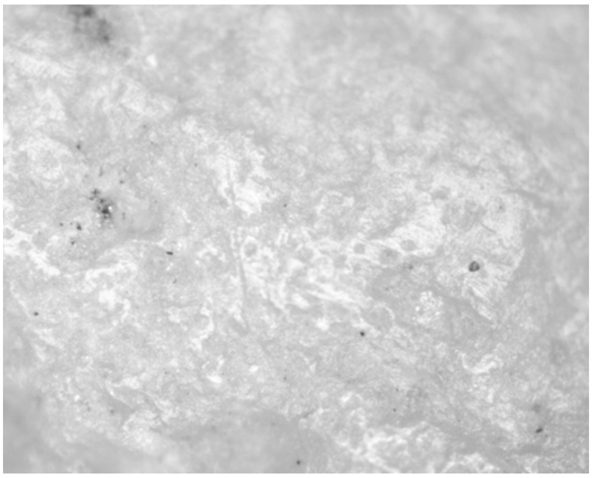


Fig. 11. Anse à la Gourde: Shell celt nr. 4095 (drawing E. van Driel)



12. Cutting burned wood while hafted as axe (shell nr. 4095), orig.magn. 200x (photo Y. Lammers)

Both flint and stone were used intensively, which is to be expected since this material had to be brought to the site from considerable distances (Knippenberg 1995). Shell bivalves display traces in four variations; three resulting from scraping motions (one to work soft materials such as plants and siliceous plants, two to work materials such as wood and leather-hard clay), one (limited to the shell species *Tellina radiata*) resulting from a longitudinal cutting movement on plant material. In general it might be concluded that from this sample of artefacts no preferences for certain raw materials in relation to worked materials can be deduced. Apparently the choice for the raw material of tools was based on the specific task at hand, taking into account the specific advantages of the chosen tool. In the various wood and (siliceous) plant processing activities stone, flint as well as shell played a part. The processing of animal products (bone, hide, meat) is very limited, which could have been anticipated considering the almost lack of these products in both archaeological and ethnographical context. Furthermore the limited possibilities for use wear analysis to register soft animal products are apparent.

In the production of shell tools hard stone and flint played an important role. Flint was used to produce shell tools and ornaments, judging both the manufacturing traces on shell and traces of use on flint tools. Flint tools were produced frequently by the bipolar technique, which can be endorsed by the presence of intensively used hammer stones and anvils. In conclusion it can be stated that the pre-Columbian inhabitants took full advantage of the available toolkit, choosing in an opportune way the best tool for the specific task at hand. In doing so, they demonstrate to have been completely aware of the possibilities offered by the raw materials available.

The specific problems involving use wear analysis on shell tools and the final results of the analysis of the shell, flit and stone tools from both sites will be presented in the form of a PhD-thesis at the end of 2006 (Lammers-Keijsers in prep.).

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Experimental testing with polished green stone axes and adzes: technology and use

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Summary. *This paper presents my experiments about the manufacturing process and use of the polished stone axes/adzes made from green stones. The aim is to analyse their technological and use-wear traces. Experimental data are compared with archaeological data.*

Rèsumè. *Cet article vise à présenter mes expérimentations à propos de la fabrication et de l'utilisation des haches/herminette en pierre verte polie dans le but d'analyser leurs traces technologiques et fonctionelles. Les données experimentales sont comparées avec les données archéologiques.*

Key words: stone polishing, axes, adzes, use-wear analysis, technology.

Introduction

This paper comes out of my observations about the experimental axes and adzes I made employing rocks similar to the prehistoric green stones. The current research on ground stone tools increased our knowledge about the choice of rare and shock-resistant raw materials by the North Italian Neolithic communities (D'Amico 2005, D'Amico *et al*. 2004). On the other hand, the experimental activity with polished stone tools is not so much developed than on the chipped stone: this causes some unresolved questions about the manufacturing process and about the use of these tools. For these reasons I based this study on the analysis of: a) the different steps of the blades technological process; b) the way to use the tools to test their functionality and c) the wear patterns of the cutting edge.

Experimental programme

a) The manufacturing process:

At the moment I made 5 polished stone blades and some rough-outs are now still in manufacturing. The raw material come from the Po river bed. I followed the same operational sequence used in the archaeological artefacts (Thirault 2005; Lunardi 2001/2002; Starnini and Voytek

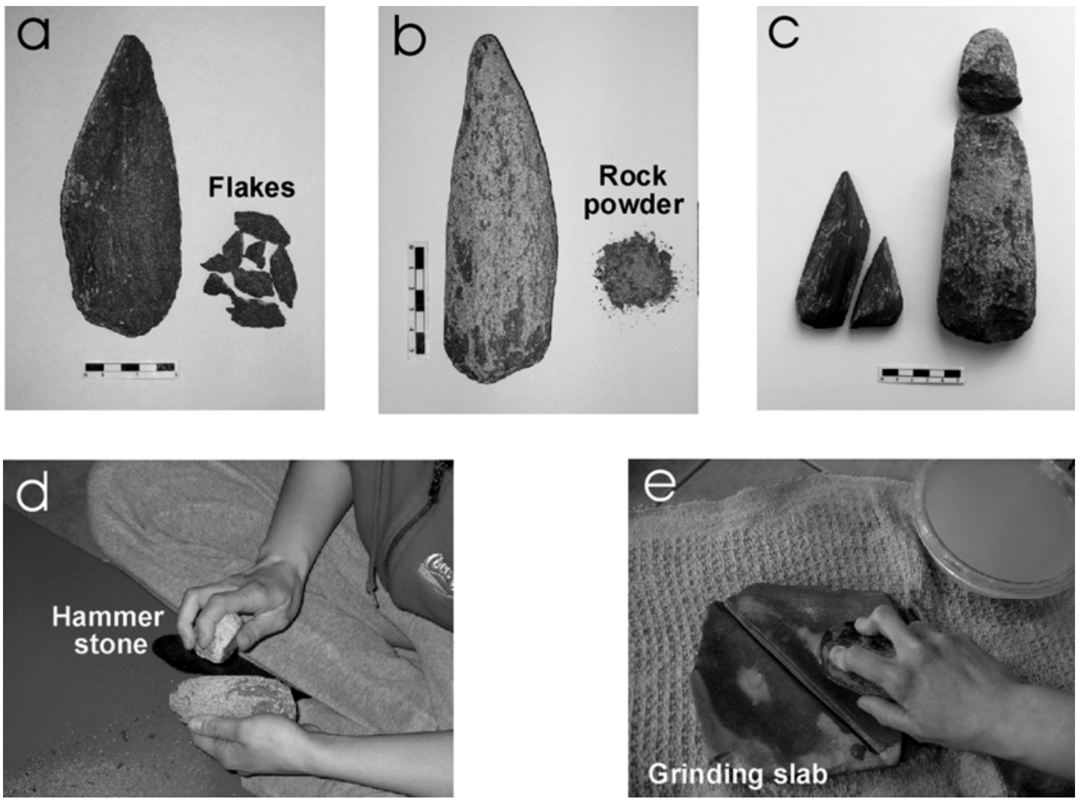

Fig. 1: Steps of the manufacturing process: the flaking (a); the pecking (b, d); broken blades (c) and the grinding (e).

Exp. Blade	Raw material	Flaking time (minutes)	Pecking time	Grinding time	Weight (grams)	Length; width; thickness (millimetres)-
1	Eclogite	40	480 (9 g/hour)	510 (2 g/hour)	358	162; 55; 34
2	Fine-grained omphacite	50	420 (10 g/hour)	1560 (1 g/hour)	342	165; 55; 23
3	Fine-grained omphacite	-	-	690 (0,5 g/hour)	15	44; 27; 8
4	Course-grained eclogite	-	90 (9 g/hour)	180 (2,5 g/hour)	45	48; 38; 15
5	Course-grained eclogite	45	450 (11 g/hour)	270 (2,5 g/hour)	335	119; 63; 33

Tab. 1 Summary of the experimental tools manufacturing

1997) and in the ethnographic contexts (Stout 2002; Petrequin and Petrequin 2000; Hampton 1999): the flaking, the pecking and finally the grinding (Fig. 1).

The first step is the flaking of the lithic support to give to the blade its general form. The nature of the raw material (crystalline fine-grained rocks) is such that this technological phase is not extremely easy and efficient (Fig. 1a).

The second step is the pecking of the whole support to finish off the general blade morphology and dimensions. The pecking is a gradual reduction of a lithic mass: the surface is hammered by an hard lithic hammer that removes small particles and rock powder (Fig. 1b,d). The pecking is effective only on crystalline rocks consisting of different minerals with an high degree of jointing. By pecking it is easy to remove much more mass of material than grinding: a good pecking can save a lot of time in the next grinding phase.

The last step, the grinding, is a gradual reduction of a lithic mass by continuous rubbing on a sandstone grinding slab with water. With the help of an abrasive substance (sand) the process is more efficient (Fig. 1d). This method needs a lot of time to give some visible results. The grinding of experimental blades was made on sandstone grinding slabs working on two opposite directions:

- transverse to the cutting edge, to examine the rounding of the manufacturing striations after the use of the tool;
- parallel to the cutting edge, to distinguish the manufacturing striations from the wear traces.

Finally, I further tried to polish the cutting edge on a hide strip helping me with some water: the resulted surface was very smoothed.

During the more risky operation, the pecking, it is possible to break the tool (Fig. 1c).

For the experimental handles I inspired mainly to the ethnographic hafts of Irian Jaya (New Guinea) (Pétrequin and Pétrequin 2000; Hampton 1999), because there are only few rare archaeological handles for axe/adze in the North Italian Neolithic sites (Fig. 2).

b) How the tools were used:
In the Neolithic economy the wood was a very important raw material to produce a lot of goods such as containers, bows, pirogues, huts, palisades, combustible material etc. (Beyries and Hayden 1993). Therefore, efficient tools were necessary for the woodworking tasks and I tested the efficiency of axes and adzes used for the following tasks: cutting, splitting and working wood. I used the tools on fresh and dry wood (Fig. 3). The aim was to produce specific wood-wear traces. The experimental testing was made during the winter season because the botanical analysis on archaeological wood document this practice (Monnier *et al.* 1991).

In this work I keep the traditional definition of "*axe*" (cutting edge parallel to the long axis of the shaft) and "*adze*" (cutting edge transverse to the long axis of the shaft) (Semenov 1964) (Fig. 2). Both tools are used with a chopping motion and are swung with percussive force to strike a blow with the cutting edge. The adze has to be used with a straight forward and straight downward motion. The axe has to be used with a lateral motion (Gutiérrez Sàez 1993; Leroi Gourhan 1993) (Fig. 3).

The shape and size of the cutting edge are very important to carry out the different woodworking tasks (Choulot *et al.* 1997; Starnini and Voytek 1997; Mills 1993; Semenov 1964). By my experience, a heavy tool with a wide and curved cutting edge is more appropriate to split wood and clear brush because it has a big surface to penetrate the wood fibres (axe No..1 and adze No..5). The narrow and sharp cutting edge is efficient for these tasks: pointing stakes, cutting little branches, taking off the bark and digging a wood mass (adze n.3 and 4). Nevertheless, the adze n.4 has a bigger cutting edge angle which is not very efficient to be used for precise tasks.

During experimental testing, the axe n.1 has been quite difficult to use, manly when I tried to chop wood with the blade perpendicular to the trunk: it is better to use it diagonally with the working surface (at about 50°). Moreover, it is very difficult to chop dead or dry wood with a stone axe because the breakage of the edge may

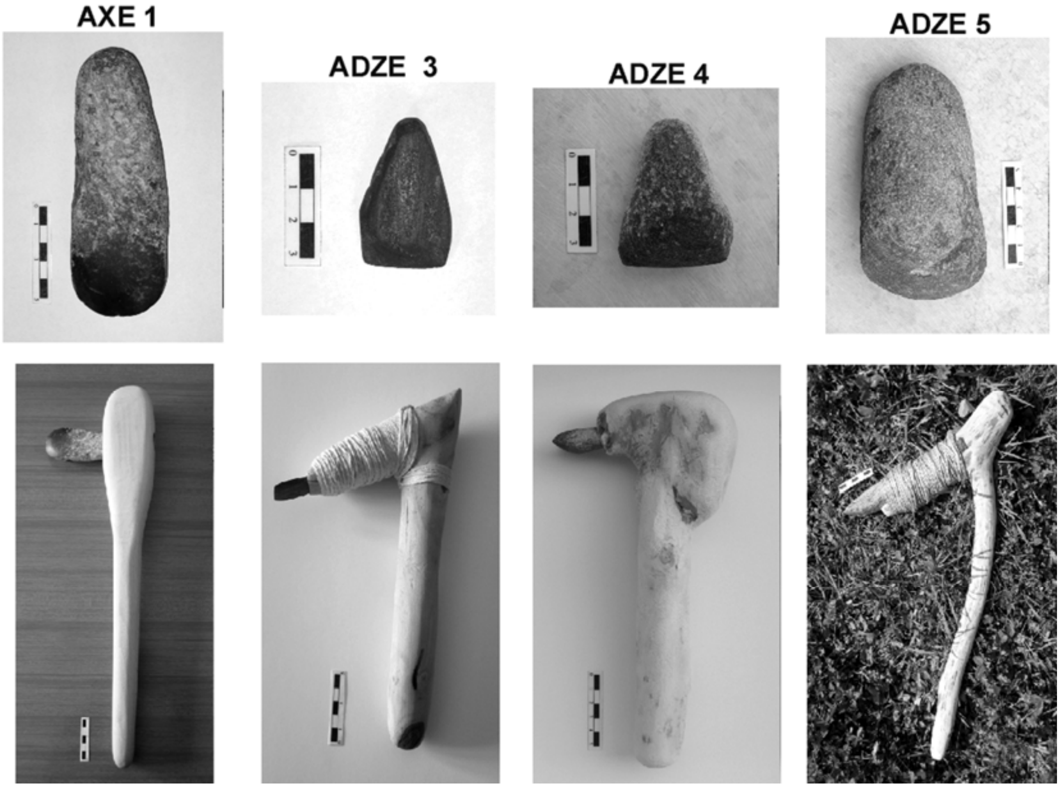

Fig. 2: The experimental axe and adzes.

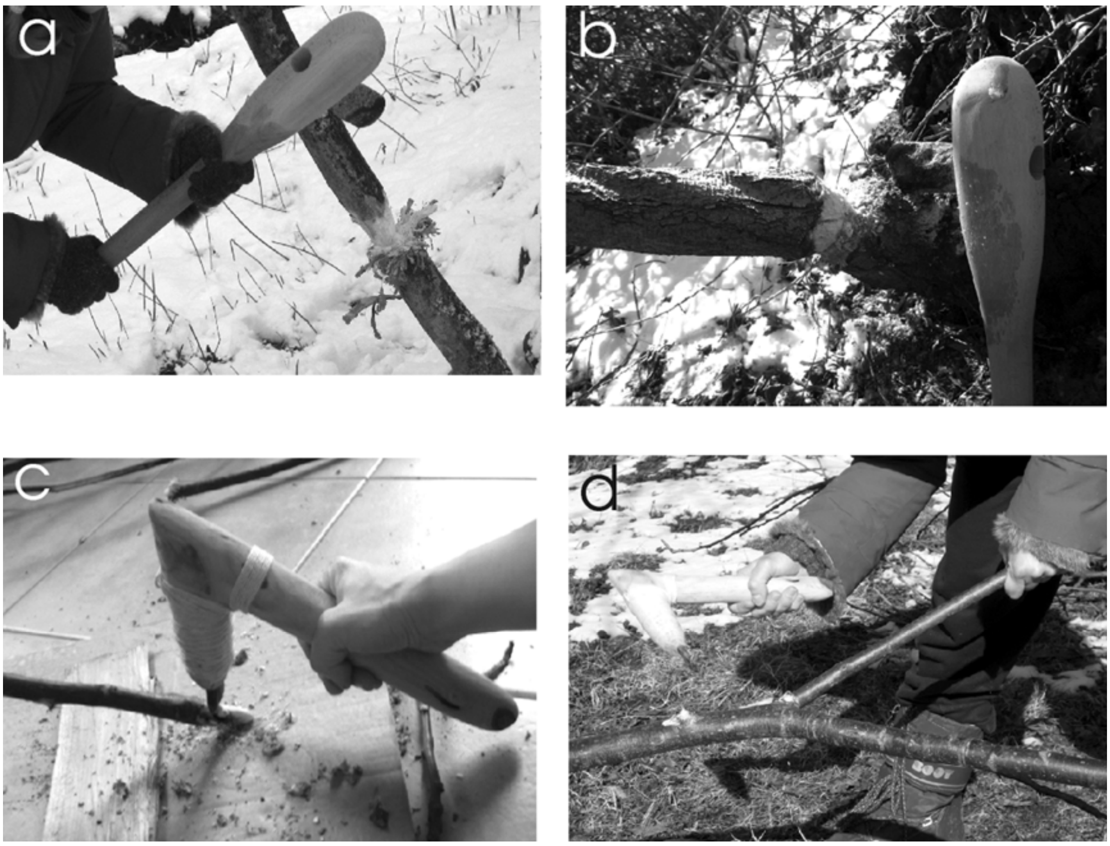

Fig. 3: The uses of axe and adzes for woodworking: felling trees with the axe n.1 (tree diameter: 22 cm and 33 cm) (a, b); pointing (c) and cutting (d) little branches with the adze n.3.

Exp. blade	Stone tool type	Substance contacted	Woodworking	Duration of use (minutes)	Damage of the cutting edge
1	Axe	Fresh and dry wood	Felling trees, cutting branches and trunks	180	The breaking of cutting edge, microflakes, striations
2	Axe	-	Unused	-	-
3	Adze	Fresh wood	Cutting branches and twigs, pointing branches, taking off the bark of the branches	480	Decreasing of sharpness, microflakes, snaps, striations, polish
4	Adze	Fresh wood	Taking off the bark of the trunk	30	Only two microflakes
5	Adze	Fresh wood	Felling trees, cutting branches	60	Microflakes and snaps

Tab. 2 Summary of the experimental tools uses

occur easily. The small adzes (Nos. 3 and 4) are light and mould to employ, but it is impossible to use them to cut big branches.

c) Microscopic Traces:

Microscopic traces on ground stone tools are the alterations of the lithic surface visible at low magnifications (10x to 40x) (Adams 1996; Mills 1993) (Fig. 4). They are produced by naturals, accidentals and anthropic causes (Mansur 1997). If the first and second causes are unforeseeable, the last cause has a precise archaeological value and it can be produced both by the manufacturing process and the use of the tools.

The technological traces consists in:
- an hole-and-bump surface produced by the pecking (usually on the sides and on the faces of the blades);
- a smoothed surface with or without macroscopic striations, produced by grinding (always on the cutting edge and often on the body of the blades).

It is possible to identify also the flaking traces when they are not removed by the pecking.

The wear-traces on the polished cutting edge consists in (Fig. 4):
- Microflakes: frequents on the cutting edge and detached from the edge when a percussive force is applied. Some microflakes can result from accidental causes and it is not ever easy to distinguish the use-wear microflakes.
- Striations: groups of linear marks that run on the lithic surface. They result both from the tool manufacturing (grinding) and tool use, but also from other unforeseeable phenomena. The technological striations are normally more long, numerous and they have unlike direction. Instead, the use-wear striations are short and they are placed on the cutting edge. Moreover, there is a difference between the adze and the axe use-wear pattern in relation with the use-tool direction. In the adze the striations occur mainly on the upper face and they run perpendicular to the cutting edge. In the axe the striations usually occur on the both faces and they run diagonally to the cutting edge (Lunardi 2001/2002; Semenov 1964).
- Micropolish: smoothed portion of lithic surface that reflects the incident light in a different way than the other parts of the microtopography (Mansur 1997; Semenov 1964). It is formed during the use of the tool on the working surface and it is visible, on one or two faces, at about half centimetre from the blade border. The polish characteristics (like smoothness, brightness and placing) depend on the kind of material worked on, on the blade raw material and on the intensity and duration of the use (Mansur 1997). If the tools are made of fine-grained rocks it is easy to see a polish on the polished surface, but it must not be confused with the functional micropolish.

Comparison with the archaeological data

Some analogies can be noticed from an optical point of view linking the experimental data with the archaeological data. Firstly, the manufacturing traces and morphologic characteristics of the tools are the result of some precise technological choices (pecking and/or grinding) of the craftsman that depend mainly both on the raw material characteristics (hardness, texture, fracture pattern, etc.) and on the morphology of the lithic support (general form, dimension, thickness of the section etc.) (Thirault 2005; Lunardi 2001/2002), but also on the personal skill (Stout 2002). This seem to show the great variety of morphology, dimensions and different working traces of archaeological artefacts, therefore their different socio-economic value as attested by their occurrence in the habitat and burial contexts.

By the functional point of view, both my experiments and the ethnographic comparison (Petrequin and Petrequin 2000; Hampton 1999) remark the importance of the dimensions, morphology and the haft-type (adze or axe) useful to carry out the different wood-working tasks. It is important to note that the ethnographic studies suggest other minor functions, some ones practical, like the breaking of the animal bones (Petrequin and Petrequin 2000) and some other ones ritual, such as war indemnity and amputating fingers (Hampton 1999). In conclusion the repetition of these experiments on other materials could enhance greatly our understanding about the role of ground stone tools in the economic, social and symbolic prehistoric context.

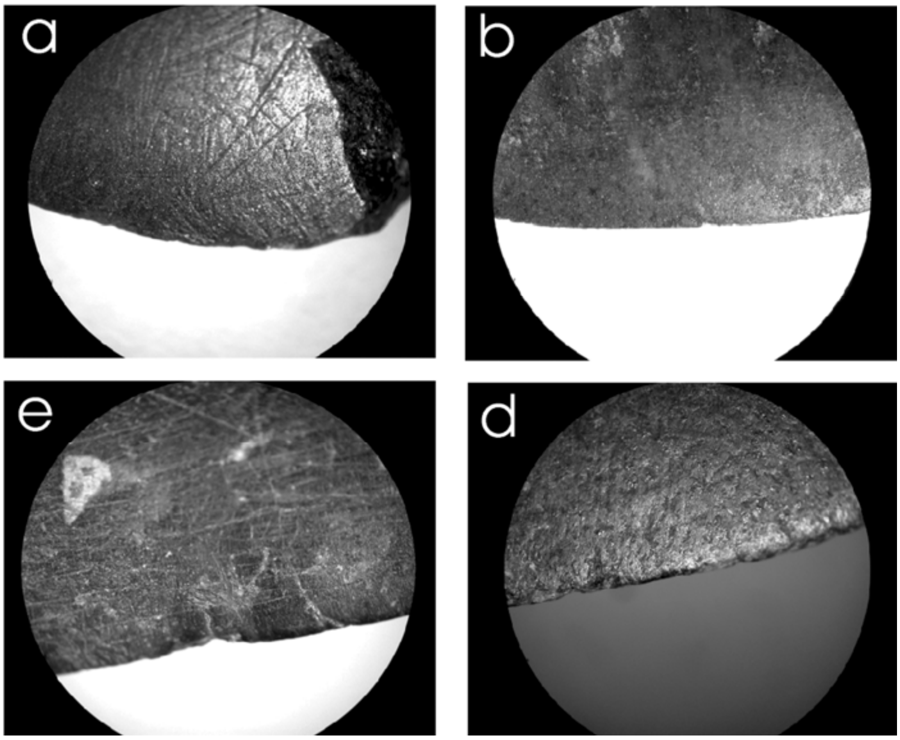

Fig. 4: The use-wear patterns of the experimental and archaeological tools: axe n.1 after 180 minutes of use, 15x (a); adze n.3 after 420 minutes of use, 15x (b); adzes come from the Middle Neolithic sites of Rivoli (c) and Quinzano (d) (Verona, North East Italy), 12x.

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Bone tools use-wear analysis and image analysis: test of 3D digital restoration of worked and used surfaces

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Summary. *This paper deals with a method of 3D digital restoration of bone worked and used surfaces. This method uses profilometry. Digital image in grey levels restores relief of the surface, while revealing in light the high zones and in dark the zones in hallow. Each pixel composing the image is associated to a grey level ranged from 0 (black) to 256 (white). It's possible to represent the topography of a digitalized surface, measuring intensity of light (grey level) for each pixel.*
The second part of the paper proposes new line of research based on mathematical modelling for solving those 3D restorations. Mathematical modelling could useful not only for the characterization and the identification of use-wear traces but also for the constitution of experimental references.

Résumé. *Cet article présente une méthode de restitution numérique en 3 dimensions des traces techniques et fonctionnelles enregistrées sur la surface d'outils en os. Cette méthode fait appel à la profilométrie. Les images numériques en niveaux de gris restituent le relief d'une surface donnée, en faisant apparaître en clair les elevations et en foncé les depressions. A chaque pixel qui compose l'image est associé un niveau de gris échelonné entre 0 (noir) et 256 (blanc). On peut ainsi représenter la topogaphie d'une surface numérisée en faisant correspondre à chaque pixel, l'intensité lumineuse (ou niveau de gris) qui lui ait attribué.*
Dans une seconde partie, nous verrons l'intérêt de la modélisation mathématique pour traiter ces restitutions en 3 dimensions. Cet outil de travail peut s'avérer particulièrement utile non seulement pour la caratérisation et l'identification des traces d'usures mais, également, pour la constitution des réferentiels expérimentaux.

Key words: digital imaging, 3d digital restoration, mathematical modelling.

Introduction

To compensate the subjective character of classical traceological observations, which harm microscopic characterization of use-wear, several researchers have carried out other techniques study and, in particular, image analysis (Vila and Gallart 1993, Yamada and Sawada 1993, Gonzalez-Urquijo and Ibañez-Estevez 2003). Image analysis systems can express in real measurements use-wear patterns, which are usually estimated through metallographic microscope (extend of the polish, topography, dimensions and orientation of the striations, etc.). During our first tests with image analysis system, we quickly gave up the idea to work on counting, on measurements and on the direction of the striations. Although this way seems very fertile, the procedure returns to an extremely complex binary image processing. So, we have decided to work about structure of osseous surface (used or not) in grey levels.

3D digital restoration of bone worked and used surfaces: methodology

Digital image in grey levels restores relief of the surface, while revealing in light the high zones and in dark the zones in hallow. Each pixel composing the image is associated to a grey level ranged from 0 (black) to 256 (white). So, we can represent the structure of a surface by a curve where each pixel (x axis) is allocated to one grey level. With this method, we can obtain a "grey profile" which corresponds to a virtual cut of studied surface. A representation of three "grey profiles" obtained from the picture of a bone level used to split in half a rib is given in figure 1. Image size is 1300 x 1030 pixels. Black segments drawn on the image localize each "grey profiles". On these graphs, y-axis corresponds to grey level set on each pixel composing the measured segments. Segments are 512 pixels long. These virtual cuts emphasise the faithful representation of the relief linked to use-wear (heights, holes, striations) and other information specific to osseous tissue. Black circles give some sample of characteristic areas able to be seen on digitalized image. Although invaluable, the sum of these data is inclined to confuse curves reading. That's why we have systematically superimposed on the "grey profile" a smoothing, calculated starting from moving average. This smoothing makes it possible to remove the particular points and to reproduce in a more total way the superficial structure. The two levels of reading are equally significant and each one brings its own information.

When we multiply the cuts and their orientations, we can lead to a digital reconstitution of a surface in three dimensions. Figures 2, 3 and 4 show 3D digital restoration of bone worked and used surfaces. Black frame drawn on the pictures gives reconstituted surface part. Into those matrix of 512 by 512 pixels, grey levels (z-axis) have been measured each 5 pixels (x and y-axis). So, Graphs include 10,000 measurements. Peaks and troughs illustrate relief of bone surfaces. For a best representation, it's possible to extend measure frame or/and to record grey levels on each pixel.

How could we use these numerical data?

A number of proposals have been advanced in recent years for quantify the characteristics of polished surfaces

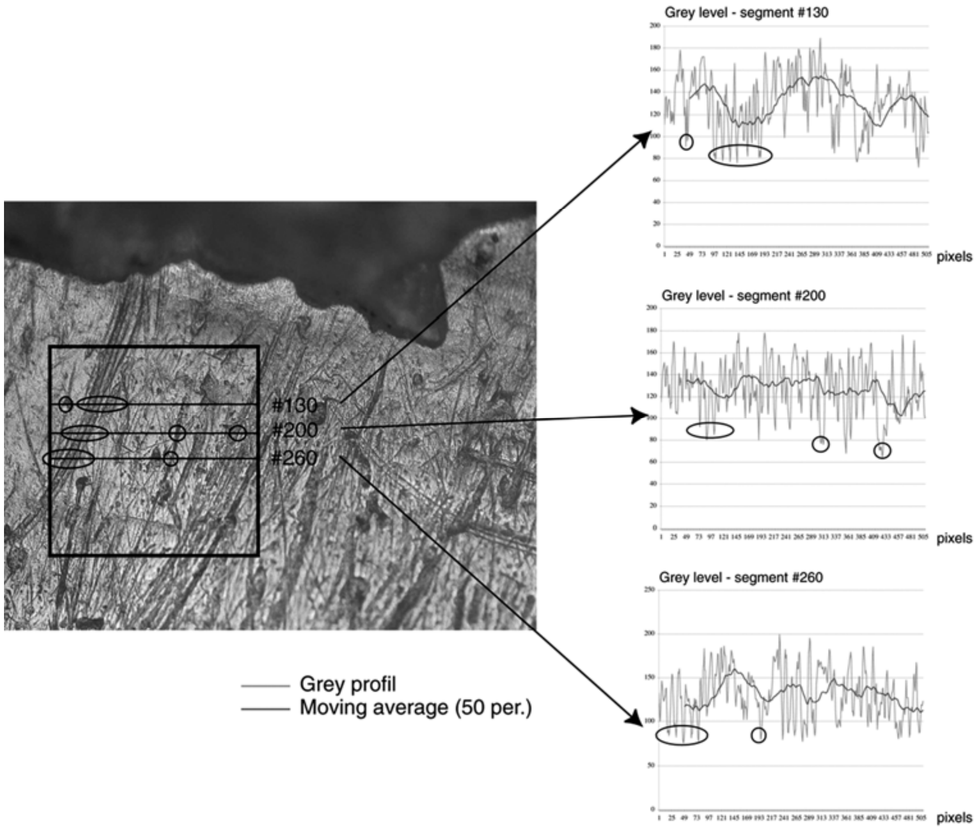

Fig. 1: Graphical representations of grey profiles obtained from the picture of an experimental bone bevel used to split in half a rib (x100). On this graph, y-axis corresponds to grey level set on each pixel composing the measured segments (#130, #200 and #260 localised by a black line on the picture). Black circles call attention to characteristic points like striations.

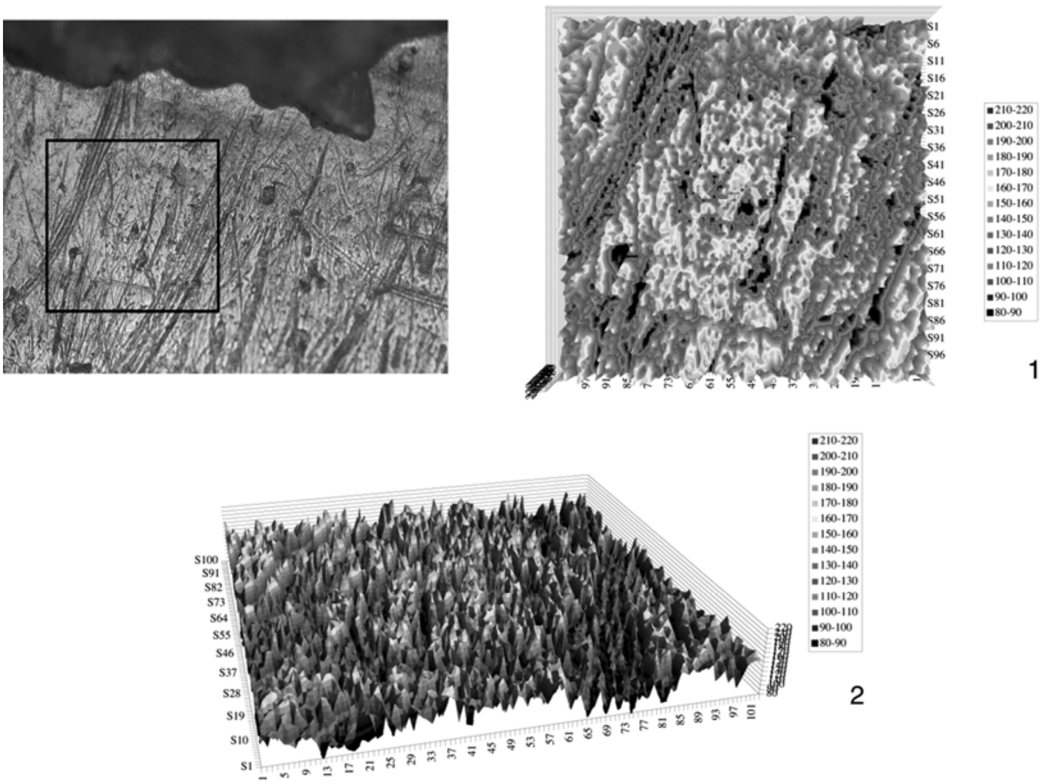

Fig. 2: 3D digital restoration of an experimental bone bevel surface used to split in half a rib (x100). The black measure frame (512 x 512 pixels) drawn on the picture localizes the restoration. The measures have been taking each 5 pixels. 1: 3D view at 90°. 2: 3D view at 25°.

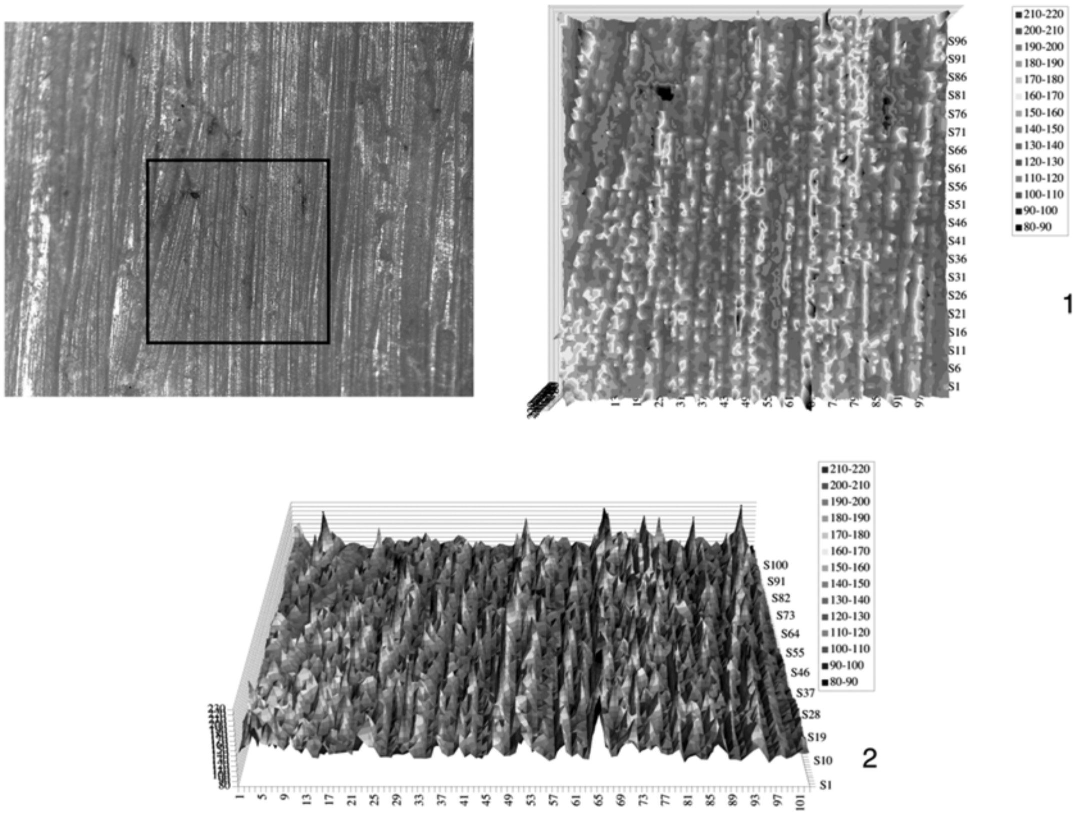

Fig. 3: 3D digital restoration of an experimental bone surface worked by scraping (x50). The black measure frame (512 x 512 pixels) drawn on the picture localizes the restoration. The measures have been taking each 5 pixels. 1: 3D view at 90°. 2: 3D view at 25°.

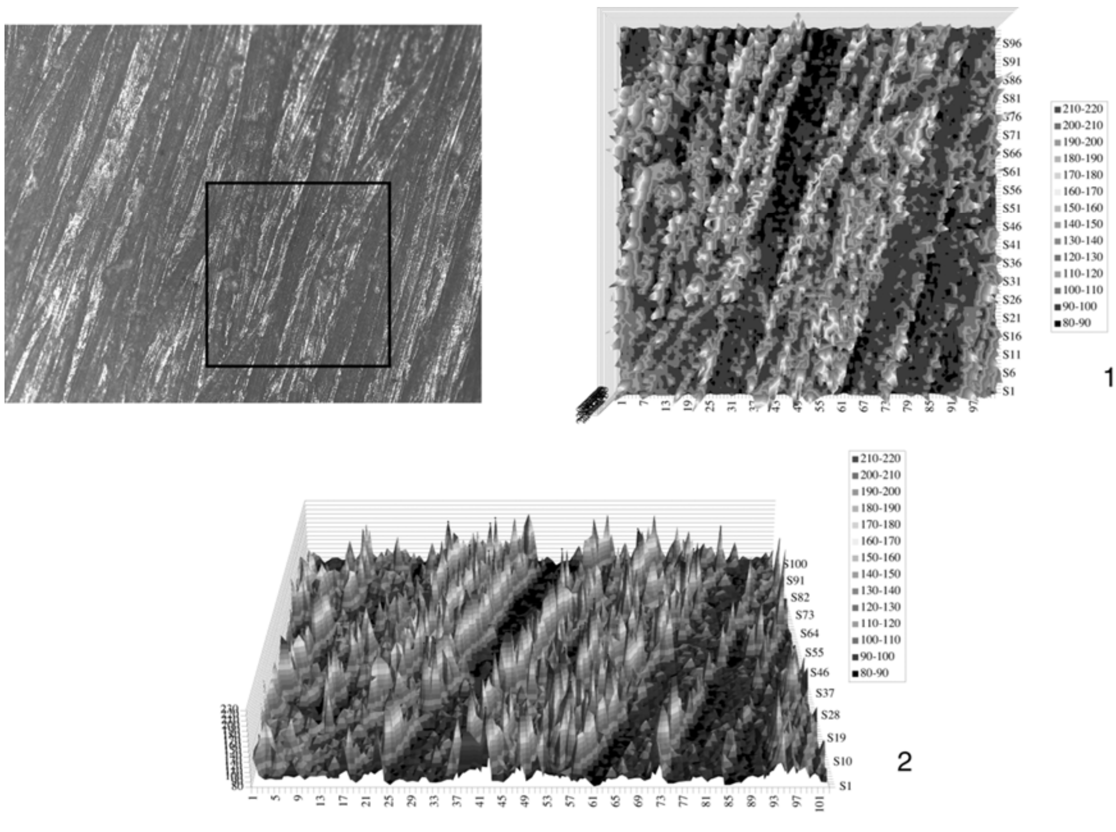

Fig. 4: 3D digital restoration of an experimental bone surface worked by abrasion (x50). The black measure frame (512 x 512 pixels) drawn on the picture localizes the restoration. The measures have been taking each 5 pixels. 1: 3D view at 90°. 2: 3D view at 25°.

of lithic implements starting from profilometric data. Gonzalez-Urquijo and Ibañez-Estevez have quantified texture, pattern of distribution and degree of development of polished surfaces starting from profilometric data (Gonzalez-Urquijo and Ibañez-Estevez 2003). For sample, they represent texture of polished surface by the variability in the value of grey level given by the standard deviation of the value pixel in a sampled area. They obtained promising and very interesting results. This kind of work could be applied to other raw materials like bone, antler or metal object. From digital restoration of numerous experimental bone tools, we have tried to emphasise some characteristic grey level histogram on various experimental use-wear, which we could thereafter seek on archaeological implements.

In this paper, we would like to propose another alternative to quantification of use-wear patterns. It's mathematical modelling. Mathematical modelling is used in various fields of research: Astronomy, Natural Science, Medicine, etc. Mathematical modelling consists in representing real phenomenon by mathematical equations (Cherruault 1998). Model a real phenomenon makes possible to control it and act on it thanks to simulation.

Use-wear analysis can upon to mathematical modelling. Use-wear could be considerate like a system with multivariable characterised by: properties of the tool, its operating mode, worked material, etc. These variables are subjected to various processes (chemical laws, mechanical laws, etc.) that are possible to translate by mathematical equations starting from profilometric data. First, mathematical modelling allows identifying unknown parameters in use-wear processes. Second, features of use-wear processes could be controlled. Thanks simulation built from modelling, it's possible to go further than experimental stage. It could be very useful to evaluate damage processing of polish for a large range of taphonomic contexts.

In our view, Image analysis and mathematical modelling are two promising approaches for use-wear analysis. With mathematicians, we are going to carry out a program of research on experimental bone tools. We will expose our results in the next years.

N.B.: For this work, images have been acquired with Zeiss Axiocam adapted to the Nikon microscope. Measurements have been obtained starting a program written on Leica Qwin image analysis system, in the Laboratory "*Chrono-Ecologie*" (UMR 6565 du CNRS, Besançon) then translated and improved for Zeiss KS300 image analysis system, in the "*Maison d'Archéologie et d'Ethnologie*" (MAE, Nanterre). All graphs have been edited with Microsoft Excel.

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Barbed and tanged arrowhead of extra-Cantabrian Solutrean: experimental progamme

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Summary. *Barbed and tanged points (BTP) are one of the specific elements which characterizes extracantabrian Solutrean. Its morphology contributes to fix the hypothesis that its possible function can be arrowheads propelled by a bow. However, until date there are not specific studies to contrast the idea. In this sense, we have carried out an experimental program to characterise the arrows from a technological, functional, ballistic and hunting qualities point of view. Some of the results show that barbed and tanged points of the Spanish Solutrean are morphologically and metric well suited to be thrown by a bow. The replicas had a perfect ballistic behaviour, so we can think that the origin of bow can be earlier than traditionally thought.*

Résumé. *Les pointes de pédoncule et ailerons sont un des éléments spécifiques qui caractérisent le Solutréen extracantabrique. Sa morphologie contribue à établir l'hipothèse de que sa probable fontion peut-être des pointes des flèches propulsées par an arc. Cependant, jusqu'à maintenant il n'y a pas des études spécifiques pour contraster cette idée. C'est pour cette raison que nous avons développé un programme expérimental pour caractériser les flèches du point de vue tecnologique, fonctionel, balistique et des qualités de chasse. Quelques resultants montrent que les pointes de pédoncule et ailerons du Solutréen espagnol sont métrique et morphologiquement performantes pour être lancées avec an arc. Les répliques ont eu un comportement balistique parfait, et pour cette raison nous pensons que l'origine de l'arc a du être antérieur à ce qu'on pense traditionnellement.*

Key words: arrowheads, bow, Solutrean, experiments, Iberian Peninsula.

Introduction

Extracantabrian Solutrean BTP are one of its most characteristics elements. It consists on a triangular point with invasive and plate retouch, mostly bifacial. Barbs either can be well developed and differentiated from the tip, having an acute angle or hook like morphologies, or form a right angle with the central stem. This last element is always well differentiated by means of deep retouches which separates them from barbs and tip. This type appears in most Upper Solutrean sites, where is more characteristic and abundant. At Evolved Upper Solutrean moments, it will be gradually replaced by the notched points of abrupt retouch. Nevertheless, its appearance in the archaeological record can be dated back to final phases of Middle Solutrean, as the result of the culmination of the essays of stem fabrication in arrows with invasive retouch. Both in Parpalló Cave -5,25-5,5 m.- (Pericot, 1942) and Les Mallaetes -East sector, level V-Va- (Fortea & Jordá, 1976) appear projectiles whose morphology is between laurel points of H type (Smith, 1966) and these points, with well differentiated stem and incipient barbs (Muñoz, 2000).

This phenomenon of progressive appearance of cinegetic tools with barbs can be also observed in french, Cantabria and Catalonia Solutrean as well as in the Arenien of Provence and Italian Ancient Epigravetian.

Tanged and barbed points, which disappeared with the Evolved Upper Solutrean, came back to form part of the neolithic cultural contexts and lasted until now. This proves that its technomorphologic peculiarities give them a high suitability as arrow point conceived as projectile point in cinegetic or war activities. From a ballistic point of view, some works have proved that at least the BTP and notched points of abrupt retouch were conceived to be used as light projectile arrow points. Their characteristics both morphologic and metric fulfil all the ballistic requisites to be propelled by a bow (Muñoz, 2000; Jardon-Giner *et al*. 2000). Use-wear analyses can determine from an objective point of view the real use of the pointed elements, sometimes as truly projectile elements.

The experiment

This work forms part of a wider experimental program to characterize, from a ballistic and cinegetic point of view the light Solutrean points. Some of the results of our research show that BTP fulfil the morphometric and metric requisites to be hafted in arrow shafts.

Some resin casts of points coming from the archaeological site of Cueva Ambrosio (Almería, Spain) have been made. These have been mounted on arrows in order to test their ballistic capabilities to be thrown by a bow (Fig. 1). This has been an analytic experimentation, so we have played with variables changing (shaft length, fletching and arrow type, bow, etc.) in order to determine their role on arrows velocities and trajectories.

The bows and arrows

We have used three simple bows: two laminated longbows (40 lb. and 50 lb.) and an elm longbow of a single piece and 40 lb. We have used 47 arrows with a total length between 74,2 and 137 cm. and weight from 21,6 to 92,5 gr. From a ballistic point of view, the arrow is the most important element because it is in charge of connecting the bow with the prey. An arrow with good

Fig: 1: General view of the arrow sample used in this experiments (Mario Torquemada photo)

stability and rightness can be effective even though the bow is not very well designed. But on the contrary, the possibilities of hitting the target are smaller. The basic elements of the arrow are the stabilizers (fletching), shaft, nock and point.

The shafts are cylindrical sticks of cedar, beech and oak industrial wood. Their diameter is between 8 and 10 mm. Their length between 72,5 mm. and 133,80 mm, even though most of them are not longer than 83 mm. Shaft weight of shorter ones is between 20,2 and 31,9 gr., while those longer than 83 mm. present weights between 32,2 and 87,7 gr. The number of feathers oscillates between 2 and 3 for the shorter ones. Stabilizers of four elements have been kept back for the longer shafts: from 130 mm.

The arrow points

Casts of 12 items from the solutrean levels of Cueva Ambrosio have been mounted on these shafts. The sample cover all the types established to this projectile. They have been made with high resolution moulds of silicon (Silicon RTV 863). The original morphology of the broken pieces has been reconstructed by this system. The moulds have been filled with polyester resin. The resin was mixed with marble powder and iron oxide (ochre) in order to conquer the same weight of the originals. After a few experiments, we could obtain the exact proportion to each arrow: in general, to 20 cm^3 of polyester resin, 22 gr. of ochre and 17 of marble powder are needed. Arrow weights oscillate between 0, 40 and 4, 60 gr. and their total length between 20 and 51 mm.

The arrow tips were attached to the shafts with mastic formed by pine resin (50%), bee wax (30%) and ochre (20%) as agglutinative to form a more homogeneous mixture. In order to link these three elements, a heat source is needed (120º). If there is more than 50% of pine resin, the glue gets too brittle. Once the glue is getting hardened, the haft is reinforced with fresh lamb guts applied to the joint part between the shaft and the tip, and around the immediately lower part, to reinforce it.

Fig. 2: View of the shot gallery. It can be seen the velocity measurer.

Finally, the nock is performed with a slot at the proximal end of the arrow. Its orientation is always the opposite to that of the nock of the distal end. All the feathers have been prepared by hand. All of them, coming from the same part of the bird (mainly vulture), have been attached to the shaft by horse mane.

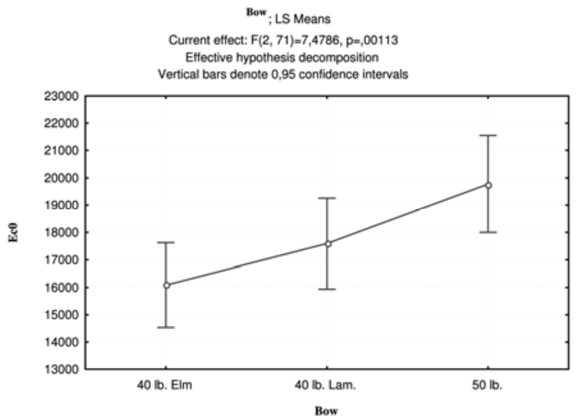
The shots

Other authors have performed experiments in order to test the ballistic features of homogeneous samples of projectiles. As compared to those of replicative character, aimed at contrasting experimental use-wear with archaeological ones (Bergman & Newcomer, 1983; Carrère & Lepetz, 1988; Odell & Cowan, 1986), there are analytic ones which align with our (Carrère, 1990). These allow us to know those aspects related to the capacity of prehistoric weapons to do their function (Márquez, 2004).

The experiments were performed at the installations of the Scientific Police in Madrid. We have used their shooting gallery which allowed the performance of the shots in best conditions. The velocity measurer (Drello & BAL4042 V-computer) provides measurements of the projectile in m/sc. The bows were mounted on a frame to prevent drawing length variations. This way, we have obtained a standard draw length of the bow (40-50 cm). It’s necessary that the arrow passes through an arch and two photoelectric cells in order to obtain the measurements (Fig. 2). We have registered two values, the first one in the same moment of the shot, and the second one, at a certain distance of the bow to control the loss of kinetic energy. Then, the first measurer was placed a 1,10 m. from the bow, in order to control de initial velocity (Velocity 1). The second one, which recorded the final velocity (Velocity 2), was placed 8,5 m. from the bow. The results, recorded in m/sc, have been transformed into Kinetic Energy ($\varepsilon c0$ initial energy, $\varepsilon c1$ final energy and εcr mark the loss of energy between the shot and a second moment located at a chosen distance). 92 shots have been done.

Univariate Tests of Significance for Ec0 (Shots DGP_1)
Sigma-restricted parameterization
Effective hypothesis decomposition

	SS	Degr. of Freedom	MS	F	p
Intercept	9,601477E+09	1	9,601477E+09	826,4120	0,000000
Bow	1,737772E+08	2	8,688858E+07	7,4786	0,001129
N feathers	1,849643E+07	1	1,849643E+07	1,5920	0,211168
L_cod	2,376741E+07	1	2,376741E+07	2,0457	0,157024
W_cod	3,062659E+07	1	3,062659E+07	2,6361	0,108893
Error	8,248971E+08	71	1,161827E+07		



Tab. 1: Results of the ANOVA with the variables "Type of bow", "Number of feathers", "Length" and "Weight" to the initial Energy (εc0). Only the type of bow has a significant role.

As we have already said, among the considered variables to test their influence on arrow flight we can say the type of bow. We have used three different bows. Two of them are laminated industrial bows, and the third is a replica of Holmegaard bow (Becker, 1945). This was a simple bow of 1, 5 m. long. It has plate limbs and biconvex grip. As the original, the experimental bow has been made in the traditional manner with a single piece of elm wood. According to the arrows, we have taken into account when statistical treatment, the total weight of the arrow (taken in grams), total length of the arrow (in centimetres) and number of feathers.

Statistics

We have carried out an ANOVA test (Analysis of Variance between groups) which allows variance analysis searching for the significant differences between means. In order to use the data obtained of the experiment, we have convert the weights and lengths of the arrows into categorical variables.

In the weight case, we have grouped the arrows into heavy (H= >30 gr.) and light (L= <30 gr.) ones. According to the length, they are grouped into short (S= <90 cm.) and long (L= >90 cm.) arrows.

We haven´t included the data coming from the longest arrows, those four fletched. Their behaviour has been defective and the analysis can be distorted.

Univariate Tests of Significance for Ec1 (Shots DGP_1)
Sigma-restricted parameterization
Effective hypothesis decomposition

	SS	Degr. of	MS	F	p
Intercept	4,629482E+09	1	4,629482E+09	614,6114	0,000000
Bow	2,889357E+08	2	1,444678E+08	19,1796	0,000000
N feathers	1,932622E+07	1	1,932622E+07	2,5658	0,114453
L_cod	1,326895E+05	1	1,326895E+05	0,0176	0,894855
W_cod	3,608401E+07	1	3,608401E+07	4,7905	0,032520
Error	4,519424E+08	60	7,532373E+06		

Tab. 2: Results of the ANOVA with the variables "Type of bow", "Number of feathers", "Length" and "Weight" to the final Energy (εc1). Again the type of bow and the weight of the arrows have a significant role.

The results show that the arrows shot with the 40 lb. elm bow have a significant lesser εc0 than those shot by the 50 lb. one (Table 1). In addition, to the εc1, both the bow and the weight of the arrow have a significant role (Table 2). In this case, the heavier arrows are which have a higher kinetic energy at a second point (εc1).

The shot performed with bows and solutrean barbed and tanged points have been satisfactory, from a ballistic point of view, according to their trajectories and effectiveness.

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Food preparation traces in ceramics. Functional interpretation of pots and jugs from Sant'Antimo (Piombino– Central Italy) based on organic residues

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Summary. *Among the different traces that human activities leave on objects, it is possible to consider the organic residues produced by the use of the ceramics. These residues, trapped in the ceramic matrices of pottery, are "invisible", but can be identified by chemical analysis such as simple spot tests and gas chromatography - mass spectrometry. As the residues are related to the content and to the coating of the ceramics, they may suggest what the ceramics were used for.*

In the present work we show the results of the analyses of some ceramic vessels found during the excavation of the filling of a vault of the church of Sant'Antimo in Piombino, Central Italy (13th century AD).

Interesting results were obtained comparing the residues preserved and the form of the vessels: it doesn't seems to exist a strict correlation between form and function. Different functions are carried out by the same typology of vessels, while the same function is carried out by vessels that have different forms. Jugs were in fact used for cooking different kinds of food, for storing water or grains, and for storing pitch; small jugs were used to heat and store water, wine and meat broth. Furthermore, most of the vessels analyzed served to cook meat broths. This can be related to the so called "monopoly of the "boiled meat"" proposed by Giovannini (1994) for the Middle Age. These data were confirmed by experiments that were carried out cooking different kind of soups.

Résumé *Entre les différents traces que l'homme laisse sur les objets, il y a aussi les résidus organiques qui sont produit pur l'usage des céramiques. Ces résidus, conservées dans les pores de la céramique, ne sont pas visible a « yeux nu », mais peuvent être identifiés avec des analyses chimiques simples ou, mieux, avec la gas chromatographie - spectrometrie de masse. Les résidus sont liées au contenu et au revêtement de la céramique, pourtant ils peuvent donner des informations sur son usage. Dans ce travail on va montrer les résultats de l'analyse de quelques céramiques rencontré pendant l'excavation de la volte de l'église de Saint Antimo à Piombino(Italie Centrale) du 13e siècle. Comparant les résidus absorbés dans la céramique et la forme des objets on a obtenu des résultats intéressants: il parait que il n'existe pas une corrélation forte entre la forme et la fonction d'une céramique et que à la même forme peuvent correspondre plusieurs fonctionnes et à plusieurs formes corresponde une sole fonction. Les casseroles ont étés utilisées pour cuir des aliments différents, pour conserver de l'eau ou des grains, et pour conserver de la poix. D'ailleurs, la plupart des céramiques analysées était utilisées pour cuir de potage de viande et végétal. Ça peut être mis en liaison avec ce que Giovannini a défini, pour le Moyen Âge, le « monopole du « bouilli ». Ces résultats ont été confirmées par des expérimentes que ont été réalisées cuisant diffèrent types de viande et végétales.*

Key words: residue analysis, ceramics, gas chromatography, spot test, Middle Ages.

Introduction

Human activities leave different traces, some of them are "invisible", such as the chemical residues left by the contents or coatings of the vessels that are absorbed by the pottery. Organic substances can infact survive trapped in the ceramic matrices of pottery even for centuries after they were used (Dunnel and Hunt 1990; Evans 1990). These residues can be identified through different chemical analysis and may suggest what ceramics contained or with what they were coated (Rottlander 1990; Charters et al. 1993).

Usually functional interpretation of ceramic vessels has been done by a formal and typological approach. Some specific forms are infact particularly useful for specific functions - i.e. amphorae are perfect transport containers and jugs are traditionally related to a liquid content, whereas jars and pans are associated to cooking activities (Rice 1987; Orton *et al*. 1993). When archaeologists are lucky, they find the content preserved, such as olive stones, fish bones, wine solid residues (Heron and Pollard 1988; Orton *et al.*1993), but in most of the cases the content is not visible any more. That is why it is important to carry out chemical analyses that could be able to identify the presence of organic residues that can be related to the function of the vessels.

In order to study the invisible traces of the content or coating of pottery, different kinds of analyses can be carried out: among others, simple analyses (spot tests) verify the presence/absence of fatty acids, proteins and organic materials (Barba *et al*. 1991; Pecci 2004, 2005). More specific results can be obtained by GC-MS (gas chromatography - mass spectrometry) analyses, that can state the presence of vegetable or animal fats, wine, resins and beeswax (Condamin *et al*. 1976; Charters and Evershed 1995; Charters *et al*. 1993; Charters *et al*. 1997; Copely *et al.* 2003; Dudd *et al.* 1998; Biers and McGovern 1990; Evershed *et al*. 1990, 1991, 2002, 2003; Guash-Jané *et al.* 2004; Kimpe *et al.* 2002; Kimpe *et al.* in press.; Mottram *et al.* 1999; Pecci 2004; Regert *et al*. 1998; Regert and Rolando 2002; Salvini *et al*. 2004; Colombini *et al.* 2005). These data, related to the traditional study of the ceramic can help to establish a relationship between the form and the function of the vessels.

The Sant'Antimo church

The materials analyzed for this work come from the church of Sant'Antimo in Piombino, Central Italy. The church was built during the 13th century. It was transformed several times until the beginning of the 19th century when it became an hospital as wished by Elisa Buonaparte (Fichera 2004).

The building was abandoned in 1994 and in 2003 the restoration works began in order to transform it into a commercial and domestic space. During these works, a great number of ceramic vessels of the end of the 13th century were recovered in the filling of the vault of the abside of the church (Fig 1). Some of these objects were pots, jugs, colanders and pans probably used for cooking meals or as food containers (Fig. 1, Fig. 2). Most of them were characterized by a coarse ware and burnt traces. It could be reasonably supposed that they preserved some traces of the foodstuff cooked or stored in them, therefore they were analyzed in order to identify the organic residues absorbed during their use and learn more about their function. We also wanted to verify hypothesis that are usually made on the function of medieval ceramic forms, such as jugs, jars and pans, on the basis of the results of the chemical analyses and of experiments performed using modern ceramics.

Methodology: chemical analyses and experiments

Samples were recovered drilling small holes in the ceramic body with a Drennan Drill, after having cleaned the surface smoothly. About 1 gr of dust was recovered for each sample.

The samples were firstly analyzed with spot tests developed in Mexico (Barba *et al.* 1991), in order to identify the presence of phosphates, fatty acids and protein residues. The analyses were performed in the Archaeometry Laboratory at the University of Siena.

For the GC-MS analysis, performed in the CIADS Laboratory at the University of Siena, we used the methodology developed in the University of Bristol (Mottram *et al.* 1999). For the tartaric acid extraction, we carried out the methodology reported in Guash Jané *et al.* (2004).

Gas chromatography - mass spectrometry (GC-MS) analyses were done by using a gas cromatographer (CP3800 Varian, Walnut Crick, CA) equipped with a 30 m x 0.25 mm internal diameter (i.d.) fused silica capillary column coated with a DB5 stationary phase (0.25 µm film thickness), and a mass spectrometer Saturn 2000 (Varian, Walnut Crick, CA) operated in the electron ionization mode (70 eV).

Fig. 1: Jars from the Sant'Antimo church (Piombino, Central Italy).

Fig. 2: One of the small jugs from the Sant'Antimo church (Piombino, Central Italy).

In order to interpret the results, experiments were performed by separately and repeatedly cooking chicken, pig, veal, fish and cabbage broths and soups in ceramic jars that were not coated (Fig. 3).

The experimental vessels were afterwords buried in the soil (30 cm deep) near an archaeological site for two years. The results were not satisfactory, as the analyses of the "aged" samples showed that they were not degraded enough to be compared with the archaeological ones. The vessels were therefore put in an oven for one month at 70°C, as suggested by Malainey (Malainey *et al.* 1999). This time the experimental aging gave good results and the samples obtained could be used for the interpretation of the residues absorbed in the archaeological ones.

Fig. 3: Experimental cooking of a meat broth.

Results

In the interpretation of the data we tried to establish a relationship between the different forms analyzed (jars, jugs and pans) and the residues absorbed. For instance we wanted to verify some hypothesis that are usually done about some ceramic forms, such as that jars were used to cook broths and soups, that pans were used to roast meat or other foodstuff and that jugs were used to store or serve solid materials (such as grains), and more often water or wine.

The jars

The results of the analyses of 15 jars showed interesting differentiation among the samples. No organic residues were detected in few of them, indicating that they were probably used to store solid materials, heat water, cook vegetables that cannot be "seen" with the analysis performed, or even that they were never used.

Evidence of burnt traces on the rest of the jars suggested that they were used for cooking or heating purposes. The analyses confirmed this hypothesis. The results of the spot tests indicated the presence of fatty acids and protein residues in most of them. The GC-MS analysis of the samples showed a high amount of saturated fatty acids particularly $C_{16:0}$ and $C_{18:0}$ components that are characteristic of degraded animal fats, and this was confirmed by the presence of cholesterol (Charters and Evershed 1995, Charters *et al*. 1993, Evershed *et al*. 1990, 2002, Kimpe *et al*. 2002, Mottram *et al*. 1999). The same results were obtained by cooking meat broths and aging the ceramics. Most of the jars were then used mainly for cooking meat broth. In some jars residues of *brassica oleracea* (cabbage and similar), were found as well, indicating that they were also used to cook vegetables (Evershed *et al*. 1991, Charters *et al*. 1997). This was the case not only for medium size jars but also for "small" (10 cm. rim diameter) and "big" (30 cm. rim diameter) vessels.

However, the analysis of a dark, apparently burnt deposit of two "big" vessels, at first interpreted as a burnt meal, showed instead the presence of an important amount of pitch (Heron and Pollard 1988; Colombini *et al*. 2005; Eerkens 2002; Egenberg *et al*. 2003). This showed that the jars were probably used in the nearby harbour of Piombino to waterproof the boats with the pitch.

The pan

Only one coarse ware pan was found in the vault. The analysis of the samples taken from it showed that it contained animal fats (Evershed *et al*. 1990; Kimpe *et al*. 2002; Mottram *et al*. 1999). In order to understand whether the food was cooked in presence of water, semiquantitative analyses on samples recovered in different parts of the pan (rim and bottom) were performed. Chartres *et al*. (1993) have in fact proved that when broths are cooked there are more fats in the rim of the vessel, whereas when food is roasted there are more residues in the bottom. Our results indicated that there were more residues in the rim than in the bottom of the pan, suggesting that not only jars were used to cook broths, but also pans.

The small jugs

Usually small jugs are thought to be used for wine or water storing or serving. The results of the analyses of 3 of them were somehow surprising. In fact, while in one of them wine markers were identified, in another ruminant fats were identified (could they show the presence of milk? - Copely *et al*. 2003) and in the third animal fats together with *brassica oleracea* were detected (Evershed *et al*. 1991; Charters *et al.* 1997) (Fig. 4).

This suggests that only sometimes these vessels were used to serve or heat wine, and they were also used to heat soups and eventually milk.

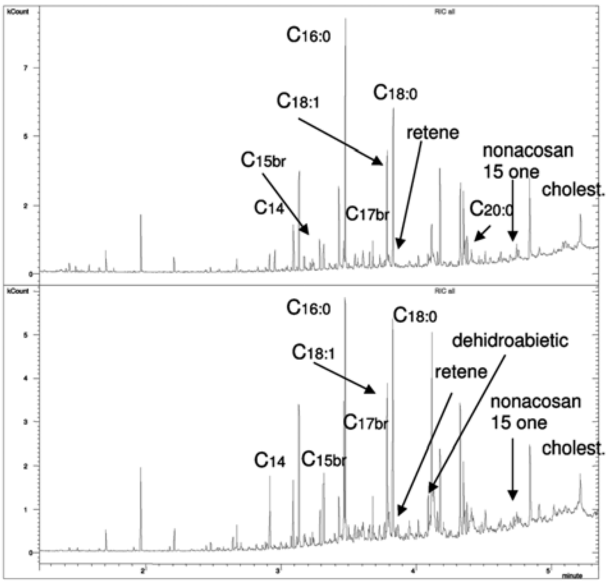

Fig. 4: Chromatograms obtained by the analysis of two samples of a small jug that show the presence of animal fat, *brassica oleracea* and *pinaceae* resin.

Conclusions

Comparing the results of the analyses of the archaeological samples and those of the experimental ones, as well as with the data published in literature, it was possible to obtain interesting data on the relationship between the content and the form of the vessels. Jars were used to cook different kinds of food, to store water or grains, and to store pitch; small jugs were used to heat and store wine, maybe milk, and meat broth and cabbage soups. This seems to show that the same form could have had different functions. Furthermore, the same function was common to different forms, as jars, pans and jugs served to cook or heat meat broths, a typical cooking practice of the Middle Age (Giovannini 1994; Montanari 1999). These data show that it didn’t exist a close relationship between form and function of the vessels and that in order to perform a good functional analysis of pottery, chemical analyses should be carried out.

The results of the analyses of Sant’Antimo vessels showed also that they all had an organic coating. This was made either of *Pinaceae* resins (sometimes heated and eventually transformed in pitch), or of beeswax (Heron and Pollard 1988; Egenberg *et al*. 2003; Regert and Rolando 2002; Colombini *et al.* 2005). Possibly, part of the animal fats detected was mixed with the resins or the wax for this purpose as well (Charters and Evershed 1995). This finding points out new problems on the reasons of these coatings: Were they used for waterproofing the vessels or, as Shiffer *et al*. (1994) suggested, the coating is related to a minor fuel consumption? Did all the potters use coatings? Were they related to a particular skill?

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6.2. Hunter-Gatherers

The bone assagaies of Grotta Continenza (Trasacco, L'Aquila, Italy): technological and microscopic analysis

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Summary. *At Grotta Continenza in Trasacco (L'Aquila) a great amount of assagaies (11 pieces) was found in levels 32-37, as well as one piece from level 44. Nine of the eleven assagaies found are decorated with engravings and the typological study consisted of metric and morphological features, through a deductive method based on a different-level analysis.*

Résumé. *Dans la Grotta Continenza de Trasacco ont été trouvées nombreuse sagaies (11 pièces), dont 10 pièces dans les niveaux 32-37 et une dans la couche 44. Neuf sagaies sont décorée par gravures.*
L'étude typologique a tenu compte des caractéristiques métrique et morphologiques et a suivi une méthode déductive basée sur plusieurs niveaux analytiques.

Key words: assagaies, microscopic analysis, decorative pattern.

Excavations carried out at Grotta Continenza in Trasacco (L'Aquila) supplied an important stratigraphic sequence spanning the Metal Age/Upper Palaeolithic (Barra, Grifoni Cremonesi 1991; Bevilacqua 1994; Grifoni Cremonesi 1998, 2003). Current archaeological investigations are inspecting the Epigravettian levels (27-44; Table 1).

Dates of the Epigravettian Levels (layers 27-44)			
Layers	Laboratory	BP	BC
l. 27	Rome 554	9330 ± 100	
	Rome 555	9650 ± 100	
l. 28 (from stalagmite)	ENEA	8000 ± 1000	
l. 28	Rome 556	9680 ± 100	
l. 31c	Rome 1196	9885 ± 75	
l. 32a	Rome 1195	9700 ± 75	
l. 32b	Rome 1194	9680 ± 75	
l. 32c	Rome 1197	9840 ± 75	
l. 32	Rome 557	10280 ± 100	
l. 33 (from a bone of a burial site)	ANSTO 070410		8065/7957
l. 34	Rome 558	10230 ± 100	
l. 35	Rome 1198	11500 ± 120	
l. 37	LY10755	11830 ± 110	11069/10707
l. 40	LY10754	11560 ± 100	11854/11250
l. 41	LY10753	10760 ± 140	11065/10419

Table 1

Osseous artefacts are widely distributed in the sequence, and a great amount of assagaies (11 pieces) was found in levels 32-37, as well as one piece from level 44 (Fig. 1).

The typological study consisted of metric and morphological features of the sample, through a deductive method based on a different-level analysis.

Fig. 1: Points and assagaies fragments from Grotta Continenza.

Although the degree of conservation of the sample is not homogenous (most of the 11 pieces *corpus* are represented by fragmentary stalks and proximal parts), exhaustive information can be obtained about their technology, morphology and use.

From a metric and morphological point of view, the damaged fragments by dihedral angle fractures show lateral margins and sections encompassing all the characteristics useful for technical considerations. The distal part and a good portion of the medial stalk were only preserved in four samples. The two intact assagaies come from distant levels and different contexts. The first one (-3DD, t.33), found in a burial context, belongs to the typological group of the "*sagaies à base raccourcie"* and is 164 mm long with circular section (Fig. 2). The base is

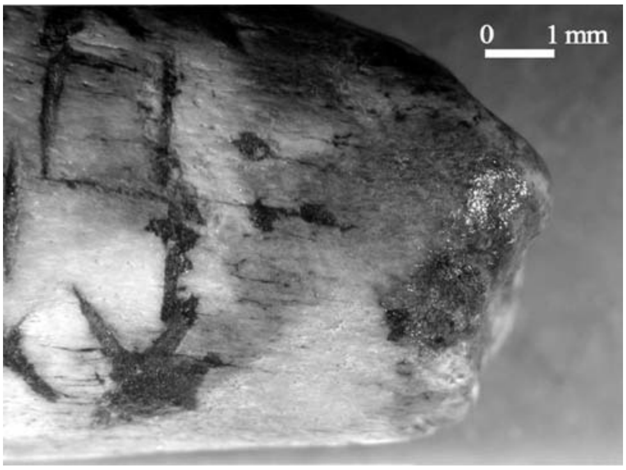


Fig. 2: Assagaie ***a*** point base.

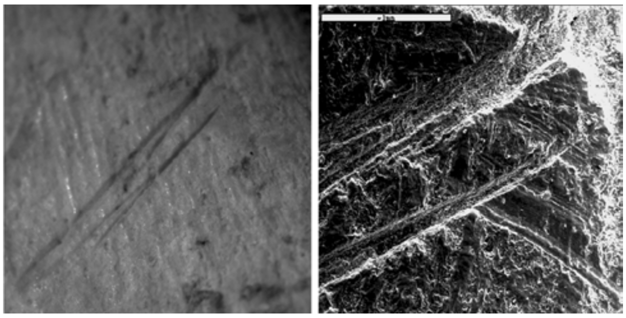


Fig. 3: Assagaie ***m*** point base.

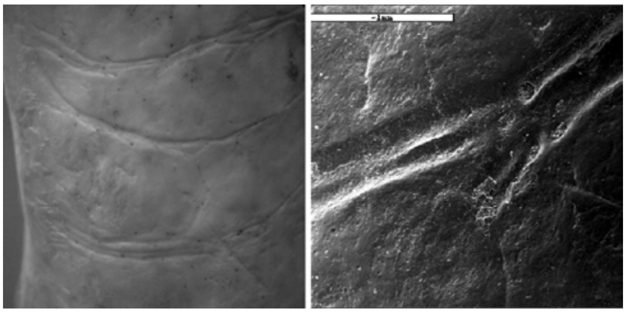


Fig. 4: Assagaie ***a*** point showing evidence of scraping on the stalk.

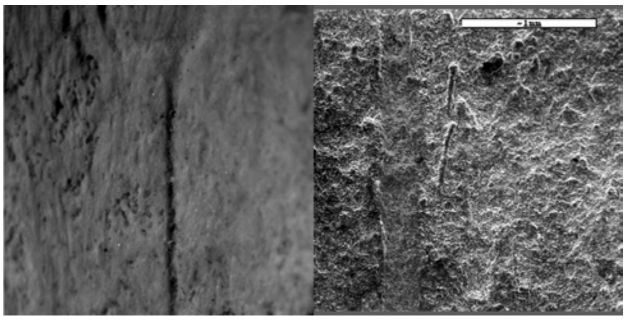


Fig. 5: Assagaie ***d***: SEM image showing rubbing-traces and incisions detail.

finely engraved but no evidence of hafting traces were observed.

The second one (-1AA, t. 44) was found in a clastic deposit which suggests a collapse phenomenon. It is typologically different as it shows a simple *biseau* at the proximal portion (Fig. 3); it is 126 mm long and shows a stalk with circular section. Due to its uniqueness, such a finding was only reported, and a direct comparison with the above mentioned materials was not possible.

The assagaies are carried out exclusively on long bones of large ungulate, and the working techniques used are: *débitage* by double grooving and the *façonnage* by rubbing and scraping. The double grooving technique represents a *débitage* procedure which allows for the extraction of a *baguette* from bones (or antlers), by means of the incision of two parallel grooves.

Evidence of scraping (Fig. 4) and rubbing (Fig. 5) was detected through SEM analysis on the whole sample of artefacts and interpreted as *façonnage.*

Furthermore, evidence of scraping was observed on the distal thirds available, although the apex is missing in most cases. Wear traces were found on the only apex available for analysis (Fig. 6-7).
(A. G.)

Nine of the eleven assagaies found are decorated (Fig. 1, assagaies a, b, c, d, f, g, h, i, l). These show sequences of transversal lines (Fig. 8), V-patterns (Fig. 9), zigzag-patterns, with the exception of the assagaie found near the burial which also includes more complex patterns - several series of "X" connected to sets of parallel or crossed lines (Fig. 10-11).

Relying upon such patterns, most pieces appear to be very homogenous, so that a standardized type of decoration can be supposed.

In general, the execution of the incisions is very detailed and precise, such that it points to a highly controlled ability in working with the hands and material being used as testified by prevailing complex patterns.

The internal morphology area of the engravings was observed microscopically showing that these were produced by a to-and-fro movement of a cutting edge (Fig. 11) so as to make the decorative pattern more visible.

The decorative pattern observed on the assagaies falls within the diffused linear-geometric repertoire of the Italian Final Epigravettian, such as the decorated osseous artefacts coming from Maritza (Grifoni, Radmilli 1964), Polesini (Radmilli 1974), and Settecannelle Caves (d'Errico, Ucelli Gnesutta 1999).
(P. A.)

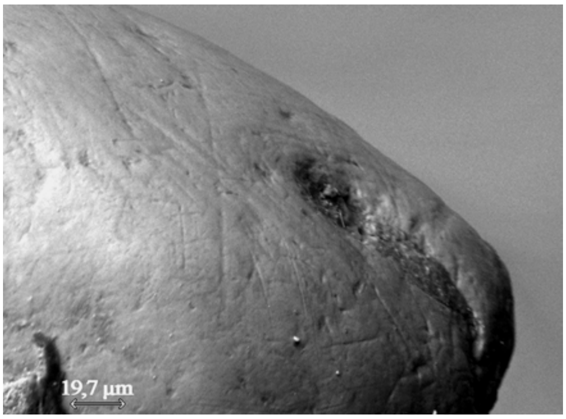


Fig. 6-7: Detail of assagaie ***d*** point displaying a polished appearance due to its use; SEM image showing a series of striae caused by utilization on soft materials.

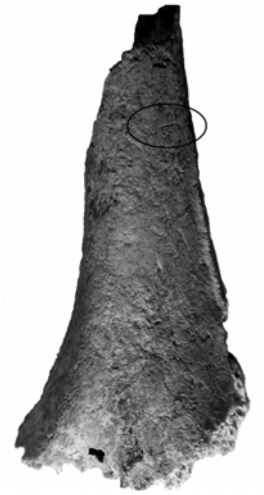


Fig. 8: Assagaie ***f*** fragment: sequences of single-stroke lines.

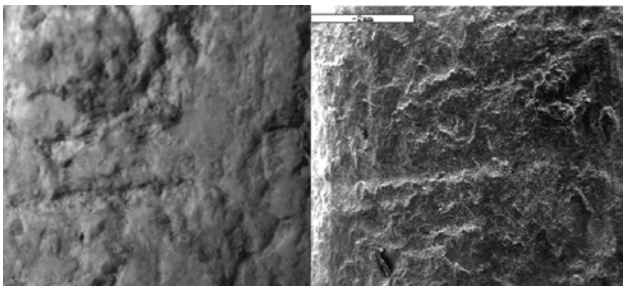
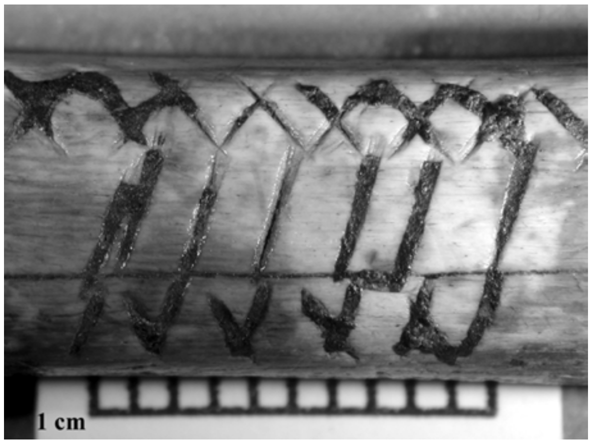
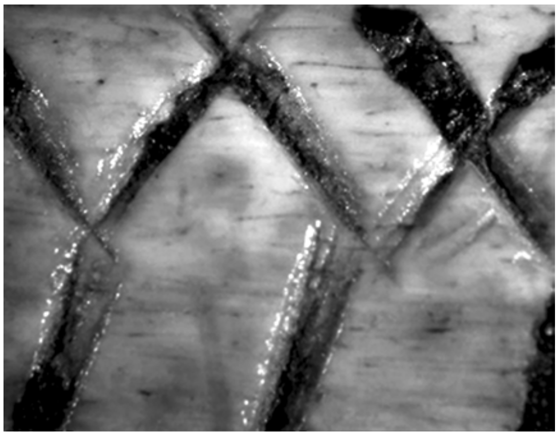


Fig. 9: Assagaie ***i*** fragment: sequences of V-patterns.





Figs. 10-11: assagaie ***a*** point showing X-shaped patterns; decorative pattern detail. The engravings show micro-morphologies due to a multiple pass of the tool.

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Stone Tools and Early Agriculture at Kuk Swamp, Papua New Guinea

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Summary. *Recent studies document an independent emergence of agriculture at Kuk Swamp in the highlands of Papua New Guinea. We summarise here the functional analysis of stone tools and describe starch granules of two significant economic species, taro (Colocasia esculenta) and yam (Dioscorea sp.). Usewear and residue analyses of starch granules indicate that both these species were processed on the wetland margin by at least 10,200 calibrated years before present (cal BP). From at least 6950 to 6440 cal BP taro, yam and other plants are likely to have been cultivated.*

Rèsumè. *Des études récentes documentent une apparition indépendante de l'agriculture à Kuk Swamp dans les montanges de Papoua Nouvelle-Guinée. Nous récapitulons ici l'analyse fonctionnelle des outils en pierre, et nous décrivons des granules d'amidon de deux espèces économiques significatives: taros (Colocasia esculenta) et ignames (Dioscorea sp.). L'analyse fonctionelle et les analyses de résidu des granules d'amidon indiquent que ces deux espèces ont été traitées sur la marge du marais par au moins 10.200 années calibrées avant présent (cal BP). D'au moins 6950 à 6440 cal BP, il est très probable que taros, ignames et d'autres plantes ont été cultivées.*

Key words: Papa New Guinea, functional analysis, taro, yam, plant processing.

Introduction

Starchy plants have been fundamental to subsistence in both agricultural and hunter-gatherer societies for millennia (Smith 1998), and may have been critical in early human evolution (e.g. O'Connell *et al.* 1999; 2002; van Peer *et al.* 2003). Agriculture involving independent domestication of cereals or other starchy plants developed at different times in at least 10 different parts of the world: in the Americas, West Asia, East Asia, Africa and Melanesia (e.g. see Diamond 2002; Piperno *et al.* 2004). Recent archaeological and palaeoecological investigations confirm an independent emergence of agriculture at Kuk Swamp in the highlands of Papua New Guinea by about 7,000 years ago (Denham *et al.* 2003).

Kuk Swamp is about 1560 m above sea level (Figure 1) and excavations by Golson and Hughes (1980) documented archaeological evidence of raised garden beds and canals – probably like the recent agricultural landscape of the Grand Baliem Valley in West Papua today (Swadling 1991). The archaeological evidence, which includes stone artefacts, indicates several phases of exploitation and modification to the swamp margins spanning the last 10,000 years (Denham *et al.* 2004). Plant foods currently grown in the New Guinea Highlands include taro, yams, sugar cane, bananas, green vegetables and sweet potato (a relatively late introduction). However, there had been little direct palaeoecological evidence of early plants until the recent multi-disciplinary research by Tim Denham and colleagues (Denham *et al.* 2003), who described phytoliths, pollen and starch grains of a broad range of edible plants, including *Musa* bananas, and *Colocasia esculenta* taro.

Usewear and residues on the excavated stone artefacts from Kuk Swamp provide direct evidence of prehistoric resource exploitation, and we present here summary information and examples of stone tool functions (see Fullagar *et al.* 2006). We analysed artefacts primarily to assess the range of functions, and to identify any starch granules. A key question was to determine when taro (*Colocasia esculenta*) and yams (*Dioscorea* spp.) had first been processed.

Methods

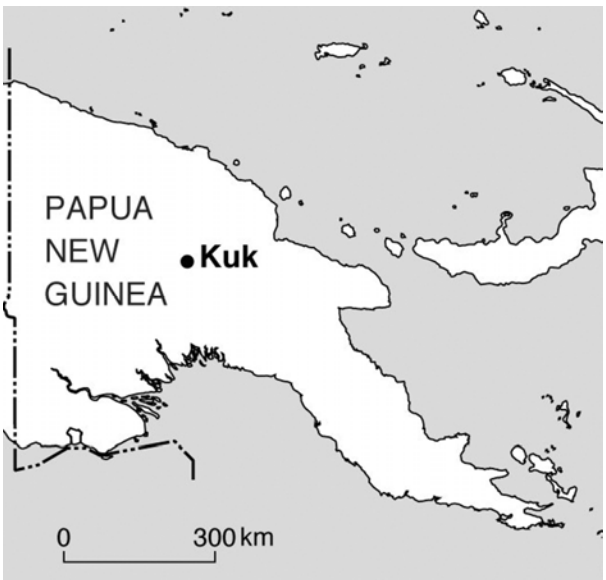

Fig. 1: Location of Kuk Swamp, Papua New Guinea. After Denham *et al.* 2003, Fig. 1.

We studied a sample of excavated artefacts (n=55) from the three oldest archaeological units: Phase 1 at 10,220 – 9910 cal BP, Phase 2 at 6950 – 6440 cal BP and late Phase 3 at pre-3260 – 2800 cal BP. Artefacts were examined under stereomicroscopes, and then under metallographic microscopes, in order to document usewear and residues. We recorded the nature of edge rounding, scarring, striations and smoothing or polish formation at different magnifications. We extracted residues by immersing tool edges in a sonic bath, and centrifuging the solution to isolate starch and phytoliths (Fullagar *et al.* 2006). Wear pattern and residue identification are based on experimental tools and residue reference collections (see Fullagar 2005) including a large number of starchy plant specimens (>100 species) from the PNG and Australian regions. Starch grains were photographed under both polarised light and Nomarski (differential interference contrast, DIC) microscopy.

Results

Stone artefacts included chert flakes and smoothed volcanic cobbles used as pounding stones from Phase 1 and Phase 2 contexts, as well as an intervening stratigraphic unit. Preservation of organic residues was generally excellent, and our analysis showed evidence for the grinding, pounding and scraping of plants, including siliceous, woody and soft starchy parts (Table 1). Wear patterns indicate that skin and bone working tools were also probably used for plant processing.

Contact Material	No. of artefacts	No. of artefacts with starch granules
Wood	17	7
Wood/skin	1	1
Wood/reeds	1	1
Wood/bone	1	
Soft plant	7	6
Ochre (?)	1	1
Uncertain	22	2
Not used	5	
TOTAL	**55**	**18**

Table 1: Tool functions of Kuk artefacts (n = 55).
After Fullagar *et al*. 2006, Table 1.

Fifty artefacts had traces of use, and 18 of these had starch granules (Table 1). We selected 12 artefacts with secure stratigraphic provenance for more detailed analyses. We then extracted new residue samples and studied usewear and the starch granules and phytoliths for taxonomic identification (Table 2).

We observed larger starch granules typical of *Dioscorea* sp., and smaller granules typical of Colocasia *esculenta* (Figure 2). Artefact K75/S178 is from a Phase 1 channel with smoothed surfaces and abundant starch granules typical in size and shape to *Dioscorea alata* and *D. pentaphylla*. We can eliminate other *Dioscorea* species on the basis of size and shape. Artefact K75/S179 is a

Artefact No.	Age cal BP	Starch granules	Phytoliths	Artefact type and contact material indicated by usewear and residues
Phase 1				
K75/S178	10,220 - 9910	YES, D	NO	Altered volcanic cobble (greenstone): pestle or pounding/ grinding stone, starchy plant
K76/S28	10,220 - 9910	YES	YES	Broken chert flake: starchy plant
K76/S29A	10,220 - 9910	YES	NO	?Retouched chert flake: hard woody tissue, starchy plant
K76/S29B	10,220 - 9910	YES, C	YES ND	Retouched chert flake: hard woody tissue, starchy plant
Grey clay (between Phases 1 and 2)				
K75/S179	~10,000 - 7300	YES, C, D	YES G Sac? Th	Volcanic cobble core: uncertain usewear, starchy plant
K98/217	~10,000 - 7300	YES	YES P/Z, G Sac?Sorg?	Retouched chert flake: hard woody tissue, starchy siliceous plant
K76/36	6950 - 6440	YES	NO	Chert flake: hard woody tissue
K77/S4	6950 - 6440	YES	YES	[2]Retouched chert fragment: starchy siliceous plant
K77/S9	6950 - 6440	YES	YES G	Volcanic cobble: probable grinding stone fragment, starchy plant
K77/S20	6950 - 6440	YES	NO	[2]Retouched chert fragment: hard woody tissue
K77/S17	6950 - 6440	YES, C	YES [1] ND	Volcanic cobble: probable grinding stone, starchy plant, ochre
Phase 3				
K76/S19	pre-3260 - 2800	NO	YES P/Z, G Sac?	[2]Retouched chert fragment: hard woody tissue; bone?

Table 2: Starch granules and phytoliths on Kuk artefacts from Phases 1 – 3.
C - *Colocasia esculenta* starch granules; D - *Dioscorea* sp. starch granules; G – Grass phytolith morphotypes (Sac = *Saccharum*, Sorg = *Sorghum*, Th = *Themeda*); P/Z – Echinate globular phytolith morphotypes found most commonly in palms (Palmae) and gingers (Zingiberacae); ND – Non-diagnostic phytolith morphotypes.
[1]The majority of the phytoliths on tool K77/S17 were fractured and incomplete, consistent with grinding and pounding.
[2] These small fragments lack definitive flake attributes. They are small tabular pieces ~1 cm thick with steep retouch. Technologically, they are cores (Fig.11).
(After Fullagar *et al.*. 2006, Table 2).

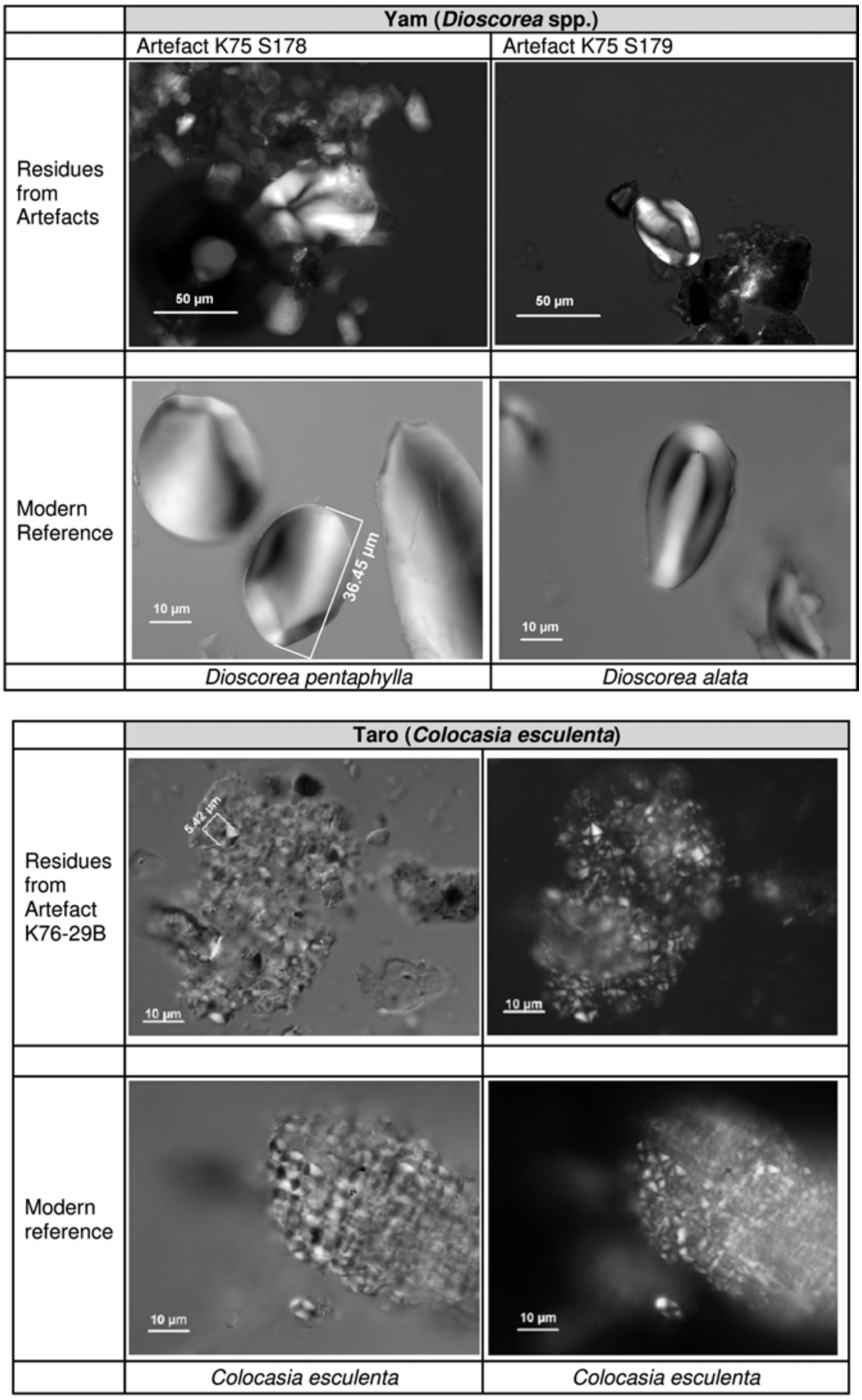

Fig. 2: Starch granules from early and mid-Holocene artefacts at Kuk compared to modern reference sample.

large volcanic cobble core from a clay layer between Phases 1 and 2. Edges are retouched, rounded and polished with abundant residues including starch granules typical of *Dioscorea alata* and *D. pentaphylla.* In addition there are spherical starch granules, about 5 microns diameter, with faceting and clustering typical of *Colocasia esculenta*. Artefact K76/S29B is a retouched chert flake fragment from Phase 1 with abundant starch granules typical of *Colocasia esculenta*, phytoliths typical of grass, palm and/or ginger, and use polish typical of hard siliceous plant (probably palm wood).

Conclusions

Our main findings are

- Slicing, scraping and mashing of taro and yam commenced by at least 10,200 calibrated years before present at Kuk.
- From at least 6950 to 6440 cal BP taro, yam and other plants are likely to have been cultivated on the wetland edge.
- Stone artefacts with usewear and residues provide an extraordinary record of plant food processing and agricultural origins.

Golson (1977) argued how lithic technology in PNG is unlikely to provide distinguishing features that might clearly indicate emergence of agriculture. Rowley-Conwy (2004) described a similar problem in comparing the roles of technology and ideology in the European Neolithic. Our study shows how usewear and starch residues may provide direct evidence of plant exploitation of particular species. However, it remains to be seen precisely how the PNG stone tool evidence itself can provide independent indicators of agriculture – perhaps by starch morphologies indicative of domestication, by particular tool functions indicative of agricultural practices, or by more subtle changes in technological organisation.

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For advice and assistance, we thank Jack Golson, Michael Therin and the late Tom Loy (1942-2005), who undertook pioneering studies on ancient starch residues. Tom previously examined residues on many of the artefacts we have analysed here, and he noted the high potential for further study. We also thank conference organisers and the editors who encouraged this expanded text based on the poster we presented at the Verona conference.

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Villa Ladronaia: a Middle Palaeolithic site near Cecina (Livorno, Italy)

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Summary. *The Palaeolithic site of Villa Ladronaia (Cecina-Tuscany) has given back a lithic industry composed by about 8,000 finds. The Author presents in this note the main techno-economical characteristics which come from two reduction processes. The main one is interested in the exploitation of sub-rounded blocks, the second one, on the contrary, employs flakes which are produced by the main reduction processes. The technological analysis has put a large use of Levallois conception in evidence, the preliminary data of which will be presented about the variability of the methods and its relation with the different local raw materials, of an industrial facies which typical Mousterian rich in scrapers widely documented in Tuscany during the Upper Pleistocene.*

Résumé. *Le site paléolithique de Villa Ladronaia (Cecina, Livorno) a livré une industrie lithique composée d'environ 8000 vestiges lithiques. L'Auteur présente dans cette note les caractéristiques principales techno-économiques, qui dérivent de deux chaînes opératoires. Celle principale voit l'exploitation de blocs, la deuxième, au contraire, utilise des éclats, qui sont produits de la chaîne opératoire principale. L'analyse technologique a mis en évidence un large usage du concept Levallois, duquel on présentera les données préliminaires sur la variabilité des méthodes et son rapport avec les différentes marières premières locales, d'un faciès industriel Moustérien typique riche en racloirs, amplement documenté en Toscane pendant le Pléistocène supérieur.*

Key words: technological analysis, Palaeolithic, Levallois method.

Introduction

The Palaeolithic site of Villa Ladronaia near Cecina was discovered by the underwriter and it extends to the South-Eastern slope of a wide terrace on the left bank of the river Cecina, between 25 and 35 a.s.l. The terrace is formed by the so-called "Red sands of Val di Gori", formation of a bright red colour with a large clayey composition which deposited during the Middle Pleistocene period (Mazzanti and Sanesi 1986).
The zone of collection of the finds occupies a surface of about 20,000 sq.m, which at present is occupied by vineyards. The assemblage is composed by over 8,000 finds; about 900 of them have been classified following Bordes' typology (Bordes 1961).

The lithic industry

The first analysis on the techno-economical aspects has the purpose to report some general considerations which concern the type and the use of raw material, as well as the information about the most significant points which characterise the technical reduction sequence. This is represented by two fundamental reduction processes, the main one in the production of predetermined blanks using different operational schemes applied to different raw materials which are present in the shape of sub-rounded blocks, tabular cobbles and so on; the second one, which is quite secondary in the production of technical objectives, which employs, instead, some flakes which are produced by the principal reduction sequence.

Raw material
The main raw material used is the reddish-brown-green jasper (about 70% of the finds), followed by microquartzarenite, employed less frequently, on the contrary the use of other types of flint is very rare.
As regards the core blanks, we remark a large use of sub-rounded blocks; all the other categories are represented very little (tabular cobbles, cobbles).

They think the jasper supply source must be found in the fluvial deposits of the river Cecina and its tributaries, only marginally in the primary deposits of the Upper Jurassic still to locate, at very reduced distances from the site of Villa Ladronaia, as well as the complete reduction sequences for this lithological kind would let us think. At present, it's uncertain the position of the place of origin of microquartzarenite, the formations of which would seem absent in the basin of the river Cecina. Some microquartzarenite deposits are know, in this area of Tuscany, in Val di Cornia and in Val d'Era, which are about 30 km far from Villa Ladronaia and they might represent the supply places of this lithotype, seeing that its frequency in the lithic assemblage in consideration is modest. It's possible the quantity of the raw material which constitutes the above-said lithological kind may have been brought from the above pointed out distance. However, the consideration ask for the confirmation of further checks.

The main reduction sequence

Cores
They are represented by about 2,000 specimens which bear witness to an undifferentiated use of the lithological kinds, without any distinction in the application of the different modalities of flaking. In this production system a certain importance is undertaken by the category of cores, which is regulated by the technical characters of Levallois predetermination (Boëda 1994). A first macroscopic analysis of the operational schemes has brought out the use of two methods at least.

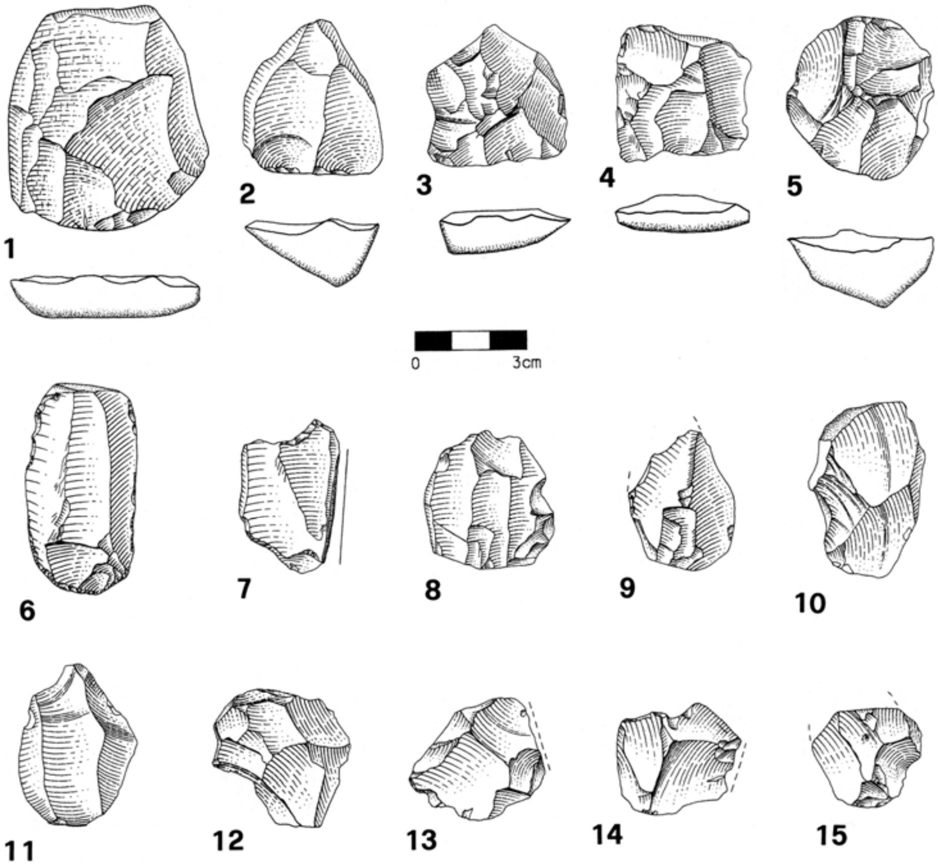

Fig. 1: Jasper: Levallois recurrent unidirectional cores (1, 2); Levallois recurrent bidirectional core (3); Levallois recurrent orthogonal core (4); Levallois recurrent centripetal core (5); unidirectional (6-9), orthogonal (10), bidirectional (11), centripetal (13-15) recurrent Levallois flake; preferential Levallois flake (12) (drawings by P. Giunti; scale 3:4).

The first one is based on the criteria which regulate the recurrent unidirectional Levallois method (Fig. 1, nn. 1, 2; Fig. 2, n. 1), the structure of which is characterized beginning from the intermediate phase also because of the presence of orthogonal (Fig. 1, n. 4; Fig. 2, n. 2) and bidirectional (Fig. 1, n. 3) Levallois cores which points out some important technological variations in order to optimize the raw material at disposal.

The second one joins to the recurrent centripetal Levallois method (Fig. 1, n. 5; Fig. 2, nn. 3, 4), and in this group we have included also a series of preferential flake Levallois cores, the dependence of which on a structural level must be confirmed by further researches, which can reveal us in opposition the presence of a third independent method.

Another whole of cores is composed of a small number of specimens which, because of their volumetric conception and because of some technical criteria of predetermination joined to it, might point out the presence of a Discoid (Boëda 1993) reduction sequence. Their small influence lead us not to exclude the possibility, these specimens may be put into the field of the Levallois production in which they would represent the results of hyper-exploitation.

At last the other typologies of cores are represented by some polyhedric specimens and by forms we can compare to choppers and chopping-tools.

The products of flaking

The products of flaking, more or less than 6,000 finds between retouched and unretouched, bear witness to the presence of different technological types which can be joined in the most cases to a reduction process which is typically Levallois.

To the initialisation stage we can join the following types of blanks:

- among the half-cortical blanks we point out some elongated blanks, with parallel, convergent dorsal scars, sometimes overshot and slightly twisted, where it begins to create the distal convexity of flaking surface, or some less elongated blanks with parallel margins which point out the decortification core stage pertaining to the unidirectional method;
- from the previous ones we can distinguish some half-cortical flakes, with more reduced size categories and sub-oval forms, orthogonal or centripetal dorsal scar, sometimes *débordants* with cortically backed or prepared backed, which can point out an initialisation method different from the previous one.

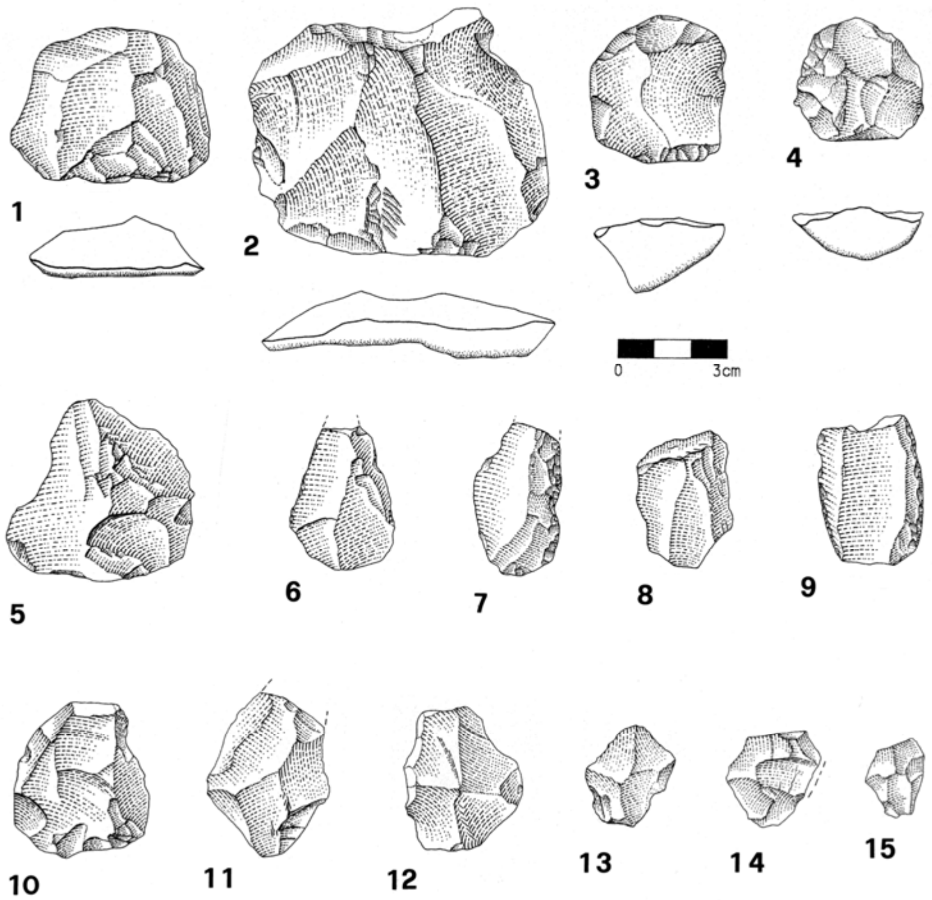

Fig. 2: Quartzarenite: Levallois recurrent unidirectional core (1); Levallois recurrent orthogonal core (2); Levallois recurrent centripetal cores (3, 4); unidirectional (5-10), centripetal (11-15) recurrent Levallois flakes (drawings by P.Giunti; scale 3:4).

As regards the reshaped or maintenance of the core convexities we can list:

- among the core edge removal flakes we point out the presence of Levallois flakes or not with cortically backed, very elongated with parallel dorsal scars which are typical of the shape of lateral convexities of the recurrent unidirectional Levallois cores, in which such operation during the development of the process of reduction was done also through the removal of short flakes, on the contrary, for the distal convexity the removals present an opposite direction as regards the unidirectional sequence;
- a second whole of core edge removal flakes is composed of some more typical specimens of the recurrent centripetal Levallois method (Discoid method?); it's a matter of pseudo-Levallois Points and core edge removal flakes "*à dos limité*" which take part to the maintenance of the convexities during the development of the reduction process.
-

As regards the phase of production of the predetermined blanks we have the following situation:

- the predetermined blanks which are attributed to the recurrent unidirectional Levallois method (Fig. 1, nn. 6-11; Fig. 2, nn. 5-10) prevail decidedly on those which come from the recurrent centripetal Levallois method (Fig. 1, nn. 12-15; Fig. 2, 11-15);
- among the previous ones we remark the presence both of elongated blanks and less elongated blanks with very functional parallel edges and the rarity of triangular and sub-triangular blanks;
- in the second ones, the number of which is decidedly smaller than the previous ones, the sizes take part mostly to the smallest classes and their form, in the most cases, is sub-oval;
- the few preferential blanks, in a smaller number as regards their cores, present some size which take part to superior typometrical categories and morphotechnical characteristics which can be joined both to the unidirectional Levallois method (Levallois point) and the centripetal one.

Economical aspects of the products of flaking

A swift examination of the typological characteristics of the industry is done following the order of Bordes' typelist (Bordes 1961).

In the group II the single straight scrapers and the single convex scrapers balance out almost in a perfect manner, with about a hundred specimens for each type. The single concave scrapers are very few. The transverse scrapers are about thirty elements, which have mainly a convex shape morphology. In decreasing numerical order it follows the scrapers on interior surface, the double scrapers in different combinations, the abrupt scrapers and at the end the *déjeté* scrapers. The Mousterian points are very rare (less than ten elements) and almost all are elongated. We point out moreover the presence of a *limace* which as a rather approximate making.

The group III has a very high percentage and this aspect represent, in our opinion, the main typological characteristic of the industry. There are numerous burins, the end scrapers are more scanty which result of a rather summary technology which has nothing in common with the classical specimens of the Upper Palaeolithic. On the contrary it is very large the number of the truncation, the making of which seems technically good. At the end we have about ten atypical *perçoirs*.

The group IV is very weak. It is a matter of denticulate scrapers, the denticulate endscrapers, instead, are very rare.

Among the other types of Bordes' list we point out a number of *raclettes* and notches and lots of flakes with irregular retouch.

As regards the choice of the blanks to use for the production of the retouched ones, the trend is both to the by-products of flaking and the predetermined blanks. In the previous ones it is evident the steady use of the cortical and half-cortical blanks, or undifferentiated no cortical flake, in the second ones, instead, the choice is mainly to the unidirectional Levallois flakes (and their variations) rather than to the technical objectives which come from the recurrent centripetal Levallois method. At the level of typological groups we remark a preferential selection of the unidirectional predetermined blanks forward the group II, in which the most frequent use is verifiable in the single convex and straight scrapers.

The secondary reduction process
It is represented by few flakes cores (less than ten). The cortical blanks point out a flaking which is articulated on the interior surface coming from a striking platform which is generally not prepared.

From a first analysis, the cores have been discarded during different times of a same recurrent method flaking which can be joined to a Levallois conception. The operational scheme, which is decidedly simplified, is based on the exploitation of the natural convexity of the interior surface of the blank which permits to control the flakes production. The first intrusive struck off flake will have the name both of predetermined flake, because its striking off will be controlled by the interior surface convexity, and predetermining flake because it will create on the surface of flaking an arris guide which will take the place of the convexity and it will permit the striking off of a new intrusive flake which has the same name of the preceding one.

This production sequence is characterized by some unidirectional removals, the fracture plane of which is parallel to the plane of intersection of the two surfaces. A first variation to this method is represented by some cores where we remark a change of the orientation of the flaking axis through a rotation of the core of about 90 degrees after the first sequence of the unidirectional removals. However the new sequence of striking off, which is orthogonal to the preceding one, is generally broken precociously.

Remarks

This work brings to knowledge of a new industry which goes and enters an outline of sets which point out the Mousterian culture in a zone (Livorno coastal belt), which, with the increase of the researches, is going to gain a great importance because of the diffusion of the proofs which can be attributed to Middle Palaeolithic.

From a typological point of view the industry, we are considering, seems till now to be arranged in the industrial *facies* which can be attributed to the typical Mousterian, rich in scrapers. Even if the industry of Villa Ladronaia is devoid of palaeoecological and stratigraphical data, it gives us new information which concern the exploitation strategies and management of raw materials resources.

At present, at the level of reduction sequence, we are not able, with the data we have got, to check the existence of an independence among the different know method. If we suppose it's essential by the Neandertals a research of predetermined blanks which are attributed to the unidirectional recurrent Levallois method and supposing the smallest sizes of the centripetal predetermined blanks, the reduction process might be characterized through an only operative structure, in which the onset sees the use of the unidirectional recurrent modality, the middle phase avails itself of the orthogonal and bidirectional variations, on the contrary in the final one we remark also the use of the centripetal recurrent Levallois modality.

Being inclined in this note to the first assumption, the Levallois production is addressed essentially to the achievement of the predetermined blanks, which can be attributed to the unidirectional recurrent Levallois method to use as potential tools with or without any retouch, whereas it points out how the centripetal recurrent Levallois method takes part to the final exploitation phase only in economical sense, in order to optimize the residual product of the raw material as soon as the production of unidirectional predetermined blanks might be discussed by probable accident risks.

Such reduction process becomes part of an environmental framework where the resources of raw materials are represented by secondary deposits which are composed mainly of jasper and microquartzarenite of small size in the shape of sub-rounded blocks and cobbles, which, because of their physical characteristics, seem impose certain strategies about the production of blanks with determinate typometrical, morphological and functional features.

To conclude we will point out, how such operative strategies have already been remarked in other sites of central Italy (Grimaldi 1995, 1998a, 1998b), where it seems to be developing since the Late Middle Pleistocene in accordance with dr. Grimaldi, a mutual opinion as for different human groups, that is the development of an only operative structure, the variability of which is in direct relation both with the productive needs of the single group and with the duties which are imposed by the physical features of the raw material.

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Hunting, what? Early Mesolithic backed points in north-eastern Italy

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Summary. *A sample of Sauveterrian microlithic arrowheads coming from both high and low mountain sites in north-eastern Italian Alps are analysed. Sample comes from open-air high mountain "Colbricon" and "Buse" sites (about 2000m asl), located near glacial lake shores and considered as seasonally-occupied hunting camps, and from "Pradestel" rockshelter (225m asl in the Adige valley floor), that provides a complete Mesolithic stratigraphic sequence showing chronologically-differentiated faunal and floral associations. Experimental observations provide further data concerning ballistic and functional properties of these lithic items.*

Résumé. *Des pointes Sauveterriens provenant des sites de Pradestel, Lago delle Buse et Colbricon (Italie du nord-est) ont été étudiés. Des fleches experimentales ont été produits et utilisées. Les resultats de cet etude semblent suggérer la possible "inefficacité" des ces points si l'objectif de la chasse était l'abattage immédiat d'animaux de taille moyenne à grande, comme le bouquetin, le cerf, l'ours ou le sanglier. Nous formulons l'hypothèse selon laquelle les pointes microlithiques du Sauveterrien peuvent être mises en relation avec des activités de chasse vers le petit gibier de forêt tel que le chevreuil, la marmotte, le castor, et d'autres animaux à fourrure.*

Key words: Early Mesolithic, Sauvetterian points, north-eastern Italy.

Introduction

Extant literature (among others, Bagolini 1971; Broglio & Kozlowski 1984) considers the so called "Sauveterrian" early Mesolithic points, together with other microlithic forms such as geometrics, under the definition of projectiles. This definition is generally equated to that of throwing weapons, or more commonly, given their sizes, to arrow points or projectile components that were probably used with a bow mainly for hunting. The quest that we asked ourselves was the following: is it possible that such small arrow points could have been used to kill medium to large sized animals such as deer, ibex and wild boar, all characterised by heavy musculature and thick hard skin?

Technological analysis

A sample of single- or double-backed lithic points coming from four archaeological sites located in the Trentino Province (north-eastern Italian Alps) has been analysed. The sites are Pradestel rockshelter, Laghi delle Buse, Colbricon 6 and Colbricon 8 open air sites (complete references in Dalmeri *et al*. 2000). Fig. 1 shows the analysed sample: on the left side, unbroken points; in the middle, broken points, frequently represented by distal parts; on the right side, fragments. All of the items have been made from flint. Points are mainly characterized by a double-backed retouch even if a single-backed retouch is also observed. Frequently, single-backed points show a "more or less" abrupt retouch located on the opposite edge, generally providing a better pointed morphology. Usually, the upper surface of the blanks shows a flat morphology: consequently, point's transversal section appears more and more quadrilaterally shaped, according to the width/thickness ratio. Dimensional features of the analysed early Mesolithic backed points are shown in Fig. 2. It is worth mentioning the clear relationship between thickness and weight. Most of the sample weights less than 0,1 grs.

Experimental activity

Experimental blanks (Fig. 3) have been produced (direct percussion) by a hammer made on wood (Buxus sempervirens). Points (Black area) have been produced by pressure technique; a large part of blank volume has been reduced in debris (White area). Microburin technique has been applied (Light Grey area). Some experiments have been interrupted because of the fracture of the point (Dark Grey area).

Two experimental points (Fig. 3:1,3) have been hafted on shafts made from *Cornus sanguinea*. Arrows are about 70cms long and about 6-7mms in diameter; their final weight is 25 and 28 grs. (Fig. 4). Both arrows have been shot by using two Long-Bows, made from *Taxus baccata*, of 30 and 55 lbs, respectively. A 5mms-thick, 1m-high, plastic panel have been used as a target. Shooting distance was 7 and 12 meters. Indipendently from distance, arrows shot by the lightest bow showed a remarkable decreasing of their speed and, consequently, of their power of penetration (see arrow in the target, Fig. 5). Arrows shot at the 7ms shooting distance by the heaviest bow showed a better balistic impact and an increased power of penetration. When shot from the maximum shooting distance, arrows showed reduced functional properties (see flying arrow, Fig. 5). Arrows have been also shot to a 4kgs lower limb of a small pig (Fig. 6). A 40lbs Long-Bow has been used. Shooting distance was about 10 meters. Arrows hit the target without touching the bone. Even if arrows penetrated meat about 3cms in depth, no projectile succeded in completely perforating the target. In one case, arrowhead broke up: fracture occurred where hafted stone was in contact with the wooden shaft. The proximal part of the point remained in the shaft (Fig. 6).

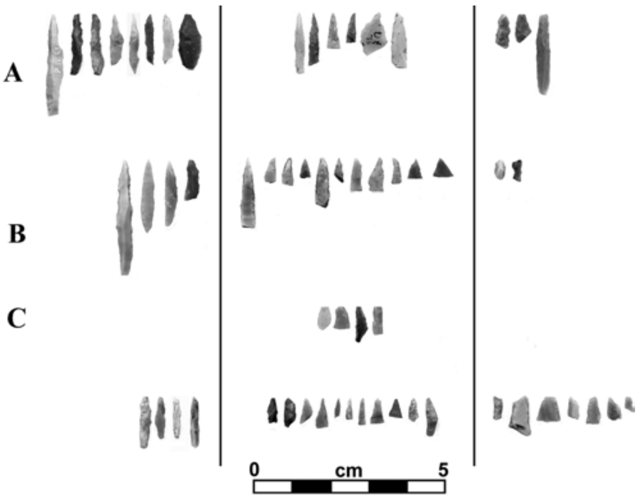

Fig. 1: The analysed archaeological sample of Sauveterrian points.

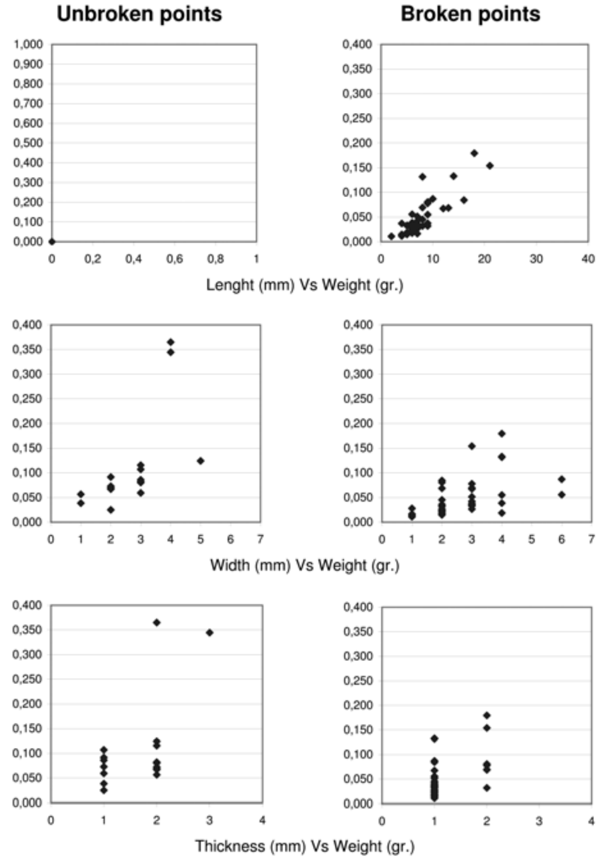

Fig. 2. Dimensional features of the analysed points.

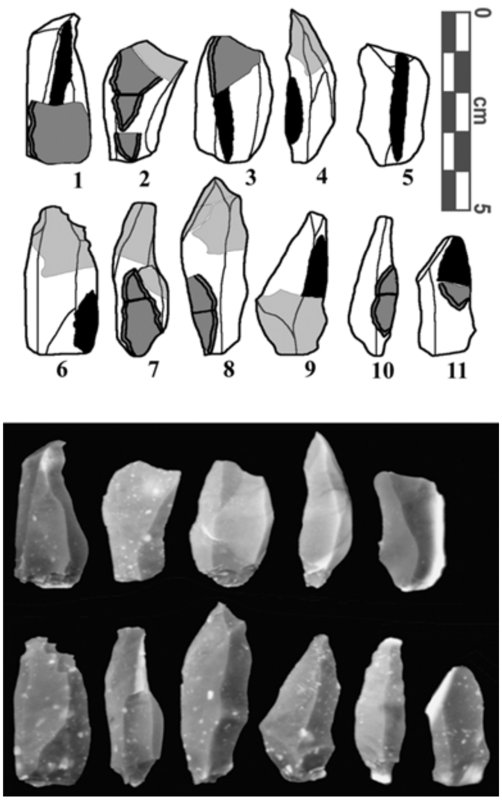

Fig. 3: Experimental production of Sauveterrian-like points.

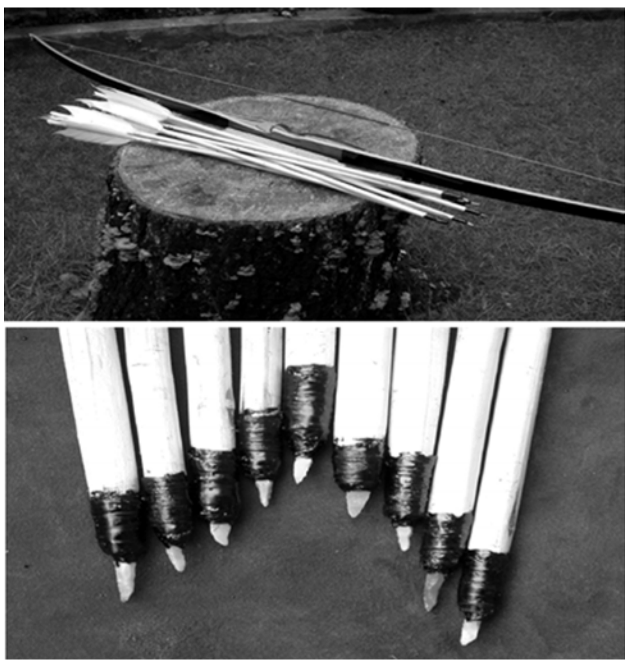

Fig. 4: Experimental arrows.

Fig. 5: Ballistic properties of the experimental arrows.

Fig. 6: Functional properties of the experimental arrows.

Fig. 7: Bone points from Pradestel Rockshelter (Adige valley, Trentino)

Conclusion

Observed both experimental and archaeological data allow us to suggest a more available utilisation of the microlithic projectiles in hunting activities toward small/medium game - such as Roe deer, Marmot and other furred animals. At the same time, it remains quite difficult to relate these morphologies to big game - such as Red deer or Ibex - hunting practices. As pure speculation, therefore, it is possible to put forward the hypothesis that hunting large animals was carried out, without ruling out the partial or exclusive use of spears, with bows with a high draw weight which could fire heavy arrows which had points made in different ways, such as a fire hardened wood point, or a bone or horn point mounted on the shaft using resin or ligatures. A support to this hypotesis comes from the archaeological sites present in the valley floor sites of Trentino Province (Fig.7) that have provided bone and horn artefacts which may have been used as points for arrows to be fired from a bow or for spears.

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Payre (Ardèche, France) early Middle Palaeolithic site. An example of macroscopic traces on tools and flakes: utilization as side-scrapers and stone tips (hand implements, projectile points) in an OIS 5 human occupation

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Summary. *This paper introduces the study of the "stone implements" from the upper archaeological level (D) of the Payre rockshelter. Macroscopic use traces on flint tools provide evidences of different uses for the same piece regardless of/ independently of its morphology. We will focus this study on the side-scrapers, the retouched and unretouched points related to a discoid core reduction method, but we find the crushing traces/marks also on some quartz flakes, basalt pebble tools and quartzite large flakes.*
By ethnoarchaeological and experimental studies, we could suggest that these artefacts would be use as handle projectile points, hand implements either like cutting edge tool over one of their functional areas.
Furthermore, subsistence behaviours involved in the lithic technology and faunal processing patterns will be compared focusing on the way that human activities were differently performed regarding the available resources.

Résumé. *Cet article présente l'étude des artefacts de l'occupation archéologique supérieure (D), qui a eu lieu sous abri dans le site de Payre. Les traces macroscopiques d'utilisation sur les outils en silex indiquent différentes zones d'utilisation pour une même pièce, indépendamment de sa morphologie. L'analyse porte principalement sur les racloirs et les pointes retouchées et brutes, dans un contexte de débitage discoïde, bien que les mêmes types de traces soient également visibles sur les éclats en quartz, le gros outillage en basalte et les grands éclats en quartzite.*
A partir des études ethnoarchéologiques et expérimentales, ces types des traces peuvent suggérer une utilisation des ces artefacts comme projectiles ou outils tenus en main, avec une ou plusieurs zones fonctionnelles.
Par ailleurs, les comportements de subsistance, au travers de l'étude comparative du matériel lithique et des données fauniques, permettent de reconstituer les activités humaines qui se sont déroulées dans le site.

Key words: Middle Palaeolithic, Payre, OIS 5, crushing marks, macroscopic traces, stone tips, side-scrapers.

The site of Payre

The Middle Palaeolithic site of Payre is one of the rare sites in the Middle Rhône valley dated to the isotopic stages 7 to 5 by ESR, U-Th and TL. This site has yielded human remains (Moncel and Condemi 1996). On the border of the Rhône valley, opening to southeast, the karstic complex is 60 m above a small tributary of the Rhône river. Since 1990, regular excavations have taken place (Moncel *et al.*, 2002).

The sequence (5m thickness) is composed of 5 main levels (G, F, E, D-C and B-A from bottom to top), each of them including sub-layers. The study of the sequence indicates that the site was a cave, and then a shelter after collapsing of the cliff. Prehistoric people occupied this place several times, because of its specific location, at the junction of various ecosystems.

Unit D Archaeological Assemblage

The fauna assemblage suggests hunting of a single species, *Cervus elaphus*, during winter, associated to an opportunistic hunting of other herbivores. All the stages of the treatment of the animals have been identified, most of them have being brought already dismembered. *Ursus spelaeus* occupation seems to be more frequent than the human occupation. A few carnivores occupied the shelter, only after bears and humans, perhaps attracted by the meat remains. The site was a hunting seasonal short camp (Moncel *et al*. 2002). Burned bones and flint artefacts show the use of fire.

Most of the palaeoenvironmental studies and the radiometric data place the occupation during the OIS 5 (5d, 5e or end of 6) (Masaoudi *et al*, 1996; Moncel *et al*. 2002; Moncel *et al*. in press).

80% of the assemblage is made from flint nodules and pebbles, collected within 20 km perimeter, on a southern plateau. Some flint pebbles have also been collected in the nearby Rhône Valley. Other rocks come from the small river near the site, except for quartzite and some limestone pebbles coming from the Rhône Valley. The stones were differently worked: knapping processing system of discoidal type for the flint, quartz, limestone, and shaping for the basalt and the quartzite. A few artefacts were brought already prepared: large flakes in flint, basalt and quartzite, small flakes in quartz and limestone, flakes in hexogen flint.

Methodology

Flint artefacts do not show any kind of postdepositional traces. Therefore, we were able to examine the cutting edges, which often show anthropic crushing marks. The marks have been observed only on the debitage products, measuring at least 15-20 mm. These macroscopic

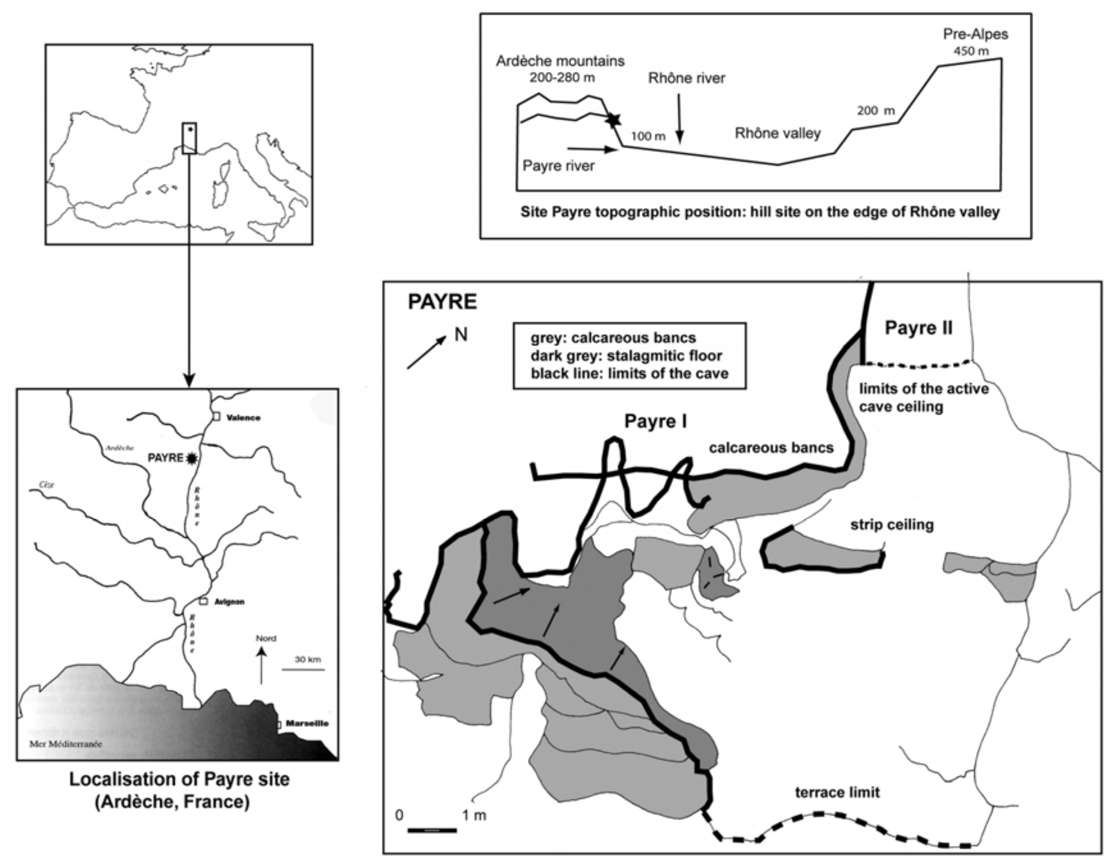

Fig. 1 : Location of the site of Payre and morphology of the excavated area.

Excavation : 70 m² thickness : 20-60 cm	basalt	quartz	limestone	quartzite	others	flint	total
unworked nodules	87	-	1	1	1		90 (3)
broken nodules	43	-	-	3	-		46 (1.6)
Pebble tools	20	1	1	1	-		23 (.7)
flakes and flake fragments	202	221	22	38	1	1847 (433 < 20mm)	2331 (76.6)
retouched artefacts	3	21	1	2	-	437	464 (15.2)
cores and core fragments	-	6	-	-	-	84	90 (2.9)
total	355 (11.6)	249 (8.2)	25 (.8)	45 (1.5)	2 (.06)	2368 (77.8)	3044
Artefacts density							*272/m²*
Total bone remains							*15027*

Table 1: Composition of the lithic assemblage from the level D (values in %)

stigmata are enough deep and well preserved to be qualified as used marks (Lemorini 2000).

The level D has yielded 437 flint flake tools (18.4%), including 200 are side-scrapers (45.8%) and 179 retouched points (41%). Most of the tools were prepared on the longest and thickest flakes (Moncel 2003; Chacón and Moncel 2004; Moncel *et al*. in press).

Results

-unretouched flakes with crushing marks (n = 244, 2.3%)

The traces are located on one or several cutting edges. The flake measure less than 50 mm, they are thin and the proportion of backed flakes is high (26.8%).

- *retouched edges = side-scrapers (n = 200, 39.6%)*

65% of these tools have one retouched edge, while the other ones show two retouched edges or the entire periphery. The retouch is ordinary and small, except for 11% with a deep-step retouch.

The traces are observed on around 30% of the tools:

- on one retouched edge: on the total edge (ordinary or step retouch), or on a part of the edge,

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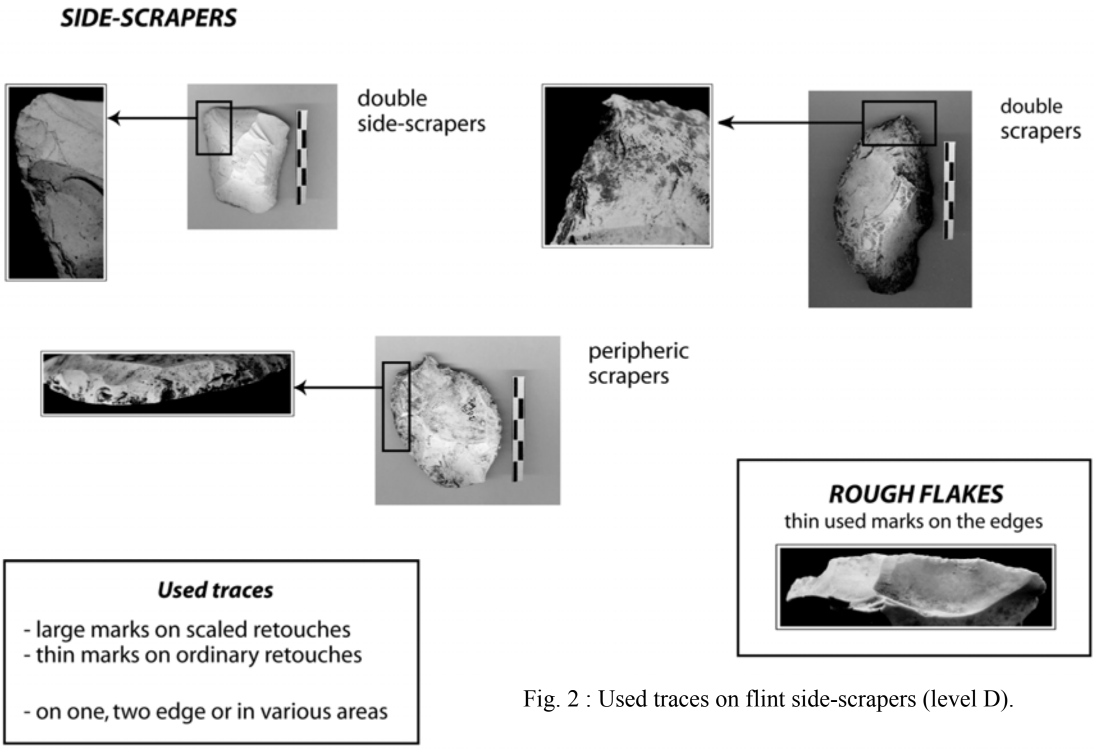

Fig. 2 : Used traces on flint side-scrapers (level D).

- on all the retouched edges: deep crushing marks on an edge, associated to limited traces on the other edges; traces on several areas,
- on unretouched edges, associated to small retouched areas.

The angles of the cutting edges with macroscopic traces show a large range of values, in relation to the type of retouch. The extent of the use marks depends on the edge morphology, deeper and limited on convex or concave edges, longer on straight ones. There seems to be specific utilised and active areas on the artefacts. When a flat retouch is used, the cutting edges do not carry macroscopic marks.

-whole retouched points (n = 179, 53.7%,), point fragments (n = 71) and unretouched points (n = 83, 24.9%)

The retouch is located on one or two cutting edges converging into a point, whatever is its location on the flake (“pointes d’axe” = 23.4%). The tip is pointed (n = 122) or rounded (*n* = 50).

The retouch is marginal, mainly direct and thin, and is performed to obtain a symmetry of the extremity or the whole tool. It does not change the flake shape, except for 26 points with scaled retouches. The points are short (breadth>length) or slightly elongated.

The location of the macroscopic traces suggests different tool uses, to the point and/or the cutting edges:

- Unilateral points: on the retouched edge, total (deep retouch) or partial + crushed point or not
- Bilateral points: on one edge (scaled retouch), on two edges (ordinary retouch) + crushed point or not
- Points retouched on the entire periphery: on several areas, including the base and sometimes the point
- 127 retouched points show a small and thin removal on the tip. No crushing marks occur on the cutting edges
- Points with thin removals on the base (9%): no macroscopic trace on the edges (numerous bifacial retouch), traces sometimes on the edge with invasive removals
- Thin unretouched flakes (*n* = 83, 24.9%) with small crushing traces located on the two converging edges, often associated to a crushed point.

A total of 8 points, retouched or unretouched, carry a fracture of 3 or 4 mm deep. 21.3% of the points are broken (proximal or distal point fragments). The fracture often shows a lip, as a result of a use and break by bending.

Use marks are related to the type of intentional retouch and its location. The crushing marks extend on the whole edges when the retouch is scaled, and sometimes occur on the point. When the retouch is absent or ordinary or marginal, the marks frequently occur on two edges.

What kind of use for the flake tools?

	Stigmata	Type of work ?	Type of tools	Way of using
Edge with scaled retouch	Strong crushing marks Abrupt angle	Hard work, long use	Side-scrapers or retouched point	Hand tool
Edge with a thin ordinary retouch	Small crushing marks	Light work, short use	Side-scrapers or retouched point	Hand tool
Sharp point or rounded point	Crushing marks	More or less hard work	Retouched or unretouched point	Hand tool
Sharp point	Micro-fractures	Strong impacts	Retouched or unretouched point	Narrow and large base, short point, thin removals at the base: projectile?* hand tool ?
Unretouched edge	Micro-traces	Light use	Unretouched point	Projectile * Hand tool
Broken points	Fractures	Impacts Hard work	Retouched or unretouched point	Projectile * Hand tool

* Nelson, Ellis, Greaves, Knecht, Shea, in Knecht ed. 1997; Shea 2001 ; Plisson and Beyries 1998

Table 2: Kinds of micro-traces from flint stone implements of Payre level D and use hypothesis according to the literature

- Retouched and unretouched cutting edges

The variability of the angles of the retouched and the unretouched edges indicates a large diversity of uses and needs. Both micro-wear and technological studies show that the products resulting from the discoidal core reduction sequence are robust and polyvalent and they can be used for occasional activities without retouch (Martinez *et al*. 2003; Peresani *et al*. 2001). The working edge is not related to the blank shape (Beyries, *in* Tuffreau *et al.* 1993 ; Lemorini 2000 ; Peresani *et al*. 2001 ; Lemorini *et al*. 2003).

- Points

The points frequency is high in this level D compared to other European series: 49.5% of retouched convergent tools and 56.6% with the unretouched triangular product with stigmata. 20% of the ends are broken with large fracture or micro-fracture. The great majority of these fractures show in a lip, which indicates on what face the pressure took place. In the direction of Fisher *et al.* (1984), Shea (1997, 2001, 2002) and Lombard (2005), this lip could indicate the utilisation of the tool according to its axis. Moreover the location of the traces implies that several functional areas on a same artefact.

The micro-wear analysis brings evidence of a large diversity of use for triangular instruments (Shea 1997; Milo 1998; Boëda *et al*. 1996, 1999; Grünberg 2002; Trinkaus 1983; Thieme 1997; Shea 1997, 1998; Plisson and Beyries 1998; Lombard 2005).

From the ballistic point of view, the level D points are short, not elongated, perfect to be use as "projectiles" and strong enough to resist to the breakage (Knecht 1997; Ellis 1997; Shea 1997, 2001; Lombard 2005). A perfect triangular shape is not necessary (Nelson 1997; Ellis 1997; Greaves 1997; Shea 1997, 1998, 2001). According to the location of the crushing marks and fractures of the flint point ends, the hypothesis of the use as projectiles has to be considered.

However, marks also indicate other kinds of use. Some extremities similar to borers or becs bear a micro-removal, often on the ventral face. Such removals have been observed in the Near-East and identified as wood working stigmata (Plisson and Beyries 1998). Moreover, some retouched or rough points carry deep marks on the whole cutting edge, especially when the retouch is scaled and invasive. Marks on the blank edges are smaller. Butchery activities can produce such stigmata. Consequently, the cutting edge may have been the only functional area of some pointed artefacts (Beyries 1988; Plisson and Beyries 1998).

The tool assemblage of Payre show a great variability of functional areas as in other Middle Pleistocene sites in Europe. The products resulting from a discoidal knapping are less standardized. The macro-traces indicate several functional areas on a same piece, whatever the shape. The products were polyvalent, and the retouch could be a way to modify the edge, to adapt a working area in an assemblage including both complex and simple tools that were complementary.

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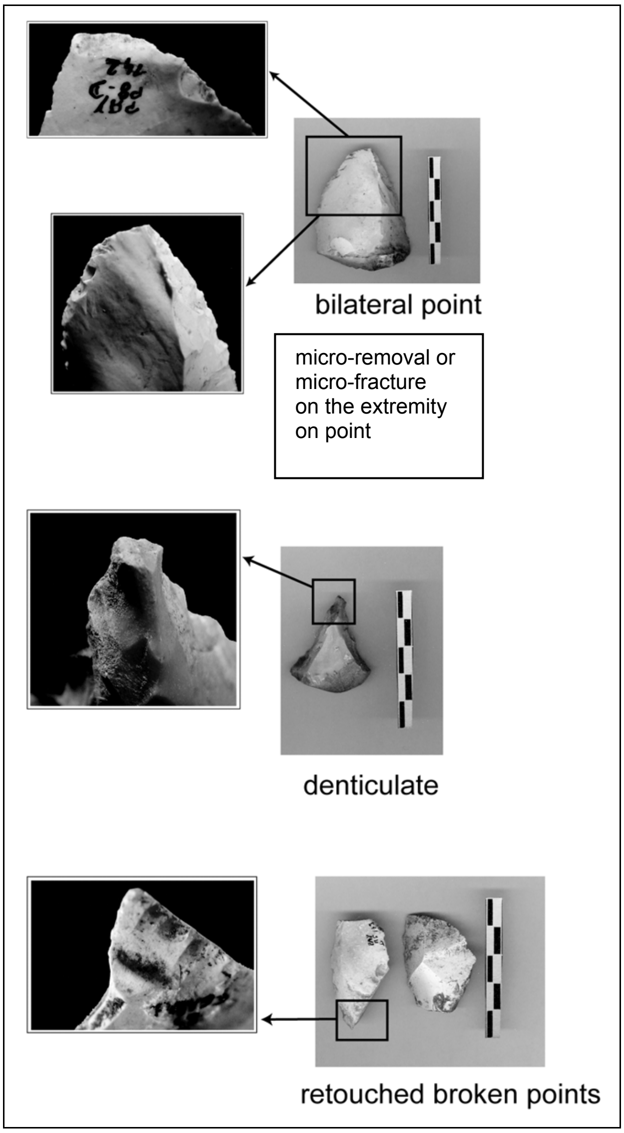

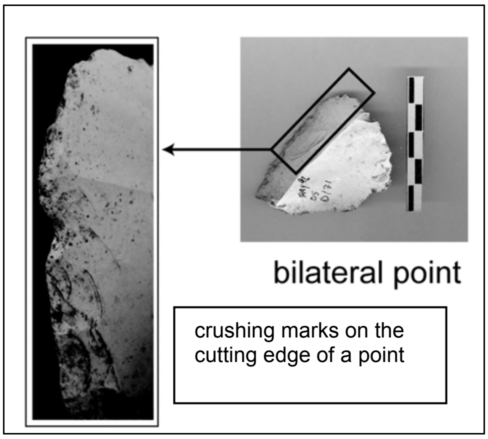

Fig. 3 : Used traces on flint points (level D).

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Functional inferences of flint implements of the Mousterian site at La Mouline (St. Astier, Dordogne, France)

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Summary. *During 2002 excavation at La Mouline (St. Astier, Dordogne, France) different concentrations of Mousterian lithic artefacts were documented (Folgado 2004).*
The refitting data indicated the various loci utilised as knapping areas.
The selected blanks in the chaîne opératoire procedure have sharp edges often opposing natural backs.
In spite of tools PDSM (Post Depositional Surface Modifications) and absence of bone remains, use-wear analysis has shown in situ animal resource processing, limited to a largest assemblage (Locus 1).

Résumé *La fouille du site de La Mouline (St. Astier, Dordogne, France), qui s'est déroulée en 2002, a mis en évidence des concentrations différentielles de matériel lithique attribué au Moustérien (Folgado 2004).*
Grâce aux remontages, les différents loci ont été identifiés comme étant des aires de débitage.
Les supports recherchés à partir de la chaîne opératoire ont un ou plusieurs bords aigus souvent opposés à un dos naturel.
Malgré la présence d'altérations sur les outils (Modifications de Surface Post-Dépositionelles : MSPD) et le manque de vestiges osseux ou végétaux conservés, l'analyse fonctionnelle a pu mettre en évidence le traitement in situ des carcasses animales, particulièrement pour l'assemblage relatif au Locus 1.

Key words: use-wear analysis, flint tools, Mousterian.

The site[1]

The settlement of La Mouline has been recently discovered (2002) during the construction of the motorway A 89, in the Dordogne region (France) between the towns of Neuvic and St. Astier, at La Mouline locality. During the excavation of the Palaeolithic layer five, lithic material assemblages (*Locus* 1, 2, 3, 4, 5) emerged (Fig. 1). The largest among theses *loci* (*Locus* 1), on a large area of 500 m^2, shows the majority of artefacts (937) distributed in five concentrations (*Amas* 1, 2, 3, 4, 5) (Fig. 2). Besides numerous knapping artifacts, some pebbles used as hammers show impact traces.
Numerous refittings were carried out on each *locus* connecting the different concentrations inside each *locus*, in particular within *Locus* 1 (28 refitted elements involving 78 blanks) (Fig. 2). However there are no refittings among the *loci*; then we can only suppose the simultaneousness of *Locus* 1, 2 and 3 from stratigraphical and technological convergences.

In spite of lack of absolute dating (bones and burnt flints are absent), a preliminary assessment places this site in the recent phase of Middle Palaeolithic, around the 3rd or 4th isotopic stage because of partial technological resemblance with Champ de Bousset site's assemblage, in the same Isle valley.

Raw materials[1]

On the site the implement's raw material is a flint of two different types. The first is a grey-black senonian flint of good quality and fine grain size, which could be found in the same archaeological layer (local flint, fig. 3).
The second type (caramel-like colour flint from Bergerac) is present, in small quantity, only in the *Locus* 1, but the blanks – of considerable size – are on an advanced stage of reduction sequence (exotic flint, fig. 4).
This flint's kind is allochthonous and has been found about 25 km far from the site (Moussidan place).

The lithic industry[2]

The reduction sequence (*chaîne opératoire*) of stone tool production *in loco* shows a certain conceptual variability (*débitage convergent/sécant*, disc-core technique, unipolar and blade Levallois technique). The aim always was obtaining regular and thin edge blanks, often opposite to the back, such as enlongated flakes with natural back, uncommon blade-like flakes, core hedge flakes (*éclats débordants*) and pseudo-Levallois points, all retouched or not. The last two regularize the flaking face of the core and they are equally functional.

Functional analysis

Sampling
A total of 87 artefacts from the *Locus* 1 has been analysed, that is 16% of implements subject to analysis (557).

Post-depositional surface modifications (PDSM)
Under the naked eye, implement's edges and ridges appear very well preserved, without chaotic microflaking, typical of the soil movements. A single tool shows mechanical alterations, as edge wide scarring (Fig. 5).

[1] All data here exposed and figures 1 and 2 had been drawn from excavation's DFS of La Mouline site, by M. Folgado (2004).

[2] The spatial analysis linked with functional data is still in progress.

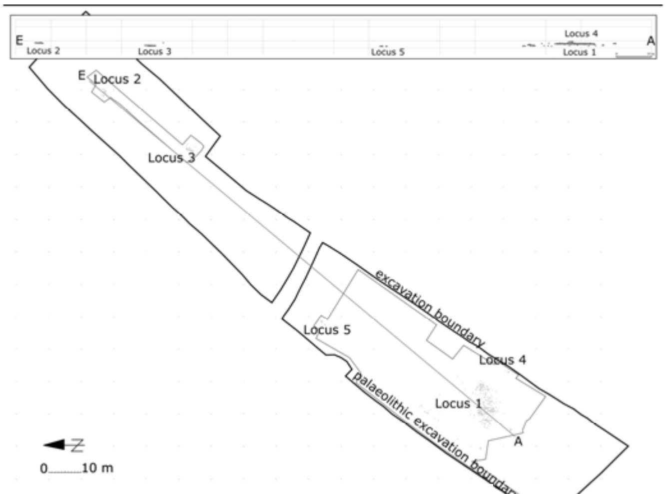


Fig. 1: Plan and section of the excavated area at La Mouline.

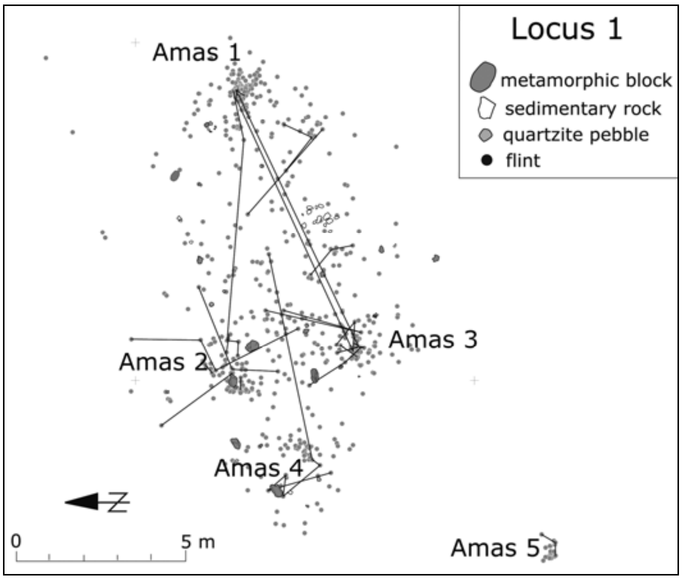


Fig. 2: Spatial distribution of refitted artefacts among the *Amas* inside the Locus 1.

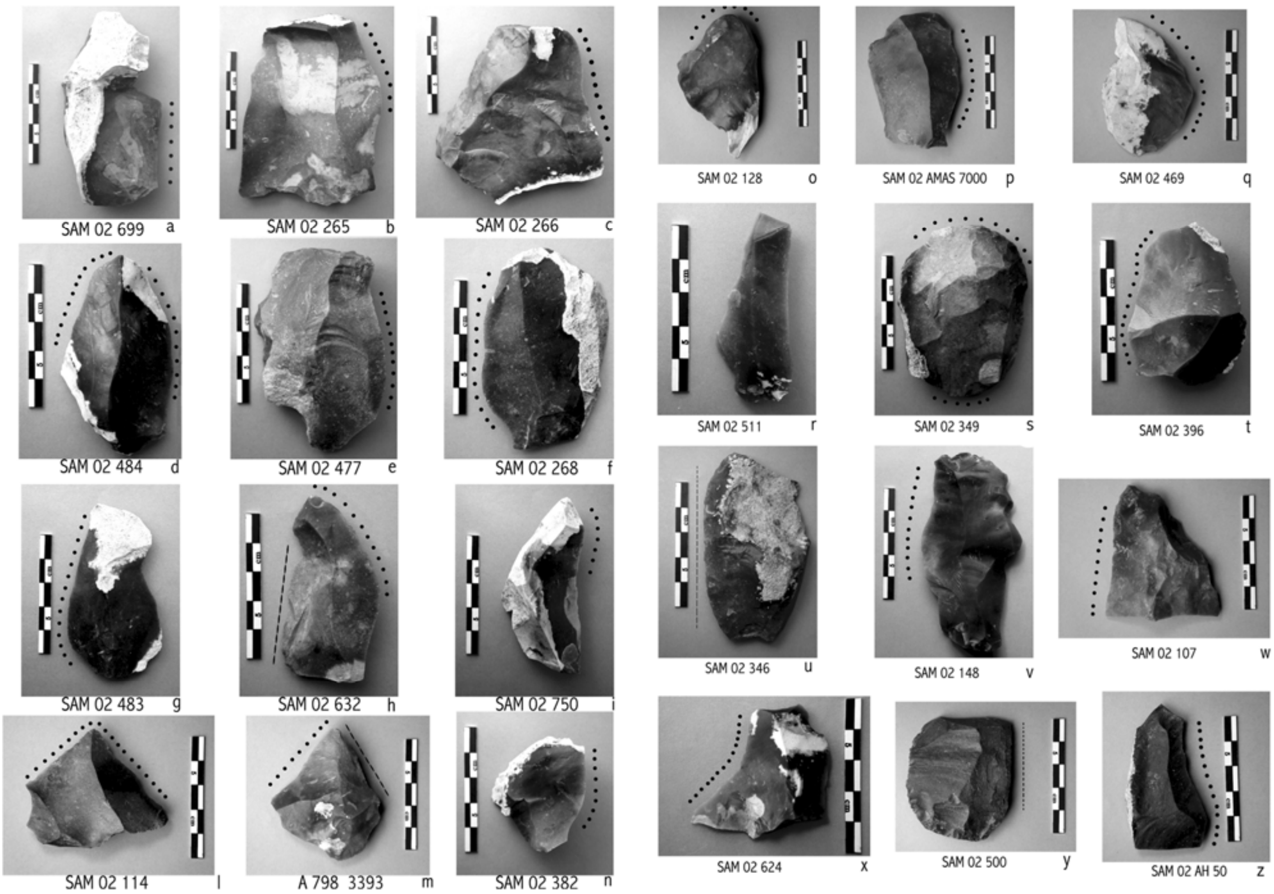


Fig. 3: La Mouline implements: local flint. (The dotted line indicates the use wear traces; the broken lines indicate the retouched areas).

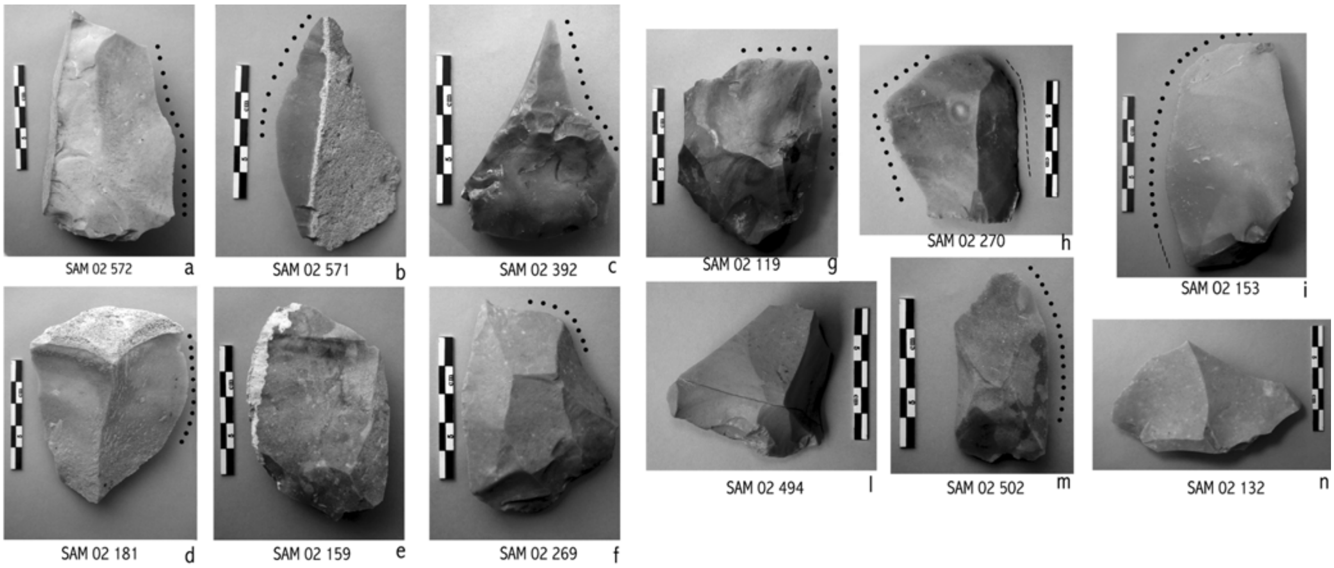


Fig. 4: La Mouline implements: exotic flint. (The dotted line indicates the use wear traces; the broken line indicate the retouched areas).

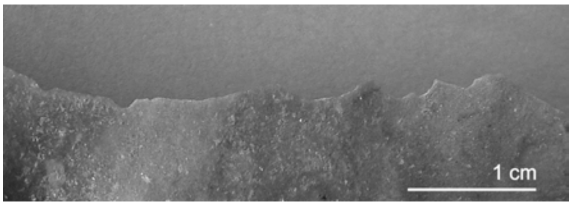


Fig. 5: Post-depositional alteration due to mechanical movement into the soil (*pseudo-retouch*).

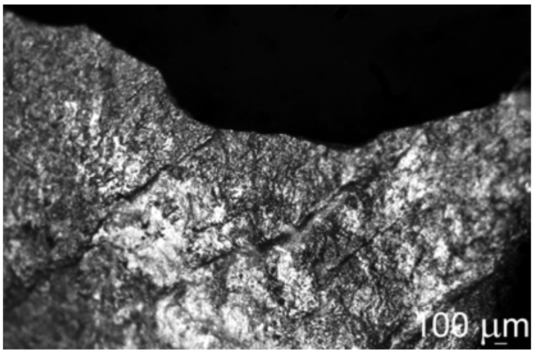


Fig. 6: SAM 02 382, chemical alteration, such as brilliant spots on the surface (*glossy patina*).

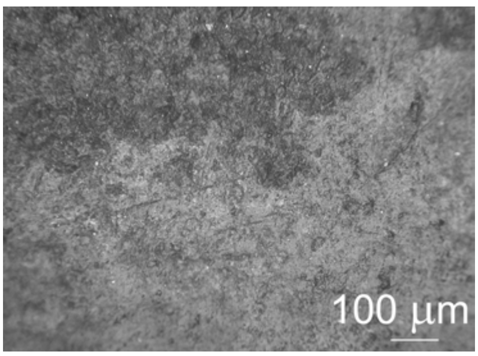


Fig. 7: SAM 02 382, chemical alteration, such as brilliant spots sometimes overlapping with striations (*glossy patina*).

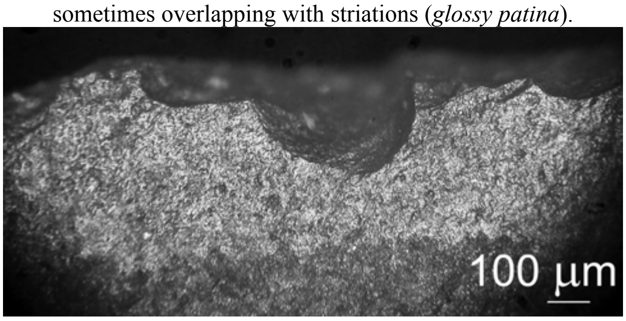


Fig. 8: SAM 02 511, chemical alteration such as a band along the edge (*pseudo-polish*).

Tool's surfaces exhibit different degrees of alteration: some implement seems preserved, but others show, more or less, brilliant and wide spots on both edges.

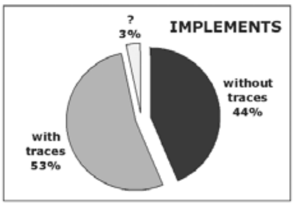
The most part of pieces which already shows visible PDSM appears much more altered under microscopic examination with large overlapping spots and wide shallow striations (Fig. 6, 7).

The brilliant spots develop sometimes a band along the edge, like a polish (Fig. 8).

Probably is a question of chemical alteration caused by acid substances into the soil, more than a mechanical movement, because edges are very well preserved and bones have been completely dissolved.

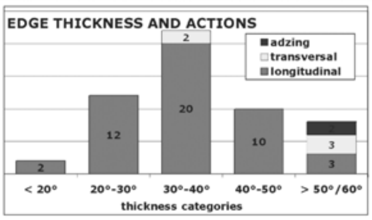
Frequently tools that show macroscopically usewear traces (edge damage) did not keep any micro-wear polish.

The hypothesis should be that the alteration had erased only the polishes, without damaging the flint surface.

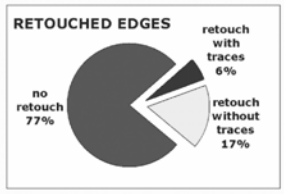


Graphic 1

Graphic 2



Graphic 3



Graphic 4

Results

The functional analysis carried out by A. Coudenneau (2004), at high magnification, of the assemblages of *loci* 2, 3, 4 and 5, shows no evidence of use-wear traces.

On the contrary, in the *locus* 1 the 53% of the 87 analized blanks results surely used (46 elements); 44% doesn’t show any use-wear trace and only the 3% shows ambiguous evidence of use (out of account).

In total there are 54 AUAs (Actually Used Area) (Graphic 1).

The 9% of theses edges (5) has been used in transversal action, 87% on longitudinal action (47 edges), and only 4% (2) in adzing.

We have only been able to estimate the relative hardness of contact material (the polish is pratically absent), observing a vast majority of edges used in soft material (96%) and just two of them on medium-hardness material (4%).

Five edges (8%) show a contact with abrasive material, such a very rounded scraper front’s end (Fig. 9, graphic 2).

Only in one case (SAM 02 750; fig. 3 i) the edge keeps microscopically polish and rounding, which demonstrate its use on hide in a transversal action (Fig. 10).

In the others cases we trusted in the observation of the edge damage.

Micro-flaking of different shapes (half-moon, triangular, oblique, etc) often indicates a longitudinal action, bidirectional as well, on soft materials, probably meat and hide.

This attribution issues from the analogy between these traces and those obtained experimentally (Fig. 11, 12, 13, 14 and 15).

On the other hand the two edges used in adzing, show a large impact areas, demonstrating a violent action on medium-hardness material, such as wood (Fig. 16).

According to the predominance of cutting actions on soft materials, the thinness of edges is predominant (36 edges

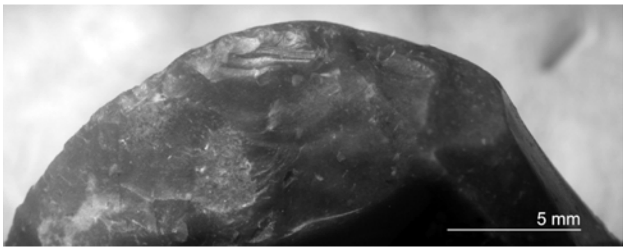


Fig. 9: SAM 02 128, extended rounding on the end-scraper.

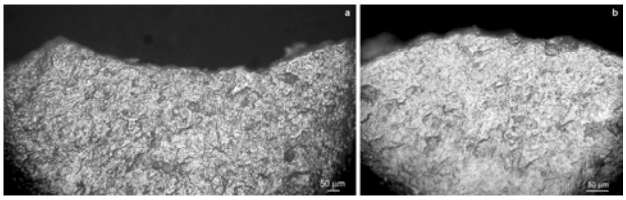


Fig. 10a, b: SAM 02750, micropolish with transversal features.

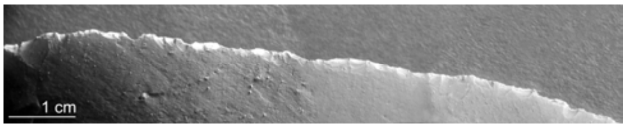


Fig. 11: SAM 02 483, edge damage due to the longitudinal action on soft material.

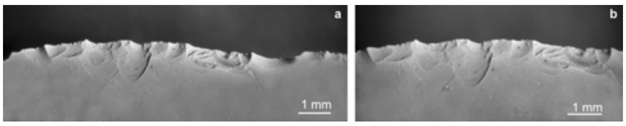


Fig. 12a, b: AM 02 484, edge damage due to the cutting action on soft material.

show a thickness less than 40 degrees, viz. 68%), even if wider edges exist (17, viz. 32%) (Graphic 3).

Only 31 edges are retouched, that is the 23% (Graphic 4).

Due to the lack of the polish it is very difficult to distinguish the technological retouch from the use-scars. The majority of retouched pieces seems unused (74%), except for eight implements.

In some cases, in particular about the backed knives, the retouch can be considered as a resharpening after and/or before use.

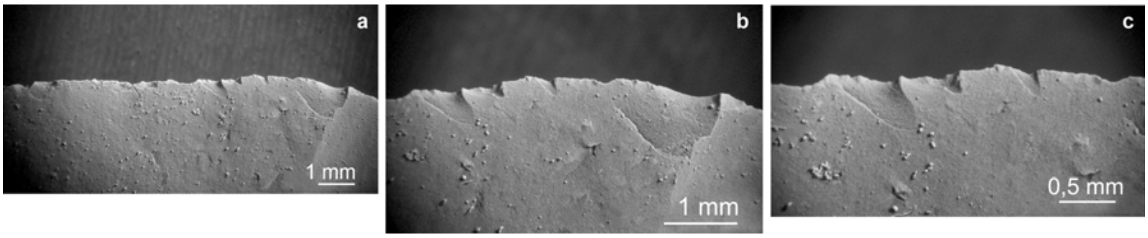


Fig. 13a, b, c: SAM 02 AH 50, edge damage due to the cutting action on soft material.

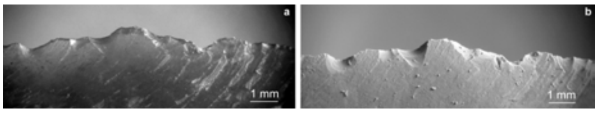


Fig. 14: SAM 02 114, a) edge damage due to the cutting action on soft material; b) the same area treated with magnesium powder.

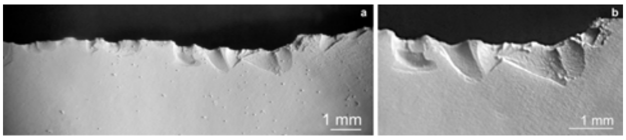


Fig. 15 a, b, c, d: experimental implement edges used in butchery activity.

Fig. 16: SAM 02 349, wide impact area due to medium-hardness material.

Five implements show one retouched edge opposite to another with use-wear traces; in this circumstance we can hypothesize an accomodation to hafting or prehension (Fig. 3 h, m; fig. 4 h).

- Only 15 tools show use-wear traces, in particular on 19 active edges (Graphic 6).
- There is no difference of the use between local and exotic flint: almost the totality of actions observed is longitudinal on soft material, the adzing is absent and there is only one transversal action.
- The angles thickness respects the general trend: the majority of angles lay between 20 and 50 degrees (Graphic 7).
- The cutting edges length seems to be a discriminating parameter, because it is over 50 mm for 13 used edges.

Due to their considerable size, many backed knives, natural or not (types 36-38on the Bordes typology), probably did not imply any hafting (Fig. 4 a).

Neverthless various smaller flakes have been used, choosed for their thin, convexe edge and a practical cortical back (Fig. 3 i, n, q, t, z).

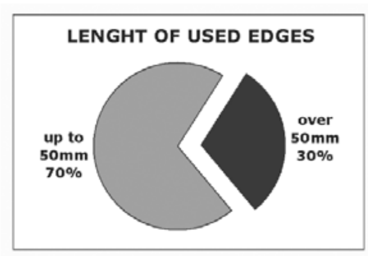
Blank's choice

The tools with edge's length shorter than 50 mm have been not much utilised (indipendently from their width), while the edges longer than 50 mm have been used in the 70% of cases (38 edges versus 16 shorter than 50 mm, graphic 5).

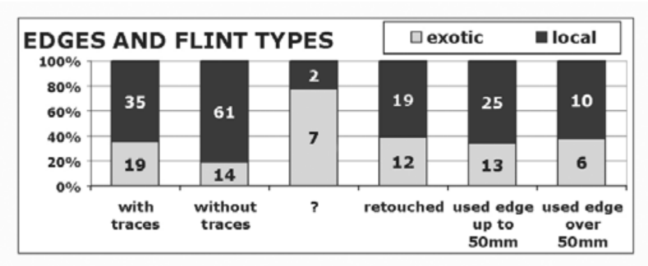
68% of edges shows a thickness lower than 40 degrees, very useful to cut soft material with convex and regular profiles.

Raw material use

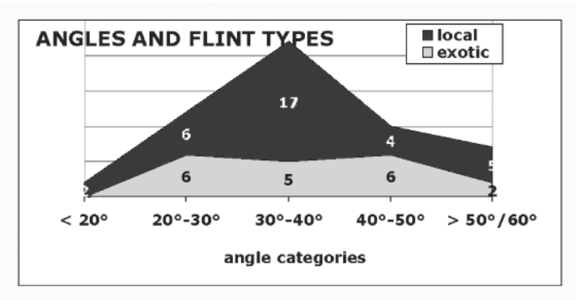
Some remarks:
- exotic flint blanks are very few, 26% of total.
- Their size exceeds in length and width the local flint blanks (length over 70 mm and width over 50 mm in the 74% of cases).
- The PUAs (Potentially Used Areas) is high (40), considering the local flint blanks, thanks to their regularity and the presence of technological retouch.



Graphic 5



Graphic 6



Graphic 7

Conclusion

The different *loci* appear to have been punctual *débitage* places.

In many cases (*loci* 2 and 3) the lack of blanks on advanced stage of reduction sequence makes think about their knapping *in loco*, but their use elsewhere.

The functional analysis of *Locus* 1 allows to confirm, as regard to La Mouline, the hypothesis of a palaeolithic location, that includes some scattered areas for cutting implements production and a localized space (among the *Amas* 1, 2 and 3)[2] for the use of tools on animal materials, such as meat and hide.

Only one implement, which has widely diverging characteristics from the others, shows an adzing action on wood.

Furthermore others tools show abrasive action traces, due to an unknown worked material combined with abrasive substances.

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Blade technology of the eastern Bromme (Podol culture, Valdai Uplands). Allerød- Dryas III (11.8 – 10.2 ka)

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Summary. *A series of archaeological cultures was identified during the last decade in the territory of the Valdai Uplands, dating to the tardiglacial period (Allerød-Dryas III). One of the most ancient of them, the Podolsk cultural complex, has direct analogies with Dutch Bromme techno-complexes. Flint knapping technology of the most ancient stage of the Allerød period appears to be identical to typical Bromme group. It is characterised by the use of a hard hammer and/or abrasion of the striking platform. Large blades (8-10 x 3 x 1.5 cm) detached from prismatic or conic cores are dominant. Striking platforms of blades, as a rule, are linear, with well pronounced bulb and a bulb scar. Transition from hard hammer method, having been used at the initial stage of the flint knapping processes, to the soft hammer method aimed at obtaining smaller blades (5 x 1.5-2 x 0.5-0.7 cm) are the diagnostic feature for the next stage of the cultural evolution in the Dryas III period. Alongside with the change of the typological set, the change in knapping method appears to have the chronological meaning in the evolution of eastern Bromme (Podol) cultural complex.*

Résumé. *Une série des cultures archéologiques a été mis en évidence à la dernière décade sur le territoire du massif élévé de Valdai pour la période tardiglaciaire (Allerød-Dryas III). Un de plus ancienne de ceux-ci, Podol unté culturelle, trouve les analogies directes dans le techocomlex Bromme. La technique de débitage du stade ancien, d'époque d'Allerød, soit identique à la technologie de Bromme typique Danoise. Elle base sur l'utilisation du percuteur dur à côté du méthode de la réduction du plan de frappe par percussion ou/et par abrasion. Détachement des lames larges (8-10 x 3 x 1.5 cm) des nuclei pismatiques et coniques soient prédominants. Les talons des lames sont lineaires, le bulbe à eraillure est bien dévellope. Le passage de la technique du percuteur dur, n'utilisait qu'en stade initial de la percussion, à la technique du percuteur douce, orientée sur détachement des lames plus mimces (5 x 1.5-2 x 0.5-0.7 cm) soit l'attribut diagnostique pour le stade siuvant d'évolution culturelle durant la période de Dryas III. À côté du changement de la composition typologique des assemblages lithiques, le changement de la technologie de débitage ait ici la signification chronologique dans l'évolution de Bromme oriental (Podol) unité culturelle.*

Key words: Final Paleolithic, tardiglacial, eastern Bromme, flint-knapping technology.

Colonization of the territories freed from the ice sheet during the Pleistocene-Holocene transition includes two main issues: chronology and direction of population movement. The principal problem of the first, is that most part of archaeological material from this period lies in a secondary context as a result of the massive erosion occurred during this period. Common scientific methods cannot be used for the dating of these deposits, or may be used very rarely. Traditional comparative-typological methods remain the main instruments for determining the chronological time-frame. Technological analysis, as part of the more traditional approach, provides significant information in terms of retracing the origins of technological traditions and for understanding the dynamics of the adaptation of pioneering colonists to the new environment and to local raw material resources.

The Valdai Uplands is the area where the springs of the principal eastern European rivers are located: Volga, Dniepr and western Dvina. In turn, these rivers represent the main directions for population dispersals for both pre- and proto-historic periods. A series of cultural complexes: Epigravettian, Bromme-Lingby, Swiderian of western type and local Zolotorouch'e were identified for the tardiglacial period at Valdai on the basis of the techno-typological features displayed by their material culture assemblages. Chronological relations among them remain debatable as the most part of archaeological assemblages were surface finds or recovered from secondary contexts. Few cultural layers have been found in intact deposits (primary depositional contexts), and these appear to have the main function of starting point for cultural differentiation and stratification.

Field studies undertaken in the last decade in this area provided a body of new data and presented an array of new problems related to early colonization of the region. A series of cultural layers *in situ* were identified at some sites on the northern coast of the lake Volgo (Selizharovo distr., Tver region) in stratified geological deposits of the tardiglacial period. This period is distinguished as the transitional one, from Final Pleistocene to Early Holocene (Bolling-Dryas III) in geology, and as the Upper Palaeolithic in archaeology.

One of the most ancient evidence of human colonization of the Valdai Upland area was associated with the Podol archaeological culture, of the Bromme-Lingby group. Particular assemblages, fossil guides of which are tanged projectile points of Bromme type (Sinitsyna 2002), were recovered from stratified cultural layers on the multiperiod sites of Podol III/1 and Podol III/2, Baranova Gora, Lanino I on the northern coast of lake Volgo, (Sinitsyna 1996, 1997), and Ust-Toudovka I in the Upper Volga (Zhilin and Kravtsov 1991). Lithic assemblages from the sites of Troitskoye 3 (Lantsev and Miretsky 1996) and Tioply Ruchey II (excavated by A. Miretsky), Rostislavl' (Trusov 2004) in the neighboring area, provided typologically similar material, but with the addition of some particular tool types.

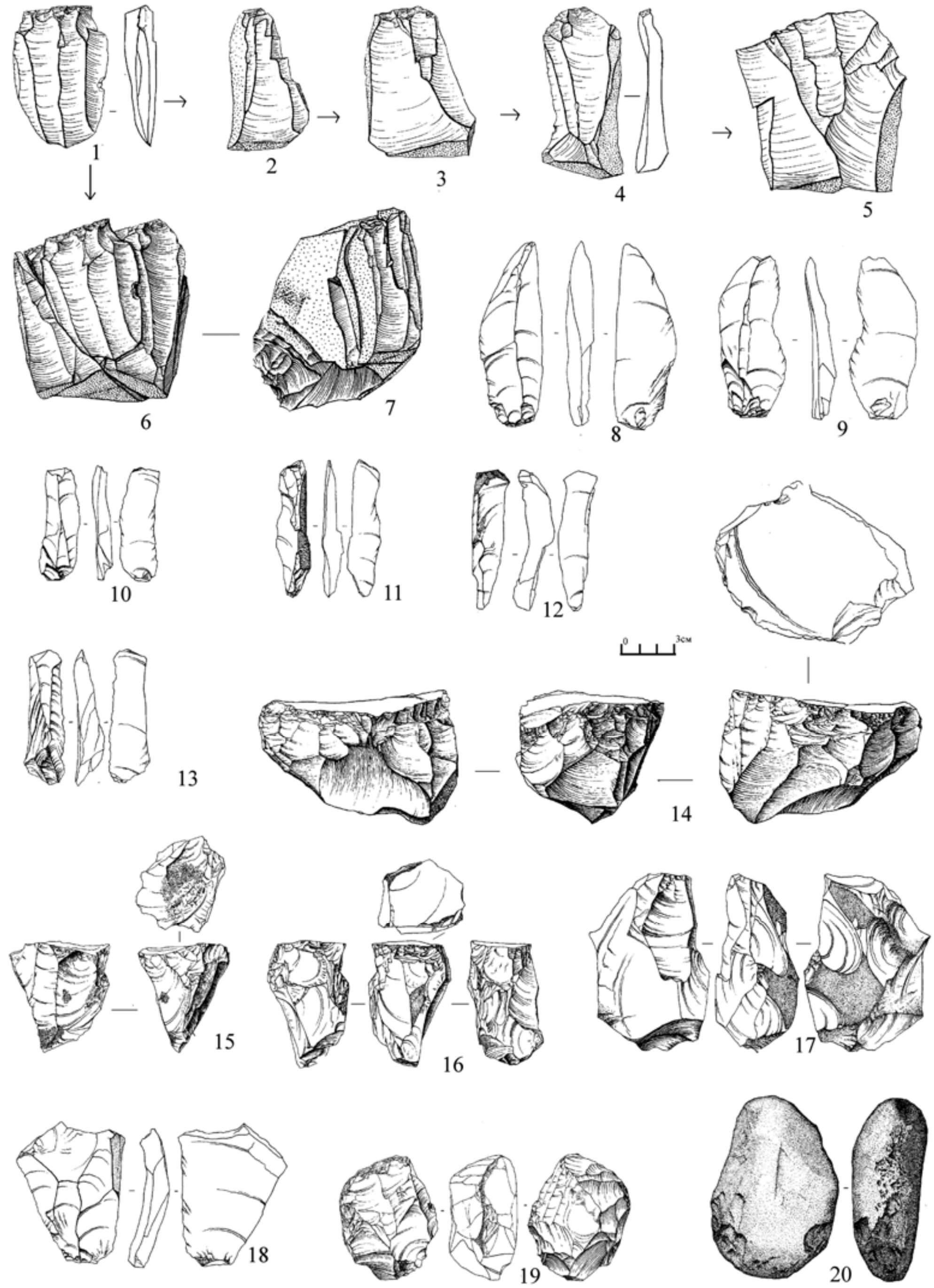

Fig. 1: The Flint knapping technology of Podol III/1 (Allerød period).

In addition to the 'traditional' Dutch Bromme sites, other Bromme group sites were identified in England (Roberts and Barton 2000), Germany (Taute 1968), Poland (Schild 1975; Schild *et al*. 1999), Lithuania (Rimantene 1971), Belorussia (Ksenzov 1988; Charniauski *et al*. 1996) and Ukraine (Zalizniak 1998). Bromme assemblages from the Valdai Uplands were recognised as belonging to the Podol cultural complex and appeared to be the most eastern evidence of this tardiglacial techno-complexes of wide north-European distribution and was put in connection with the west-east hunters following red-deer herds through the cold and dry forest-steppe environment during the Allerød-Dryas III period (Zalizniak 1998).

The sites Podol Ш/1 and Podol III/2 are the most informative owing to the available data on spatial organization as well as radiocarbon dates, palynological data, and palaeomagnetic evidence. The magnetic excursus Göthenburg (~I2 ka) was identified inside the lower deposits with cultural remains of the Bromme-Lingby cultural group (Gus'kova *et al*.

2006). At first, the Allerød dating of this deposit was defined by palynological analysis (Spiridonova and Aleshinskaya 1999). Dating of the sites, obtained with different methods, highlighted their contemporaneity and common cultural background, i.e. Dutch Bromme-Lingby (Allerød-Dryas III).

The sites are located one opposite to the other on the edges of a narrow ravine on the northern coast of Volgo lake: 166 sq.m on the right slope (Podol III/1) and 187 sq.m. on the left (Podol III/2) were excavated. Features of everyday life such as dwelling structures with a hearth, flintknapping areas and storage pits were identified at Podol III/1. Three concentrations of archaeological remains in a natural depression among rocky outcrops were identified at Podol III/2. Undisturbed layers were preserved only in this sheltered depression. According to pollen analyses, pit filling was dated to the Dryas III (Spiridonova, Aleshinskaya, 1999).

The aim of this paper is to present results of the technological analysis of two assemblages of the Bromme group belonging to the Allerød-Dryas III period.

Siliceus slabs were the principal raw material for the Podol culture. It is significant that all tools of the assemblages, including projectile points, were made on light-grey flint.

Blade cores dominante the assemblages. Blades have a well-pronounced bulb, as a result of hard hammer use. The most important feature of this assemblage are points, which are similar to the typical Bromme-Lingby tanged projectiles (Sinitsyna 2002). The lithic assemblage of Podol Ш/1 is the most ancient evidence of the Bromme technocomplex in the Valdai area and seems to represent the first stage in the evolution of the Podol culture.

A 3 sq.m flint knapping area was identified at Podol III/1. This concentration of 2633 chipped stone items includes: 26 cores, 13 pre-cores, 84 thick blanks, 53 crested blades, 49 thick blades, 53 blades, 177 bladelets, 119 small blades. Flakes (Fig.1: 18) represent 68 % of the total assemblage. There are also a stone anvil, an axe, 4 burins (2 on fractures and 2 dihedral), 4 end-scrapers on blades, which compose the typological repertoire.

Blade-flake ratio as well as general typological composition of the total assemblage and flint-knapping workshop appears to be identical. Unipolar cores with a flat striking platform and a detachment angle of 80° are dominant (Fig. 1: 14-17). Multifacetted cores in the initial stage of their use have a cubic form. Six varieties of cores are distinguished: prismatic (68); conic (24); multi-platform (17); wedged cores (2); dihedral (8); cores on thick flakes (3). Thick massive blades removed from such cores (width of 2-3 cm; thickness of 0.5-1.5 cm; length of 8-10 cm), have a well pronounced bulb, a diagnostic feature attesting hard hammer (Fig. 1: 8-13). A number of stone hammers was identified (Fig. 1: 19-20). Striking platforms of blades are linear, most bulbs have a bulb scar. A series of cores from the workshop were refitted and put in evidence the method and the sequences of knapping techniques on the basis of prepared longitudinal blanks (Fig. 1: 1-7). Blade blanks have a series of negatives which suggest striking platform reduction and preparation by means of abrasion.

The technology characterising the great majority of the assemblage of the site Podol III/1 (Allerød age) may be recognised as typical of the Bromme group with few peculiar varieties of knapping method, probably related to particular local raw material.

The next cultural stage in the area was identified at the site Podol III/2. According to pollen data this assemblage dates to the Dryas III period.

78 cores from this site suggest that the prismatic unipolar method with the negatives of convergent removals dominated. Several cores show change of platform through the detachment of a transverse blade. Removals were made from both smooth and retouched striking platform, and sometimes from the lateral edge (Fig. 2: 7-9). There are seven preforms of cores in the assemblage. These are massive (12x14x10 cm) nodules with several prismatic negatives.

Large blades connected with initial stage of core utilization have a length of nearly 10 cm, width of 3 cm, and an average thickness of 1.5 cm. Striking platforms of these blades are in general linear, the bulb is well pronounced and carries a bulb scar (*eraillure*). Blades provide a set of attributes diagnostic for hard hammer use in association with abrasion of the striking platform, as it was identified in the lithic assemblage of Podol III/1. Such blades represent nearly 30% of the total assemblage. Cortex often remains on theirs dorsal surfaces. Their size and morphology would point to the initial stage of core reductions. Blades of 5 cm in length, 1.5-2 cm in width and 0.5-0.7 cm in thickness are dominant (up to 70%) in this assemblage (Fig. 2: 1-3). One of the diagnostic features of these blade blanks appear to be the asymmetry in section. Hard hammer use is attested by the following: a well pronounced bulb with a bulb scar, a linear and wide striking platform (Fig. 2: 6), deep scars on conic cores (Fig. 2: 5). Change of hammer type during the process of core reduction was recognised through refitting analysis. The use of soft hammer was identified on the basis of punctiform striking platform and lip (Fig. 2: 4).

In general, technological analysis of eastern Bromme assemblages (Podol culture) has highlighted the principal developments of the flint knapping method from typical Bromme large blade-technology (Fisher 1985; Madsen 1996) produced with a hard hammer to middle size blanks obtained with a soft hammer.

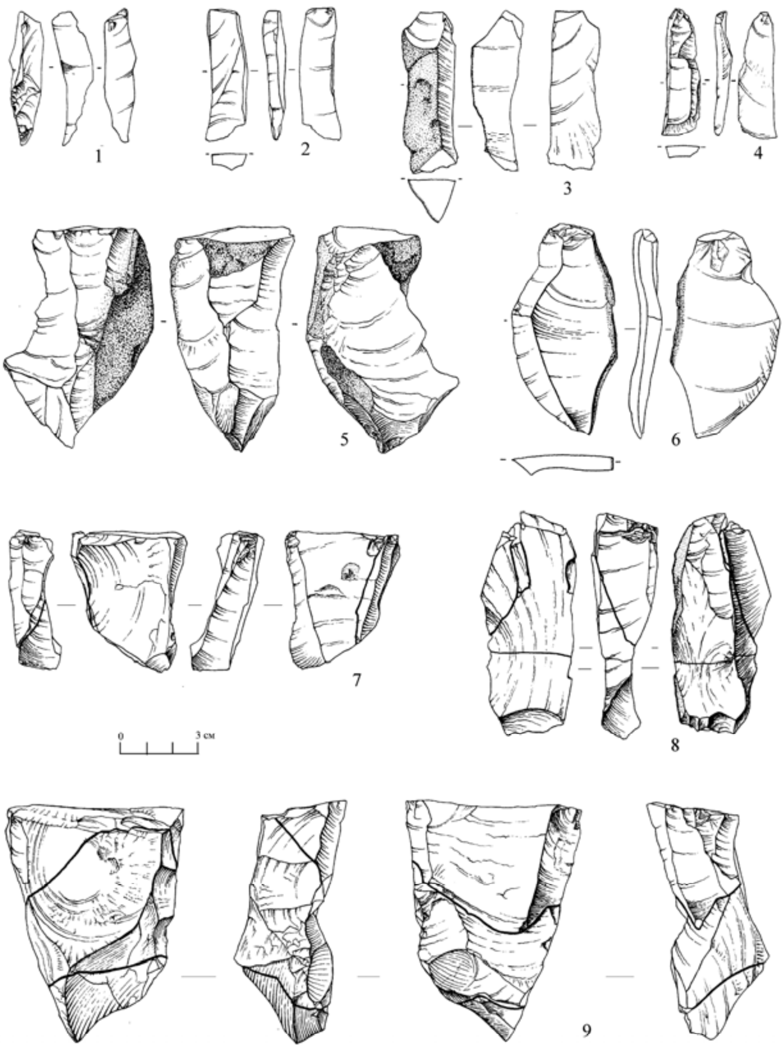

Fig. 2: The Flint knapping technology of Podol III/2 (Dryas III period).

The typological character of the Podol culture assemblage appears to be closely related to the ‘traditional’ Dutch Bromme according to tanged projectile points (Sintsyna 2004), burins and scrapers. Particular features are connected mostly with Valdai types of side-scrapers and axes.

The most probable explanation of the processes of cultural diversification may be related both to the adaptation of foreign populations to the local variety of raw material, and to the influence of the neighbouring aboriginal population.

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Engraved stones from the San Bartolomeo Upper Palaeolithic flint workshop (Abruzzo, central Italy)

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Summary *The work examines four angular limestone fragments, coming from the S.Bartolomeo Upper Palaeolithic flint workshop and presenting engraved lines on a smoothed face. All these stones, observed under a stereomicroscope, were compared to those carried out on experimental objects. Preliminary results are proposed here.*

Résumé *Cette recherche examine quatre fragments angulaires en calcaire, provenants de l'atélier de débitage du Palaeolithic superior de S. Bartolomeo et portant des stries profondes et rectilignes sur une surface régulièr plane. Tout ces pierres, observes avec un stereomicroscope, ont èté compares avec des objets expérimentaux. Resultats préliminaires sont propose ici.*

Key words: Upper Palaeolithic, engraved stones, use-wear analysis.

Introduction

The site of S.Bartolomeo is located on the north-western side of Mt. Maiella, near the Pescara valley at about 750 m above sea level, in the territory of Roccamorice (Pescara).

The excavations, organised by the Dipartimento di Scienze Archeologiche of the Pisa University, started in 1990 and are still in progress.

Several traces of flint processing activities were observed in the shelter: first, the flint nodules were quarried from the rock layers cropping out from the bottom wall of the shelter; then, after the extraction, these nodules were tested to check if the raw material was suitable for knapping and eventually flaked.

Two main living areas were observed within the excavation: the flint workshop and a hearth were subsistence activities were carried out (Boschian 2003).
Some engraved stones were collected during the excavations; the purpose of this work is to infer their use and meaning.

Methods

All the engraved stones were examined under a Leica stereomicroscope with up to 63x magnification, to observe form and shape of the engraved lines. These observations were compared tho those carried out on experimental objects. Preliminary results are proposed here.

The engraved stones

Four angular limestone fragments were found in level 4 of the excavation area, inside the flint workshop. Two of them refit and the others were all lying within a small area, suggesting that most of them probably belong to the same stone slab.

All these stone present engraved lines on a smoothed face.

The first one (9.1 x 1.9 x 2.1 cm) shows two bundles of deeply engraved parallel stripes, that intersect each other at about 15° on a concave surface (Fig. 1.2). Most of the lines have a V-shaped profile (Fig. 1.3,4).

The second one (6.3 x 2.6 x 2 cm) shows thin, slightly wavy, subparallel engravings (Fig. 1.5); their profile is wide and complex, with undulations on the bottom. Dissolution pits are also osservable (Fig. 1.6).

The last one (2.9 x 1.4 x 1.8 cm) shows modest traces of bundles of lines, mostly occuring on broken edges (Fig. 1.1).

The deep and rather thin V-shaped lines may be interpreted as traces left by a hard and sharp tool, possibly a freshly knapped/ unused flint blade or flake.

The wider and shallower traces suggest that the tool was blunt and that it was used pushing it with less strength.

The experimental work
A large, flat and reasonably smooth stone, whose petrographic characteristics are similar to those of the studied artefacts, and coming from the shelter was used as working base. A dry hide was laid on thgis stones and cut into thin stripes by unretouched flint blades whit thin margin (Fig. 2.1).

The wear traces observed on the smooth surface of the base stone are similar to those on the archaeological findings. Flint blades with fresh margins leave V-shaped traces, while the blunt ones leave wider lines with rectangular and complex shape. It must be pointed out than the cutting margin of the flint must be pushed very strongly onto the hide to obtain a sharp cut, so that the blunting of the fresh blades starts very soon (after about 20 cm of cutting) (Fig. 2.2,3). The blunting usually consists in the detachment of small flakes from the edge (de Beaune 1997, p. 98, fig. 84-85).

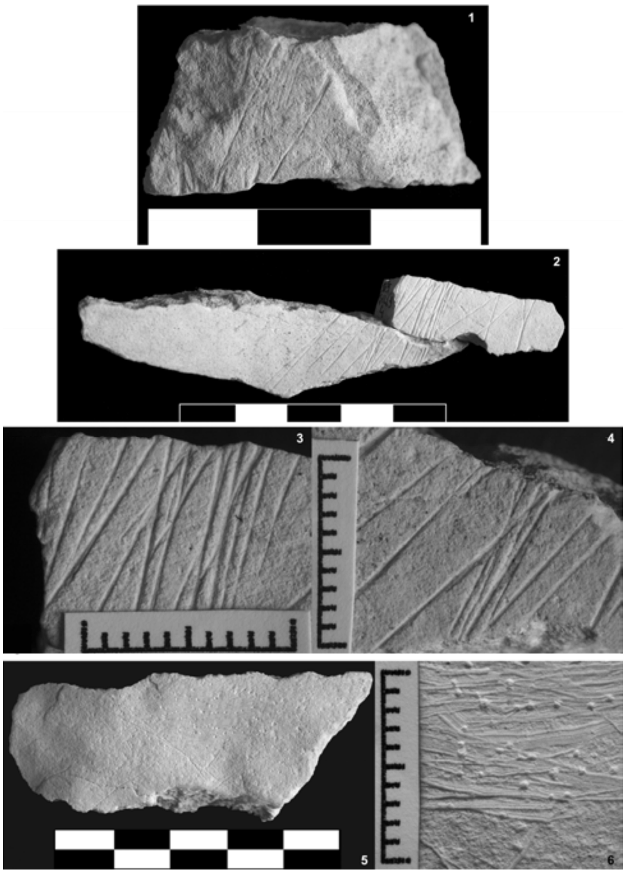

Fig. 1: 1) This stone shows modest traces of bundles of lines, mostly occurring on broken edges. 2, 3, 4) The stone shows two bundles of deeply engraved parallel stripes, that intersect each other at about 15° on a concave surface (2). Most of the lines have a V-shaped profile (3, 4). 5, 6) The stone shows thin, slightly wavy, subparallel engravings; their profile is wide and complex, with undulations on the bottom. Dissolution pits are also observable.

Results

These peculiar finds are usually interpreted as art works, but may also be interpreted in a different way. It is possible, in fact, that these fragments belonged to larger stones used as plain support for cutting or working various kinds of material (i.e. skin, leather or meat).

This hypothesis is also suggested by other Authors: stones with stripes that may be isolated, parallel or in bundles, are well testified throughout the Upper Paleolithic (de Beaune 1989; 1997; 2000; 2002). It must be kept in mind that some technical activities need a strong pushing of a lithic instrument on a plain stone base.

Apparently, these preliminary results of an experimental work give more support to this hypothesis.

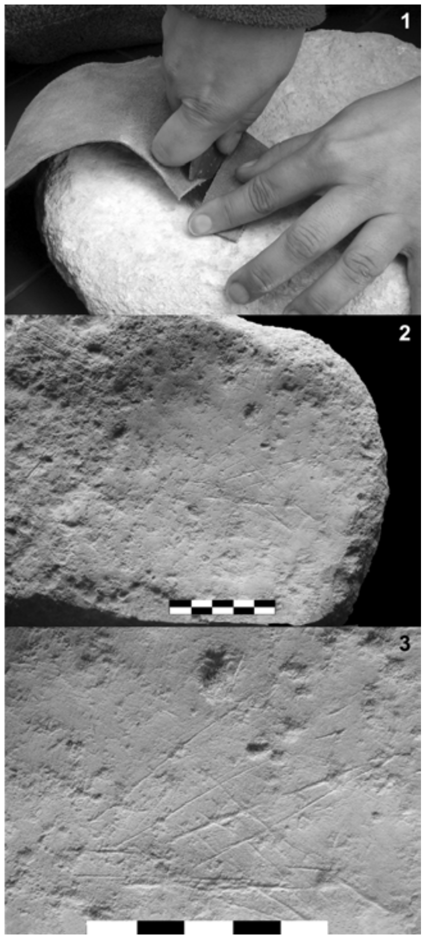

Fig. 2: 1, 2, 3) The experimental work. A dry hide was laid on a large and flat stone, coming from the shelter, used as working base stone; the hide was cut into thin stripes by unretouched flint blades whit thin margin (1). The wear traces observed on the smooth surface of the base stone are similar to those on the archaeological findings (2, 3).

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Perforated bone plates and string production in the Mesolithic: a case-study from site Stanovoye 4, Upper Volga

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Summary. *Two elongated flat bone plates with several perforations 2 – 3 mm in diameter were found during excavations of the peat bog site Stanovoye 4 on Upper Volga, Central Russia. Both come from cut 3, layer III, dated to late Preboreal period by pollen and about 9220 BP uncal. by 14-C. They look much like pendants, but the use-wear analysis revealed clear traces, indicating that they were used for a different purpose. Each of them produced similar patterns, indicating that only two perforations were used at the same time. Wide groove runs across a side of the dorsal face of the plate, falls into the first perforation, comes out of it, runs along the ventral face of the plate and falls into the second perforation, comes out of it and runs across the dorsal face of the plate to its edge. Polish and long fine longitudinal striations, parallel to each other are clearly seen under stereomicroscope at magnifications 8x – 32x. Such traces indicate, that some rather dry and dirty material was pulled through these holes. Most probably these were used for stretching and calibration of various strings, cords and small diameter ropes, made from hide, sinew and plant materials. They were especially important in the Mesolithic as bowstrings and cords for fastening points to arrow, leister and spear shafts, for making nets and many other things. Sinews and hide are not preserved, but twisted cords and ropes made from various plant materials come from Mesolithic sites of Central Russia and other places. Similar plates were also found at late Mesolithic sites on Upper Volga and in Oleneostrovski late Mesolithic cemetery, indicating that the skill of producing very accurate strings and cords was well developed in the Mesolithic of the East European forest zone.*

Résumé. *Deux plaques allongées plates en os avec plusieurs perforations (2-3 mm de diamètre) furent trouvées durant la fouille du site de marais tourbeux de Stanovoye 4 sur la Volga supérieure, en Russie centrale. Toutes deux de la coupe 3, niveau III, daté du Préboréal final par les pollens et environ 9220 BP en C14 non calibré. Elles ressemblent beaucoup à des pendentifs, mais les analyses d'usure montrent des traces qui indiquent clairement qu'elles furent utilisées à un autre usage. Chacune d'elles présente le même arrangement indiquant que seules deux perforations étaient utilisées en même temps. Un large sillon court au travers d'un côté de la face dorsale, tombe dans la première perforation, en sort et court le long de la face ventrale avant de tomber dans la seconde perforation, en ressort et continue le long de la face dorsale jusqu'au bord. Un poli et de longues et fines striations parallèles les unes aux autres sont clairement visibles sous un grossissement de 8-32x. De telles traces indiquent qu'une matière plutôt sèche et sale fut tirée au travers de ces trous. Très probablement, ils furent utilisés pour étirer et calibrer diverses cordes ou ficelles de peau, tendon et de fibres végétales. Celles-ci étaient très importantes au Mésolithique pour les cordes d'arc, pour la fixation des pointes sur leurs fûts, pour la fabrication des filets et pour maintes autres choses. La peau et les tendons ne sont pas conservés mais on connaît des cordes torsadées et des liens faits dans diverses matières végétales trouvées dans des sites mésolithiques de Russie centrale et d'ailleurs. Des plaques similaires ont aussi été retrouvées dans des sites du Méolithique final de la Volga supérieure and dans le cimetière de Oleneostrovki, indiquant que l'habileté pour produire des cordes et ficelles très calibrées était répandue dans le Mésolithique de la zone forestière d'Europe orientale.*

Key words: Mesolithic, Upper Volga, perforated bone tools, use-wear analysis, pendants.

The site Stanovoye 4 is situated in the Upper Volga region of European Russia, about 250 km to the northeast of Moscow (Fig. 1), in the Podozerskoye peat bog (Komsomolsk district, Ivanovo region) between Ivanovo and Yaroslavl. The river Lahost, a tributary on the right bank of the river Kotorosl, which is a tributary on the right bank of the Upper Volga, starts from this bog. The site occupies a gentle slope of a promontory in the bog, which is a glacial lake terrace at the outlet of the river from a peat bog (ancient lake gulf) and a boggy area just below it. The site was discovered in 1992 by the author. About 600 square meters were excavated between 1992-2002. Three trenches produced several cultural layers, belonging to the Early, Middle and Late Mesolithic, Early Neolithic and the Bronze Age (Zhilin, Matiskainen 2003).

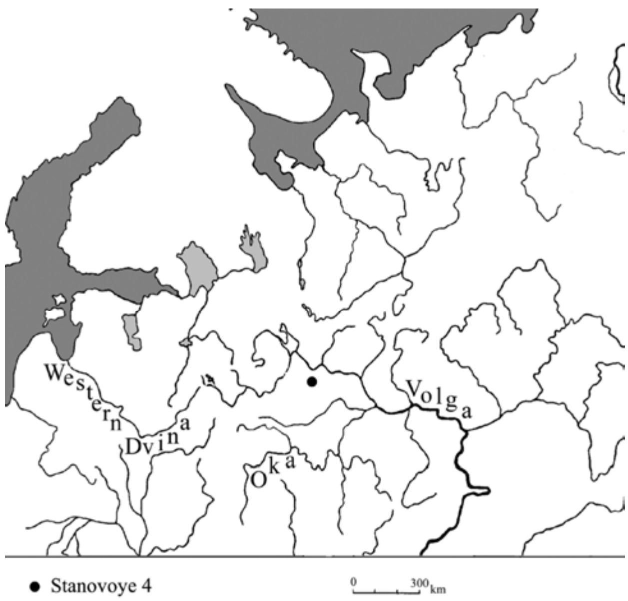

Fig. 1: Location of the site Stanovoye 4.

Two perforated bone plates were found in the upper (III) Mesolithic layer in trench 3. Pollen data indicate that this layer was formed during the last quarter of the Preboreal period. The layer of gyttja with finds is dated by C14 to 9280±120 (GIN-10122 I), 9090±400 (GIN-10124 I) and 8610±40 (ГИН-GIN II) BP (all C14 dates in the article

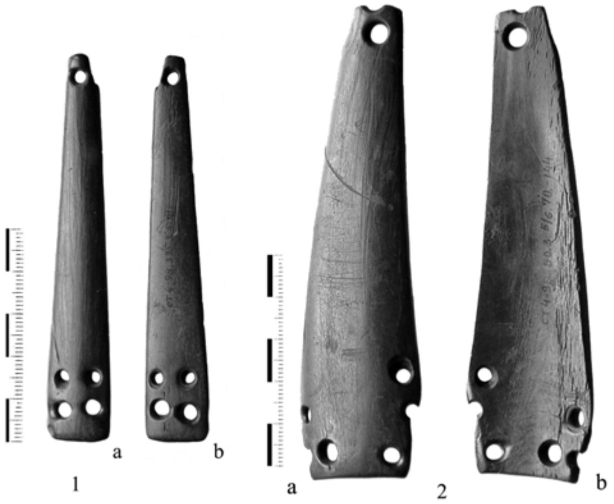

Fig. 2: Stanovoye 4, cut 3, layer 3. Perforated plates 1 and 2.: a – dorsal face; b – ventral face.

are uncalibrated). The radiocarbon date of the birch stake, sharpened with a flint adze, driven from layer III into the lake bottom estimates the habitation period more precisely - 9220±60 (GIN-8375) BP (Zaretskaya et al 2005).

Two elongated bone plates with several perforations 1.4 – 2 mm in diameter were found in this layer. The first one, about 9 cm long, is sub-triangular in shape; the cross section is lens-like (Fig. 2:1). The narrow distal end contains one perforation 2 mm in diameter, but initially there were two such holes, one above the other. The distal end of the tool was broken off along this hole and then rounded by planing and smoothed by polishing. Part of the wall of the second hole is still visible at the breakage. The wider proximal end contains four similar perforations, drilled with a flint borer rather accurately from both dorsal and ventral surfaces. The lower pair of perforations is about 3 mm in diameter; while the upper pair is about 2 mm. Scraping, planing and polishing carefully treat both surfaces of the plate. Traces of scraping are partly removed with traces of planing, as seen most clearly at fig. 5; and both are rounded and partly removed with fine polishing. This suggests the following chain of operations: scraping, planing, fine polishing.

This artefact looks like a pendant, but use-wear traces, studied by the author with a help of stereomicroscope MBS-10 with magnifications 8 – 32 times, indicate another use of the tool. Two upper perforations at the proximal end look rather fresh and display no distinct use-wear traces (Fig. 3: 1, 5). On the contrary, the two lower ones are heavily worn. A wide groove runs from the left marginal edge across a side of the dorsal face of the plate, falls into the first perforation, comes out of it, runs along the ventral face of the plate and falls into the second perforation, comes out of it and runs across the dorsal face of the plate to its right marginal edge (Fig. 3:1-5). Polish and long fine longitudinal striations, parallel to each other are clearly visible. Such traces indicate, that some rather dry and dirty material was pulled through these holes (fig. 3:6). Similar use-wear traces are observed on sides of perforations at the distal end facing each other, indicating their use in the same manner.

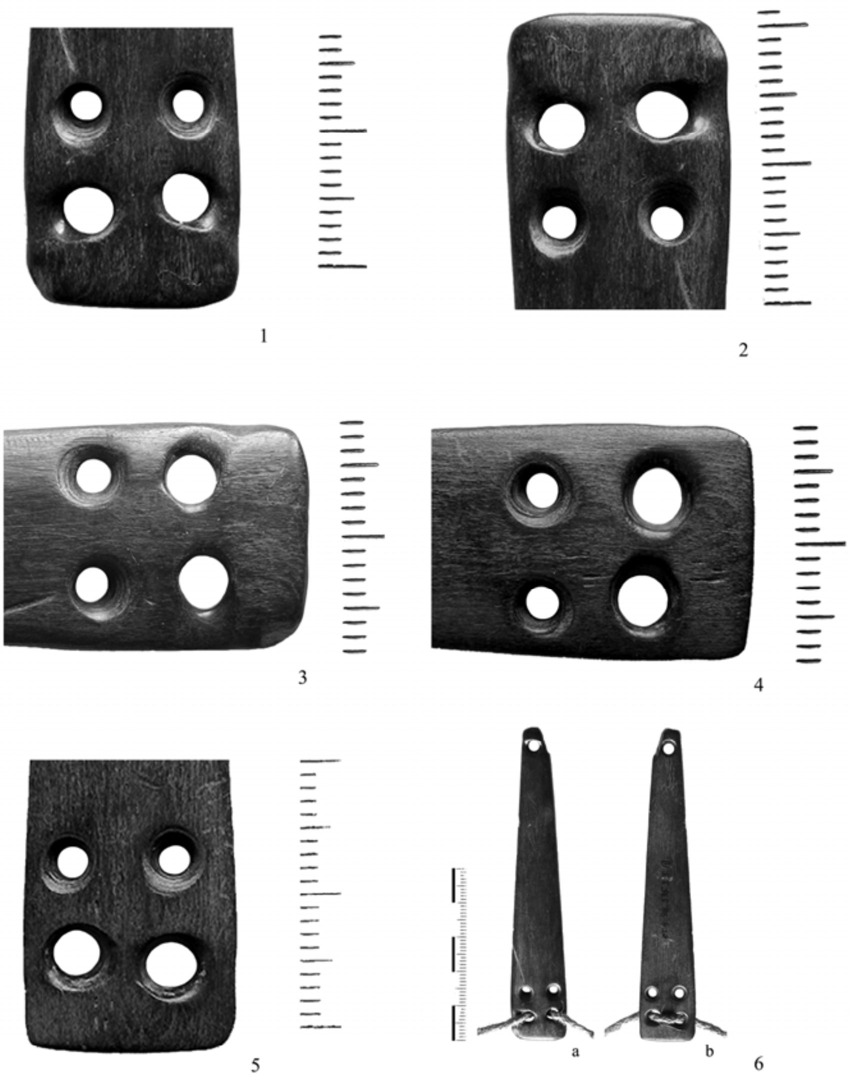

Fig. 3: Stanovoye 4, cut 3, layer 3. Perforated plate 1: 1-3 - dorsal face; 4-5 – ventral face; 6 – reconstruction of use.

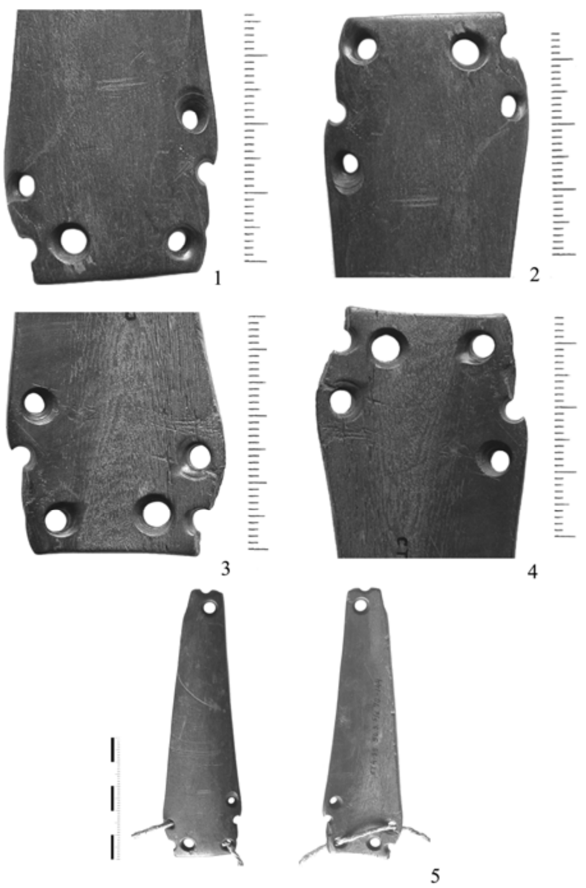

Fig. 4: Stanovoye 4, cut 3, layer 3. Perforated plate 2: 1-2 - dorsal face; 3-4 – ventral face; 5 – reconstruction of use.

The second tool is similar, but slightly larger and wider (fig. 2: 2). The narrow distal end also had two perforations, one of which is broken off. Two pairs of perforations are preserved at the wide proximal end, and two other perforations at marginal sides are broken. Poorly preserved traces of one more perforation are observed at the right corner of the dorsal face of the proximal end of the plate. Scraping, planing and fine polishing are carried out very carefully. Perforations are drilled from both ventral and dorsal sides. Half erased decoration in an oblique cross pattern is visible on the dorsal face of the proximal end. Each beam of the cross starts from a perforation at one lateral side of the plate and runs to the other lateral side. It is composed of a double line of very fine and shallow holes, drilled by a very sharp flint point (Fig. 4:1-2). Ornamentation was done before polishing of the tool surface.

Use-wear analysis showed the same pattern as observed on plate 1, but the pairs of unused and used perforations at the proximal end of the plate 2 are situated not one above the other, in the same way as the former, but at the acute angle to the tool axis (Fig. 4:1-4). It indicates, that the string was pulled through one corner over the dorsal side, that across the ventral face of plate to the other lateral side and than over its dorsal face again(fig. 4: 5). Use-wear at the distal end of plate 2 indicates that a string was pulled through two perforations at this end. Bright polish, produced by hand while using the artefact is observed. A small fragment of the third similar tool was also found in this layer.

Most probably these artefacts were used for stretching and calibration of various strings and small diameter ropes, made from hide (or leather), sinew and plant materials. They were especially important in the Mesolithic as bowstrings and for fastening points to arrow shafts, leister and spear shafts, for making nets and many other things. Sinews and hide are not preserved, but twisted strings and ropes made from various plant materials come from Mesolithic sites of Central Russia and other places. The earliest are dated to the late Preboreal period (Palsi 1920) and contemporary with the plates described above. Various ethnographic data and experiments suggest that such plates were used for strings made from hide and sinew with much more probability than for ropes made from plant materials. Similar plates were also found at late Mesolithic sites on Upper Volga (Zhilin 2001:131) and in Oleneostrovski Late Mesolithic cemetery (Gurina 1956:151). Finds of specialised tools indicate that the skill of producing very accurate strings and cordage in general, was well developed in the Mesolithic of the Eastern European forest zone.

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6.3 Food Producers

Sickles of early farmers of Azerbaijan

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Summary. *This article is dedicated to the study of sickles from the earliest settlements of Azerbaijan. The variety and improvement of the sickles reveals the technical traditions in their production. The most widespread type of agricultural tools was sickles with the sickle blades set in handle and forming the serrate working edge.*
Early farmers of Azerbaijan, similarly to most of the inhabitants of the Middle East, used the sickles with the direct serrate edge consisting of obsidian blades tightly adjusted to one another. In the late stages of progress of early farming culture (IV millennium BC.) the sickles with one obsidian sickle blade (macro blade) were mostly used.

Résumé *Le présent article est consacré à l'étude des faucilles des premiers agriculteurs de l'Azerbaïdjan. La diversité et le perfectionnement des faucilles permettent de parler des traditions techniques dans leur fabrication.*
Les faucilles dont les lames servant à couper sont installées d'une façon inclinée ont été trouvées dans ces lieux d'habitation. Comme la plupart des premiers agriculteurs du Proche Orient, dans les lieux d'habitation de l'Azerbaïdjan on donnait la préférence aux faucilles à la lame droite comprenant les plaques en obsidienne serrées l'un contre l'autre. Dans les étapes tardives du développement de la première culture agricole (4 ème millénaire) on utilisait déjà les faucilles dotées d'une seule macro – plaque en obsidienne.

Key words: Azerbaijan, sickles, early agriculture, obsidian, flint blades.

At the beginning of the 6th millenium BC Caucasus, including Azerbaijan, saw the appearance of early farming communities. Archaeologically, such communities have been identified with the 'Shomutepe culture'– named after the main surviving monuments of western Azerbaijan (Narimanov, 1966: 121-126). Recovery of wheat varieties and other cereal types among palaeobotanical remains reveals that agriculture played an important role in the economy of the early farming communities of Azerbaijan.

The latter argument is confirmed also by recovery of bone and stone hoes, grain grinders, sickle blades of flint and obsidian (Arazova, 1986). The latter were found in large numbers. In general, they represent 20 to 40% of stone tool assemblages.

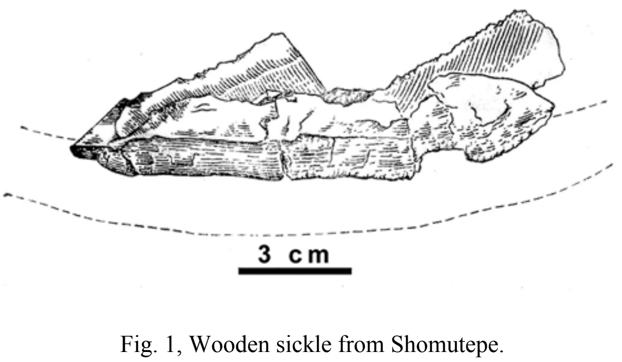

Fig. 1, Wooden sickle from Shomutepe.

This paper is dedicated to use-wear analysis of sickle blades. Usually, segments of rectangular-shaped blanks and sometimes flakes were used for blade production (Fig. 2, 1-7, 12, 13). Their working edge is thin and sharp, without any additional processing. They are typical of early farming settlements, located in western Azerbaijan (Shomutepe, Toyretepe, Gargalartepe). Sickle blades have a sharp or blunt retouch along either part of or the entire longitudinal edge.

Differently from the above-mentioned sickle blades, are those found in the southern settlements of Azerbaijan (Kultepe I – in Nakhchivan, Chanagepe – in Karabakh, Alikomektepesi – in the plain of Mugan). These were often made using prismatic, larger and longer blade blanks (Fig. 2, 8-11). Segments are almost disappearing into the sickle shaft. The working edge bears retouch. This is big and sharp retouch, marked along the longitudinal edge.

Microscopic analysis carried out on numerous blades, showed that distinctive polish concentrated either in the corners or along the working edge of the blades. These distinctions suggest different positioning of the blades into the sickle shaft.

Use-wear analysis of these tools gave also the opportuinity to reconstruct the harvesting instruments. Experimental reproduction lead to suggest that 6th-4th millennia BC early farmers in Azerbaijan were making use of curved sickles, even though at some settlements archaic 'reaper knives' with straight handles survived in use.

The mostly wide-spread was the curved sickle, with blades transversally inserted in it. These blades were characterised by a large serrated working edge. Confirming such reconstruction is a bone sickle, found in Shomutepe and five wooden sickles from Shomutepe and Toyretepe (Narimanov 1964, No. 1, Figs. 5, 6). Obsidian and flint blades, fixed with bitumen, were preserved intact in their settings on a wooden sickle (Fig. 1). This type of sickle is typically found at settlements of the central basin of the river Kur in western Azerbaijan (Figs. 2, 14), eastern Georgia, eastern and central Europe (Bibikov, 1962: Figs. 1,3). However, sickles of eastern and central Europe had flint blades of rectangular shape and were glued with plant resin. Sickles from Shomutepe

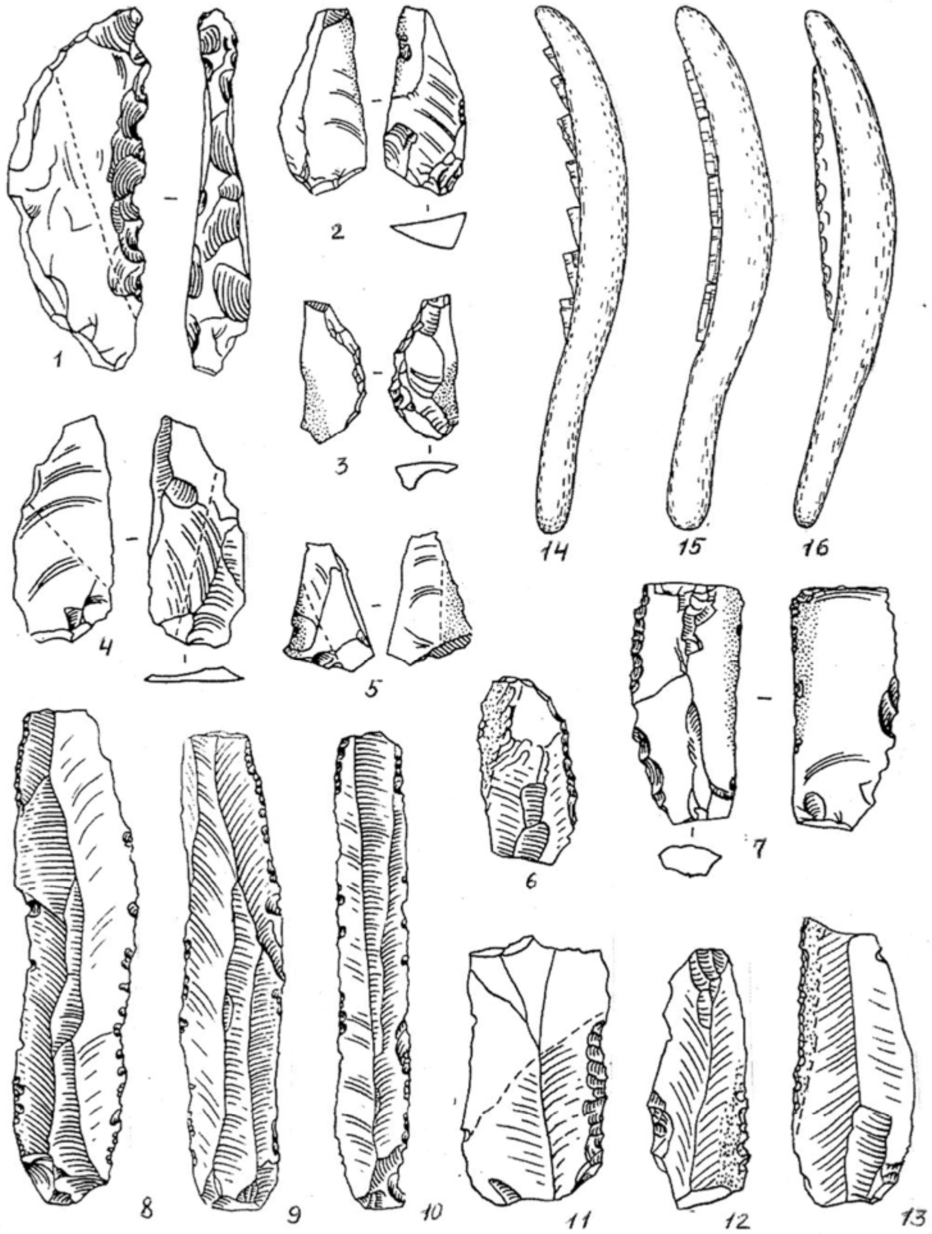

Fig. 2, Flint (1-7, 12, 13) and obsidian (8-11) sickle blades and the reconstruction of the sickles from the earliest settlements (14-16) of Azerbaijan.

and Yarimtepe (northern Mesopotamia) are very similar (Munchayev and Merpert 1981, p.218).

At settlements in southern Azerbaijan, such as Kultepe I, Chanagtepe, Alikomektepesi, farmers used other types of sickles: prismatic blades are tightly adjusted to one another and horizontally placed into the shaft. As a result of this, a direct serrated edge was formed. Also it is possible to notice traces of polish along the longitudinal edge (Figs. 2, 15). These sickles result in a high productivity and they are only 1.7 time less productive than modern metal sickles. The method of fixing of the blades is similar to reaper tools found in the Near East – e.g.VI horizon at Hajilar (Mellart 1970: Plate CXX), Tell es Sawwan (El-Wailly, Abu es - Soof 1965: Fig. 78).

Sickles of the third type differ from others (Figs. 2, 16). Tool settings are those of a curved sickle. However, its working edge was made of one big blade, inserted in a horizontal position. It is interesting that in the Kultepe I settlement there were widely spread obsidian macro-blades worked along the longitudinal edge. The present study reveals that in the IV century BC early farmers of the Caucasus preferred curved sickles (Korobkova 1978, p.39). Transition to this type of sickles was caused by the necessity to increase agricultural productivity. Such sickles are 1.5 time less productive than metal sickles.

The sickle found at Alikomektepesi is of great interest. It was made of the scapula of an animal. The thin working edge of the sickle blades is polished and shows a serrated retouch. Intensive utilization of this sickle made its working edge more polished.

Experiments produced interesting data about sickles, not only their high productivity was determined, but also the durability of flint tools. For example, the sickle found at Shomutepe could be used for two harvesting seasons. During that period, the tool was repaired only once. Besides, the blades glued in the shafts with bitumen could bear an heavy weight (up to 100 kg.).

Use-wear analysis of sickles has given sufficient information about agricultural tools used by early farmers in Azerbaijan. The wide variety and subsequent improvement of these sickles show that early farmers in Azerbaijan had the technical know-how for making tools of traditionally high level.

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Production and function(s) of obsidian tools at the Neolithic site of Contrada Diana (Aeolian Islands, Sicily)

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Summary. *This work focuses on typological, technological and functional analysis of obsidian industry. From the trench XVII (square G) from Contrada Diana. The site, is located in the Lipari island , the biggest of the volcanic Aeolian Archipelago, with accessible obsidian sources regularly used starting from the Neolithic. The typo-technological analysis gives indication that the lithic production could be devoted to specialized tasks and its data have been integrated with those of use-wear trace analysis in the effort to decipher the nature of these performed activities.*

Rèsumè *Ce travail se concentre sur l'analyse typologique, technologique et fonctionnelle de l'industrie d'obsidienne du fossé XVII (place G) de Contrada Diana. Le site, est situé en île de Lipari, le plus grand de l'Archipel éolien volcanique, avec des sources accessibles d'obsidienne régulièrement utilisées à partir du néolithique. L'analyse typo-technologique donne l'indication que la production lithique pourrait être consacrée aux tâches spécialisées et ses données ont été intégrées avec ceux de employer-portent l'analyse de trace dans l'effort de déchiffrer la nature de ces derniers des activités exécutées.*

Key words: Neolithic, obsidian tools, typology, technology, functional analysis.

Introduction

Lipari island, the biggest of the volcanic Aeolian archipelagos, located off the north coast of Sicily in the Tyrrhenia Sea (Fig. 1, A), during the Neolithic played a strategic role in the production, trading and exchange of the black volcanic glass better known as obsidian (Tykot *et al.,* 2005). The presence of Lipari obsidian (Fig. 1, B, C) is documented not only in the closest areas, like Sicily island and the southern Italy but, it has been found in Italian northern areas such as Emilia Romagna, Liguria, Friuli, and also further northeast in Dalmatia, Croatia, and further northwest in France. Evidence of human stable occupation at Aeolian Islands dates back to the end of Vth millennium BC (so called Stentinello phase). The oldest evidences found are those of Rinicedda village, located in the island of Salina, and of Castellaro Vecchio, located in Lipari. The high occurrence of obsidian industry (89.3%) with the low percentage of the flint one (10.7%) has been pointed out (Martinelli 1995) from the excavation of a hut dug in 1989 at Rinicedda (Bernabó Brea, Cavalier 1995). The rarity of whole cores (0.3%) and rough knapping production are among its peculiarities. A group of 26 intact cores, with height ranging from cm 10.7 to cm 6.5, has been found at the settlement of Castellaro Vecchio, which is located in a plain area 10 km far away from the coastline. The absence of cores at Rinicedda, on the Salina island,rises a hypothesis that, during the Neolithic phase of occupation, these were produced only at Lipari and traded with other exotic raw materials not available on the island such as flint, basalt to make grinding stones, green stones for adzes and clay for pottery (Leighton and Dixon 1992). The archaeological excavation at *Contrada Diana*, directed by L. Bernabó Brea and M. Cavalier, provides a tangible evidence of new developments in economy and type of settlements. Contrada Diana village is located on a plain area of Lipari islandand its deposit contained a large quantity of characteristic red pottery and of obsidian artefacts (Bernabó Brea, Cavalier 1960). The main trade diffusion of Lipari obsidian took place during this phase, named the Diana pottery culture, radiocarbon dated at the late 5th and at the first half of the 4th millennium BC from Lipari sites and at the early 5th millennium BC from southern Italian sites (Leighton 1999, p.271). During this period at the Aeolian Islands a population growth is supposed by the presence of both big and small size settlements belonging to the Diana pottery culture.

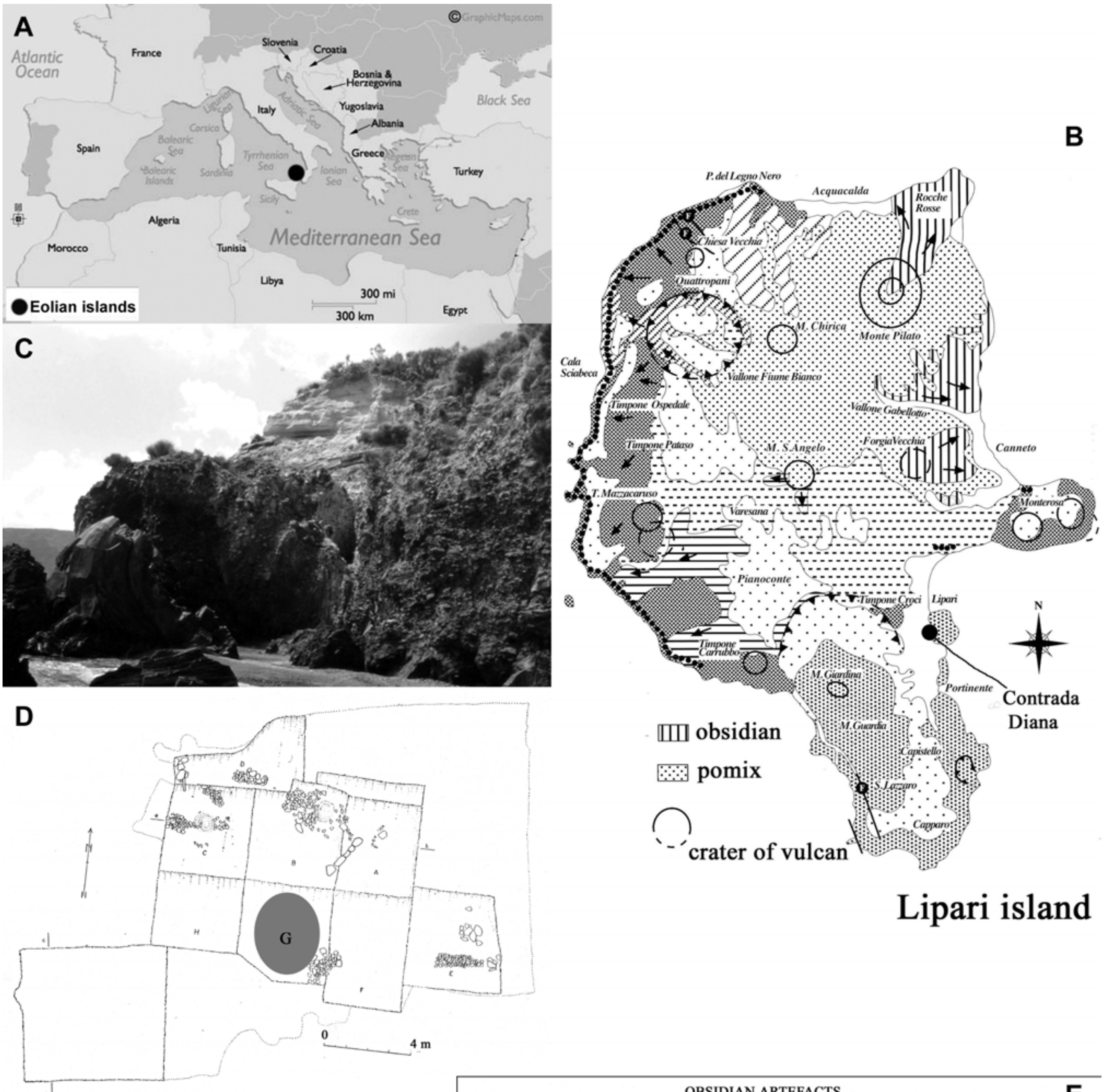
Research goals

This work focuses on the typological, technological and functional analyses of the obsidian lithic industry from the trench XVII (square G) at the Neolithic settlement of Contrada Diana (Fig. 1, D), at which an excavation has revealed an almost intact stratum not disturbed by the later Greek and Roman age necropolis. Two main factors must be considered in studying obsidian industry from Neolithic sites at Lipari: I) abundance of raw material; II) the different structure of the raw material compared with other rocks such as flint. Both factors may have a strong "impact influence on the knapping technique. A high frequency of flakes and cores not fully exploited, with only one or two flake scars, have been often observed. A desirable hardness, the conchoidal fracture and the sharp edge of obsidian must have been a very important features in orienting tool morphology.

Typological and technological analysis

The preliminary results of typological and technological research indicates that this is a lithic industry (Fig. 1, E) with very distinctive features:

1) A sophisticated knapping technique has been observed. Reconstruction of the reduction stages of



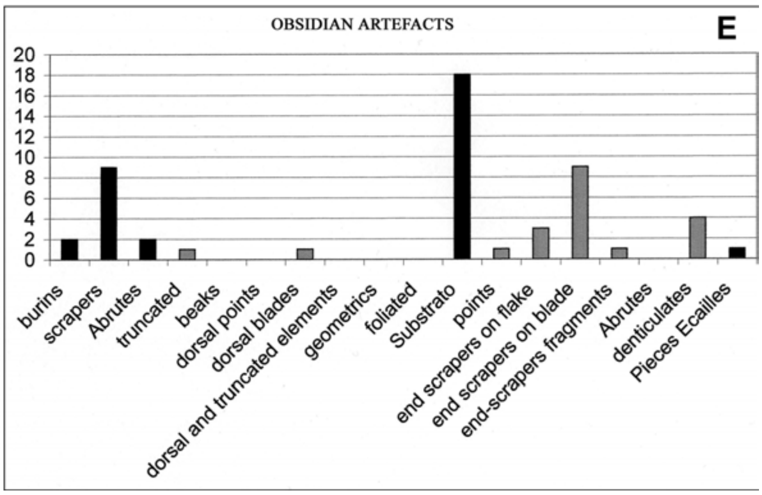


Fig. 1: A) Eolian Islands in the Mediterranea Sea; B) Lipari Island. Geological map; C) obsidian rock; D) Contrada Diana, excavation 1960,Trench XVII (Fig. 2 from *Meligunis Lipara* I, 1960); E) Trench XVII: grafic of the obsidian artefacts

the knapping method shows that blade blank production was in large quantity. For this task large blocks of raw material, after being removed by pumice cortex, were used and shaped by flaking. Intact cores and rejuvenation tablettes have been found. Abundance of flakes and blades has been testified.

2) A large quantity of laminar items are present among retouched and unretouched tools.
3) The use of thick blanks is a distinctive feature of burin and scraper types. The latter shows a specialized manufacture. Abrupt retouch is observed on backed points.
4) From a macroscopic analysis it has been possible to identify the knapping of two different types of obsidian, one in black colour and the other in white colour; the former constitutes the majority.
5) Flint knapping was also conducted at the site as attested by the presence of cores and reduction products as well as by unretouched blades. Flint industry (Martinelli 2000) is characterized by "backed products" (points, blades, truncated elements, becs and geometrics), foliates and sickle elements.

Functional analysis

Seventy-five obsidian artefacts have been selected from the square G-F of trench XVII to be subjected to the use wear trace analysis. The integration of macro and micro use wear traces (edge removals, edge rounding, polish, striae) has contributed to the interpretation of the observed edge modifications. Observations, started with a macroscopic analysis by a stereomicroscopy showedthat the surface of obsidian implements was in good condition for further analysis, although a few pieces presented post-depositional alteration wears. Among the studied specimens a total of 74 used edges have been recorded. The used edges were analysed by a Nikon Opthipot 100 metallurgical microscope, some of the specimens were also observed by the ESEM (Jeol 6060) in order to obtain more details of wear trace features and possible residues.

The 55 % of analysed items have been interpreted as possible used for the transformation and manufacture of bone/antler tools (Fig. 2,A).Hafting traces were not clearly recognised in terms of use wear traces and no residue of mastics have been found. From these preliminary data, it has been observed that edge angles from 20 to 30 degrees have been preferred for the processing of both soft and hard materials (Fig. 2, E). A higher percentage of edge angles from 30 to 50 degrees have been intentionally chosen to work on hard materials. More specifically, from the abandoned/discarded obsidian implements found at the square G of the trench XVII, it has been possible to reconstruct the transformation process of the following materials:

Bone/Antler working

Implements interpreted as related to the bone/antler working mainly shows scraping activity (Fig. 2, B). Used edge angles of scrapers range from 25° to 50°. Some of the scrapers show use wear traces both on the convex-end edge both on the convex distal edge and on the straight lateral edges. Rounded edge, striations, flat polish and abrasion are observed. Use wear traces concerning bone/antler working through perpendicular action have been observed also on burins.

Two points show longitudinal and transversal actions on hard materials interpretable as bone/antler. Blades (Fig. 2, E) have mostly been used to execute transversal actions on bone/antler, while multidirectional and longitudinal ones are observed on a small number of blades.

Hide-working

Even if very limited in quantity, hide working has been identified on two end-scrapers (n. 9 and n. 7). The convex distal edge has been in both cases used for hide processing. The angle of used edge shows a value around 30°. The used edge is highly rounded and abraded with a good degree of surface modification characterised by a micro corrugation due to the high number of striations.

Some of the used areas show highly developed abrasive wear with small spots of bright smooth polish on the abraded area. (Fig. 2, C).

Wood-working

Woodworking has been observed on a blade (Fig. 2, F) and on two scrapers. One of the scrapers (n.7) has been previously interpreted as involved in hide working (Fig. 2, C) because of the pattern of use wear traces observed on its convex edges. Its lateral edges are rounded, with a smooth-domed polish, sleek and intermittent striations, and large areas of linear abrasion that seems derived from a prolongated perpendicular action rather than a possible hafting system. This tool may have been used until the full exploitation of its edge potentiality. The recognised actions and the long-term usage allow us to hypothesize that this tool, beside the hide working, have been also used for the manufacture of wooden objects. The obsidian raw material for tool n. 7 is of high quality, with a matrix macroscopically without inclusions, very compact and vitreous.

Discussion

The lack of an exact mapping of these implements makes the reconstruction of eventual toolkits for the distincted tasks impossible. Multiple uses of the artefacts have been mostly observed on endscrapers so that they can be considered as multi-functional tools. These implements were discarded after being used on one or more edges, most likely after performing the task for which they were

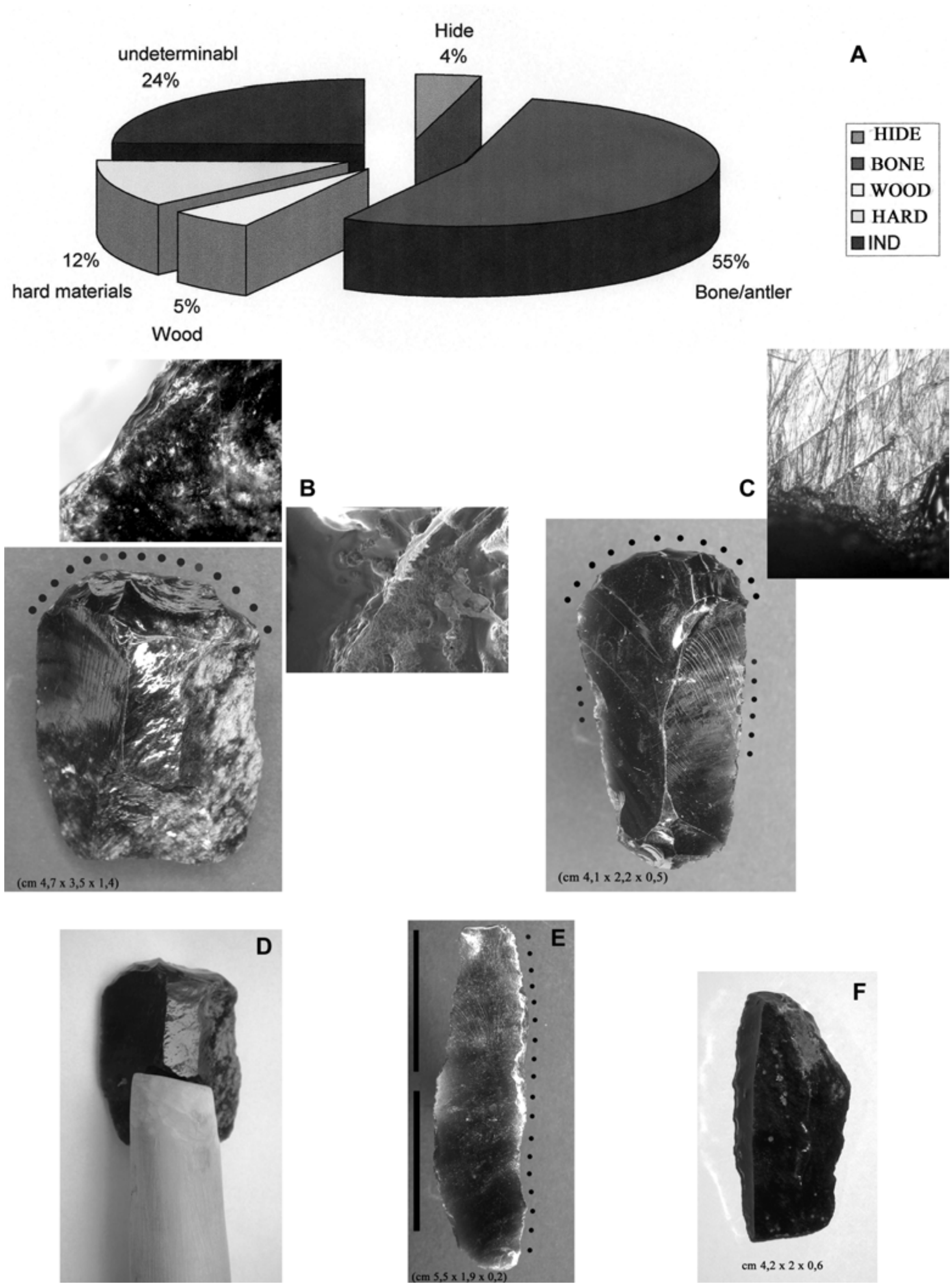


Fig. 2: A) Percentage of worked materials from the analysed sample. B) Used area of tool n. 5 and wear trace interpreted as bone/antler working. Top image is by stereomicroscopic observation, left image by JEOL 6060 SEM. C) Used areas of tool n. 7 and micro wear trace interpreted as (dry) hide processing. D) Hypotesis of a possible hafting system for tool n. 5. E) Blade used to process hard material interpretable as bone or antler. Ventral view. Intentional retouch on the left of the figure. F) Fragment of blade n. 58, dorsal view, probably used for the working of wooden material.

planned. Absence of tools recycling has been observed. Due to their size these tools from trench XVII could be of course used by bare hands, but some technological features (as that seen on tool n. 5, Fig. 2, D) could be related to the hafting technology. Even if little attested in the studied sample, the observed use wear traces interpreted as hide working can indicate a particular step of hide manufacture: that of dry hide. Although the scarce attestation of bone remains, we can raise a hypothesis that the area of trench XVII was devoted to knapping of obsidian and hard animal material processinginstead of being dedicated to food procurement and processing.

The manufacture of tools with both convex and straight edges, as seen for endscrapers, with high and low edge angle, can be linked to a need of executing mixed action on materials of different hardness. The choice of shaping thick blanks with high edge angle may have helped overcoming the limitation of the short duration of edges used for working of hard substances. As already demonstrated by Martinelli for the technological factors, in Lipari, people mainly exploited obsidian to knapp tools because it was the primary lithic resources being locally available. Microwear analysis provided the proof that activities other than obsidian production were carried out.

Acknowledgements
The authors wish to thank the Luigi Bernabò Brea Aeolian Regional Archaeological Museum in Lipari and mainly the honorary curator dr. Madeleine Cavalier for approving, stimuling and supporting the starting of the project on Aeolian Obsidian Tools Analysis. This work has benefitted of the experimental knapping obsidian work done by Leandro Lopes. We wish to acknowledge Shoh Yamada for his advice on the manuscript. Thanks are due to the C.E.A. Consulting lab of Siracusa for the possibility to work with the JEOL SEM microscope.
The authors contributed equally to this work, integrating the results of use wear trace analysis by M.R.I. with the techno-morphological analysis by M.C.M.

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Neolithic bone needles and vegetal fibres working: experimentation and use-wear analysis

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Summary. *Archaeological bone needles are often studied from a typological and technological perspective (Stordeur 1977; Stordeur-Yedid 1979). However, very few studies deal with their function (Bouchud 1977). In order to start to document the needles' function(s), we have opted for a comprehensive study including experiments and high-power micro-wear analysis on the rich assemblage of bone needles from the aceramic Neolithic village of Khirokitia (Cyprus). In this paper, we present the first results of the functional analysis which reveals that these tools were mainly used on soft vegetal fibers.*

Résumé. *Les aiguilles en os ont souvent été étudiées d'un point de vue typologique et technologique (Stordeur 1977; Stordeur-Yedid 1979). En revanche, très peu d'études fonctionnelles ont été conduites (Bouchud 1977). Afin de commencer à documenter la ou les fonction(s) de ces outils, nous avons procédé à l'analyse tracéologique d'un important ensemble d'aiguilles en os provenant du village de Khirokitia (Néolithique pré-céramique – Chypre). Notre démarche repose sur l'élaboration d'un référentiel expérimental et sur une analyse macro- et microscopique des usures. Les premiers résultats révèlent que ces outils ont majoritairement été utilisés sur des fibres végétales souples.*

Key words: bone needles, use-wear analysis, aceramic Neolithic, Cyprus.

Introduction

Because of their morphology, which suggests their use-mode, their low frequency within Neolithic bone assemblages and their often bad preservation and high fragmentation, needles were often excluded from the functional analyses. However, considering that the identification of the worked materials and of the use-modes of the tools provides insights into the way of life and technical traditions of the prehistoric populations as well as into the exploitation of their natural environment, we have chosen to start to document bone needles' function(s). We have opted for a comprehensive study including experiments and high-power micro-wear analysis on the rich bone needles assemblage found at the aceramic Neolithic village of Khirokitia (Cyprus – from 7th millennium to the first half of the 6th millennium cal.BC) (Fig. 1) (Legrand 2005). Based on their good surface preservation, which makes them suitable for microscopic analysis, a sample of 155 tools over 624 needles was selected to carry out the functional study. Our aim was to identify the worked materials and test the functional homogeneity of the tools to explore the possibility of craft production involving the use of needles.

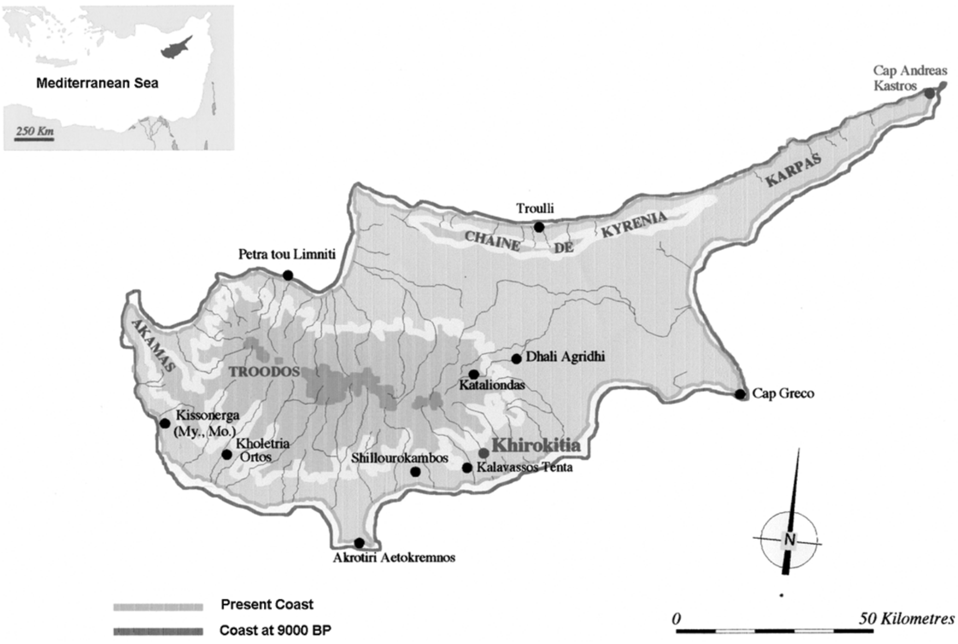

Fig. 1: Map of the Aceramic Neolithic sites in Cyprus (adapted from Gomez and Pease 1992).

Ethnographic evidence supports the idea that needles were often used on linen, inner bark, reeds or bast, for the production of clothing, baskets, fabrics, etc. (Miles 1963; Stewart 1973; Roger and Smith 1981; Nelson 1983). Moreover, different remains discovered at Khirokitia, such as mats and baskets prints and fabric fragment very clearly show that vegetal fibres were exploited for the production of various implements (Le Brun 1989). In this context, experiments were mainly led on vegetal fibres working – the sewing of leather was also tested. In this paper, we present the first results of the functional analysis.

Fig. 2: Flax sewing experimentation.

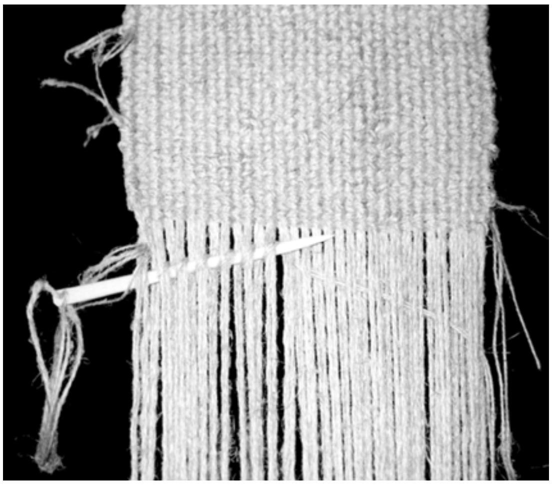

Fig. 3: Weaving experimentation.

Methodology

The methodology chosen included experiments and use-wear analysis at low (up to 64x) and high magnifications (100x and 200x). We conceived of our experimental program considering ethnographic and archaeological evidence. The nature of the vegetal fibres used to manufacture the fabric fragment discovered at Khirokitia, is unspecified, but one can consider the use of flax fibres even if no seeds were found in the site. Indeed, flax was recognized, even if its remains are rare, on the Cypriot sites of *Mylouthkia* 1 and Cape Andreas-*Kastros* which are respectively earlier and contemporaneous than Khirokitia assemblage (Van Zeist 1981, p.98; Peltenburg *et al.* 2001, p.71). Moreover, the absence of seeds does not mean that flax was not used (Barber 1991, p.12). Lastly, we know that flax was used in the manufacture of fabrics in southern Levant since the 7th millennium cal.BC (Schick 1989). Thus, experiments were conducted on flax sewing and weaving (Figs. 2-3). Use-times varied from 20 minutes to 50 hours. Flax was used for sewing thread. Additionally, we also tested reed and bark working with bone points. Volume and surface patterns observed on these tools have been considered to characterize bone needles wear.

The methodology employed to characterize needles' wear includes analysis of the macroscopic traces, in particular "volume alterations" (Sidéra 1993; Sidéra et Giacobini 2002), and of the microscopic traces with high magnifications (100x and mainly 200x), provide a metallographic microscope, by following the criteria presented in Christidou 1999. Other criteria such as the use wear development along the tool were also employed (Legrand 2005; Sidéra et Legrand 2006).

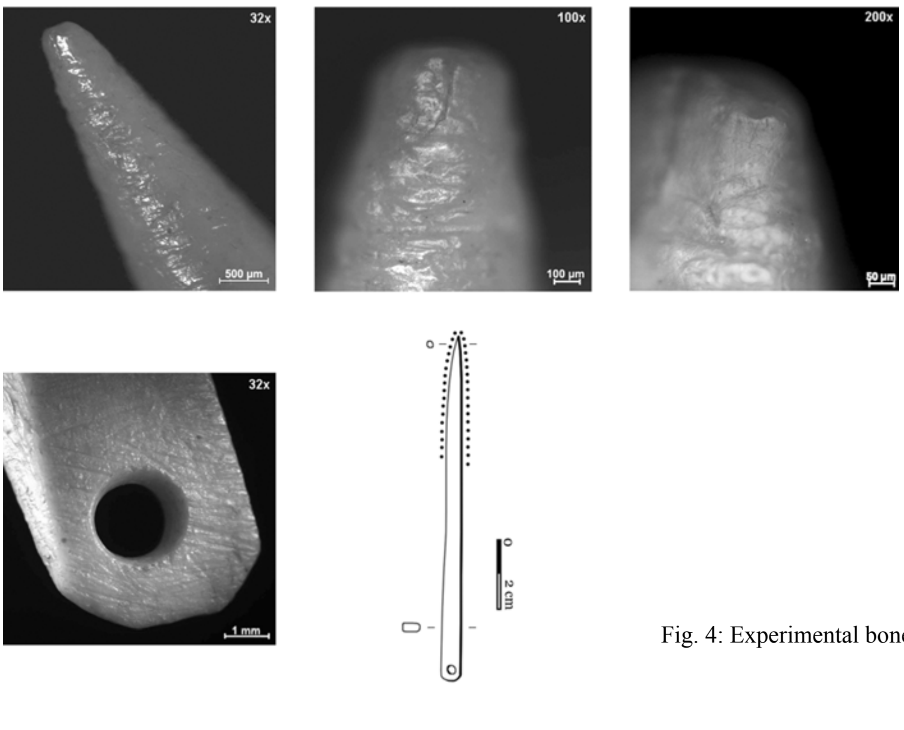

Fig. 4: Experimental bone needle used for weaving flax.

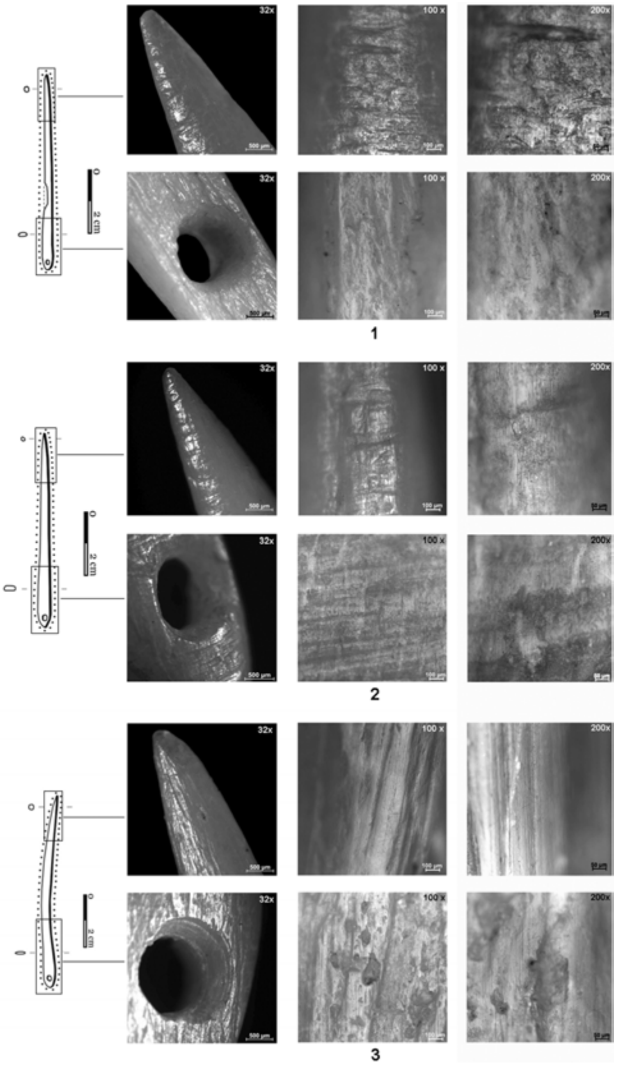

Fig. 5: Use-wear patterns observed on experimental needles used to sew flax fabrics. 1 – use-time 20 minutes; 2 – use-time 40 minutes; 3 – use-time 120 minutes.

Use-wear patterns on experimental tools

First, let us examine the wear observed on the needles used in flax weaving (use-time: 50 hours) (Fig. 4). The extent of wear from the distal part of the needle was moderate, and the development of wear was gradual. The eye zone does not present any significant wear, but manufacture traces were still observed. Macroscopic analysis showed that the tips were highly deformed by numerous and localized chippings. Microscopic wear patterns consist of an unmodified original surface topography. At 200x, the rises were varnished with flat or domed aspect and smoothed texture. Numerous micro-pits and multi-directional, short, fine (less than 1 µm), superficial, straight and continuous striations were also observed.

Needles used to sew flax fabrics show more developed wear, in spite of a shorter use-time (from 20 to 120 minutes). This probably can be explained by a more important contact with the worked material. Whatever the use-time, wear was extensive and shows gradual development. Scratches progressively appear on the needles eye zone. Chippings progressively invade the faces of the tip and highly modify the tip original volume (Fig. 5-1). At high magnification, the original surface topography was progressively regularized (Fig. 5-2). The rises became varnished and smoothed with domed or flat aspects and grainy or smooth textures (Fig. 5-3). Striations were longitudinal, long or short, fine or broad (between 1 and 2 µm), superficial, straight, organized and continuous. The largest striations had smoothed edges and were partially affected by the polish. Toward the end of the use, craters appeared while micro-pits progressively disappeared.

Archaeological results

A sample of 155 needles including small and large sizes, were selected (Table 1 - Fig. 6). Small needles were more numerous (145 needles). Their dimensions suggested unconstrained, delicate work on soft materials and the use of very fine sewing thread.

	Lengh		Proximal width		Eye diameter	
	Small module	Large module	Small module	Large module	Small module	Large module
Minimum	12	36	1	3	0.5	1.5
Maximum	75	125	4	11.5	2	4
Average	31.89	73.82	2.23	6.96	1.12	2.38

Tab. 1: Khirokitia bone needles dimensions (mm).

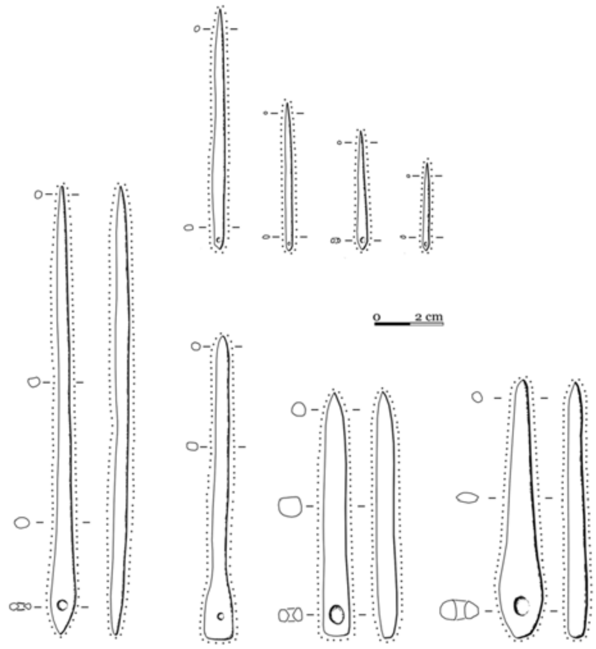

Fig. 6: Khirokitia bone needles selected for the functional analysis.

On complete needles, wear was invasive and show a gradual development. Manufacturing traces observed all along the needles' length, were more or less smoothed and sometimes completely disappeared. Three kinds of volume alterations – smoothing, chipping and crushing –

Fig. 7: Smoothing more pronounced on one side of the needle tip (14x).

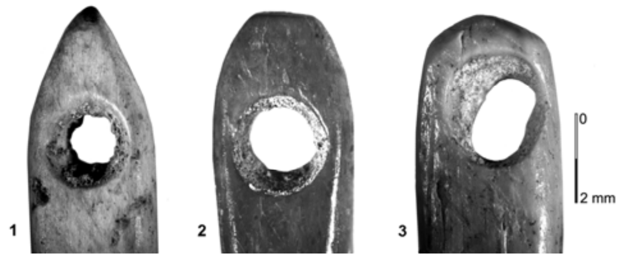

Fig. 8: Different degrees of eye volume deformation.
1 – low volume deformation; 2 – moderate volume deformation; 3 – high volume deformation.

	Degrees of tip volume deformation			Total (n)
	Degree 1	**Degree 2**	**Degree 3**	
Smoothing	15	11	4	**30**
Chippings	-	1	3	**4**
Smoothing and chippings	-	4	2	**6**
Smoothing and crushing	-	-	3	**3**
Total (n)	**15**	**16**	**12**	**43**

Tab. 2: Tip volume alterations and degrees of deformation.

were observed on the needle tips. Smoothing appeared as the most common type of wear. It can mainly concerns the entire tip but can also be more pronounced on one side of it (35.71 %). In these cases, the worn side was 3 to 5 mm in length and this gave the needle tips oblique morphologies (Fig. 7). This kind of wear, which was not observed on experimental needles, suggested an oblique working angle and localized contact with the worked material. Chippings and crushing are rare. They result from rather specific mechanical constraints on rigid material and/or long use-time. The association of these wears and their localization at the tip end of the needles makes the tip volume deformation more or less significant. Three degrees of deformation have been defined from the less-used needles (stage 1) to the highest used ones (stage 3) (Table 2) (Sidéra and Giacobini 2002). The needle eye surfaces and their inside perimeter can also be deformed by smoothing. Within the sample, a majority of needle eyes were middle deformed (37.04 %) (Fig. 8). Many craters and longitudinal or multi-directional scratches were observed on the needle surface at low magnification.

Three different micro-wear types relative to vegetal fibres working were distinguished:

1. Use-wear No. 1 was observed on 38 complete or fragmented small-sized needles. Their tip was highly deformed by smoothing. The comparison with the experimental tools showed that this wear presented the same irregular topography and rise aspects as the ones observed on the needles used to sew flax fabric for 120 minutes (Fig. 9). However, the archaeological wear was distinguished by a smooth texture of the rises, disordered and multi-directional scratches and a higher number of rough craters. The heterogeneity of the scratches and the fact that craters have slightly worn bottom suggest a fibre nature other than the flax while being flexible.

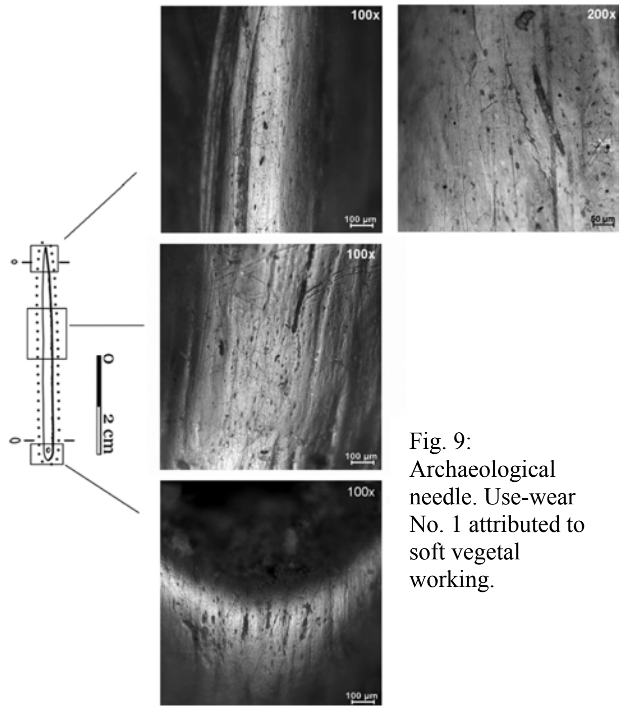

Fig. 9: Archaeological needle. Use-wear No. 1 attributed to soft vegetal working.

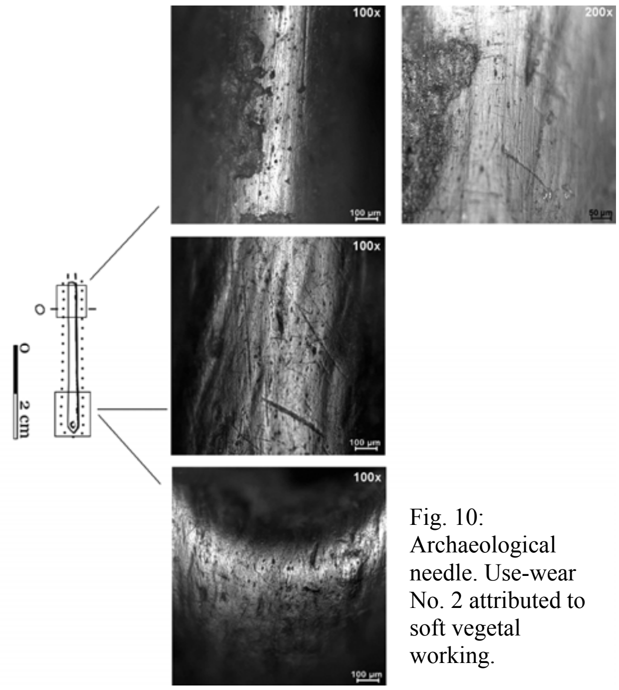

Fig. 10: Archaeological needle. Use-wear No. 2 attributed to soft vegetal working.

2. Use-wear No. 2 was observed on 22 complete or fragmented small sized needles (Fig. 10). On the

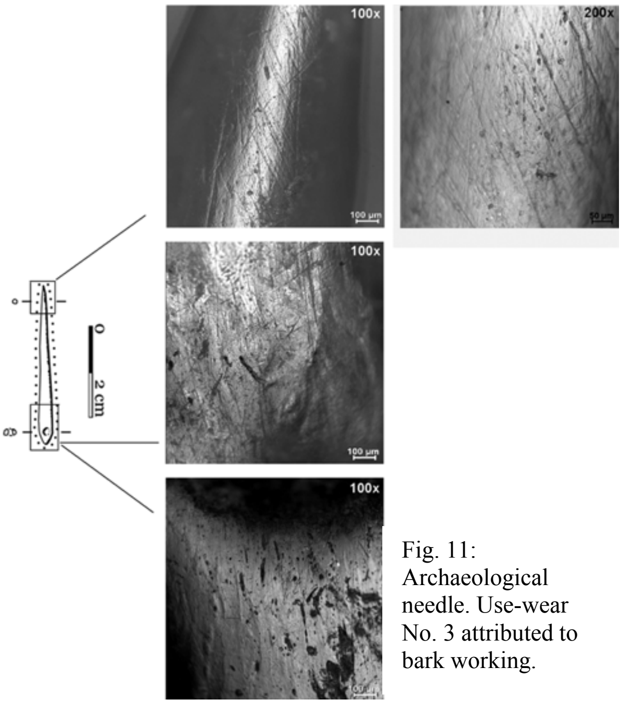

Fig. 11: Archaeological needle. Use-wear No. 3 attributed to bark working.

macroscopic level, volume alterations were similar to the ones described earlier. Four needles presented a smoothed facet on the tip. The characteristics of the topography and the aspect of the rises were also similar. The differences between these two types of wear relate to the rises texture, the organization and dimensions of the scratches, and the number of craters. Indeed, in the case of wear No. 2, the rise texture was grainy, the orientation of the scratches was much more homogeneous, they were mainly longitudinal and slightly broader. The craters were fewer. Their edges and bottom were slightly affected by the wear. The directional and morphometric homogeneity of the scratches can be explained either by a more regular movement during the use, or by the nature of fibres, which were also more homogeneous. A different fibre treatment could also be considered. The wear observed on the needle-eye zone was different than the one observed on the tip. It was characterized by a higher number of craters and by multi-directional scratches. This wear could correspond to wear that happens because of gripping.

3. Use-wear No. 3 was observed on 6 complete or fragmented, small needles and on 1 large- sized needle (Fig. 11). Macroscopic volume alterations consisted of smoothing. At high magnification, manufacturing scratches and other broad and deep depressions were slightly worn. In contrast, rises were strongly smoothed and this clearly showed that rather rough, rigid material had been worked. We deduced that these tools could have been used on bark fibres to manufacture baskets for example. The presence in this sample of needles of small and large sizes could suggest the production of baskets of various sizes. One can also suppose that these needles, according to their size, were used in different production stages. The needle eye zone showed, at 200x magnification, varnished surfaces covered with many fine scratches and circular craters. This type of wear, which is similar to kind described earlier, corresponds to wear that occurs because of gripping. This, in addition, suggests that, because of the significant gripping wear development, these needles were used at length.

Conclusion

Khirokitia needles show a certain functional homogeneity since a great majority of needles, especially small-sized needles were used on soft vegetal fibres (84.51%, 60 artefacts over 71 determined). The sample of large-sized needles was too small to validate a relationship between the size of the needle and the material worked. However, we can note that the large-sized needle studied was used on bark (Table 3).

	Bark	Soft vegetal fibres	Total (n)
Small module	6	60	**66**
Large module	1	-	**1**
Total (n)	**7**	**60**	**67**

Tab. 3: Needles module and worked material.

The wear experimentally reproduced by vegetal fibres, especially by the flax fibres, is not evident within the archaeological sample. To a certain degree this could be due to problems related to the intensity of use of the tools, experimentation showed that the use-time sets one of the most pervasive problems in the analysis of the use-wear which develops very slowly on the surface of the needles. The use-conditions but also the various natures of the worked fibres can as well be considered. Experimentation may set in the future new standards of identification of the use of the various vegetal fibres.

If there is no evidence of any craft production, different activities involving vegetal fibres can, however, be considered such as sewing or weaving, but because of the high number of needles, which makes Khirokitia bone assemblage original, other uses must be mentioned like basket making or embroidery of small decorative elements.

Acknowledgements
I am very grateful to Alain Le Brun for giving me the opportunity to study Khirokitia bone assemblage. I also thank Isabelle Sidéra for her guidance and Rozalia Christidou for presenting my poster during the Congress "Prehistoric Technology: 40 years later. Functional Studies and the Russian Legacy".

All the pictures are by the author.

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Eneolithic flint workshop-settlements in north-eastern Bulgaria

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Summary. *During the Eneolithic intensive exploitation of the flint resources started in south-eastern Europe. Rich finds of quality flint characterise the whole of north-eastern Bulgaria. This is probably one of the reasons for the appearance of a great number of settlements in this region during the Eneolithic. According to analysis carried out on assemblages from the area, flint tool production did not take place on all settlements.The study of the flint assemblage from the settlement of Chakmaka in the region of Isperih, gave reason to think that this is one of the numerous (probable) workshop-settlements which existed during the Eneolithic in north-eastern Bulgaria.*

Résumé. *Pendant Eneolith a commencé une exploitation intensive des trouvailles de silex en Europe du sud-est. Des trouvailles riches du qualité silex sont rencontrées dans le tout nord-est La Bulgarie. C'est probablement une des raisons de le grand nombre de villages a surgi dans cette region pendant l' Eneolith. Malgre de nombreuses trouvailles il n'y avait pas une production d'outils de silex dans tous les villages selon l'analyse de trouvaille. La recherche materielle de silex au village de Chakmaka dans la region d'Isperih donnent une raison de penser que c'est un des nombreux (probablement) villages-atelier a existe pendant les differentes phases de l'Eneolith en Bulgarie nord-est.*

Key words: Eneolithic, north-eastern Bulgaria, flint tool production, flint workshop.

During the Eneolithic, intensive exploitation of flint outcrops started in south-eastern Europe. At the same time, flint-working techniques improved. The production of perfect, from a technical point of view, flint tools required special craft skills. That is why settlements specialised in flint working appeared close to good quality raw material outcrops. Rich quality flint resources are available in the whole of north-eastern Bulgaria. This is probably one of the reasons for the great number of settlements found in this region during the Eneolithic. However, according to analyses carried out on flint assemblages from the area, flint tool production did not take place in every settlement. In many of them, only finished tools and blades were found (Skakun 1987, p.14). This suggests the presence of workshop-settlements where these tools were made and from which they were spread over a large territory.

During the Eneolithic, long blades are the standard products created in the workshop-settlements for trade and exchange. As expected, quite a few long blades were found in the workshop-settlements themselves. Longer blades were also from other settlements and burial sites. At different settlements (e.g. Durankulak, Golyamo Delchevo, Ovcharovo-Skakun 1987, pp.1-18) whole blades and blade fragments with signs of utilization were found, as well as whole long blades without signs of utilization which were stored and treasured such as at Golyamo Delchevo (Skakun 1996, p.159) and Hotnica (Chohadjiev 2003, p.18). Extremely large blades were also objects which showed the owner's social *status*, this is probably the reason for their deposition also as burial gifts (e.g. at Varna cemetery) (Manolokakis 2002, pp.4-5)

The study of the flint assemblage from the settlement site of Chakmaka, in the Isperih region, suggests that this was one of the numerous (probable) workshop-settlements which existed during the different phases of the Eneolithic in north-eastern Bulgaria.

Fig. 1: Nuclei and remaining pieces of the flint production from workshop-village Kamenovo, region Kubrat, N-E Bulgaria.

Fig. 2: Nuclei and remaining pieces of the flint production from workshop-village Chakmaka, region Isperih, N-E Bulgaria.

Fig. 3: Long blades with sings of utilization from the settlement of Demir baba, region Isperih, N-E Bulgaria.

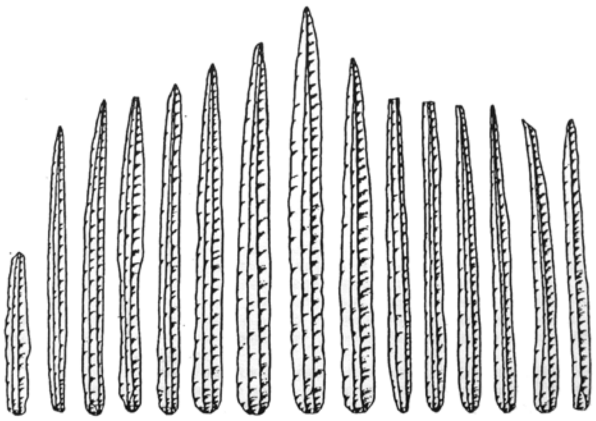

Fig. 4: Long blades without signs of utilization from G.Delchevo, N-E Bulgaria, H. Todorova's excavations (fr. Skakun,1996).

Finds represent all phases of flint production: raw material, pre-cores with distinct working platform preparation, cores, blades with and without cortex, plastinis retush and using tracks, tools, whole and fragmented utilized tools, discarded pieces and debitage/knapping byproducts (Mateva 2003, p.76). A larger and more varied assemblage is found at Chakmaka. When compared to other contemporary settlement sites, such as Delchevo and Durankulak (Skakun 1982) the quantity of tools for flint working from Chakmaka is

Fig. 5: Flint finds site near the workshop-village Chakmaka, region Isperih, N-E Bulgaria.

three times bigger and the quantity of cores and their remains is 70 times larger (Mateva 2003, p.77). A difference was also noticed in the type and quality of the flint assemblages from the contemporary settlements situated close to Chakmaka (e.g. Sredoseltzi, Demir baba and others).

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Cereal harvesting and processing at the Middle Neolithic site of Schipluiden, a coastal site in the Lower-Rhine basin

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Summary. *The Middle Neolithic site of Schipluiden is located on a small dune surrounded by marshlands. The wet environment was not considered ideal for crop cultivation. However, analysis of macro-remains showed the presence of seeds and glumes of naked barley and seeds of emmer. Flint tools displayed sickle gloss. The analysis of phytoliths from a selection of querns, rubbing stones and pit fills confirms that either wild or cultivated grasses were processed at the site.*

Résumé. *Le site Néolithique moyen de Schipluiden est situé sur une petite dune, entouré par marécage. Un tel environnement n'est pas considéré comme idéal pour mettre la terre en culture. Néanmoins, l'analyse des macro-restes organiques indique la présence des graines et des glumes d'orge nue (Hordeum nudum) et du blé amidonnier (Triticum dicoccum). Des outils de silex démontrent des traces de moisson. L'analyse des phytolites dérivées d'une sélection des pierres de mouture et des contents des fosses confirme le traitement locale des céréales, soi des espèces sauvages, soi cultivés étaient.*

Key words: Lower Rhine basin, Middle Neolithic, sickle gloss, phytoliths analysis.

Phytoliths

Plant microfossils like pollen, starch and phytoliths can be found as residue on prehistoric tools used for plant processing. Phytoliths are plant silica bodies that are formed when silica is taken up into the plant from the ground water and precipitates in or between cells. Being inorganic, phytoliths can be preserved for thousands of years, long after the plant has decomposed.

Phytoliths are formed in a variety of three-dimensional shapes, like conical, cylindrical, rectangular or pyramidal. Many plant taxa have distinctive phytolith types. Morphology, size and quantity of phytoliths may indicate processing of specific plant families. Besides, the size and morphology of phytoliths is specific to certain parts of the plants.

The study of prehistoric tool functions has gained significantly since wear traces are being correlated with residues. This integrated study has been performed for many years at the Laboratory for Artefact Studies of the Faculty of Archaeology at Leiden University. The analysis of phytoliths proved to be an important asset to functional artefact studies. Therefore, the laboratory was further equipped with material and expertise for phytolith analysis in the past two years. The recently excavated and well-preserved material from the Dutch site of Schipluiden offered a unique opportunity to test the possibilities of phytolith analysis.

The site of Schipluiden

The middle Neolithic site of Schipluiden, dating to c.3750-3400 cal BC, was excavated in 2003 by Archol, the commercial archaeological unit of Leiden University. The habitation traces were located on a small dune surrounded by marshlands, and consisted of postholes, a house plan, waterholes, a few graves and a fence surrounding the dune, as well as an enormous amount of artefacts (Louwe Kooijmans and Jongste in press).

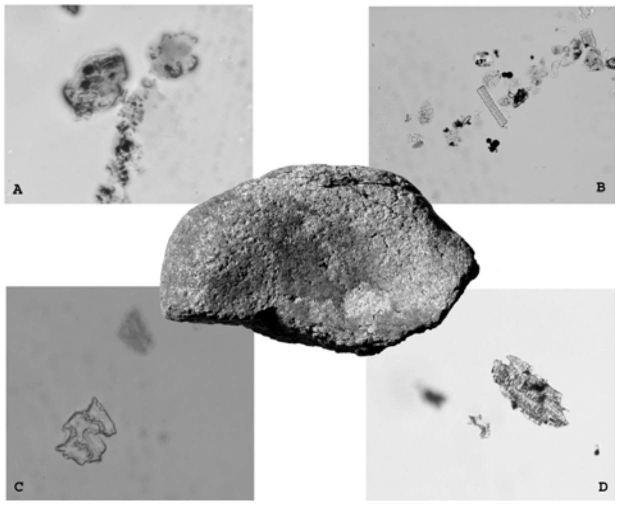

Fig. 1: Quern of weathered sandstone (no.2857): a) fragment of spodogram of grass or cereal leaf sheath or stem with stomata; b) possible fragment of barb from cereal/grass head; c) spodogram, d) glume spodogram, of wheat or barley.

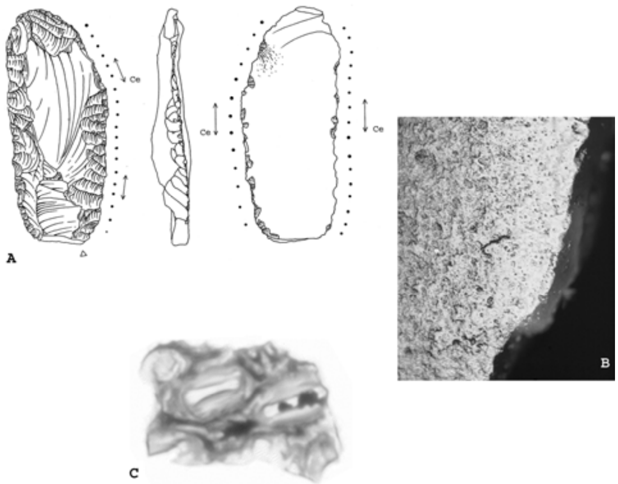

Fig. 2: a) Flint sickle with traces from cereal harvesting; b) use wear polish on sickle (orig. mag. 100x), c) fragment of spodogram with papillae.

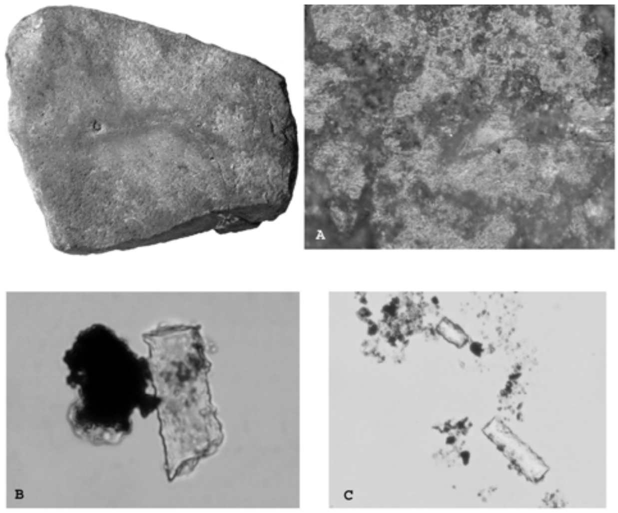

Fig. 3: a) Quern of sandstone (no. 2038); b) use wear polish on quern (orig. mag. 200x); c,d) worn rods from cereal/grass stem.

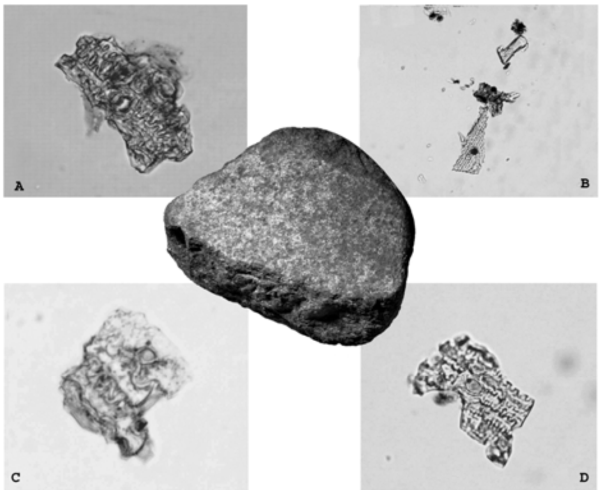

Fig. 4) Quern of unidentified stone type containing olivine minerals (no.7165): a) small spodograms of glume fragment from cereal/grass, looks processed, b)spodogram (possibly a leaf fragment) from cereal/grass, looks processed, c) glume spodogram from cereal/grass; spodogram from cereal/grass.

Preservation of organic finds was very good. The location of the site, in a wet environment, was not considered ideal for crop cultivation. It came therefore somewhat as a surprise when the analysis of the macro-remains showed the presence of not only the seeds of naked barley and emmer, but also of the glumes of naked barley. This points to local cultivation. Additional arguments are formed by the presence of flint tools with sickle gloss (Fig. 2a, b) (Van Gijn *et al.* in press).

Composition of the sample and cleaning procedures

In order to obtain more insight in eventual processing activities, five querns and one rubbing stone were selected for phytolith analysis (Figs. 1, 3, 4). These artefacts were made of coarse grained stone, either quartzitic sandstone or granite. While being analysed for wear traces, possible residues were observed on these artefacts (Van Gijn and Houkes in press). Additionally, four soil samples were taken from pit fills for phytolith analysis.

For the extraction of residue no chemical treatment was applied. The stones were completely immersed in distilled water in an ultrasonic tank in order to remove all residues and the rinses were centrifuged at 3000 rpm. This procedure was repeated twice in order to compare the results after the first and second rinses to account for possible contamination of adhering sediments.

The soil samples were soaked for 10 minutes in distilled water and then sieved in four steps (through 0.25 mm, 0.175 mm, 0.125 mm and 0.075 mm). The samples were then centrifuged twice for 5 minutes at 3000 rpm and the supernatant was discarded between the two sessions. Samples were mounted on glass slides that were examined under a transmitted light microscope (magnification up to 1000x).

Results

All quern samples revealed phytoliths typical of *Poaceae*, *i.e.* wild grasses or domestic cereals. Various characteristic phytoliths were found both on the tools and in the soil samples, such as dendriforms, hairs, hair bases, fragments with stomata, glume spodograms and rods. In two cases (tools nos. 7165 and 8393) some of the phytoliths appeared to be of the Hordeum type, an inference based on the shape of the cell margins in the spodograms (Fig. 4d). Two querns (nos. 2038 and 2857) showed bilobate phytoliths of the Panicoid type, probably from a wild grass. The last tool (no. 9215) showed only crushed rods deriving from Poaceae (cereals, grasses), which could not be further differentiated. Although it is not usually possible to distinguish between wild and domesticated species, the size of the phytoliths seems to point to domestic cereals. Interestingly, many of the phytoliths display signs of processing. A considerable number of spiky rods have lost their spikes and seem to have been ground (no. 2857, Figs.1b, 3b,c). Some of the grinding seems to have involved dehusking of the grain on the querns, as testified by the presence of spodograms of leaf sheaths (no. 7165, Fig. 4b). However, the presence of these chaff fragments is not necessarily attributable to dehusking, as quite a bit of chaff may have ended up on the quern along with the grain (Procopiou *et al.* 2002). There were numerous crushed and fragmented leaf and stem fragments, which probably formed part of the same winnowed fraction as the (hulled) grain (no. 7165, Fig.4a). One sample showed a processed dendriform phytolith of a glume, indicative of the process of flour making. The use of the querns for making flour is also demonstrated by the presence of tiny broken phytolith fragments.

The analysis of the soil samples showed a similar picture. The phytoliths were found to be comparable with those observed on the stone tools in terms of both type and size.

The phytoliths found in the soil samples were extremely well preserved, probably because they were covered with sediments soon after deposition. One sample from a shallow well contained phytoliths from cereals suggesting dehusking. Another sample was found to contain phytoliths from dicot leaves, which were highly fragmented due to processing. The presence of phytoliths in these pits may initially come as a surprise. But if winnowing was practised at the site, fragments of stems and leaves will have been blown around and will have become trapped in the waterlogged pits. It is also possible that processing waste was dumped in the pits while they were silting up.

Conclusions

The phytolith analysis of the querns and the soil samples from pits showed that the inhabitants of Schipluiden certainly processed seeds to make flour. Whether wild grasses were also processed is not altogether clear as the phytoliths of wild grasses and cereals are virtually the same, but the fairly large size of the phytoliths points to domestic cereals. Processing of wild grasses by hunter-gatherers was however not unusual in prehistory (see Fullagar and Field 1997). The fact that phytoliths were also found in the pit fills indicates that winnowing was done at the site. These data corroborate the archaeobotanical evidence of the local growing of cereals, an inference further supported by the presence of flint sickles.

Acknowledgements

The analysis of the phytoliths is partly based on the expertise of Patricia Anderson and Pascal Verdin (CRA, Valbonne, France), who kindly identified phytolith samples we had trouble with. Eric Mulder prepared all the phytolith samples.

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The Neolithic settlement of Lugo di Grezzana (Verona, Italy). A lessinic flint *emporium*

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Summary. *Lugo di Grezzana (VR, Italy) is one of the most important neolithic settlements of Fiorano Culture in Northern Italy (5500 a.C. cal ca). The finding of a large quantity of lessinic flint (semi-finished and finished one) suggested us a functional study on lithic artifacts. The first results confirm the main impression that Lugo was a working station, probably such as a "flint emporium" to external trade.*

Résumé. *Lugo di Grezzana (VR, Italie) est l'un des plus importants sites néolithiques de culture Fiorano dans l'Italie du Nord (5500 av. J.-C.). La découverte sur place d'une grande quantité de silex lessinic semi-ouvragé et d'outils a conduit à une étude fonctionnelle. Les résultats – encore provisoires – suggèrent que ce lieu a été exploité pour l'extraction, le travail et le triage du silex vers l'extérieur*

Key words: Neolithic, Fiorano Culture, lessinic flint, functional analysis, flint emporium.

In the last tirthteen years the site of Lugo di Grezzana (VR, Italy) has become one of the most important Neolithic settlements of northern Italy. The excavations at the site are supervised by prof. A. Pedrotti (University of Trento, Italy). This site is referred to Fiorano Culture, in the Ancient Neolithic Period (5500 BC), and lasts until the VBQ (Vasi a Bocca Quadrata= Square Mounthed Pottery) Culture (First Period).

Lugo includes a rich flint assemblage. All the artefacts are obtained from lessinic flint whose outcrops lie on Lessinic hills nearby. There are several burins, which the most common type is the burin on a side notch on narrow blade (so-called Ripabianca Burin), rhomboids (typical marker of this Neolithic period), long endscrapers, truncations, borers, denticulates, retouched and un-retouched blades.

The XB area, on which the excavations concentrated in these last years, is a very interesting one, revealing layers and structures, such as post-holes (that define a particular alignement) and a hearth, almost entire. Organisation and connection between structures and layers seem to show the presence of a small, sub-rounded built up area. Inside, disposition of layers and cultural artefacts can provide us valid information about use destination of inside areas.

Unfortunately, we were unable to gather sufficient information about faunal and botanic remains, because of acidic soil; therefore information about the economy and subsistence activities of those human groups are lacking.

In order to partially resolve this problem, we decided to undertake a functional study of the lithic artefacts, recovered from XB built up area. A use wear study can supply us with valid indirect information about possible daily activities carried out within the settlement, providing a significant contribution to the understanding of the archaeological record. In this particular case - a settlement close to many flint deposits - the finding of a large quantity of flint semi-finished/finished artefacts does not necessarily imply their use. Infact, the results of the functional analysis confirm this hypothesis: many of artefacts were unused.

A significant sample of 183 flint blades and lithic implements was examined by optic microscope (50x, 100x, 200x), and 11 archaeological artefacts with use wear traces (macro-micro traces) were recorded. 5 out of 11 artifacts show use wear traces, however whereas it is possible to reconstruct the actions which left such traces, it is pratically impossible to guess on which material those tools were used (it seems that the wear trace did not have time to develop further).

On the basis of analogies between polishes on the artefacts from Lugo and those described in literature, it was noticed that flint blades - often with the cortex - and lithic implements were used to scrape leather, cut fresh and dry vegetables (in one case also cereals), to saw and bore bone/antler, to smooth fresh pottery. Artefacts are not nearly enough to determine any specific orientation in spatial disposition inside and outside the XB built up area.

Lugo's flint assemblages (XB area) include several hundreds of artefacts; if the percentage used-unused artefacts is the same also for the rest of flint assemblage, then the main activity of the site was probably flint working, compared to a general lack of any other activity (lied to lithic implement usage). In fact, small and rare use wear traces on 11 implements can be explained with their use implied in activities on a small scale, for a little community in a short time (as Generic Weak Polish on these implements shows it).

Many specimens were obtained from semi-finished artefacts and technological rejections, but probably considered as useful as the other finished implements. In particular, corticated blades and large flat flakes with 40-50% cortex were chosen, as like as blades with triangular section. In one case one Borer was obtained on a large flat flake.

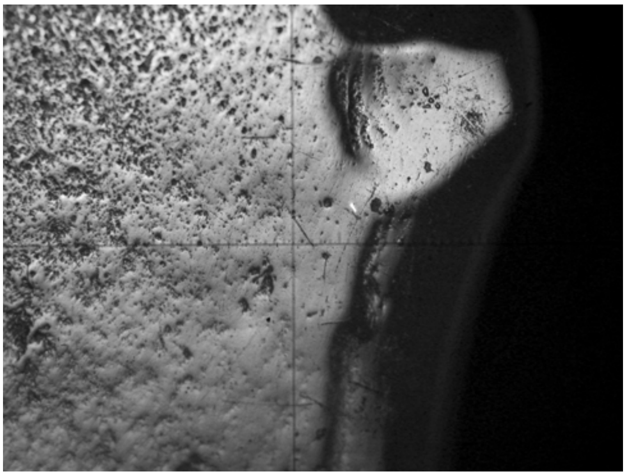

Fig. 1: Cereal polish on flint sickle's element, 200x.

Fig. 2: Harvesting *triticum monococcum* with a flint sickle.

In general, there is a determined will to use corticated implements, maybe to avoid any hafting (there is no hafting wear traces on implement's surfaces). Cortex infact often covers a half of the blade/flake surface, improving the hold itself.

Why did they choose also this kind of "rejections" for their activities, when they could had taken advantage of being so close to one of the best flint quality outcrops that could give them a long, regular and flat implements? Why didn't they use this type of implements, that were definitely unused? Maybe this kind of choises implies a management interested in artefacts rather than natural resources economy.

An interesting hipothesis links those previous considerations with the fact that the most-worked material was wood and hard substances, like bone/antler for instance. The low percentage of used artefacts, its low degree of use wear and the typology of worked material can be explained - for example - with an use of these implements focused on maintenance and resharpening of some other tools.

In conclusion, the interpretation of Lugo di Grezzana as a flint emporium (working and external trade of lessinic flint by finished-implements) is correct, because it is confirmed also by the examination of use wear traces on flint assemblages in XB built up area (substantially unused).

Experimental programme

The experimental program included these premises:
- use of the same lithotype as those recorded in the neolithic site;
- same *débitage* technique attested for manufacture of neolithic original artefacts.

A mould (in resinous material) of working edge of every experimental lithic copy was made to observe the evolution of use wear traces before using it (time 0) and after using it (time x).

Simple actions were chosen, to disclose puntual exploitation contexts; the experiments were been:
- harvesting *Triticum monococcum*, a spelt species attested in neolithic sites of Northern Italy. I used a sickle with blades obliquely inhafted, based on finding of one original sickle's element, with gloss obliquely oriented;
- cutting and scraping fresh and dry reed (*phragmites communis,* used to handicraft and housebuilding);
- cutting weeds;
- cutting and barking hard and soft woods.

Experimentation on vegetable plants included some specific variables. Besides those foreseen in every experiment (action length, type of working and movement, number of movements), it had to consider some other contextual variables that influence polish formation and gloss accumulation speed. These are some specific variables recorded during the experiments:
- condition of stems: green, semiripe or ripe;
- cut's height: a "lower" cut (15 cm ca) often includes an high percentage of weeds and soil's particles. This element can modify the polish;
- field density;
- hafting and binder presence/absence: an haft increases the worker's strength and consequently the work's yield.

Every experiment was completed with notes, photos, videos and drawings, to verify movement and activity as well as possible, controlling also the environmental context.

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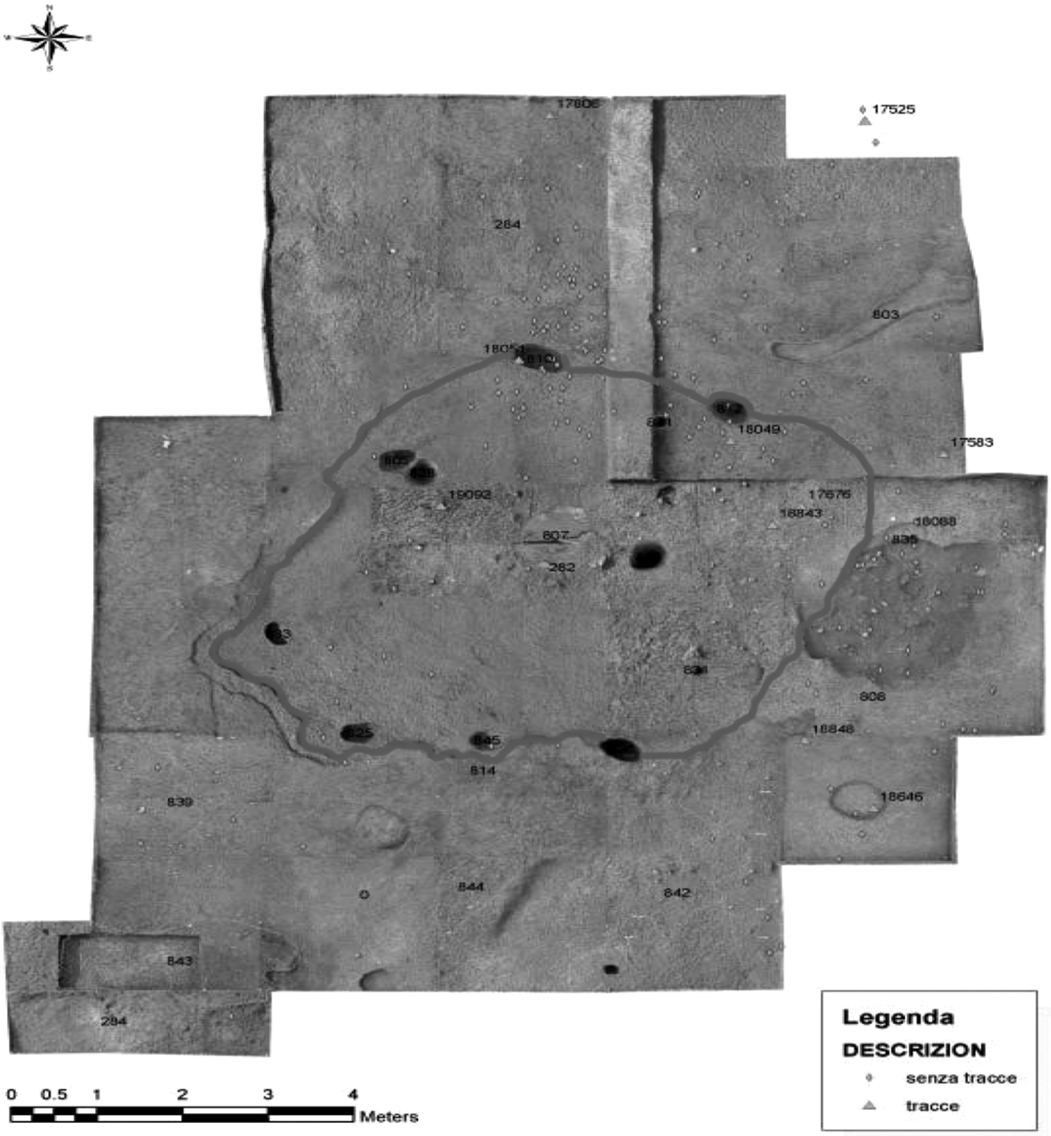

Fig. 3: XB built up area.

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Use wear analysis: application on the Ripatetta lithic industry. Preliminary results

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Summary. *This work is based on the microwear analysis of a drawn sample of the lithic industry found at Ripatetta. In this Neolithic settlement, attributed to an advanced moment of the Impressed Ware, has brought to light a 80-90 sq. m. cobbled pavement. The results of functional analysis - conducted in order to identify the function of this area - have shown that stone tools were mostly used for soft or semi-soft material workings.*

Résumé. *Le sujet de cet étude est l'analyse fonctionnelle réalisée sur un échantillon de l'industrie lithique retrouvée à Ripatetta. Dans cet habitat néolithique, attribué au moment avancé de la céramique imprimée, on a mis en évidence un pavage de cailloux de 80-90 mètres carrés. Les résultats de l'analyse fonctionnelle - visée à identifier les activités qui ont eu lieu en cette zone – ont démontré que la plus part des outils étaient employés dans le travail des matières tendre ou demi-tendre.*

Key words: Neolithic, lithic industry, functional analysis, stone tools.

The site

The site of Ripatetta (Fig. 1) was excavated between 1982 and 1992. Archaeological investigations, headed by C. Tozzi (University of Pisa) in collaboration with D. Evett (Ithaca College, New York), were carried out yearly. In particular, excavations yielded the remains of a neolithic settlement located in a Pleistocene marine regression surface, deeply cut by the Volgano river.

The following areas were found:

- A main area (saggio A) with remains of a settlement consisting of various structures, such as hearths, *silos*, a plaster structure and cavities different in shape and dimension;
- An area characterised by a 70-80 sq. metres cobbled pavement (area B);
- A fencing ditch.

Remains of *Triticum bicoccum*, *T. monococcum* and *T. aestivum-durum* as well as domestic fauna were found, elements that indicate an already neolithic economy.

Ripatetta is fully inserted in the middle and evoluted *Ceramica Impressa* phase developing in south-east Italy (Guadone and Lagnano da Piede phases).

Use wear analysis

In order to identify the function of B area, where a cobbled pavement was found, a microwear analysis has been done. The absence of stake-holes or plaster has allowed to us to suppose this zone as an open working area.

The preliminary results, here presented, deal with a retouched and unretouched artefact sample, so that the quantitative relationships existing within the different typological groups were unaltered.

The assemblage was examined through a stereoscopic binocular microscope (magnifications up to 400x) and a Scanning Electron Microscope (SEM) for higher magnifications. The data were compared to experimental wears (Figs. 3.1, 3.2), obtained with an intensive experimental activity organized by a research group of the Dipartimento di Scienze Archeologiche at the University of Pisa.

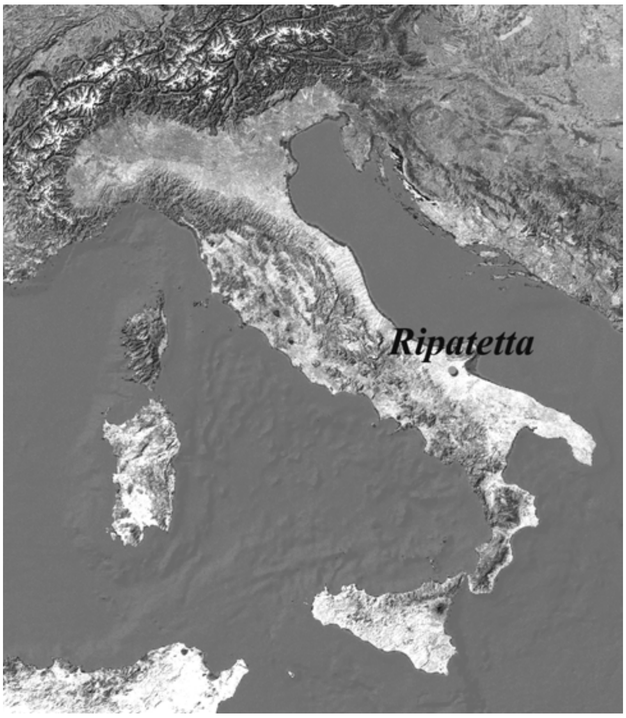

Fig. 1: Location of Ripatetta site.

Results

A preliminary study on materials was conducted in order to check the presence of post-depositonal surface modifications (Levi Sala 1986), that could have partially or totally altered microwave use traces. The analyses have shown that Ripatetta materials are in excellent condition and have no evidence of heavy PDS modifications.

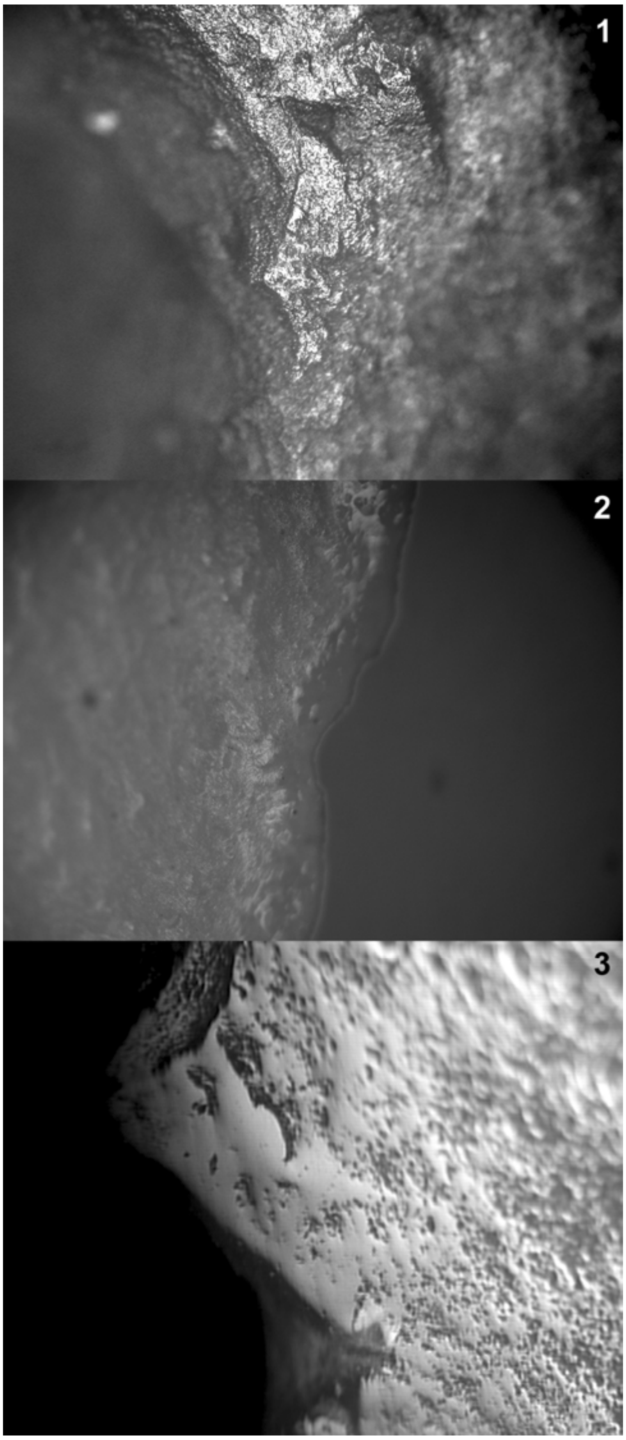

Fig. 2: 1) Archaeological artefact: used for butchering (OM 100x); 2) Archaeological artefact: used for hide-working (OM 100x); 3) Archaeological artefacts: sickle blade used for cereal working (OM 100x).

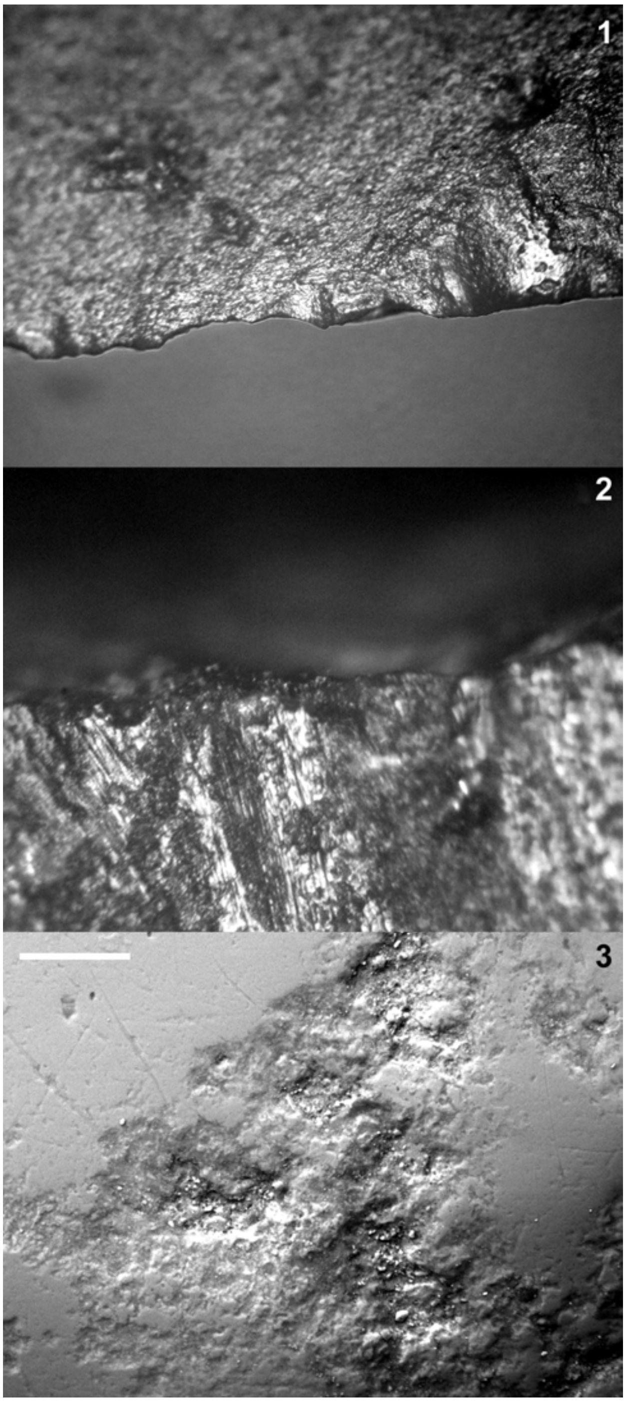

Figure 3: 1) Experimental artefacts: used for butchering (OM 100x), the edge shown microscars due to the contact with bone; 2) Experimental artefacts: used for hide working (OM 100x); 3) Archaeological artefact: sickle blade used for cereal working (SEM 450x, scale value 50 µm).

Five out of 35 specimens did not display any use wear, while the remaining 30 showed a total number of 33 working edges.

The absence of refreshing cutting edges was proved through a preliminary macroscopic observation: this is not surprising since the closeness to row materials' sources.

The polished appearance observed on only one edge as well as its extension towards the implements' inner surface can be referred to a transverse movements, suggesting slicing and scraping activities with an angle lower than 45°. The feeble development of polished areas observed on eight specimens does not allow a certain identification of the materials; due to the low presence of microflakes, and the absence of striations on the remaining tools, the work of soft or semisoft materials should be supposed. In particular, the feature and topography of polishes, mainly developed on the very end of the edge, distributed on the microflakes, suggest in most cases a contact with meat or hide (Figs. 2.1, 2.2).

Dry hide work seems to have occurred in two cases (a endscraper and a blade fragment). Possible microimpact wears was noticed on two specimens, while a third tool (backed knife) has shown slight traces on the retouched edge as well as blackish material residues could imply the presence of a handle.

Six specimens analysed (of which only one was found in the B area) are characterised by a gloss parallel to the artefact axis. Analyses show typical polishes clearly related to cereals-working (Figs. 2.3, 3.3). A case still under examination seems to display traces related to reed-cutting: this would be coherent with the plaster analyses, which evidenced traces of reeds belonging to the species *Arnudo* and *Fragmites*.

Conclusion

In conclusion, the gathered data seem to depict an area used for meat- and, to a smaller extent, hide-working. Thus, the undifferentiated polishes observed on 8 specimens could be attributed to a butchering activity. Further investigations on a wider sample and a comparative analysis with materials from other areas of the settlement will provide a wider scenario.

Acknowledgements
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Functional analysis of tools used in ancient ceramic production

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Summary. *Ceramics, in addition to being a commonly found archaeological material, is also one of the most important sources for solving numerous cultural-chronological problems. Analysis of tools belonging to the Tripolsky agricultural society in Ukraine (4th millennium BC) identified several types of instruments used for preparing ceramic clay, vessel shaping, surface treatment and decoration. This study presents an important example, for identifying tools used in the preparation of ceramics from a huge number of polishers used for leather processing on the basis of the recognition of distinctive use-wear traces.*

Key words: Ceramic, working tools, ceramic production, cultural links, changing by production, local producing.

Ceramics, in addition to being a commonly found archaeological material, is also one of the most important sources for solving numerous cultural-chronological problems. Learning the technology of ceramic production helps us not only to estimate its development level in the different cultures, but also to define traditional methods of ceramic making, and recognise methods taken from contemporary cultures. These analyses are especially important for understanding intercultural influence.

Fig. 1: Experimental class of making Tripolsky pottery in Lithuenia in 1978, leaded by S.A. Semenov.

Analysis of tools belonging to the Tripolsky agricultural society in Ukraine (4th millennium BC) recognised several types of instruments used for: 1) preparing ceramic clay, 2) vessel shaping, 3) surface treatment, 4) decoration. Among them are grindstones for preparing the mixture (pounded stone, shells, burnt flint etc.); knives made of flint or bone, used for forming vessels and for cutting away spare clay from rims and the vessel body; stone and bone polishers; different kinds of tools used for relief decoration of pottery. In addition, information concerning their use can be obtained with the help of micro-traceological examination of the impressions they left on the vessels surface (Korobkova 1983).

Such tools can be divided into two groups:
1. Tools used for polishing the vessel surface;
2. bone sticks used for decorating the pot.

For the first group Tripolsky craftsmen used bone, small pebbles, leather etc. The first scientist who used the micro-traceological method for studying this kind of bone tools found on Tripolsky culture sites was Semenov S.A. (Semenov 1957). He presented a group of big bones of wild pig, which showed peculiar linear traces on the surface (Fig. 2). Bones had several flat areas on a diaphysis, which were covered with clearly visible traces of work. They had straight parallel lines, showed the direction of tool movement during work. In spite of the large number of traces left on the surface, this was also strongly polished. The epiphysis did not display linear traces, althought they were also polished.

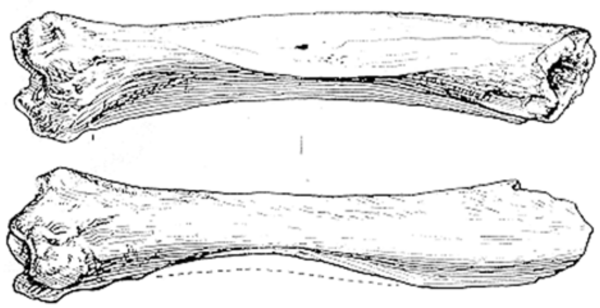

Fig. 2: Polishing bones from Luka-Vrublevetskaia, identified by Semenov S.A. (from Bibikov, 1953).

Fig. 3: Bone for polishing skins from tripolsky culture site Bodaki.

This study presents an important example, for identifying tools used in the preparation of ceramics from a huge number of polishers used for leather processing. The latter ones have a flat polished surface (Fig. 3), but we do not see deep linear marks, made by minute inclusions used for making clay more plastic.

Small pebbles, with flat polished surface, represent another type of tools, used for polishing. These are usually poorly described in publications, and authors just mention them. Opposite to bone tools, pebbles do not have deep line traces on the surface. However, their small size (2-3, cm in diameter, could not be used for hides) and accurate polished surfaces give us a reason to suggest that they were used for ceramics.

Important information about the process of vessel preparation, are also given by impressions on the ceramic surface. From ethnographical studies (Rye 1976), we can suppose that ancient craftsmen used a big variety of organic materials, for making clay bands and for giving shape to the vessel body. For this type of tasks, they could have used a piece of cloth, grass, pieces of wood. Examples of ceramics with this type of impressions can be found in the Tripolsky culture assemblage at the site of Bodaki. When comparing traces on ancient pottery with experimental ones, we can distinguish two groups: surfaces which were prepared using soft materials, such as grass, skin or cloth, and those made with the help of wood and bone. Experimental examples are presented in a work by Bobrinskii (Bobrinskii 1978).

The second group of tools on which micro-traceological analysis were undertaken, was used for ceramic decoration. In that category there are different types of bone dice with a jagged working side (Fig. 4) and bone sticks that were used for pricked decoration. This group of instruments is not very common for the Tripolsky culture, but this might also depend, in general, on the absence of studies of bone tool assemblages. In such case, it becomes very important to study techniques used in ceramic decoration, by means of analysing impressions left by the tools employed.

In this group we can recognise a wide variety of jagged tools, used for decoration of the rim and body of vessels (Fig. 5). As regards Tripolsky ceramics, we analysed the traditional decoration found on the pot neck. Studying impressions under the microscope, we could see deep, parallel lines left by tools made of hard material (such as wood or bone) pushed into the upper part of the vessels.

Another very popular Tripolsky ornament presents lines on the rim, made by the sharp edge of a shell. This can be said because the thin impressions often have an half-oval section.

In addition, micro-traceological analysis of impressed lines on the lower part of the vessel body, suggested that decorations were carried out utilizing a jagged bone dice. This is clearly visible on the surface of the impression, which is always flat with small thin lines, according to the structure of bone or wooden material.

Other tools of the second group are represented by bone sticks. Decorations carried out in this way can be distinguished only under the microscope. One of such examples comes from Bodakis` collection (Fig. 6). The pot was decorated with this technique, which is recognisable by the standard form of impressions on the surface. Impressions, like in the previous group, have the same structure, with small thin lines. This category is spread widely in Trypolie, and this kind of tools is

Fig. 4: Jagged pottery-die from tripolskaia culture site Sabatinovka, Tripolie B (from Passek, 1961).

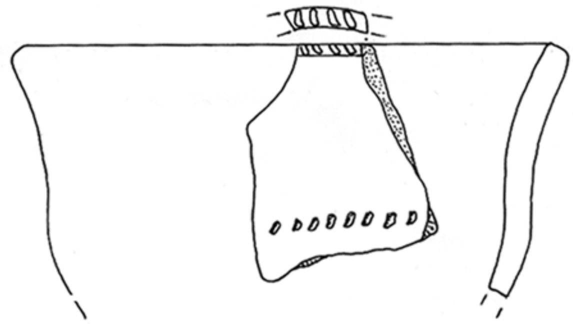

Fig. 5: Tripolskii vessel from tripolsky site Bodaki, decorated with jagged pottery-die.

Fig. 6: Fragment of a vessel decorated with bone stick, Bodaki, Tripolie B.

mentioned in description of material from many sites, such as Polivanov Iar, contemporary to Bodaki , Luka - Vrublevetskaia (Tripolie A), etc. An outstanding tool was found on the Tripolsky site of Mereshovka-Checetue and published by Sorokin D.I. (Sorokin 1983). It is the only combined tool known in the literature, associated to the Tripolsky culture, level A. The author argued that it was used for linear decoration of ceramic vessels.

Micro-traceological study of ceramics, in the same way as bone and flint, needs experimental data. For exploring the technique utilized in ceramic decoration several experiments were carried out. All replicas were made on industrial clay vessels, with no coarse inclusions. Purified clay vessels made experiments easier since traces were less likely to depend on different concentration of inclusions in the clay. Decorations were made using a jagged pottery-die made of horn of deer (Fig. 7). The types of traces were identified with archeological ones, and on this basis it could be possible to define the material of the pottery-die, which was used.

An experiment was carried out also to reproduce rim decoration using a shell. This test too, produced impressions similar to the archaeological ones, in both form and profile. Flattening of the vessel surface was also achieved by utilizing a sea shell. This process left specific linear traces, resembling very closely lines left by bone and wooden tools.

It is absolutely necessary to collect more experimental data, in order to compare replicas with archaeological artefacts. It is the objective of a future project to collect experimental information concerning different materials used for flattening vessel surfaces.

It could also be important to make an experiment to try to repeat step by step the Tripolsky ceramic production process. Analysis of clay preparation, vessel shaping and vessel decoration could supply new basis for identifying different agricultural and nomadic traditions in ceramic production.

The study of tools used in the ceramic production process supplies information about technological traditions of Tripolsky potters, which could in turn be valuable indicators when considering intercultural exchange. It was Passek T.S. who made a classification of Tripolsky ceramics (Passek 1849), and divided “cooking” ware into different groups. Very often, vessels had a specific type of motif, such as “pearl” ornament on the vessel neck, coiled lace impression. It was suggested that this tradition was borrowed from nomadic communities. These features could be clearly distinguished, but the difference could be also due to the decorating tradition Research concerning influence of cultures, cultural exchange and borrowing of traditions, presents the most important information about Eneolithic inhabitants of south-eastern Europe. Like in many other archaeological fields, scientists try to use a sequence of cultural traditions for solving problems concerning chronological and cultural boundaries.

Very interesting results concerning such issues were obtained during analysis of the material coming from the Tripolian site of Bodaki (Ukraine). This was one of the largest centres specialised in flint tool production. It also had its own ceramic production, evidenced by the finding of a ceramic kiln, in addition to distinctive tools used for ceramic making, such as polishers and implements used for decoration (Fig. 8). Especially interesting are the vessels decorated by these types of tools, which closely resemble ceramic of the steppe cultures of early nomads.

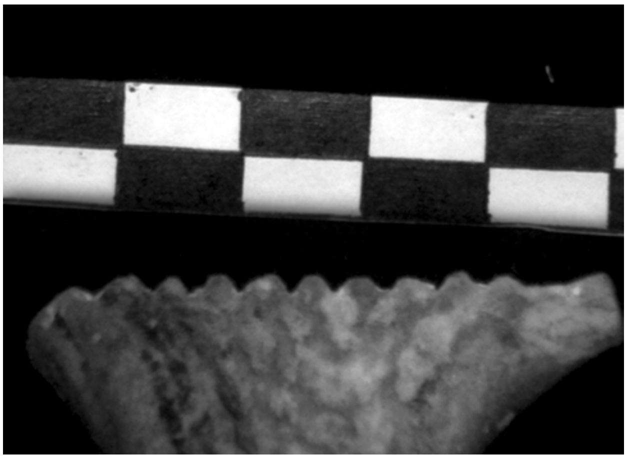

Fig. 7: Experimental jagged pottery-die, made of horn of deer.

Fig. 8: Pottery die found on Tripolsky Culture site Bodaki.

Experimental works confirm that ceramic could be produced and decorated by tools found on site. It was also proved by the ceramic kiln excavated in 1997, so we can confidently say, that this site, situated on the far north-western boarder of Tripolsky culture, had its own ceramic production.

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6.4 Complex Polities

Microwear analysis and metal tools. The study of use wears traces and the contribution to the understanding of protohistoric societies

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Summary. *The work presents an introduction to the metallic Traceology topic. From an initial experimentation we define the preliminary micro-wears. Likewise we discuss the necessity of the functional analysis in the metallic tools just as their main difficulties.*

Résumé. *Nous pressentons ici une introduction du sujet de la Tracéologie sur le matériel métallique. Sur la base d'une brève expérimentation nous définirons une approche initiale des essentielles microtraces d'usure dans étudie. Également nous discutons la nécessité des études fonctionnelles des instruments métalliques de toute manière leurs principaux problèmes.*

Key words: traceology, metallic tools, experimentation

Introduction

Traceological studies on metallic elements have been recently developed, and so, the results are scarce. Some are the problems which converge to create a delay respect other prehistorical disciplines. The first reason is our question on the necessity of application of a complex methodology on material with predictable functions. Exactly, they are tools, weapons or different elements like adornments or accessories whose morphology was early fixed in prehistoric times, most of them continuing until date.

Metallic elements present a different problem from siliceous materials. Metal versatility, cold hammered and especially hot beaten, and casting, has allowed to human groups to create elements morphologically adapted to their function. We have started from instruments already known like dagger, swords, axes, punches, saws, awls, and some more whose types and forms will be changing and diversifying while the knowledge of metallurgical techniques develops. The main question is to know if the knowledge of the tools solves all the aspects of functionality. Some of the questions that Traceology can answer are:

- Improvement of the knowledge of the metallurgic technological processes and their capacity of production.
- Necessity of a precise definition of some metallic types which can be ambiguous, either because they are elements than can be employed in different functions, or because the variety of their attributes hides different tools.
- Re-interpretation of technological, economic and social character from traceological data.

To solve all these questions we must know the response of different tools after use, in terms of effectiveness. This must be done after an experimental program and the subsequent comparison with metallic objects.

This aspect is of capital importance within the Prehistory with metals because, even with copper base, the raw materials employed are different- more or less pure copper, arsenical copper, different composition bronzes, and ternary bronze- and so are their treatments. Moreover, the metallic repertory is scarce in these early periods, their extraction procedures are already random and there is a high competence with lithic material.

The second big group of problems concerns to the lack of experimentation due to difficulties inherent to this kind of material. First of all because metallurgical processes as minerals reduction, the annealed, hammering, or cold and hot beaten, are complex and need a valid experimental framework and specialized knowledge. The performance of sistematic experimentation with a high number of variables requires selecting the start experimental morphologies. At the same time, if we want to improve in the knowledge of wear origin, the experimentation cannot be unconnected with the development of other analytical techniques, as metallography and components analyses,

The last question, not less serious, is the possibility to identify use-wear on ancient metallic objects. Corrosion on metallic elements can cause different alterations as carbonates, clorures and different oxides which can affect them deeply. On the other hand, use wear do not deposit on a clean surface but on one microscopically deformed and with wear produced by technological processes as cold and/or hot hammering and polishing which are necessary to the objects fabrication.

Parasite wear due to aggressive cleaning processes introduces more confusion, although they cannot be avoided because of the easiness of alterations and corrosion in metals. Finally, archaeological objects may suffer different accidents as impacts, falls or rounding during their functional life, after their deposition in the site or even during archaeological excavations. The latter are included into the so-called post depositional alterations.

Results

Among the methodological complete works, punctual from an instrumental point of view we can cite those by Kienlyn and Ottaway (1998) and Roberts and Ottaway (2003) on Bronze Age socketed axes. From their data, Vivet (1998) has observed similar wear on a sample of axes from Tréboul (France). Other recent but partial works on this topic are those from Bridgford (1997), Kristiansen (2002) and York (2002).

A sort of partial study is the direct analysis of archaeological pieces (Gutiérrez Sáez 2002). The aim was the evaluation of the possibility of functional study on metallic material towards use wear observation. Two conclusions: 1) a relative wide sample of traces on archaeological materials. 2) Traceology must necessarily start from an organized experimental program which allows establishing a close relationship between each kind of wear and the specific cause which generated it.

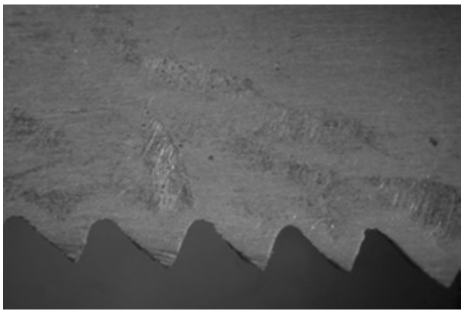

Fig. 1: Hammer impressions, and technology striations. Experiment nº 3. 10X.

Fig. 2: Tool befote use with striations. Experiment nº 5. 15,7X.

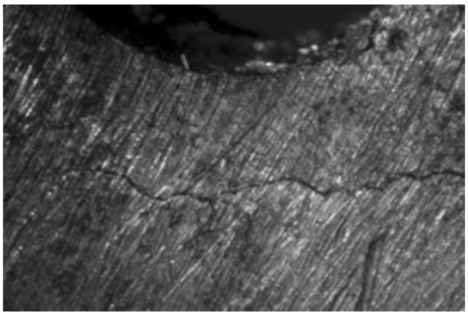

Fig. 3: Fissures by corrosion under tension and technology striations. Experiment nº 15. 25X.

Fig. 4: Punch from Bronze Age. Cleaning striations. 25X.

Fig. 5: Dagger befote use, technology striations and hammer impression. Experiment nº 1. 10X.

Fig. 6: Same dagger alter use. Wide striations and ledges on the edge. Experiment nº 1. 10X.

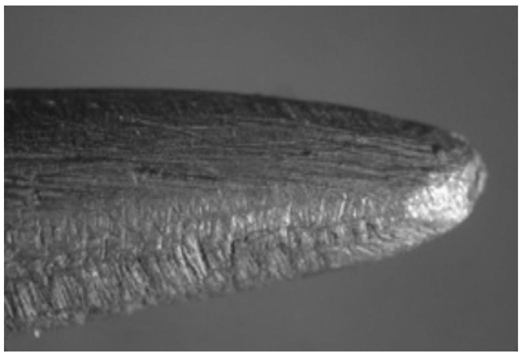

Fig. 7: End of punch befote use. Technology striations. Experiment nº 4. 25X.

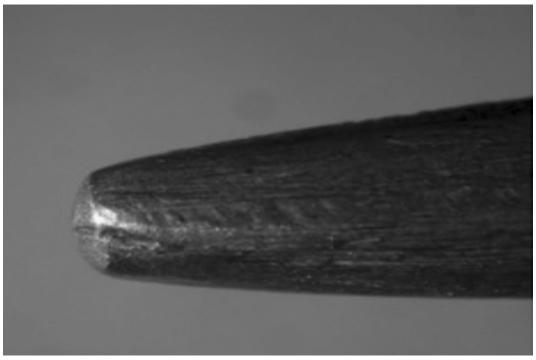

Fig. 8: Same tools alter use. Well developed rounding on the edge. Experiment nº 4. 25X.

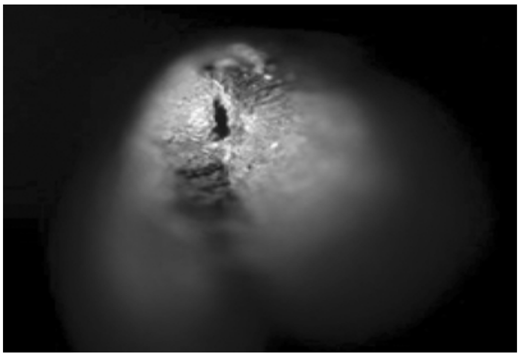

Fig. 9: End of punch befote use. Experiment nº 4. 25X.

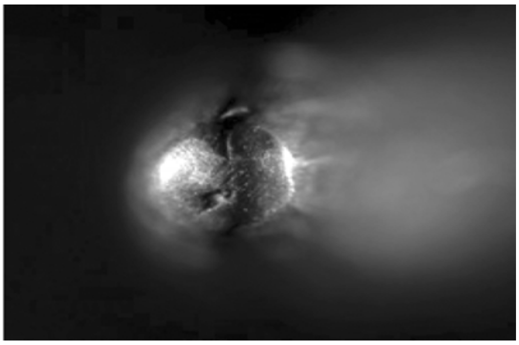

Fig. 10: Same tools alter use. Well developed rounding on the edge and use striations. Experiment nº 4. 25X.

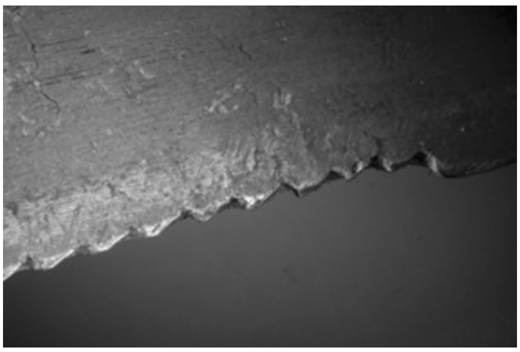

Fig. 11: Well developed roundig saw tooth and gloss band. Experiment nº 10. 4X.

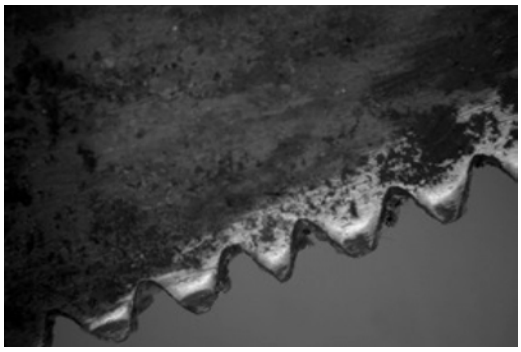

Fig. 12: Developed roundig saw tooth and gloss band. Experiment nº 17. 6,3X.

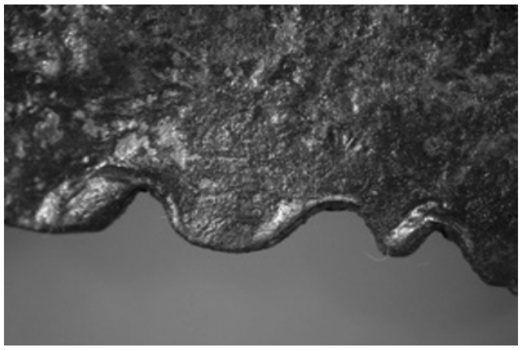

Fig. 13: Developed roundig saw tooth on Chalcolithic saw. 10X.

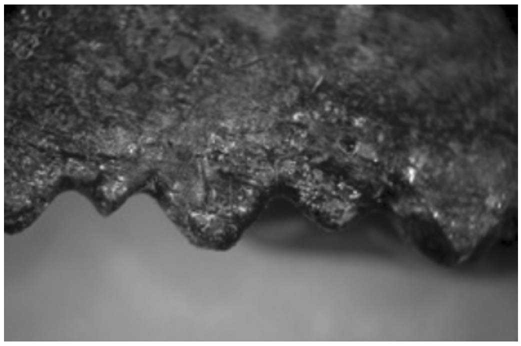

Fig. 14: Developed roundig saw tooth and Cleaning striations on saw from Los Millares, Chalcolíthic. 15,7X.

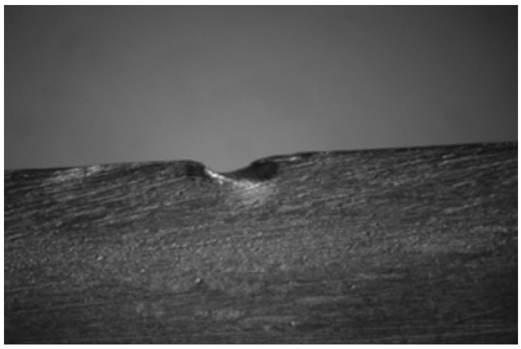

Fig. 15: Muesca con reborde superior. Experimento nº 1.

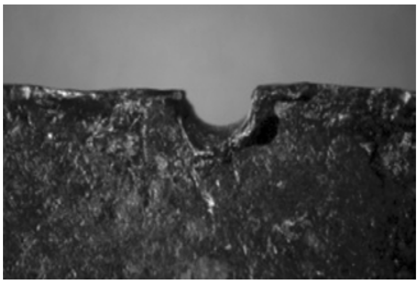

Fig. 16: Muesca con reborde superior y lateral. Puñal argárico.

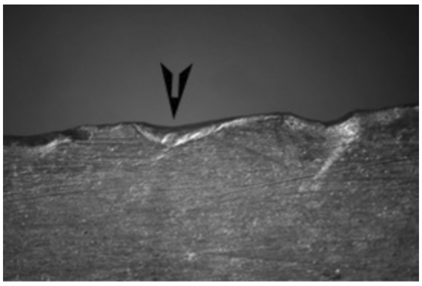

Fig. 17: Ledge on the dorsal face. Experiment 1. 15,7X.

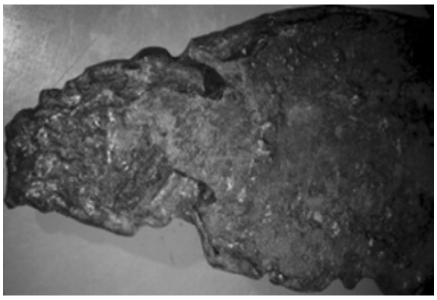

Fig. 18: Ledges by hafting on chalcolithic saw. 4X.

Fig. 19: Differential alteration. Tenorite and Copper chloride oxide. Experiment nº 17. 4X.

Fig. 20: Differential alteration. Tenorite, copper chloride oxide and hydrated copper carbonate. Bronze dagger. 3,2X.

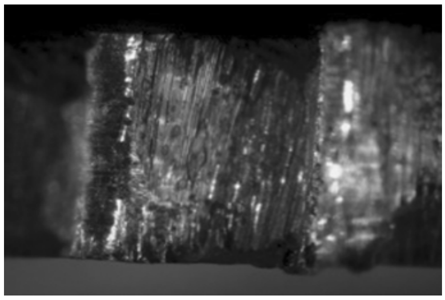

Fig. 21: Frontal view of saw. Copper oxide, rounding and use striations on thoot saw. Experiment nº 10. 25,2X.

Fig. 22: Wood polish on thoot saw. Experiment nº 2. 200X.

Fig. 23: Wood residues on punch from La Encantada I, Chalcolithic. 6,3X.

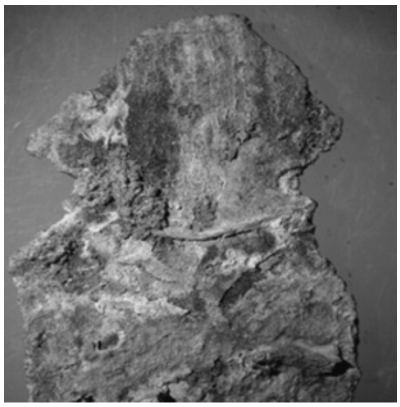

Fig. 24: Bronze dagger with wood residues and fibre flax. 4X.

The so called "selci strane di Breonio": an ethno-archaeological and social case in the Lessini Mountains (Verona)

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Summary. *Starting from the second half of 19th century in the north-western Lessini Mountains (the area between S. Anna d'Alfaedo and Breonio), an increasing number of peculiar flint artefacts of unknown forms were documented: the so called "selci strane di Breonio". For more than 30 years, they caused both studies and debates: some Italian archaeologists believed that were prehistoric, while other colleagues (both French and English) argued that were just fantastic fakes, made by local flintknappers. The typology of these artefacts included rough daggers, arrowheads and also tools shaped (by direct percussion) in the form of crosses, forks, combs and other anthropomorphic patterns. By the end of the 19th century, this socio-historical phenomenon was deeply investigated, but only recent studies, carried both by techno-experimental and wear traces analysis, have confirmed that those strange artefacts were made by retouching (both by percussion and rough pressure) with metal tools by local workers directly connected to the multigenerational experience of the folendàri (the local name for professional gunflints knappers).*

Key words: flint flaking, non-conventional typologies, gunflints, social implications, experimental reproduction chain.

The Lessini Mountains are said to be the main flint outcrop south of the Alps, with many flint varieties ranging from Cretaceous vitreous flints to other dull qualities (from Oolite and Eocene formations). Although local flint exploitation dates back to the lower Palaeolithic, lithic workshop activities increased particularly from the early Neolithic (Campagna di Lugo site in Val Pantena) and during Copper Age and Bronze Age, when traces of the so called "campignian technology" artefacts (axes, tranchets, pics and others bifacially retouched tools) were widely spread. A reduced flint-flaking economy probably continued during historical times in order to obtain firestones chips (with very simple and opportunistic operatory chain) suitable to be used with the flint-and-steel fire technology.

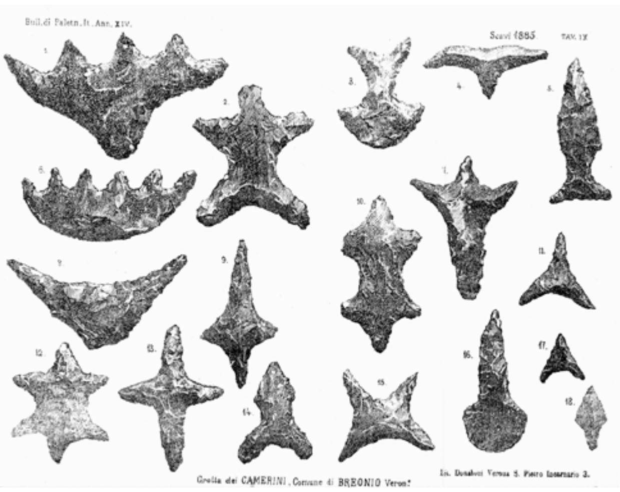

Fig. 1: Grotta dei Camerini (Verona): fake artefacts found during the excavation of S. De Stefani (1885).

Starting from the second half of the 19th century in north-western Lessinia (between S.Anna d'Alfaedo and Breonio) an increasing number of peculiar flint artefacts of unknown forms (the so called "selci strane di Breonio") caused, for more than 30 years, both studies and debates: some Italian archaeologists believed that those flint artefacts were prehistoric ones, while other colleagues (both French and English) argued that those lithic objects were just fakes, made by some local flintknappers. The forms of the lithic findings included rough daggers and arrowheads but also other types shaped (by direct percussion) in form of crosses, forks, combs and other anthropomorphic patterns. The techno-economical and cultural history of those "selci strane" can be summarized in the following main steps:

1. The gunflints industries developed in Lessinia at least from the 18th to the beginning of 19th century, and its products were sold mainly by wholesalers in Verona, but probably also by smugglers living in northern Lessinia territories, i.e. close to the border between the Venice Republic and the Austrian Empire (which was almost completely lacking of gunflints workshops within its boundaries). As a result, traces of hundreds of lithic workshops were left by local flintknappers.
2. Gunflints production was recorded as a very profitable activity in the early 19th century (especially during Napoleonic wars), when (according to the S.Destefani evaluation cited in Orsi 1886) the local production should have reached the amount of 70,000,000 pieces yearly exported, suggesting an incredible number of waste flakes and cores scattered in Lessinia.
3. This incredible amount of gunflints was produced in some specific areas, such as Fosse-Ceredo where the 1996-1998 surveys directed by Prof. J. N. Woodall (Wake Forest University) highlighted 39 gunflints workshops traces. Other workshops areas were in Cerro/Boscochiesanuova, Trezzolano-Cajò-Mezzane and S.Mauro di Saline in the eastern part of Lessinia. Between these territories only the central and the eastern ones were fairly well connected to the city by roads, so that the northwestern flintknappers could have easier sold their gunflints by smuggling through the old Austrian border. As far as we know, Lessinia gunflint industry was a professional activity

but also a seasonal part-time job within a poor sheepherding and forestry economy.

4. Only after 1820 the Verona region was included in the Austrian Lombardo/Veneto, but ten years later most European armies turned to the new percussion cap method of ignition, so determining a general sudden collapse of military gunflints demand. Anyway, Lessinia gunflints should have been still interesting in 1838: the Austrian emperor Ferdinand I, while visiting Verona, asked to assist to flintknappers production (22 specialised flintknappers from Cerro Veronese came to Verona to show directly their flaking skill)
5. In 1851 a large number of gunflints waste flakes and chips were sold as raw material to a china factory in Lodi, and also by the same time flint-flaking activities were prohibited because dangerous to the meadows economy. Therefore, we can argue that by the half of the 19th century Lessinia people had a detail knowledge of workshops areas location;

Fig. 2: a) Fake artefacts, sold to the tourists; b) Seton Karr, declaration of faked production. He reproduced the operative chain and the faking process realised by the local flintknappers; c) Other fake examples.

6. In 1885 a veronese wholesaler (Boldrini) was still exporting gun-flints (in baskets of 2-3,000 pieces each) to be sold in the main Adriatic sea ports (Chioggia, Adria, Senigallia and Trieste) as well as smaller quantities in Tyrol, Bavaria, Dalmatia and Montenegro" (Orsi 1885). Evidently he was supplied by some local flintknappers still in activity.
7. By those years, prehistoric research in Verona was in its very starting steps, and local archaeologists (such as Stefano De Stefani) used to employ local workers, entrusting them often field excavation for weeks and granting extra payment for the "finest" findings. At least one of them, G. B. Pedrini (a favourite assistant to S. De Stefani) being born in 1853 was belonging to the generation of the last professional flintknappers or at least to their "sons".
8. In 1874 early prehistoric findings were made in S.Anna d'Alfaedo by private searchers. Among them, Michele Morandini, the Breonio's mayor, who believed that archaeological findings were a good opportunity to revalue the poor local economy, based only on self-sufficient agriculture and cattle grazing.
9. The so called "selci strane di Breonio" were exhibited firstly in Venice (1881), but the Italian and international debate on their nature started in 1885, between a group of archaeologists supporting their prehistorical interpretation (De Stefani, Martinati, Chierici, Virchow, Pigorini) and others (G. De Mortillet, Mantegazza, Orsi, Seton Karr, Vayson de Pradenne) claiming that those flint artefacts were just fakes. This unknown and surprising new kind of flint artefacts were found, by thousands, in any excavation directed (from 1880 to 1892) in north-western Lessinia by S. De Stefani, who financed his excavation programs by selling samples of "selci strane" also to L. Pigorini, who bought those strange specimens as archaeological material for the Museo Nazionale Preistorico ed Etnografico, recently (1876) opened in Rome.
10. In 1905, an article by an English archaeologist, Seton Karr, demonstrated that most of the "selci strane" were intentionally patinated (ingenuously by boiling the flints in chestnut leaves and black soot). Anyway none of those strange lithic types show significant surface alteration, like local late-prehistorical artefacts very often do. Moreover he documented that local people knew that those "strangeflints"were produced (and carefully buried in wintertime) by the same workers employed by De Stefani. Anyway, the fakes production had became so wide that sets of "selci strane" were commonly sold to tourists in Verona (by the guardians of the Arena, the roman amphitheatre).
11. In 1932 Vayson de Pradenne revealed also that, many years before, Adrien De Mortillet had caught a former field excavation assistant to S. DeStefani while burying some "selci strane" in local archaeological sites.

12. In 1930-31 the problem was finally solved by R. Battaglia (an anthropologist in Padova University) whose control excavations in the same area sites evidenced the total absence of any kind of "selci strane".

Recent studies (Longo and Chelidonio 2001) on a late 19th century lithic series (still preserved in the collections of the Museo di Storia Naturale di Verona), carried both by techno-experimental and wear traces analysis, have confirmed that those strange artefacts were made by retouching (both by percussion and rough pressure) with metal tools by local workers, directly connected with the multigenerational experience of the *folendàri* (the local name for professional gunflints knappers). There is no evidence that those manufacturers produced cores or blades to be used as blanks for the "selci strane", but they simply re-used waste flakes and blades from the abandoned historical gunflint workshops.

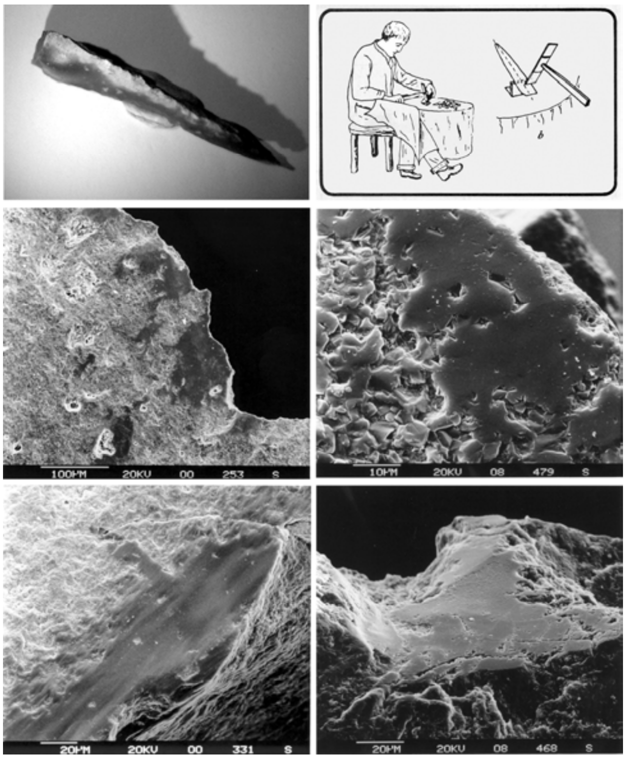

Fig. 3: Wear traces analysis on fake artefacts. SEM evidences.

Furthermore, within this late 19th century lithic assemblage, a group of artefacts have been shaped to a form which looks like a cross associated to a rough heart pattern (fig.): this peculiar kind of flint artefacts could have been manufactured as some kind of talisman, probably connected to the worship of the "sacred heart", a symbol widely diffused in the popular catholic religiousness of the Adige valley during the 18th and 19th centuries.

Finally, we can consider the so called "selci strane di Breonio" as one of the cases of flint tool fakes that have been recurrent in different European countries, such as in France and in England, during the 19th century when a large number of private collectors (but also some professional archaeologists) easily bought "fine" or "special" flint tools. Besides these common characters, the study of the Lessinia's "selci strane" offers a peculiar connection between historical gunflints techno-economy, land-use and the rising of paleo-ethnological research in Verona. All these elements offer a meaningful lesson to the recent pseudo-lithic workshops findings (modern waste flakes and cores) in Lessinia (Chelidonio 1995, 1999, 2003), as well as to the increasing number of experimental flint tools production (and related waste products) well documented in many European places connected with archaeological sites' cultural economy.

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Stone vase drilling in Bronze Age Crete

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Summary. *During the 2nd millennium, the period of emergence of the Minoan palaces, contacts between Crete and the eastern Mediterranean (Egypt and the Near East mainly) permitted the enrichment of local crafts with important technical innovations. For example, during Middle Bronze (first part of the 2nd millennium BC), the tubular drill was introduced for the manufacture of stone vases, seals and stone beads. The reconstruction of different drilling techniques aims at revealing the patterns of their introduction as well as the skills and know-how involved. The reconstruction of Minoan techniques and "chaînes opératoires" is based on : a) macroscopic analyses of artefacts from the "Craftsmens Quarter" at Malia (Quartier Mu), from the sites of Pseira and Kommos; b) microscopic analyses (interferometers, optical rugosimeters) of archaeological and experimental samples.*

Key words: Bronze Age, Crete, Minoan palaces, stone vases.

The beginning of the second millennium in Crete is characterised by the emergence of the palatial system, which will be maintained in the Aegean world until the end of the XIII century. This phenomenon was accompanied by the development of luxury craft productions and the emergence of specialised craftsmanship. During this period, the increase in exchange between Crete and the Eastern Mediterranean (Egypt and the Near East mainly), permitted direct contacts between craftsmen and lead to technical transfers in different domains: faience, stone vases, pottery etc.

Stone vase manufacture is one of the more relevant examples of technical innovation. Cretan craftsmen were highly creative during the palatial period. New shapes of vases, complex and original, and also new raw materials, occurred in the workshops, implying an evolution of techniques and know-how. New tools appeared, such as the tubular drill, which could have been introduced to Minoan craftsmen from Egypt, where it was attested to from the end of the IV millennium (Stocks 2003, p.12).

But at which precise moment did this drill appear and what were the patterns of its introduction within local crafts, which were flourishing during this phase of emergence of Cretan palaces? The necessity to establish criteria of recognition of different drilling techniques appears. It is a precondition for the reconstruction of patterns of introduction of this exogenous technique within local industries as well as for a more general reconstruction of technological transfers from the Eastern Mediterranean.

Preliminary observations on Cretan stone vases were carried out.[1] The first results have been found at the 'Laboratoire de Tribologie et Dynamique des Systèmes (LTDS)',where a drilling tribometer has been developed in order to reproduce various hollowing techniques and to obtain a database of drilling wear traces. Finally, comparisons with Egyptian techniques, better known and studied, allowed some new identifications.[2]

Methodology

The archaeological material
Dated from the Early Minoan to the Late Minoan period, the archaeological material comes from the palace site of Malia and the settlements of Pseira and Kommos (Shaw and Shaw 1996).

The objects studied are from different contexts, domestic and production areas, such as the Plateia building at Pseira (Floyd 1998) and the craftsmen's Quarter of the 'Quartier Mu' at Malia (Poursat 1996). In these contexts of stone-working we found raw material, unfinished objects and waste material. We also studied metallic or stone objects potentially used in this type of production, particularly for the manufacture of the outer walls of the vases and their decoration.

Use wear analysis
The material has been observed at different scales. Initially we observed macroscopically the traces of manufacture, from the first stage of pecking the raw material to its completion. The analysis of overlapping traces on the inner walls of the vases allowed us to reconstruct drilling's *chaînes opératoires*.

This preliminary analysis was completed by multi-scale quantitative analysis of surfaces, which characterise morphology of striations and micro roughness of polish. Observation of these marks aims at identifying abrasives employed (sand, ground quartz or emery) as well as lubricants and their viscosity (example given: water, oil or honey).

Two techniques of surface analysis were used: in order to measure striations, laser triangulation; in order to measure polish, interferometry. Silicone impressions of archaeological surfaces were measured to less than a µm resolution. Triangulation is made by the measure of a distance, with a laser beam, between the captor and the surface to analyse, which reconstructs the geometry of a three-dimensional surface, with a maximal amplitude of 10mm and with a 1µm resolution.

[1] 4 study seasons by E. Morero.
[2] Stocks 2003 and bibliography.

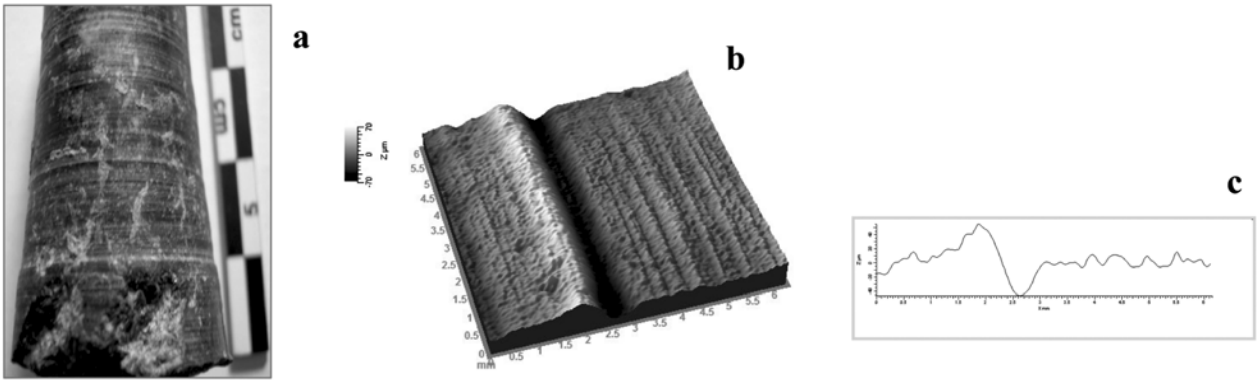

Fig. 1: 3D view (b) and profile (c) of the core surface from Mu de Malia (LTDS).
3D view highlight the multilayer structure of the striations.

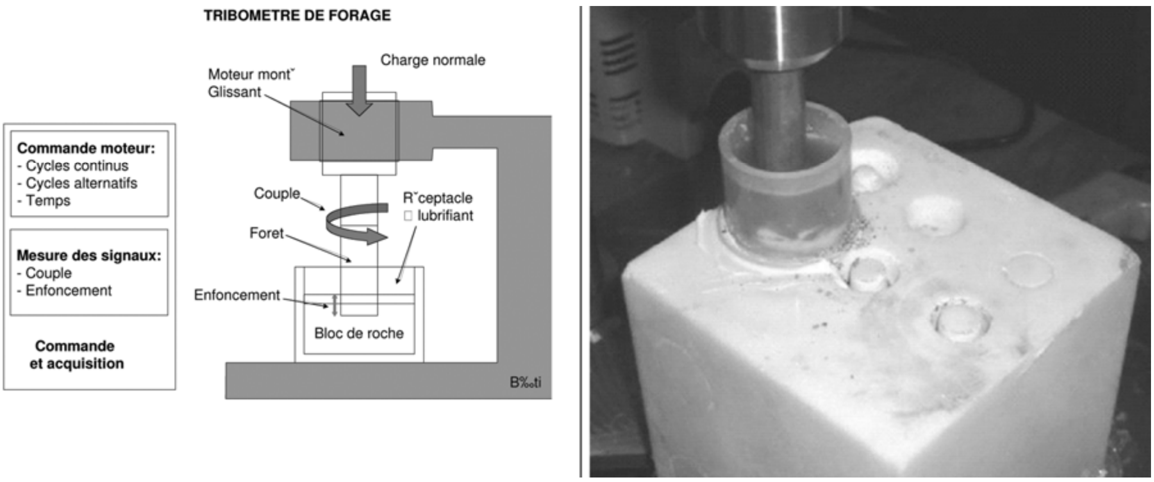

Fig. 2: Tribometry of the core: drilling of a marble block by using a copper drill with sand and water.

Interferometer measures use phase detection. Light reflected by the surface to analyse is compared with a reference surface. The resulting interference phenomenon is recorded from a numerical camera, which produces a cartography z (x,y) of the measured surface. This apparatus obtains surface measures with a maximum vertical amplitude of 1 mm and with a resolution of 2 nm. Dimensions of the measured surface (x,y) can vary from some µm² to many mm².

We thus obtained three-dimensional views z (x,y) of drilling traces (Fig. 1). Interpretation of measured morphologies can be obtained with statistical parameters of surface characterisation such as the average roughness, depth and density. Morphological signatures of drilling traces can be obtained by a multi-scale analysis.

Experimental reconstruction of the drilling processes

A motorised device reproducing drilling mechanisms (a drilling tribometer) was developed at the LTDS (Fig 2.). This device controls experimental conditions such as the speed of rotation of the drill and the load applied. The experimental protocol takes into account various parameters: morphology of the drill (tubular, solid), raw material of the drill (wood, copper, bronze) and of the drilled object (marble, serpentine), the nature of the lubricant (oil, water) and of the abrasive (sand coarseness, composition of different types of emery).[3]

Although experiments at the Laboratory allow for control of experimental conditions (load, speed), they do not reproduce the craftsmen’s working motion, which is closely related to the rotation system adopted. In Egypt, systems of setting in rotation have been reconstructed, as important iconographical data has been brought to light in tombs of the Ancient Empire. Working craftsmen are depicted offering information on tools and working motions (Fig. 3). This type of evidence is absent on Crete, where the system of rotation has not yet been identified. Therefore, the rotation device employed (bow-drill or crank borer) influences the morphological characteristics of the drilled cavity and, in the case of a tubular drill, of the drill bore. In order to reconstruct

[3] We would like to thank J. Gong, L. Molla, L. Lefrançois, H. Wu, students of the Ecole Centrale de Lyon (class of 2007), who carried out these experiments. This project on «Stone vase drilling in Bronze Age Crete» was financed by the ‘Ecole Centrale of Lyon’. Many thanks also to Patricia Anderson for revising the English version of this text.

Fig. 3: Egyptian documents: a) drilling with vertical *achette*; b) drilling with counterweights; c) drilling with a flywheel (after D. Evely 1993).

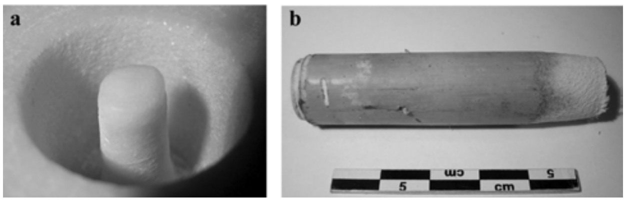

Fig. 4: a) cavity obtained by means of a bamboo. Abrasive: emery. Lubricant: water; b) bamboo employed for the drilling of the block of marble.

drilling devices and techniques, field experiments were carried out: a) survey in Crete and sampling of raw materials used for lapidary production (serpentine, marble, breccia); b) manufacture of drilling tools and rotation devices; c) reconstruction of all stages of manufacture (roughing out, drilling, polishing…).

Results: the case study of the 'Quartier Mu' at Malia

Study of three types of artefacts, 129 vases, 4 bore cores and two unfinished objects, lead to the reconstruction of manufacturing techniques. Various methods of drilling were shown to have been used, adapted to the morphology of the inner walls of the vases and to their dimensions, and requiring a series of drilling operations and the successive use of different types of drill bits. The reconstruction that we propose concerns the majority of the vases with a diameter inferior to 30 cm.

Manufacturing of a deep cylindrical/conical groove
The first stage of hollowing is identical to that identified in Egypt and Mesopotamia; its goal is to obtain a more or less thin cylindrical/conical deep groove. It corresponds to tubular drilling, as some unfinished Minoan vases suggest. For example a bridge-spouted jar from the lapidary workshop at Malia (Chapouthier, Demargne and Dessenne 1962, pp.8,27) reflects the first stage of hollowing, as the initial bore of 15.7 cm of diameter has not been detached (Warren 1969).

Different types of tubular drills can be imagined. They could be of metal (for Zakros: Hogarth 1900-01, p.132 and Fig. 44 central; for Malia: Poursat 1996, pp.106-107).

But we can also consider, as P. Warren (1969) or J. Shaw (1973) proposed, the use of a reed. This identification was confirmed at the LTDS, where we successfully drilled a marble bloc with bamboo, associated with an abrasive and a lubricant (Fig. 4).

Inner enlargement in order to obtain a cylindrical/conical cavity (bowl, cup)
Next, the groove could be enlarged with abrasives and a solid rod, in order to obtain a cylindrical or conical cavity. We have obtained identical traces (Fig. 5) to those observed on the archaeological material at the LTDS, using drilling of a marble bloc with a solid rod drill (stem of olive wood) with an abrasive (sand) and a lubricant (oil).

For soft stone, once the tubular drilling is accomplished, chisels or blocs of abrasives could have been used to enlarge the initial deep groove. Finally a solid rod, with a plane base, could have been used in order to regularise the borders and obtain a cylindrical or conical form.

Inner enlargement in order to obtain a globular or biconical form ('bird's nest' bowls or carenated cups)
Manufacture of vases for which the belly is larger than the collar requires specific motions and drilling devices. This type of vase was, in some cases, made by the assembly of different parts (collar and shoulder, belly) as it is illustrated by two jugs (WP 279 and 286) from the Phaistos Palace (Evely 1993, p.177).

But an enlargement method is also detectable. This latter one, limited to a deep groove, as for a bird's nest bowl from the Quartier Mu at Malia, is morphologically very similar to Egyptian objects that we observed at Qatna[4]. As D. Evely (1993, p.178) proposed, it is probable that this enlargement was obtained using a drill bit similar to the Egyptian 'figure-of-eight shaped stone borer' (Fig. 6b,c). But their absence at the Minoan workshops suggests the use of similar tools, probably wooden ones, employed with an abrasive powder and a lubricant. Finally, for vases of small dimensions, with a reduced surface to hollow out, another technique can be considered: scraping manually, with a pointed tool while the vase was being rotated.

These first results, obtained by comparison of archaeological and experimental data, revealed the use of wooden rods with an abrasive and a lubricant for hollowing Minoan vases. Complex procedures, different from those observed in Egypt and the Near East, and perfectly adapted to the intended vase morphology, show systematisation of the *chaînes opératoire* according to the type of vase produced. Know-how involved in their manufacture implies increased specialisation of craftsmen. Enrichment of the archaeological corpus of data (vases and abrasives), development of experiments in the laboratory and in the field, and wear

[4] Egyptian vases from northern Levant (dated from the Middle-Late Bronze Age) from Qatna and Tell Sakka have been studied by E. Morero.

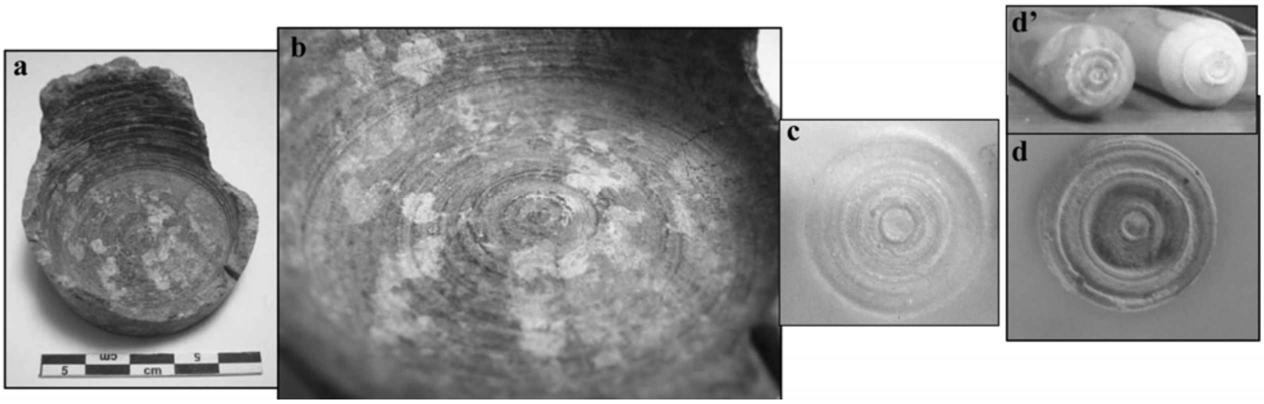

Fig. 5: a-b) Traces (general and detailed view) on the bottom of an archaeological vase. Malia (Quartier Mu); c) traces produced at the time of experimental drilling with a head out of wooden of olive-tree; d) wear of the experimental wooden head of drill; d) drills out of wooden of olive-tree.

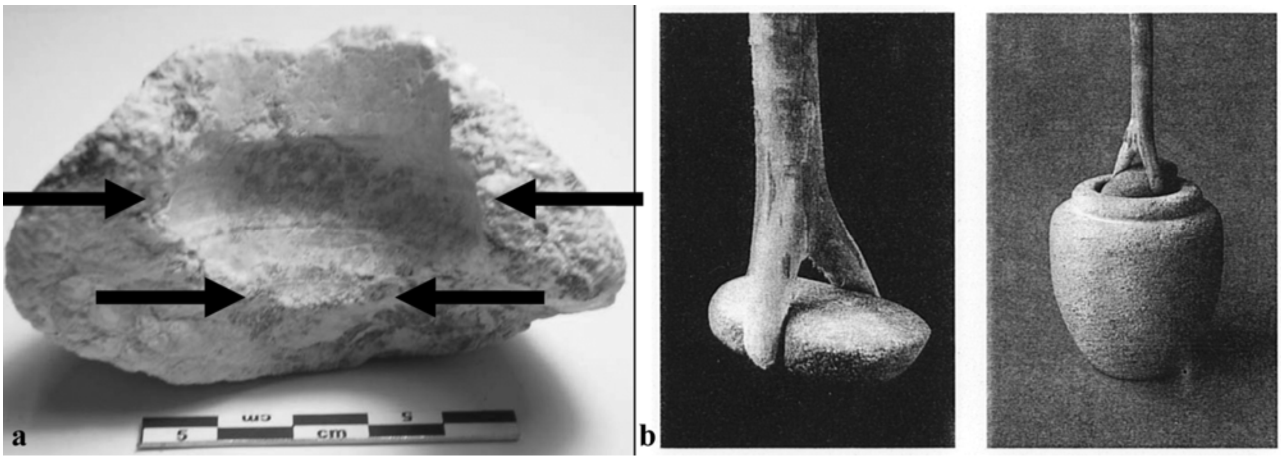

Fig. 6 : a) vase in the shape of bird's nest of the Mu Quartier in Malia; b) drills in form of eight Egyptians (according to Stocks 2003).

characterisation at the LTDS, are the necessary conditions for an overall reconstruction of drilling techniques in the Eastern Mediterranean.

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The lock of heaven’s doors

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The cretulae of Arslantepe

The excavations of Arslantepe, in the levels related to the half of the 4th millennium BC, brought to light beautiful architectural structures, several sorts of materials and a huge quantity of cretulae (Fig. 1) mostly collected in room 206, where they have been placed on purpose. The study carried out by a group of researchers on these interesting materials led to the identification of the objects systematically sealed up: sacks, jars, baskets and locks too.

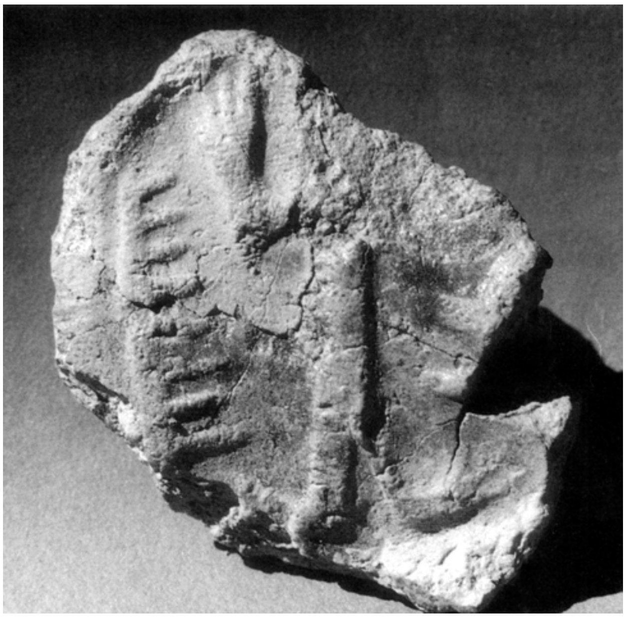

Fig. 1: Arslantepe – Malatya. Partial print of signet with dropping pivots lock key.

In relation to the last category, besides the most widespread system consisting in a rope passing through a hole in the door and then wrapped up to a pivot fixed on the external wall, there is another type of lock which represented a riddle for a long time. Enrica Fiandra and Piera Ferioli (Chighine *et al*. 1985, pp.237-248) through the observation of a rudimentary wood lock still used nowadays in the rural areas of middle-east Turkey, had been able to identify the rear mark of some of those cretulae with similar locks, which have been called “with dropping pivots” because of their operation.

The existence of such locks in the Near East and Egypt was already known: von Luschan (1916, pp.406-430) related them to Egyptian to Assyrian locks and also asserted that the symbol of god Šamaš was the key allowing to open these kinds of locks.

The data acquired in Arslantepe have an extraordinary importance because they go back to a proto-urban and pre-writing period.

The locks with dropping pivots

The locks with dropping pivots are rudimentary, made of wood or metal which prevent the opening of a door without the utilization of a key. This locking system consists of a wood parallelepiped provided with two horizontal grooves, laid one upon the other, and several vertical drills. A key runs in the upper horizontal groove, a bolt in the lower one. The pivots run in the vertical drills and they are provided with joints corresponding to the claws of the key. When the lock is closed, the pivots drop in the vertical drills and they go into the bolt, so that it becomes blocked.

Fig. 2: Exilles (Torino). Modern wooden dropping pivots lock.

Just through the insertion of the key, (as its claws perfectly enter the joints of the pivots) it is possible to lift the pivots. The bolt slides backwards, and therefore the door opens.

These locks are attested in ancient times in Egypt, Mesopotamia and Greece but they can be found as well in Italy (Exilles Figs. 2 and 3, Biella, etc.), Germany, France, United States etc.

Fig. 3: Exilles (Torino). Modern wooden key of the dropping pivots lock.

In the opinion of von Luschan, even if his theory was not proved entirely, the spreading of this lock took place in several steps: it started in the East or in Egypt, it arrived in the Mediterranean Sea through the Greeks and then the Romans brought it beyond the Alps. The Arabs spread it in North Africa and reached America through the slave trade.

O.M.

The Heaven's doors

The idea of von Luschan (1916, pp.406-430), that the object on the Šamaš's hand in some glyptic images is a sort of key (Fig. 4), was put in question by Dombart (1928, pp.1-24), on account of two reasons. The first is based on the shape of the object, that is in not always like a key, but often it seems like a modern saw. The second, philological one, is based on the analysis of the word *šaššarum*, often connected with the Sun god Šamaš, used by von Luschan to mean the key of Šamaš.

Fig. 4: Šamaš opens the heaven doors on an akkadic signet.

There is no Sumerian equivalent, so the Assiryologist must identify its meaning comparing its root with other Semitic languages. At the first, it was related with the Hebraic root *ššr*, "red colour", and Schorr (1913, p.553) suggested, after a complex reasoning, the meaning of "cadastre" of the Šamaš temple. But this meaning was not fit to other recurrences, not related with red and cadastre. Landsberger (1912, p.149) and Meißner, more convincingly, suggested to relate it with the Arabian root, meaning "saw": when it recurred with the god, may to indicate an emblem, and exactly a weapon. The meaning of *šaššarum* as a "saw" was accepted by Dombart, and he identified it with the object in the god's hand and used to open the Heaven door.

Although generally accepted by scholars, this solution is not really conclusive. In the hymns and prayers to Šamaš, after saying that the god is "who open the Heaven and Earth Doors", are mentioned technical words related with lock with dropping pivot (Potts 1990, pp.185-192; Scurlok 1988, pp.421-433). So, it seem logical to think that Šamaš, the only god to be able to open those doors, owns the key to open their locks rather than a saw to cut the rope or to saw the lock.

In short, the object in the Šamaš hand, in the glyptic representation, seems to be a key and not a saw. About the philological difficulty of the root of *šaššarum*, it can be resolve in two ways. The first is that there is no direct relation between the word *šaššarum* and the object in the seals: this last may have another name and be a key. The second one, even if it will be proved the direct relation between the object and *šaššarum*, is to extend the semantic spectrum of this word: if the root in Arabian means "saw", it is possible that the root refers to a more generic something, like "an oblong, dentate object". If in akkadian *šaššarum* means "an oblong, dentate object", it fit well either to a key or to a saw, and so the identification of the object with the *šaššarum* will be not more a problem (Simonetti 2005, pp.111-112).

Conclusive hypothesis

Shortly, the identification of impressions on the back of some cretulae from Arslantepe with lock with dropping pivot testify the existence of this kind of lock in the 4th millennium BC, in Anatolia. Its diffusion during the II and the 1st millennium BC in Egypt and in Mesopotamia is testify by several other documents, and it is possible that it was known in all the Near East. Some indicating signs, besides, induce to think that the mythical Heaven doors had also this kind of lock. The recent discovery in Turkey, Lybia, Italy, France, Germany and also in America, induce to deem that this lock was used continuatively for thousands of years, and that its diffusion was related to the Roman conquests (to the Italy, France and Germany), and to the Islamic ones (to the North-Africa), until to the American slave trade.

C.S.

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6.5 Burial Context

Stone Age burial sites in eastern Tatarstan: use-wear and technological analyses of the flint assemblages

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Summary. *The results of use-wear and technological studies of flint tools discovered in the Minnyarovo and the Russky Shugan burial places are interpreted in the paper. The Late Mesolithic/Early Neolithic Minnyarovo burial obviously was a grave of mobile hunter with his weapon and flint tool-kit utilized in hide- and wood processing. The types of the fifteen arrow points appear to be in practice during the dating of the 7th-5th millennium BC. The functions of these points have been proved by the macro-wear traces of projectile damage observed on the tips and bases. The Late Neolithic/Eneolithic burial context of the Russky Shugan demonstrates two different traceological and technological contexts based on flint raw of different quality. Concerning one of these contexts the supposition is put forward about some funerary traditions of population of Middle Volga region during the Neolithic/Eneolithic. The problem of the identification of the big blades as burial gifts manufactured by specific technique and used in specific functions has already been raised by European researchers. The chronological position of the Russky Shugan burial seems to be proved by presence of the composite sickles and its inserts which may be indicator of plant domestication.*

Key words: Minnyarovo, Russky Shugan, burials, use-wear analysis, flint tools.

Results of the study of the burial contexts revealed in the eastern part of the Russian Plain are of special interest because of their rarity. Combination of typological, use-wear and technological analyses of the assemblages from the Stone Age burial sites give us a wide range of possibilities for interpretation. Two of the burial sites were discovered by Eugeny P. Kazakov during 1974-75 in the eastern part of Tatarstan Republic in the left Kama river tributaries basin – Minnyarovo and Russky Shugan (Kazakov 1978). In the mid-1980s the Mellya-Tamak V cemetery with an exceptional bone inventory was excavated near the Russky Shugan (Kazakov 1989, p. 47). The study presented here, deals with the Minnyarovo and the Russky Shugan burial sites, in particular with use-wear and technological data on flint tools. Bone and antler tools from these burials were examined by Mikhail G. Zhilin. Unfortunately his data are not published yet.

The Minnyarovo burial site was situated on the left bank of the Syun river in the sandy dune deposits (Fig. 1a). Because of aeolian erosion, grave outlines were not visible. The supine skeleton of a 25-35 year-old man was found (according to anthropologist Rafael M. Fattakhov, cited in Kazakov 1978, p.165). The deceased was supplied with a bone dagger made from an elk legbone, flint tools and three animal incisors (rodent, fox and bear). His skull and burial goods were covered with ochre. Fifteen points from the burial were made on regular blades (narrow or medium) (Fig. 1b). Flat retouch covers the tip and base of ventral or of both ventral and dorsal faces of the blades. In some cases the edges of these blades were retouched also. Despite the small number of tools recovered, we may say that blade production technology of this flint industry seems to be sufficiently developed. It was based on quality flint flaking with use of soft hammer and pressure techniques. Shape and proportions of the points vary from rhomboid and rectangular to long leaf-shaped types. The most probable function of these points is the use as part of a projectile weapon. Use-wear analysis shows presence of macro wear traces of projectile damage (impact fractures) on the tips and bases of 9 points (Fig. 1b: 2-13, 15). It is interesting to notice that 7 arrowheads were grouped under the pelvic bone. Clearly the hunter had a quiver. The author was not successful in looking, with the binocular microscope, for micro-patterns of damage (striations). A large triangular point with an abruptly retouched base was used as scraper and perforator (Fig. 1b: 14). The distal fragment of one blade shows traces of a chisel (Fig. 1b: 1).

The Russky Shugan burial site was situated in the now destroyed dune deposits on the left bank of the Ik river (Fig. 1a). The great part of a male skeleton of 35-45 years, examined by Rafael M. Fattakhov (cited in Kazakov, 1978, p.169) was destroyed as well as the burial goods. The outline of the burial structure appears to be rectangular (4 x 3 m). Fragments of human bones (legs) were covered with ochre, fragments of ceramic vessel with tooth-comb, zig-zag decoration, 11 small flint concretions, more than 200 flat round perforated shell beads, more than 50 incisors of marmot, teeth of marmot and deer, 6 fragments of tools made on bone and antler, two talcum tools (Fig. 2b: 1,2) and a representative assemblage of flint artefacts (70 pieces).

The flint assemblage of this burial consists of:

53 blades with different width, which are represented by fragments and rarely complete specimens (Fig. 2a, 2c: 1-4, 6,7,9,10); four arrowheads on narrow blades and one medial fragment (Fig. 2c: 5,8); three end-scrapers made on a large blade fragments and flake; one notched scraper used in wood processing; one chisel made on a small flake; 1 massive big bifacial dagger; two fragments of flint cortex; two fragments of flakes; a small fragment of polished tool made of green chert and two cores: one unstructured and a prismatic regular one for micro-

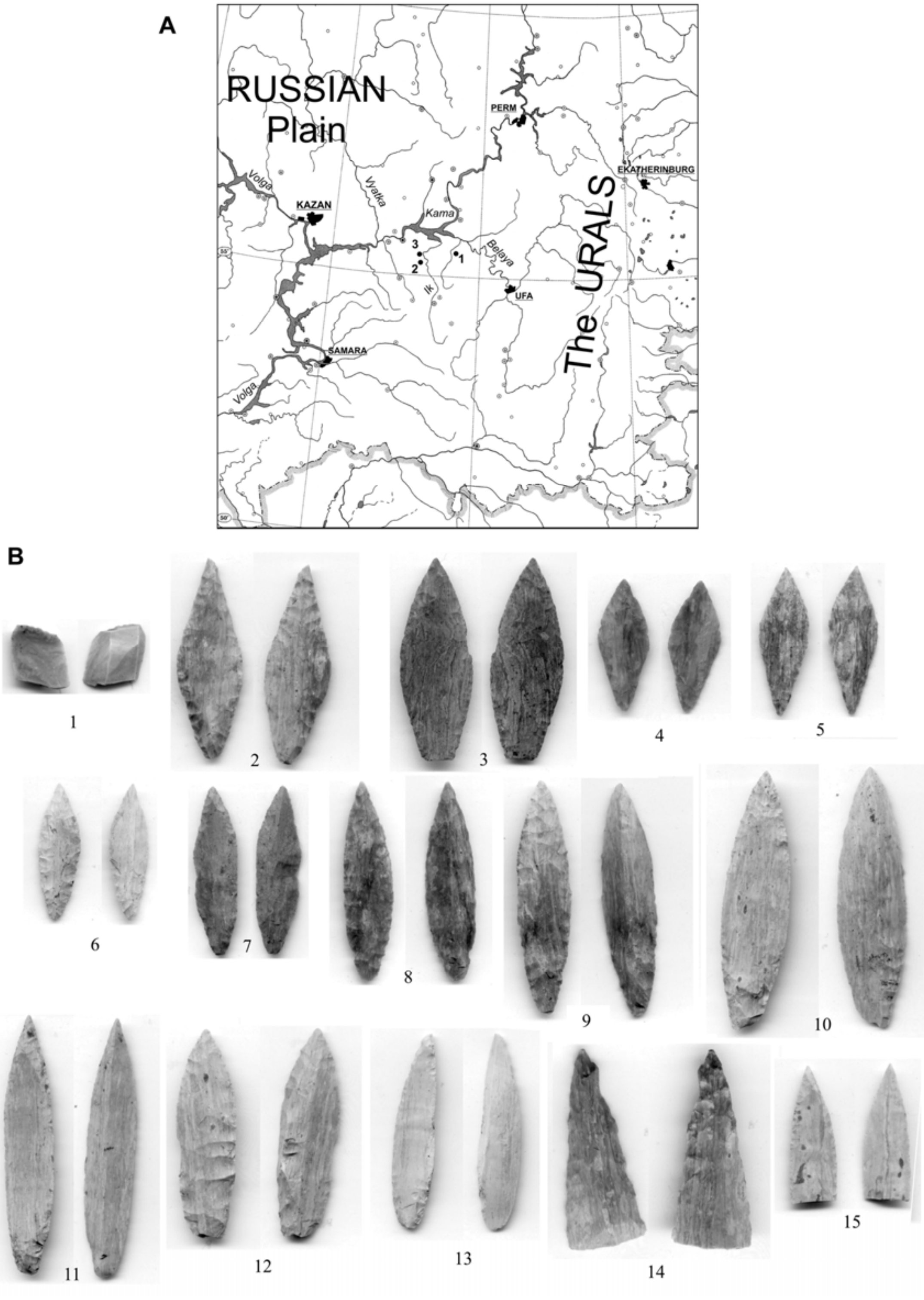

Fig. 1: a) Minnyarovo: map of the investigated area; b) 15 points from the burials obtained from regular blades.

blades. The latter one was intensively used as a pressure flaker on its distal end and as abrasive tool used for removing core platform edges (Fig. 2b: 3).

From a typological point of view, regular blades of various width without special retouch are absolutely prevailing in the Russky Shugan burial assemblage. These blades demonstrate differences not only in size and proportion but in flint quality and blade production technology. Long regular blades (18 pieces) with width between 2 and 4.5cm were manufactured using a soft hammer technique on anvil, probably with episodic

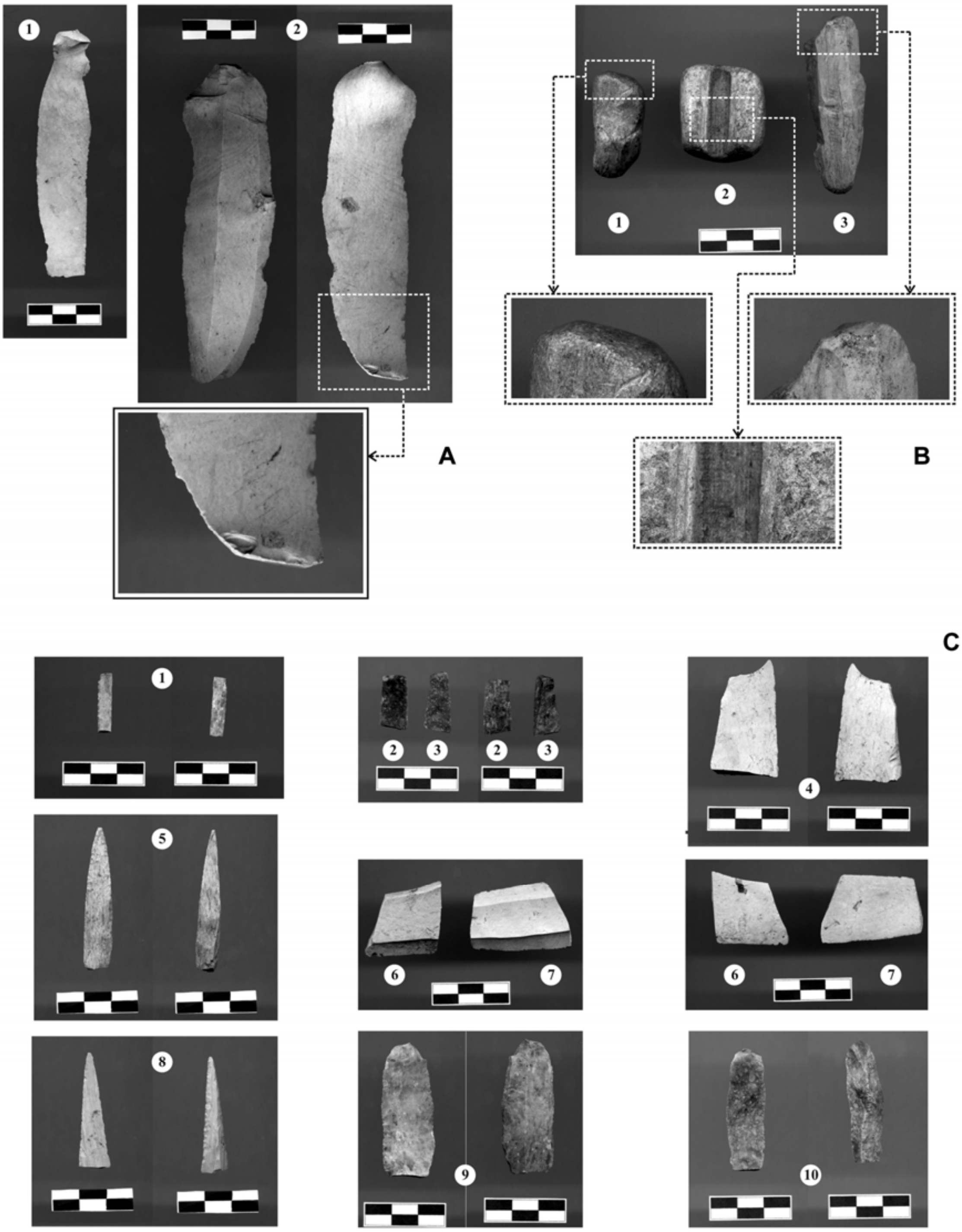

Fig. 2: a) sickle with compact polish spot and comet-shaped use-wear; b) 1, 2 talcum tools; 3 core; c) 1, 2, 3, 4, 6, 7, 9, 10 blades; 5, 8 points.

abrasion of the platform edge. These blades have been fragmented in the majority of cases and were made with a medium quality flint. Use-wear traces observed on these fragments are likely to be interpreted as intensive edge damage and scratches of bone and meat cutting or knife hafting. Moreover there is some evidence of secondary utilization of knife inserts as burins and hafted fragments of knifes or as cutting tools. Three wide blades were used in composite sickles (Fig. 2c: 4,6,7). Two hafted long blades are of special interest – one a sickle blade with a compact polish and comet-shaped use-wear on the working edge (Fig. 2a: 1), the other used as a hafted big butchering knife or dagger (Fig.2a: 2).

The blades of average width (1.1-2.4 cm) were produced by soft hammer percussion and occasionally by pressure technique. Alongside medium quality raw material (grey flint), a better quality flint similar to jasper (spotted dark-grey colour) was also used. These blades (whole and fragmented) were utilized as hafted elements for woodworking and butchering knifes. Remnants of hafting traces are preserved on a few fragments. Individual pieces demonstrate traces of utilization: 1) as part of a projectile weapon (with typical lateral flaking damage) (Fig. 2c: 2,3); 2) as part of a composite sickle (with comet-shaped micro-traces) (Fig. 2c: 10); 3) as a planing tool, combined with grooving or sawing tool (Fig. 2c: 9).

The group of narrow blades and micro-blades (width 0.5-1.0 cm) is characterised by pressure technique applied on reduction of quality flint prismatic cores. These blades are considered to be used as projectile elements (Fig. 2c: 1), fragments of arrow (?) points and of knives with a secondary engraving function (use-wear observed at the angles) and as sickle inserts. There are two interesting points in this group: the arrowhead on a large regular blade with projectile damage on the tip and the traces of insertion in a shaft (Fig. 2c: 5) and a broken arrowhead on a thin blade which was secondary utilized as perforator for hide or leather.

Conclusion

The Minnyarovo burial is likely to represent the grave of a mobile hunter with his weapon and equipment. Tools were utilized for hide working and wood processing. Typology of the arrowheads is very similar to the projectile points discovered at the Mesolithic cemetery of Oleny Ostrov (burial No. 100) in Karelia, north-west Russia (Gurina 1956, pp.94, 96-98) and the Late Mesolithic site of Ozerki 5 near Tver-city, in the Upper Volga region (Zhilin 1996, pp.123-124). Types of the points from the Minnyarovo date between 7th and 5th millennia BC. The narrow bone dagger with triangular section from Minnyarovo is similar to the daggers from the Oleny Ostrov cemetery (Zhilin 2001, pp.111) and collection of the Shigir peat site situated near Ekatherinburg-city, in the Urals (Shorin 2001, p172). Technology of manufacture of the bone and antler daggers is presented in the study by Mikhail G.Zhilin (2001a, pp.107-116; 2001b).

The burial context of the Russky Shugan demonstrates a more complex traceological and flint technological picture than the Minnyarovo one. Obvious analogies are certain to be in the neighbouring Stone Age Mellya-Tamak 5 cemetery studied by E. P. Kazakov (Fig.1). The burial assemblage of the Mellya-Tamak 5 looks more various and impressive, especially the complexity of composite tools and weapons (Kazakov 1989, pp.47, 84). Apart from this close resemblance, a definite cultural and chronological unity of burial sites on the left tributaries of Kama is suggested with the Neolithic-Eneolithic cemeteries studied in the middle Volga (Vasilyev 1981; Judin 2004) and Dnieper-Don interfluvial (Telegin 1991) regions. The typical burial assemblage of this group consists of long macro-blades, bone and antler tools and equipment, ornaments made of mammal teeth and shell beads and pottery with a tooth-comb zig-zag decoration. Another important feature of this funerary tradition is the presence of ochre in the graves.

Settlement sites associated with the Russky Shugan and Mellya-Tamak 5 burials appear to be situated nearby, in the same region of the Ik and Belaya interfluve. The Russky Azibey type of the Neolithic- Early Eneolithic sites is characterised by identical flint colour and quality, similar technologies aimed at production of long blades (with soft hammer) and micro-blades (pressure technique). Among various types of decorated pottery, the type of tooth-comb zig-zag ware occurs frequently (Gabyashev 1978). However the typological character of these settlements flint tool-kits is rather different. First of all, they lack long massive blades – knives without special retouch on its edges.

There are two different use-wear and technological contexts in the Russky Shugan flint assemblage based on raw material of different quality: 1) wide long regular blades (often massive and fragmented) without special retouch on edges; 2) tools made on medium and narrow blades and micro-blades of better quality flint (also fragmented in most cases). Tools of the first group were used as knives and inserts and subsequently reused (some after breakage) in processing of hard material (probably animal teeth or horn).

The hypothesis put forward by the author concerns the funerary tradition of utilization of special long blades and their fragments in cutting and perforating of marmot's incisors. The absolute absence, among the more than 200 incisors, of specimens with a preserved root or part of the root itself seem to support this supposition. Marmot's incisors appear to play a ritual role in the funerary traditions of the population of the middle Volga region during the Neolithic-Eneolithic. Data on the cemeteries discovered near Saratov-city (the Lipoviy Ovrag cemetery) support this supposition too (Vasilyev 1981).

Comparisons drew by European researchers (Van Gijn 1999; C. Skriver 1999) between use-wear and technology of the blades from burials and those from contemporary settlements of the Late Neolithic-Early Bronze Age period are significantly different. In such contexts, blades deposited as burial goods were manufactured using specific techniques, were often made of exotic materials and appear to be unused or utilized with specifically selected material. A similar situation was likely to exist in the region under study during the Neolithic/Early Eneolithic (the Russky Shugan and Mellya-Tamak 5 burial sites and the Russky Azibey type settlements).

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7. Round Table

From East to West; functional analysis and the analogical reasoning. A reflection on scinetific practice

Technician or researcher? A visual answer

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Summary. *Naming the field of research initiated by S.A. Semenov has been a subject of debate, for the term « traceology », which he created, is often thought to be restrictive considering the current research stakes, which are not identified by their means but their goals. However Semenov's work shows the wide range of his research, from the most basic methodological aspects, to the human technical evolution process, revealed by the reading of use-wear and manufacturing traces. Using the term "functional analysis" does not account for the potential of traceology.*
If traceologists form a scientific community, it is because they acknowledge a common language: traces on archaeological artefacts. Thus documenting those traces is the first step to any demonstration. The validity of the proposed interpretation depends on the quality of this documentation. It then appears essential not to despise the technical basis of our work and to take special care in the quality of the published illustrations.

Résumé. *La dénomination du champ disciplinaire fondé par S.A. Semenov est sujet à débat, car le terme « tracéologie », qu'il a créé, est souvent perçu comme restrictif par rapport aux enjeux de recherche actuels, qui ne s'identifient pas par leurs moyens mais par leurs buts. Pourtant, les travaux de Semenov montrent que ses domaines d'intérêt étaient vastes, depuis les aspects méthodologiques les plus élémentaires jusqu'aux processus d'évolution technique des groupes humains, à partir de la lecture aussi bien des traces d'utilisation que de fabrication de leurs objets. Le terme d' « études fonctionnelles » ne couvre donc pas l'étendue du champ de la tracéologie.*
Si les tracéologues forment une communauté scientifique, c'est parce qu'ils se reconnaissent autour d'un alphabet commun que sont les traces portées par les objets archéologiques, dont ils ont établi les clefs de lecture. Par conséquent, la documentation de ces traces constitue un préalable à toute démonstration : de sa qualité dépend la validité des interprétations proposées. C'est pourquoi il nous paraît essentiel de ne pas mépriser les bases techniques de notre travail et de porter un soin particulier à la qualité des illustrations publiées.

Key words: traceology, use-wear analysis, functional studies, methodology, microscopy, photography, digital imaging

This is a question that would not have had much sense for S.A. Semenov, considering the wide range of his interest in all aspects off the field of research that he pioneered, from particular methodological questions to the history of the evolution of paleo-technology. His oldest papers, published in 1940, "The study of traces of work on stone tools", is surprisingly modern in its methodological description of use-wear analysis on stone tools. It demonstrates that already at the beginning of his research, S.A. Semenov took into account a range of optically visible features for the determination of tool uses and more particularly microscopic features.

What was done, more than 30 years later in western archaeology, has often been a reinvention of his methodology, although not enough attention was devoted to some of its most basic points, which lead, for instance, to a misunderstanding about the importance of striations on used tools. In various papers, and in the chapter 6 of Prehistoric Technology, he underlined the necessity to neutralize the translucency of stone and bone tools surfaces by dusting them with fumes of magnesium oxide, or another compound, in order to emphasise subtle diagnostic details of manufacture and wear traces under the stereoscopic microscope, particularly the striations. Such a precaution has nonetheless been largely neglected in the study of traces in the West, which, as a cause or by consequence, has focused more on high magnification. This lead to mistakenly assume that the Russian Palaeolithic tools were more striated than the ones studied in Europe, due to a more loessic environment.

Although he was more pragmatic than sometimes we are, Semenov did not neglect sophisticated techniques of analysis. At the end of his life, he tested instruments used in tribology, such as the Linnik-type interferometer, in order to improve microscopic observations by using quantitative data (Semenov 1970; Semenov and Shchelinsky 1971).

Since Semenov, the most concrete improvements to his fundamental work, have been brought by electronic techniques, which enlarged not only the range of magnifications but also the variety of diagnostic features such as the phytoliths (Anderson 1980) or the chemical trace elements (Christensen *et al.* 1993), allowing more accurate recognition of worked materials and, thus, of prehistoric techniques: modern technology helping to investigate more thoroughly ancient technologies!

However, despite the Greek-Latin structure (*tractiare*: to draw & *logos*: dissertation, sciences) of the word "traceology", invented by Semenov, it is not infrequent to hear that we are not technician but researchers, particularly in France where this is even taught to the students. Such a depreciative point of view on the technical basis of our work is paradoxical for scientists dealing with Anthropology of Techniques, moreover when claiming an inductive approach of the archaeological facts.

As reflected by the debates of the round table "From East to West: functional analysis and the analogical reasoning.

A reflection on scientific practice", held the last afternoon of the conference, the concept of "functional studies" is more intelligible by the English speaking scientific community than the term "traceology" which is not sufficiently explicit about our common topic of research, and not exactly specific if we consider that the essence of archaeology is to deal with the material traces of past activities. But when we say "functional studies", we also focus on a particular range of questions and restrict the concept of S.A Semenov who never discriminated, among the processes of work, between the ones which were understandable via the traces of manufacture and the ones identifiable by wear traces: his founder book was entitled *Prehistoric Technology*! The fundamental concept of Semenov has been to underline that behind the objects, highly praised by a typological archaeology, were more subtle evidences able to link them not only to each others, but also to vanished events, in a kind of semiology funding a systemic approach of archaeological remains.

Consequently, whatever are our anthropological targets, starting from an inductive or a deductive epistemic position, naming our approach according to its material or virtual object (in its double meaning), we do have a common language whose words are the traces observed on the artefacts.

Few of our current theories or assumptions will resist future data and synthesis, as normally goes Science, but our concrete observations will certainly remain meaningful for our successors. So, as the principle of Science is to be founded on the replicability of the observations, it is indispensable to take the greatest care in the quality of our visual recordings: what I have seen, you have to be able to see it in the same way I did!

This is less a matter of sophisticated instruments than the knowledge to get the best from the available equipment, as proven by S.A. Semenov, and even more by V.E. Shchelinskij (1977), in Soviet Union, or by P. Vaughan (1985), on the Western side, that nobody equalled despite more modern equipments with better optics. All three used ancient (Wild M50) or very ancient (Lomo MBS) microscopes and manual cameras.

At the question asked elsewhere (Functional studies between East and West: are we finally closer? UISPP 2006, WS24), to know if it is time to walk in the same direction broadening horizons, we should reply that we are all using the methodology established by Semenov, basing the interpretation of ancient traces (of use or manufacture) on their comparison with modern references, whatever are our archaeological targets, and thus we share the same visual evidences. Consequently, before philosophising, we have first to put in common our concrete observations, and for this purpose no better means has been found than communicating pictures of explicit features.

In order to contribute to this convergence of experience, and to pay homage to Semenov, we would like to give examples of some techniques of imaging that facilitate our job, particularly in the digital field which can effectively broaden our horizon.

We will not insist on the efficiency for the contrast emphasis of the more than half century old technique of surface dusting (Semenov 1964: 24), with fumes of magnesium oxide or more modern compound. It is still very helpful for examination and photography at low magnification.

Photomacrography with a stereoscopic binocular microscope, even with a good illumination of the sample, is often very disappointing. This is due to the optical geometry of this instrument, designed for three-dimensional direct viewing and whose convergent channels generate various distortions on plan projection.[1] These can be corrected by specific designs and expensive apochromatic lenses, but will not give a better image, at the lowest magnification (the range for edge damages), than a classic 50mm macro objective on a bellows (or special macro lenses of shorter focal length such as the famous Photar, Luminar, Mikrotar, etc.).[2] However, this cheaper alternative needs some skill to get good results, and is quite awkward to use. Thanks to the compact (not SLR) digital camera and their small high resolution sensors (giving great depth of field) we have now a much easier way to produce good snapshots, at least with the models of the major manufacturers of photographic equipment. In the macro position, at a few centimetres of the object, such cameras can take directly valuable pictures, without any additional accessory but a strong stand (photo 1).

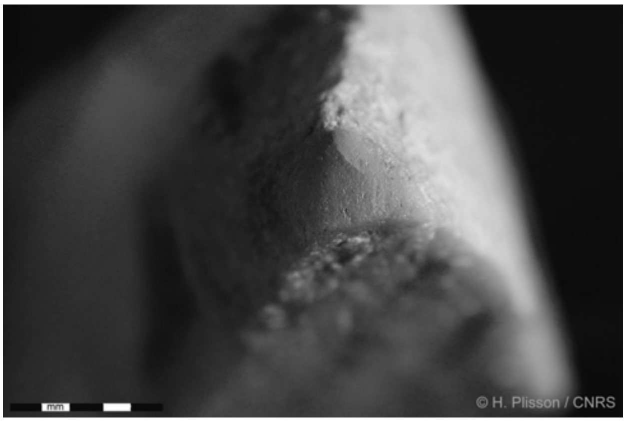

Photo 1: macroscopic detail of the blunt tip of a Palaeolithic quartzite pick, directly taken by a 3.34-megapixel articulated digital camera, in macro mode, without any additional accessory. Scale in millimetres.

[1] For example: http://www.microscopyu.com/articles/stereomicroscopy/stereointro.html
[2] http://www.macrolenses.de/

At a higher macroscopic magnification, the lowest objectives (2 to 5x) of the metallurgical microscope, with an external incident light, can be substituted to the stereoscopic microscope for taking pictures with less distortion and a better resolution, but with the inconvenience of a much smaller working distance (between the lens and the object).

With the metallurgical high power reflected (or episcopic) light microscope, another range of problems arises. Its optical geometry is perfect and its resolution increase with the magnification of the objectives, but the depth of field decrease in the same proportion and it is consequently difficult to get simultaneously the subtle details and a good micro-topographical perception. When observing, we do a mental reconstruction, however the image projected on the film or on the camera sensor is far from being so ideal.

Another trouble, induced by the loss of vertical field, is that the different wavelengths of the light no longer focus on the same plane (the refractive index of the optical glass formulation varies according to their frequency), producing various chromatic aberrations to which the digital sensors are very sensitive (purple fringes on the contrasted details; e.g. colour version of photos 4 and 6). For the films, the solution was to cut with a green filter the wavelengths not corrected by the achromatic formulation of the metallurgical objectives (Plisson 1989), but this results now in blinding half of the photodiode pixels of the digital sensor[3]! Another solution would be to use apochromatic lenses, fully corrected, but they are very costly and most of them are designed for transmitted light microscopy and compensated for specimens with a cover glass; few manufacturers have a range of true apochromatic objectives for surface analysis.

Consequently, the loss of contrast induced by the translucent and clear coloured material is only partially controlled by the metallurgical lenses, but at their scale of magnification the dusting of the surfaces is no longer possible as the dust particles become clearly visible. Sophisticated techniques of coating exist for scanning electronic microscopy (SEM), in order to prevent the electric load of the samples, but they need expensive equipment and are not reversible, which is not the best argument to keep good relations with the museums curators … And we will not consider here the SEM itself, since its wide range of tunings (angle and intensity of electronic beam, etc.) cannot help in obtaining standard pictures, easy understanding and thus direct and unilateral interpretation.

Are we doomed to produce faint photos? Not necessarily.

Photo 2: microscopic detail of an experimental suppling and softening bone tool used on the inner side of a dried and tanned hide, in bright-field microscopy (10x/0.30 lens), taken by a 8.2-megapixel SLR digital camera. Digitally post processed to enhance contrast.

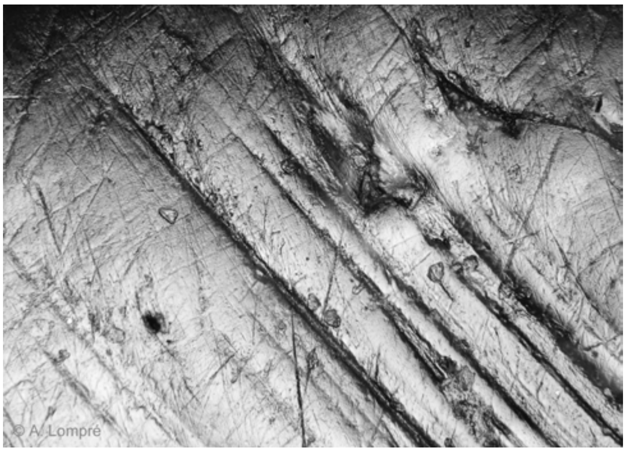

Photo 3: same microscopic detail but of acetate cast of the expérimental bone tool, in bright-field microscopy (10x/0.30 lens), taken by a 8.2-megapixel SLR digital camera. Post processed compilation of 10 shots.

Photo 4: microscopic detail of an experimental rock crystal meat knife, in bright-field microscopy (20x/0.46 lens), taken by a 5.47-megapixel SLR digital camera. Digitally post processed to enhance contrast.

[3] For example: http://ffden-2.phys.uaf.edu/212_fall2003.web.dir/Mike_Kudenov%20/CCD.htm

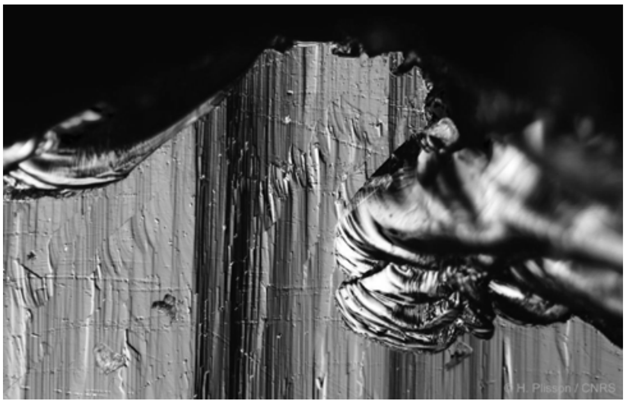

Photo 5: same microscopic detail of an experimental rock crystal meat knife, but in DIC microscopy (20x/0.40 lens), taken by a 5.47-megapixel SLR digital camera. Digitally post processed in the same way as the photo 4 in order to allow a strict comparison.

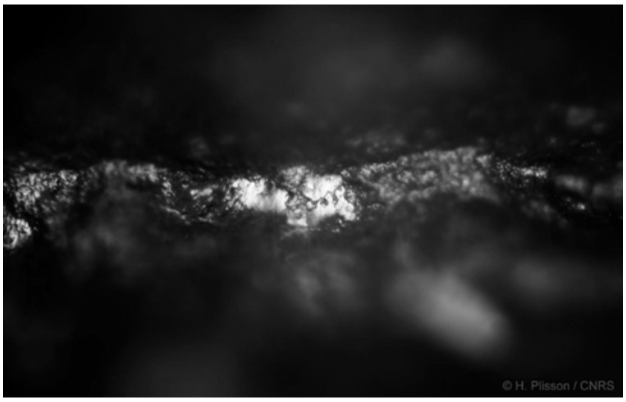

Photo 6: microscopic detail of Upper Palaeolithic flint denticulate used on bone, in bright-field microscopy (20x/0.40 lens), taken by a 5.47-megapixel SLR digital camera. Post processed single shot (with a green filter for black and white processing, without any filter for colour processing).

Firstly, the contrast of clear materials, such as bone, can be easily enhanced with the use of acetate cast replicas and blackening of their backs (Plisson 1983, 1984). As we are dealing with non stereoscopic two dimensional paradoxical images, our brain automatically reverses the negative relief of the imprint replica, and thus can see it as the original (Photos 2 and 3). It is a very simple process, usable outside the laboratory, which can be also very useful for larges objects, or to keep a more complete recording of the use-wears than the photos.

Secondly, the brightfield illumination, although the most commonly used in reflected light microscopy and standard for flint use-wear analysis, is not the only technique designed for surface examination; other types can be helpful in contrast enhancement and provide better observation and photomicrography of specimens. This is particularly the case for the differential interference contrast (DIC),[4] invented by G. Nomarski, which accentuates the subtle differences of relief on transparent or highly reflective materials. It is not only indispensable for the use-wear analysis of quartz, rock crystal or obsidian (photos 4 and 5), but also helpful in practice for reducing the chromatic aberration in digital photography and it can be subsequently applied to flint analysis.[5]

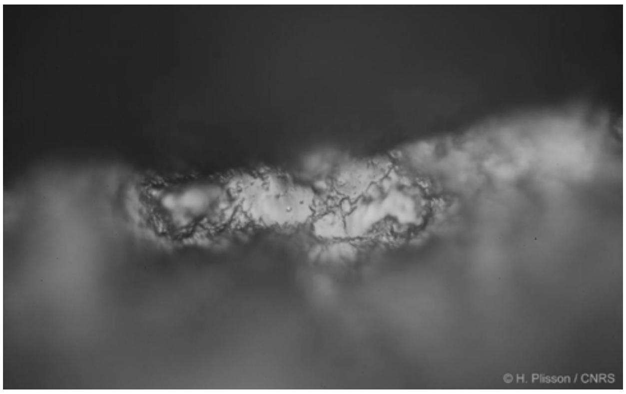

Photo 7: same microscopic detail of Upper Palaeolithic flint denticulate used on bone, in DIC microscopy (50x/0.80 lens), taken by a 5.47-megapixel SLR digital camera. Post processed single shot.

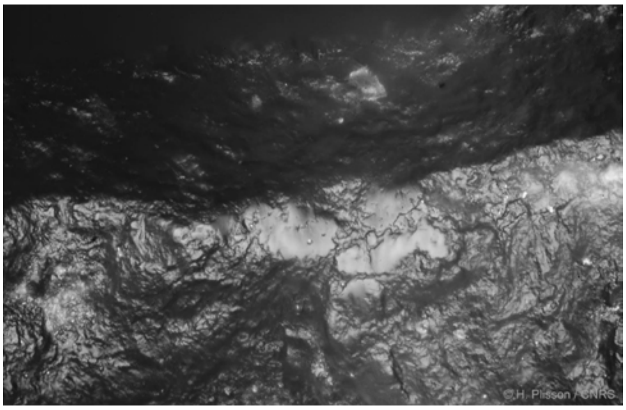

Photo 8: same microscopic detail of Upper Palaeolithic flint denticulate used on bone, in DIC microscopy (50x/0.80 lens), taken by a 5.47-megapixel SLR digital camera. Post processed compilation of 60 shots.

Thirdly, the digital photography is not just a replacement of photo-sensitive surface, but the initial concretisation of a new principle which is opening new potentials (Simondon 1989). We are no longer dealing with analogue photographs but with their mathematical encoding, so we can now use computing techniques not only for improving the pictures but also and mainly to produce new types of images, impossible to get previously. Various software are now available, from very expensive ones sold by microscope manufacturers to freeware on internet,[6] some involving technologies coming from astronomy, allowing the combination of

[4] For example: http://www.microscopyu.com/articles/dic/reflecteddic.html

[5] However, we did not get satisfactory results with all the type of prisms and tests have to be done with each model of microscope: too much relief emphasis is not appropriate for grainy surfaces.

[6] http://www.hadleyweb.pwp.blueyonder.co.uk/CZ5/combinez5.htm

different focuses on the same object in order to synthetically increase the depth of field (photos 6, 7, 8). By this means you can take advantage of the 50x, 80x or 100x high resolution objectives to produce very convincing images, more understandable than the ones formed by the SEM, and in less time than generally needed to find a relevant detail which could be demonstrative in a single 20x snapshot. The interest of such technology is of course not restricted to the very high magnifications (photo 3), nor the microscope.

All these techniques exist outside of archaeology and we could suppose that we just need to ask for them to some commercial representative. However, who could be concerned, in the industry or in other scientific fields, by the analysis and recording of translucent, light-coloured, non metallic surfaces? In practise we still have to find and adapt by ourselves such resources to our specific purposes, as did Semenov more than 60 years before. We know better than anyone what to make visible.

If the two dimensional imaging techniques seem now sufficiently adapted to flint, quartz or obsidian use-wear analysis, although underexploited, and if they become satisfactory for bony materials, this is not yet the case for grinding surfaces in which progress has still to be done (e.g. Hamon and Plisson, this volume).

Traceology is not a fixed operating procedure, involving always the same apparatus for a definite type of features. In this sense, this is not the task of a technician. As shown by various contributions to the present proceedings, archaeological situations are too much diversified to be covered by a limited range of techniques. Taking into account prehistoric assemblages as a whole, and not only from a lithic point of view, in order to elaborate systemic reasoning, opens on economic, social and even symbolic interpretations (e.g. Beugnier and Maigrot 2005). But this implies the adaptation of the analysis techniques to the diversity of prehistoric materials, process, conditions of preservation, etc. or to look for new ones, and consequently involves a technical expertise.

Being able to get the best from his instruments never prevented any researcher to formulate valuable theories, but, on the contrary, it is difficult to follow demonstrations based upon inadequate or undefined technical means and with poorly convincing illustrations. In the past, it was quite difficult to publish good photos and in sufficient number, but the multimedia (on line data bases, knowledge bases, electronic reviews,[7] printed books with CDrom, etc.) has reversed the situation and we have now no more limit to expose our observations but our own capacity to record them and produce demonstrative pictures.

So, technician or researcher? A good carpenter never blames his tools!

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[7] For example: http://www.thearkeotekjournal.org/

One who had never been false to himself

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Summary. *This paper briefly recalls the life of Sergey Semenov, placing his achievements and thoughts in the historical and political context of those years. The first quarter of the 20th century in Russia saw dramatic events that not only had an impact on the scholars' personal upbringing, education and career but also deeply affected the contemporary intellectual and scientific world around him. Semenov's tenacious personality and punctual mind drove his interest and work into the investigation of prehistoric technology, laying the basis for the development of functional studies and use-wear analysis.*

Key words: S.A. Semenov, GAIMK, use-wear analysis, experimental archaeology, Marxist archaeology, prehistoric technology.

Sergey Aristarkhovich Semyonov (Semenov), a world-renown scholar, has followers in all continents. He was the founder of the experimental use-wear traces identification technique for the determination of function of different tools or any artefacts of unknown purpose recovered during archaeological excavations.

We wish to recollect here those remote times which had formed the scholar's scientific tenacity. The first quarter of the 20th century was an impetuous period of Russia's history marked not only by revolutionary events (civil war, famine and demolition of cultural monuments), but also by a flight of creative work in all fields of human knowledge. The monopoly of the 'social realism' had not yet been established. Lively discussions continued on various problems of philosophy, moral, arts, economics, science and engineering. The ideas of revolutionary reforms had seized intellectuals. All these events, moreover, were taking place concurrently with the change of the political picture of the world. Inquisitive public, particularly humanities scholars and artists, tried to understand what in fact Plank's quantum theory or Einstein's relativistic theory were and to develop ideas about space-time continuum of Minkowski. Supporters and opponents of Darwinism were implacable to each other. In 1925 the so-called 'ape trial' took place in USA. It was a reappraisal attempt against the evolutionary theory of Charles Darwin.

In the same 1925, a Russian translation of Friedrich Engels' writings collected under the title "*Dialektik und Natur*" (Dialectics and Nature) was published. One of these articles "The *Role of Labour in the Process of Origin of Man from Ape*" immediately was added to the armoury of evolutionary ideas on the extinct human species. In the general flow of expected and unexpected discoveries, the proto-genealogy of Man was far from holding an unimportant place among public ideas. It is worth to remind that stones of unusual form like spearheads, had already been for a long time found occasionally in fields. In some cases these objects resembled axes. By some people, such finds were taken for 'dragons' teeth', but more frequently they were considered as 'thunder stone-arrows' resulted from lightning hitting the earth and useful in treatment of various diseases. The first arguments supporting the idea that these objects might have been the earliest tools created by human beings were put forward in the16th century. By the early 20th century, archaeology and anthropology had already explored the depth of ages and established that these artefacts were nothing other than tools of the most primitive manual labour. Public interest in the industrious activities of ancient people was boosted also by the fact that the main question regarding the social nature of human beings was hidden within these activities. Science was awaiting for a scholar who would be able to reveal the earliest forms of social labour.

Sergey Aristarkhovich Semyonov was born on September 25th, 1898, in Wilno (Vilnius). The roots of his family could be retraced back into the "Old Believers", fact which undoubtedly influenced the character of the future scholar, who was firm, withdrawn and tenacious. His childhood was probably fairly difficult. He had a chance to obtain only primary education, and that, too, was interrupted shortly before World War I.

He had retained his love for Lithuania during the whole of his lifetime. Later in his life he sought to conduct experimental expeditions in his homeland.

In 1915 he fled together with his family from the invading German troops into the heart of Russia – first to the Novgorod Province, then to Orenburg where he was hired as a worker at the locomotive depot of the Tashkent Railroad. The October Revolution changed his life abruptly. An ambitious and romantic young man, he volunteered for the Red Guard and literally rushed to conquer his happy future. He was known for his active participation in the fights with insurgents of Ataman Dutov and the struggle with the Basmachi in Central Asia, where he served as a commissioner and investigator in the bodies of the All-Russian Extraordinary Commission for Fighting Counter-revolution and Sabotage (VChK). This type of career evidently played an important part in Semyonov's fate. In 1922 he was sent to the Petrograd Higher Military-Pedagogical School, and in 1923, after the release from the army, without any special efforts, he entered the Historical Faculty of the Herzen Pedagogical Institute.

During that period Semyonov made attempts at special studies of the earliest tools. That subject was then extremely topical. The book by Noiret "*Tools and Their*

Significance in the Development of Mankind", published in 1925, was undoubtedly immediately noticed by the inquisitive student. This volume was found in the scholar's private library with his pencil marks along the margins.

In 1927 Semyonov successfully defended his degree work "*Vozniknovenie orudiy truda*" (*The Origin of Tools*) and a year later he left to the Kanin Peninsula in the Arctic Zone as a Geo-botanical Assistant. Clearly, he was not so much interested in the Tundra plants as he strove to enter the land of the Nenets (Samoyeds), to observe with his own eyes their primitive life, their 'primeval' tools and their fishing and hunting techniques. After his return to Leningrad he experienced an unsettle
d period. Teaching did not attract him. He rushed about in search of an interesting job and tried himself as a man of letters. At a contest of the magazine *Mir priklyucheniy* (*The World of Adventures*) he won the first prize for his story "*Urus-Batyr*" (1929) and the second prize for the story "*Pod zhalom skorpiona*" (*Under a Scorpion's Stinger*; 1930). In the same period he wrote essays about the life of the Nenets on the Kanin Peninsula. Simultaneously he was seriously occupied with self-education preparing himself for scientific work.

The year of 1931 proved to be a decisive for Semyonov's career: he became a postgraduate of the State Academy of the History of Material Culture (Gosudarstvennaya Akademiya Istorii Material'Noy Kul'tury, henceforth GAIMK). The sphere of his interests remained the same, i.e. the most ancient tools.

His previous experience as a 'crime detective', to some extent, inspired him with the direction to take in his research. We must add here that similar research was already well under way at the time. The Director of the Institute of Historical Technology N.P. Tikhonov had pointed out the necessity of studying raw materials, tools, techniques of their working and microscope examination of traces of the use of different implements in order to understand technical conditions of the ancient labour. Even earlier, G.A. Bonch-Osmolovsky supported the functional approach to the archaeological evidence. His works were greatly appreciated by Sergey Semyonov. The well-known scholars V.A. Gorodtsov, P.P. Efimenko and M.P. Gryaznov also had already mentioned several times the possibility to determine the function of different tools by traces of wear.

At the beginning of the 1930s GAIMK came to be on the threshold of an acute crisis. On the one hand, the scientific atmosphere was propitious to the young assistant's attempts to conceive the functional essence of tools, on the other hand, this atmosphere was so much impregnated with politics that research suffered from imposed dogmatic schemes. Semyonov deliberately evaded ideological dogmatism. He occupied himself only with specific technical and technological reconstructions. For him it was important to discern a fact in the archaeological evidence. We should not forget that those were terrible years for science: in 1933–1934 G.A. Bonch-Osmolovsky, M.P. Gryaznov, A.A. Miller and S.I. Rudenko were imprisoned. In 1936 arrests of the heads of the GAIMK began. They all were accused of sabotage or to be spies of some foreign countries. Semyonov escaped convictions.

At that stage of his activity he appeared as a technologist. The specific methods of studying engineering, technology and the mechanical processing concerned with them, seemed to be beyond the limits of the so-called 'Marxist archaeology' and indifferent to any ideological positions. He was however, an orthodox adherent to the historical and dialectical materialism. Much later, in the last years of his life, he was a firm opponent of the Neo-positivistic conception of J.G.D. Clark, regarding which, he would say (quite in the spirit of the 1930s): "*Archaeology [...] is able to solve successfully its methodological problems only on the basis of the Marxist-Leninist philosophy and the theory of historical materialism in particular*" (Semyonov 1978**:** 43-48).

According to Sergey Aristarkhovich himself, he started the development of the use-wear traces analytical method in 1934. Before that time, only few approaches to microanalysis of prehistoric tools had been tested. In 1937 he defended his degree dissertation "*Izuchenie funktsii verkhnepaleoliticheskikh orudiy truda po sledam ot upotrebleniya*" (*Studies on the Function of Upper-Palaeolithic Tools by Traces Left from their Use*). During the next pre-war years, the development of particular techniques in the examination of working areas of Palaeolithic tools under the microscope was carried out. Unfortunately, the scientific projects came to an halt with the beginning of the Civil War.

In the besieged Leningrad, Semyonov took part in the construction of the city's defences and served in the air-raid shelter. In 1942, he was obliged to evacuate to the 'Mainland' with a second-grade dystrophy. He lived in the town of Ivanovo where he worked at the Historical Faculty of the Institute of Education, teaching ancient history and history of art. Having returned to the Institute of the History of Material Culture after the blockade was raised in 1944, Semyonov started to carry out his scientific projects. One after another, his articles with marvellous discoveries appeared.

The revolution in use-wear observations of tools was carried out by means of a very primitive microscope with a magnification of up to 45 magnitudes. Semyonov had been working for a long time with obsolete optical equipment. Only after the war, fairly good Zeiss equipment for micro- and macro-photographing and improved microscopes adapted for photography were acquired. He was working in a small room partitioned off from the Institute draftsmen and artists who also were working here bothering him constantly with their irrelevant talks. His major work "*Pervobytnaya tekhnika*"

(*Prehistoric Technology*) was published in 1957. It described methods to identify different traces of wear, mostly on stone and bone tools, as well as traces of use of artefacts made with various materials. At that time it had been established "*...that almost any tool with traces of wear has, along with polished areas on the surface also some linear traces in the form of tiny marks, scratches or grooves indicating the direction of the movement of the tool and its position on the processed object. [...] The linear traces of wear proved to be an extremely important clue for revealing unknown functions of the first tools…*" (Semyonov 1957). The kinematics of tools became the most important object of the studies.

As the founder of the experimental wear-trace method of determination of unknown functions of tools and working processes, Semyonov became at once famous not only in the USSR but also abroad. His book was translated into English and published in London and New-York (1964). The works of the scholar met wide interest; archaeologists from France, Canada, Britain, India, Vietnam, Marocco, etc. visited him for training. He started to organise annual experimental expeditions, during which Neolithic tools replicas were produced, ancient working processes imitated, the productivity of prehistoric labour determined and, what is of primary importance, experimental artefacts with traces of wear created.

In 1968, his second book "*Razvitie tekhniki v kamennom veke*" (*Development of Technology in the Stone Age*) appeared, in which the problem of the technical progress of the oldest forms of manual labour was discussed. The third major work "*Proiskhozhdenie zemledeliya*" (*Origins of Agriculture*) was published in 1974. The experimental traceological method allowed Semyonov to bring to an end his discussion with Spurrell and Curwen on the identification of Neolithic stone sickles. A real revolution took place in distinguishing Palaeolithic flakes, points, scrapers, as well as choppers and large bifaces, i.e. the 'dragons' teeth' and 'thunderbolt arrows' mentioned above.

Some of the followers of the formal typological method in archaeology, expressed an undisguised scepticism concerning the functional determinations suggested, considering the method of Semyonov as an auxiliary one. It was often difficult for Sergey Aristarkhovich to attend sessions of the Palaeolithic Department in the 1950s and even 1960s when his reports were sometimes subjected to a 'destructive criticism'. He told me once after a session: "*Here are these young people sitting, discussing in earnest the artefacts, classifying the finds, distinguishing types, playing stones, distinguishing burins and scrapers whereas the burins were not always burins and the scrapers were more frequently used for cutting rather than scraping. This abstract nonsense is inconceivable. In the formal typology I can accept no functional definitions, but only the neutral ones as e.g. bifaces, polyhedrons etc.*". But even with the latest exclusively typological and morphological definitions Semyonov was at a loss. He wrote: "*There are for example such names as 'carinate' or 'discoid' tools, 'backed blades', 'notched tools', 'parrot-beaked tools', 'horse-hoot type', 'boot-last type', 'Chatelperronian', 'Gravettian' etc. Those are conventional names which have certain sense for distinguishing artefacts. But what were they in reality?… It is the traces of use on the tools that have proved to be the clue to reveal the purpose they were manufactured for by our ancestors*" (Semyonov, Manuscript). Semyonov rejected the formal typology based on the similarity of forms. He did not accept the ideology of Neopositivism, especially in the archaeology of 1950s-60s. Then some young scientists were captivated by methodological dogmas reduced to a logical analysis of the language of science with the formal logics taken as absolute.

Only after Semyonov's works had been recognised all over the world, the attitude towards his activity and to himself began gradually to change. At last, a separate room was provided for his laboratory. In 1974 Sergey Aristarkhovich Semyonov was awarded the State Prize. He had also a number of other awards: medals 'For the Defence of Leningrad' and 'For Heroic Work during the Great Civil War' and an order of 'Sign of Honour'. The life of Semyonov notwithstanding his natural versatility has proved to be astonishingly integral. He was interested in arts and even learned copy-painting of different canvasses in oil-paint. However, this passion had not overstepped the limits of a hobby.

The entire life of the researcher was focused on one main objective: he wanted to make 'dumb' things to 'speak'. This is true concerning not so much the mere functions of tools (with that problem he was constantly occupied) but rather the real modes of subsistence of human communities in the past. He was interested in the genesis of using tools. That is why he had always been interested in historical anthropology or paleoanthropology issues, from which there was only a short step to search for explanation of using tools by more evolved anthropoid primates. Semyonov was closely acquainted with N.A. Tikh. He knew fairly well the works of I.P. Pavlov, N.N. Ladygina-Kots and others who studied intellectual abilities of anthropoid apes, in particular, their behaviour concerned with tool using. He watched closely research carried out by the mentioned scientists. He knew also L.A. Firsov, in good health now, and visited his 'monkey-house' in Koltushi. Sergey Aristarkhovich undoubtedly was interested in the 'Rubicon' between the mind of an ape and that of a human being. During our discussions we arrived on different occasions to the conclusion that although artificial implements ('tools') do appear with apes, they are never accumulated. Their 'tools' have no history and it is natural that archaeologists never find these tools. The accumulation and history of technical means began from the very first steps of Man, i.e. from the origin of Olduvai and early Acheulian stone industries. According to paleoanthropologists these processes were occurring in eastern Africa 1.8-1.5 million years ago. The remains from Koobi Fora included stone flakes with traces resulted from cutting reed, butchering and working of wood. The origin of shape was exactly in those processes. When Semyonov told of shape-formation he implied primarily the creation of new artefacts and the use of new materials.

In spite of the popularity Semyonov had won among archaeologists, historians of technology, anthropologists and ethnographers, he was, as it seems, a lonely person in some respects. This was caused primarily by the non-recognition of his method. To my recollections, nonetheless, he liked to communicate with archaeologists, especially those of his own generation. In the manuscript quoted above I read: “*Our cause enjoyed persistent support of B.B. Piotrovskiy, P.I. Boriskovskiy, A.N. Rogachev, as well as N.N. Gurina. Invisible but strong threads of friendly concern were stretched to us from Moscow in the persons of B.A. Rybakov, D.A. Kraynov and others. We are sincerely grateful to all our above-mentioned and unmentioned friends*”. Since the late 1950s his hopes had been concerned with the experiments and new discoveries of his disciples who continued his lifework: G.F. Korobkova, V.E. Shchelinskiy, A.E. Matyukhin, N.N. Skakun and the author of the present paper. Later, Sergey Aristarkhovich wrote: “*During the second Crimean expedition A.E. Matyukhin ... over a fairly short time interval felled 35-40 trees with very hard wood by means of a chopper from a quartzite pebble. The chopper weighed 650 gram (the trunks amounting to 10 cm in diameter – A.F.). V.E. Shchelinskiy has struck from a single core 70 or 80 prismatic flakes, while A.K. Filippov has demonstrated that it is possible to work bone and horn with any fragment of flint. And those were only a few of their achievements*” (Semyonov, Manuscript).

Like any other technique, experimental use-wear traces identification of unknown functions of tools and products has its limitations. Disciples and followers of Semyonov are now occupied with a more detailed analysis of various type of work from different periods, whereas in the West, use-wear traces analysts are rather more narrowly specialised. They have excellent equipment at their disposal and working with the techniques of natural sciences they are able to identify with extreme accuracy polished areas and linear traces resulted from working of particular materials. Often electron microscopes and laser scanning are employed in these studies. The information obtained is conveyed to archaeologists who use it to their purposes. In Russia, the development of Semyonov’s method took a somewhat different direction. Most of his followers came to him directly from archaeology. Having retained the conduction of field works they carry out themselves excavation of archaeological sites, systematization and typological formalization of the recovered material, identification of the functions of artefacts and their interpretation within a particular archaeological context. Owing to Semyonov’s method we know that *Homo erectus* had a human-like economy although with extremely primitive cooperation of economic activities. Those creatures were in no way some absolutely wild half-animals and half-humans, neither their mode of subsistence was food gathering in the strict sense: they built dwellings, processed skins, cooked meat and gathered raw materials for making tools.

To conclude, it is worth to repeat that the fate of Sergey Aristarkhovich Semyonov was a difficult one, but to me it seems that he was happy. He mentioned once that he was a supporter of the ‘theory of balance’ according to which an instant of happiness for a scientific revelation is equal to many years of ordinary life.

In late January 2000, disciples and followers of Sergey Aristarkhovich gathered in Saint-Petersburg at the First Semyonov’s Readings. This was a demonstration of the triumphal parade of the experimental traceological method throughout the continents. In the second half of April 2005, archaeologists and use-wear traces analysts from all over the world gathered in Verona confirming once again the promising future of the experimental use-wear traces analytical method. According to Semyonov’s expression we are dealing with the fact of the emergence of a new science – “*archaeological functionology*”. To the latter, he devoted his entire life and never left his road.

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A story of the missing chapter: Sergey Semenov and his discovery

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Summary. *The paper deals with the history of the outstanding discovery of the use-wear analysis by Sergey Semenov. The aim of the paper is two-fold. Firstly, I want to illuminate the socio-historical context of the Semenov's research. Russian archaeology saw the early interest into lithic replication experiments and technology. Combined with the apparent influence of the Marxist ideas which dominated the Soviet archaeology of the 1930s these tendencies obviously stimulated the formation of the Semenov's approach to Prehistory. Secondly, I want to focus on some aspects of a scientific discovery. Long and contradictory history of gradual admittance of Semenov's use-wear studies in Soviet archaeology is the best illustration of typical reaction of a scientific milieu to the discovery and discoverer personally.*

Résumé. *Le présent article vise à mettre au point l'histoire de la découverte fondamentale de l'analyse fonctionelle fait par Sergueï Semenov. Cette article a deux buts. J'expose d'abord le contexte sociale et culturel de la recherche de Semenov à l'epoque. L'intérêt particulier à la technologie lithique et les expérimentations a des racines profondes dans la recherche préhistorique russe. Il est aisé de voir que la combinaison de cette tendance avec l'influence importante des idées marxistes dominantes à l'archéologie soviétique des années 1930 donne l'impulsion à l'élaboration de l'approche novatrice de Semenov. Il semble cependant raisonnable de discuter ensuite quelques aspects d'une découverte scientifique. L'histoire contradictoire de la reconnaissance assez lente de l'importance des études tracéologiques de Semenov dans l'archéologie soviétique est un exemple typique de la réaction du milieu scientifique à la découverte inattendue et au découvreur personnellement.*

Key words: scientific discovery, use-wear analysis, Russian archaeology, Marxism, lithic technology, experiments.

Introduction

The term "an archaeological discovery" is associated in the popular mind with spectacular discoveries of prehistoric sites or splendid artefacts recovered during excavation. In a very few occasions in archaeology we are dealing with the same kind of discoveries as in the "hard science", i.e. the important methodological advances opening new fields of inquiry. This is the case of Sergey Semenov (1964) and his discovery. The aim of the paper is two-fold. Firstly, I want to illuminate the historical context of Semenov's works, trying to demonstrate the importance of research traditions which existed and the concepts prevailing during the given time span for a discovery. The place and time of a scientific discovery are far from accidental. In the paper I try to explain why this important methodological achievement took place in the Soviet Union in the 1930s. I hope these facts will be of some interest to our colleagues beyond Russia not well acquainted with the history of archaeology in our country. Secondly, I want to focus on some psychological aspects of a scientific discovery. The long and contradictory history of gradual acknowledgment of Semenov's use-wear studies in Soviet archaeology is a good illustration of the reaction of a scientific milieu to an unexpected discovery and to a discoverer in person.

Background to the discovery: Russian prehistory in the early 1930s

It is impossible to analyse a scientific discovery without its historical context. Because of such connection it is worth mentioning two lines of inquiry in Russian prehistoric archaeology which obviously stimulated the efforts of Semenov during the 1930s. The first one is the deep-rooted interest in lithic technology, witnessed by the history of the Stone Age studies in Russia. As in the other

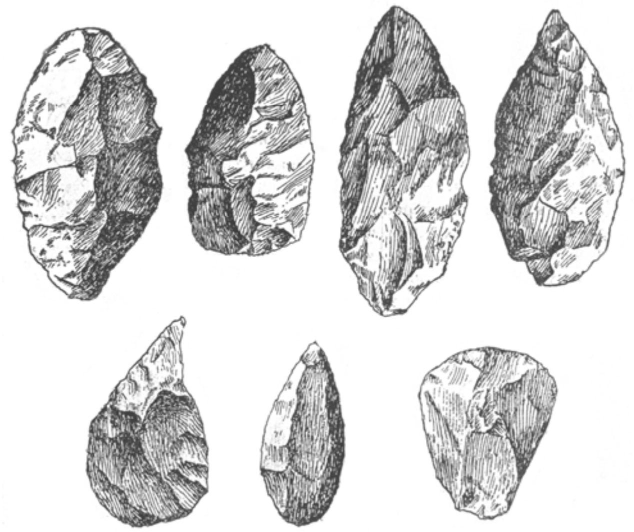

Fig. 1: Experimental lithic tools produced by Gorodtsov (after Gorodtsov 1935)

European countries (Honea 1983), Russian scholars also began flintknapping experiments. It is worth to mention an experimental work carried out at Istra near Moscow by Vassily Gorodtsov (1914; Fig. 1) as early as 1913. During the experiments the scholar reproduced artificial stone chipping comparing it with the natural splitting, thus trying to identify pseudo-artifacts. Gorodtsov mentioned that he initiated these studies without any prior experience in flintknapping, being a true pioneer of the experimental research in Russian archaeology.

The interest into technological studies in Prehistory continued later, during the 1920s. The radical re-structuring of archaeological activities in the country following the Revolution included the formation of the Institute of Archaeological Technology, one of the first

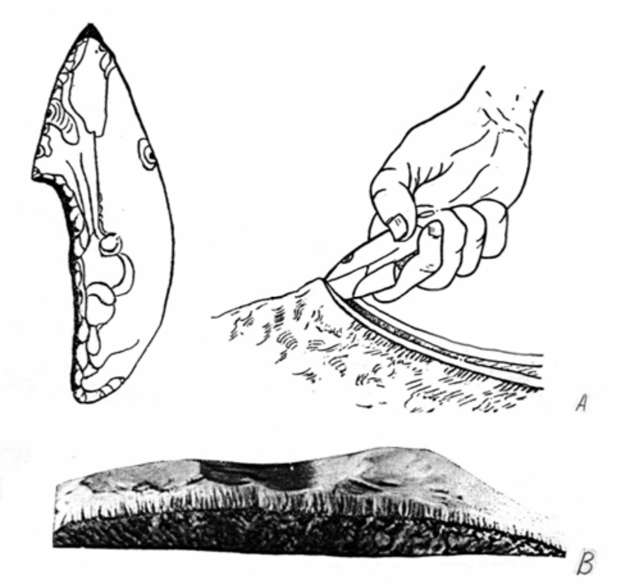

Fig. 2: First results of the experimental and use-wear research. A: shouldered point from Kostenki I and its presumed use; B: microphotograph of the working edge of a flint endscraper (after Semenov 1940b).

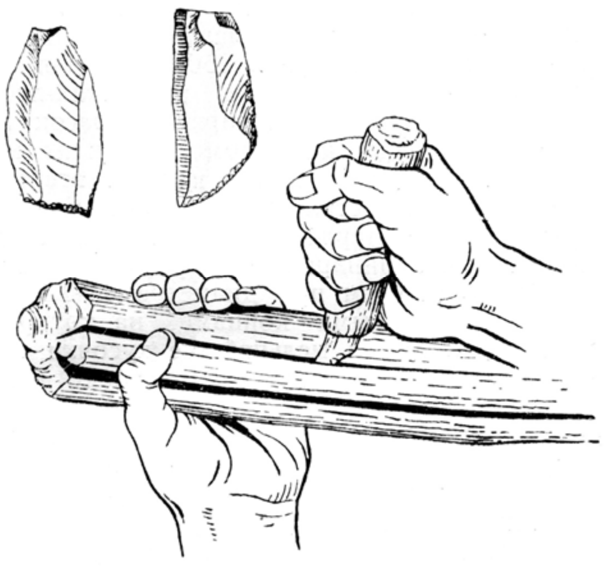

Fig. 3: Reconstruction of the ivory processing by flint tools (after Gerasimov 1941).

special laboratories for scientific studies in archaeology in the world. It was incorporated into the structure of the main archaeological institution of the country, namely the State Academy for the History of Material Culture. As for Lithic Studies, these were restricted to petrographic examination (Farmakovsky 1922). Curiously, the name of the Institute was much later restored by Rudenko after World War II as the Laboratory of Archaeological Technology. Semenov worked in it for many years before the opening of his own laboratory.

Bonch-Osmolovsky (Fig. 4) was among the pioneers of Lithic technological studies within Paleolithic

Fig. 4: Experimental flintknapping in 1956 (after Semenov 1968).

archaeology of the late 1920s-early 1930s. In many papers Semenov cited him as one of his forerunners. Bonch-Osmolovsky (1940) put forward for the first time the idea of a dynamic analysis of lithic tool manufacture, use and discard instead of static typological description. While analyzing the Mousterian assemblage from the Kiik-Koba cave (Crimea) the scholar pointed out the importance of the comprehensive study of the entire collection including lithic debitage instead of sampled formal tools and cores. Bonch-Osmolovsky emphasized the importance of those attributes as the form of working edges of tools.

The second factor is connected with the appearance of the so-called 'Marxist archaeology' pioneered by the theoreticians from the State Academy for the History of Material Culture in the early 1930s (Ravdonikas 1930). Proponents of this 'new wave' tried to substitute 'old and outdated' archaeology with a new science, titled 'material culture history'. This science should embrace all epochs of the history of humankind from the origins up to modern times, being based on Marxist concepts. In accordance with Marxist views, history of technology should be the core of this new discipline. From this viewpoint it is obvious that the study of prehistoric tools and technologies should play a crucial role for the reconstruction of the remote past.

In spite of these ambitious claims, very soon scholars realized a great discrepancy between the aims and goals of this 'new archaeology' and the lack of relevant methodologies oriented toward the reconstruction of the societies of the past. Works of the early 1930s abounded in criticisms against 'formal typology'. However, in reality, Soviet scholars of that time used the same typological classifications as their western colleagues. As for the functional identification of lithic tools these were restricted by purely speculative hypotheses and guesses (Bogaevsky 1936). Thus the elaboration of new methods of functional identification was called for. In this respect, Semenov's discovery was the one needed by Soviet archaeology.

The discovery and afterwards: a long way from rejection to recognition

Let us follow the steps of Semenov's early works. What follows is essentially based on archivist sources; some relevant biographic data have been published elsewhere (Rogachev 1983, Korobkova 1999a, b). Even before the beginning of his academic career, Semenov was interested in the study of prehistoric technology, at the time mainly based on relevant ethnological and archaeological literature. His MA thesis (1927, Herzen Institute) was entitled '*The origin of tools*'. After that, he continued his work and took part in the fieldwork in the North, where he had an excellent opportunity to study traditional crafts of local people. Semenov joined the State Academy for the History of Material Culture in 1931. Being a Ph. D. student he worked on the problems of human origins, the problem of 'eoliths', origin of fire, Early Paleolithic culture, etc. Under the supervision of the admitted leaders of Paleolithic archaeology in Russia, Efimenko and Zamyatnin, he began to examine lithic collections stored at the Museum of Anthropology and Ethnography. 1934 and 1935 saw the first experimental work on flint outcrops, in the Leningrad region. The same year witnessed the first variant of his thesis entitled (depending on the sources taken into consideration) '*The oldest tools and their use*' or '*The origin of tools*'. The years between 1934 and 1937 was crucial in the formation of use-wear studies. In 1937 Semenov defended his Ph.D. entitled '*The study of the functions of the Upper Paleolithic tools from Kostenki I, Timonovka and the Virchow Cave based on the wear traces*' (Semenov 1937). The same year saw the first public presentation of the results of the use-wear research during the Session of the European Association of Quaternary Studies held in Leningrad (Semenov 1940a, b).

While studying the collections Semenov recognised traces on the surface of tools, especially striations, damage, and micro-polish. For their examination he used the binocular microscope. He documented his observations as micro photographs of the working edges of tools made with an aid of magnesium coating (Fig. 2). As a result he established the widespread use of the famous side-notched points of the 'Kostenki-type' not only as projectiles but also as meat knives, the different use of end scrapers, borers, planing knives, etc. and the use of unretouched flakes in a variety of functions. In his dissertation he presented only microscopic data supplemented by some ethnological observations. The experiments were mentioned only as a potential source of information to be used in future research.

Semenov was not alone in his technological approach in the 1930s. At the same time Gerasimov (1941) presented his own reconstruction of bone, antler, and ivory processing at Malta (Siberia) based on observations, relevant ethnological data and experiments (Fig. 3).

After the long break connected with World War II, Semenov renewed his activities. From 1946 he began the study of Paleolithic bone tools, retouchers, mortars, etc. At a later stage, microscopic studies were supplemented by intensive experimental work on stone chipping, woodworking, working on antler, bone, etc. From 1956 onwards every year he directed the experimental expeditions (Fig. 4). Some evidence of these activities (a long wooden boat and an idol) can still be seen in dimly lighted corners of our Institute waiting for the opening of the Semenov's memorial room.

But things had changed. If during the 1930s new approaches to lithic analysis was badly needed by Soviet Marxist archaeology, it was not the same during the 1950s. This period saw fierce debates in Soviet archaeology when the stadial concept of gradual progressive development of the prehistoric culture was strongly challenged by the particularistic local culture approach pioneered by Rogachev. This focus on identifying different archaeological cultures, eliciting their genetic ties to cultures that existed before and after them, came to dominate in Russia in the 1960-80s. Unwarranted emphasis on purely local peculiarities of the Paleolithic, within the micro-areas studied, led to the consequent narrowing of the fields of research for scholars. An endless mosaic of small regional configurations replaced a coherent picture of cultural development. So it is hardly surprising that Semenov became a target of permanent and occasionally very hard critics from the members of the same Paleolithic Department of the Institute which he joined in 1951.

It is hardly possible to estimate the diversity of views of scholars based on published sources due to the peculiar character of Soviet archaeology where some critical opinions were not expressed openly and the majority of debates did not find their way to print. Some scholars simply ignored the method. Others admitted the importance of the edge polish and damage as an indicator of tool use. For instance, Boriskovsky (1953) and Rogachev (1955) used observations of this kind while describing the collections from Mezin and Kostenki IV. At the same time they criticized Semenov for his assumption concerning the lack of correlation between form and function in the Paleolithic lithic due to extreme variability in forms of lithic tools and their repair. Rogachev (1973) accused Semenov of underestimating the importance of tool forms which were considered as being ethnic indicators. Later, the most radical opposition to use-wear studies was formulated by Grigor'ev

(Anikovich 1978). He pointed out that use-wear examination could reveal only hints to the cinematic of a tool movement during the work. The use of tools could be accidental, not connected with their real function. And as for the experimental work, this had nothing to do with the reality of the past becoming the reflection of the experimenter's personal experience.

Debates were occasionally so hot that Semenov in 1954 after criticism moved by Okladnikov, Bibikov, and Boriskovsky, decided to exclude a special, second, chapter devoted to critical analysis of lithic typology, from the final version of '*Prehistoric Technology*'. This chapter later has been reworked and included in the collection of theoretical writings titled '*Methodological Problems of Archaeology*' which in its turn remains unpublished (Semenov, n.d. a).

> *"Mistrust showed by 'mainstream' archaeologists was obviously stimulated by Semenov's radical theoretical views. This aspect of his research, remains far from known, not only to foreign scholars, but also to contemporary Russian colleagues. The majority of Semenov's theoretical and methodological works remain unpublished. Semenov denied the importance of traditional culture-historical archaeology. He believed that the main aim of archaeology should be the study of material culture history, history of technology, and history of subsistence patterns instead of the study of particular cultural units".*

Semenov heavily criticized colleagues for the lack of interest into theoretical and methodological issues. He pointed out the need of a radical revision of archaeological research, including the reduction of fieldwork and the subsequent 'overflow' of collections. Instead of mere accumulation of raw data he argued for the need to develop new methods of laboratory studies of the data already collected. In accordance to his theoretical views, Semenov put forward an idea of new structural division in archaeology, introducing the idea of scholar specialization according to main material culture types, such as lithic tools, ceramics, subsistence, dwelling structures, etc., instead of traditional division according to periods and areas of study.

He pointed out that archaeological evidence represents only a restricted, fragmentary and heavily distorted portion of the culture of the past, thus all efforts to trace real historical events in remote Prehistory like migrations, or to identify ancient tribes and peoples are doomed to fail. Prehistoric reconstructions proposed by culture-historians, were considered by him as irrelevant. Semenov paid special attention to comparative analysis of different viewpoints on ethnic identification of late proto-historic cultures, trying to demonstrate the speculative and purely subjective character of studies of these kind. He demonstrated the connections between observed variability in tool assemblages and accidental factors, discard location, etc. Thus Semenov considered archaeological cultures not as clearly defined ethnic units (the view prevailing in Soviet archaeology in those days) but rather as a reflection of convergence in technology or as a result of long-term exchange networks which traditionally existed between different human groups. He believed that units established on the basis of the study of material culture should cross-cut ethnic boundaries.

Semenov sharply criticized not only traditional views on artefact typology, archaeological cultures, etc. but also more sophisticated variants of this kind of archaeology, presenting a comprehensive analysis of theoretical works which appeared in the West in the late 1960s-early 1970s (Rouse, David Clarke, Moberg, Deetz, etc.). At the same time, he welcomed attempts to develop a more dynamic approach to Paleolithic research (Sackett 1968).

The main target of his criticism was lithic typology. In some papers, Semenov limited himself to argue that typology could be of restricted value as a device for preliminary artefact description and sorting. In other cases he expressed more radical views, considering typology as a dead end. He wrote: '*... it is impossible to improve a typology like it is impossible to improve alchemy*' (Semenov n.d. b: 2). He believed that Paleolithic lithic "*functiology"* (the term coined by him for the combined study of lithics by use-wear examination and experiment) should supplement or even substitute Paleolithic typology (Semenov 1972). This radical change according to Semenov will be the real transition from the formal descriptive study typical of the early stage of development of a given scientific branch, to the real scientific inquiry oriented towards the explanation of cultural processes.

In general terms Semenov's approach was surprisingly similar to those of Leroi-Gourhan (1971). I could not find references to Leroi-Gourhan in Semenov's papers (generally the Russian scholar preferred to use English-written sources). At the same time, the two scholars shared the same set of principles, namely the fundamental unity of archaeological, ethnological and historical data, organised in order to reconstruct the global history of technology and to illuminate the law-like regularities in the evolution of tools, weapons and devices. According to Semenov, the stages of technology should form some kind of a 'cultural stratigraphy', a temporal succession of phases in cultural progress.

While discussing the history of acknowledgment of Semenov's ideas in our country it is worth to remind the Orwellian "double-mindedness'' as regards the official attitude towards scientific research in Communist Russia. On one hand, official propaganda claimed that Soviet science should be considered superior when compared to the Western one. This was considered to be especially true for social sciences like archaeology, being based on 'progressive' and 'true' Marxist theory. Following this logic it would have been a waste of time to compare Soviet achievements with the inferior Western science.

From the beginning, Semenov's method was proclaimed among the greatest achievements of Soviet science as opposed to the outdated 'bourgeois' archaeology with its 'formal typological schemes'. But on the other hand, the same science 'expert' in the Soviet Union closely watched for reactions to Soviet advances in the West, tacitly supposing that only foreign (i.e. western) acknowledgment of a Russian discovery was the true proof of its real and objective importance and value.

The case of Sergey Semenov is the best illustration of this strange phenomenon. While '*Prehistoric Technology*' published in 1957 was honored by the Prize of the Presidium of the Academy of Sciences the same year and admitted as Senior Doctorate next year, some suspects about the real value of his works remained. For many years Semenov worked alone. Only 1957 saw the appearance of his first student, future leader of the laboratory, Galina Korobkova. But only after the appearance of the English translation of '*Prehistoric Technology*' in 1964 was followed by numerous comments in foreign literature, he became a leader of a small research group, attracting Ph.D. students and guests from different research centres. Finally, in 1970 the independent Experimental Use-Wear Laboratory was founded and during the early 1970s Semenov was allowed to present his research findings abroad (in Yugoslavia and East Germany). This acknowledgment culminated in 1974 when Semenov among the few Russian archaeologists received the State Prize for two monographs (Semenov 1957, 1968).

Use-wear studies supplemented by the relevant ethnographic sources and experimental data served as the basis for large-scale culture-historical overviews of the evolution in different areas of pre- and proto-historic technology (Semenov 1968, Semenov and Korobkova 1983). The following decades saw the diversification of the research accomplished by Semenov's laboratory, including the development of sophisticated methods for use-wear examination of Lower and Middle Paleolithic artefacts, combined morphological, technological and experimental studies of pebble-tools and bifaces, studies of Upper Paleolithic bone- and antler working processes, etc. (Rogachev 1983; Korobkova 1994, 2004). Technological analysis of the Middle and Upper Paleolithic lithic industries greatly enlarged the field of inquiry (Girya 1997; Nekhoroshev 1999). Scholars from the laboratory published a manual on use-wear identification (Korobkova and Schelinsky 1996). These methodological advances coincided with the growing number of laboratories and scholars doing use-wear and experimental research. Apart from the main laboratory in St.Petersburg directed by G. Korobkova, use-wear studies are conducted in a number of research centers dispersed in Russia: from the European part of the country up to the Pacific coast (Kazan', Samara, Izhevsk, Ufa, Ekaterinsburg, Nizhnii Tagil, Novosibirsk, Barnaul, Chita, Vladivostok, Magadan, etc.) as well as in the former Soviet republics, now independent states (Ukraine, Moldavia, Georgia, Azerbaijan, Turkmenia, Uzbekistan, etc.). Overviews of use-wear and experimental studies in our country were published in European languages several times (Levitt 1979, Philipps 1988, Plisson 1988, Odell 1995, etc.) thus there is no need to enter into details.

Conclusion

Nowadays it is hard to find an archaeologist in Russia not acknowledging the importance of use-wear studies. Lithic analysis in its traditional static view is gradually giving way to more dynamic models oriented towards the study of the technology of stone knapping and tool manufacture, as well as reconstruction of the *chaîne opératoire*. It is connected with a growing trend towards the acceptance of 'behavioural' models explaining the variability in artefact assemblages. Meanwhile, the long isolation of experimental and use-wear studies from the 'mainstream' Paleolithic archaeology supplemented by the traditional mistrust between the so called 'typologists' and 'technologists' is still evident in Russia. In a number of cases use-wear studies are restricted by the functional identification of a few sampled implements instead of a comprehensive analysis of collections, thus preventing reconstruction of the whole spectrum of prehistoric activities. At the same time, the majority of scholars in Russia still tend to view the observed artefactual variability as uniquely reflecting 'cultural differences', thus the prehistoric past of Russia is interpreted in terms of the obsolete 'cultural-historic' paradigm. It seems that it would take years to gain mutual understanding and to develop more complex and sophisticated methodologies for lithic analysis.

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I owe a debt of gratitude to Nathalya N. Skakun who encouraged me to present this paper and to attend the meeting. My thanks go to the staff of the archives of the Institute for the Material Culture History where the large (144 folders) and not yet catalogued personal archive of Semenov is stored. This research has been partly supported by the 'Eurasia' Program of the Russian Academy of Sciences.

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From production traces to social organisation: Towards an epistemology of functional analysis

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***Summary**. This paper discusses the importance of functional analysis for archaeology from a theoretical and epistemological perspective. It is argued that functional analysis offers a way to place our ideas about the economic development of societies within the study of their material remains. This requires the development of an economic theory in archaeology, which proposes a way to link the "traces" of human labour with the social organisation of production and reproduction.*
Starting from the principles proposed by Classical economic thought, we approach the structure underlying social production and reproduction. Such a definition of economy obliges us to consider the forms of appropriation or allocation of the generated products and, ultimately, to ask for the objective causes of social inequality. A crucial aspect in this discussion is the social division of labour as a decisive factor in the economic development of societies and of the production of surpluses.
Finally, the discussion of economic theory in archaeology concludes that functional analysis can be understood as the study of the material changes subjects and objects experience through their participation in social production. At an empirical level, rather than use wear traces, what should be identified are production traces, understood as the physical attributes resulting from the social life of objects as well as subjects. At an analytical level, the proposed economic scheme allows us to distinguish different types of traces which are linked to the production and consumption processes in society.

***Résumé** Le présent article discute de l'importance de l'analyse fonctionnelle pour l'archéologie, d'un point de vue théorique et épistémologique. Il plaide que l'analyse fonctionnelle offre le moyen d'introduire, dans l'étude de leurs vestiges matériels, nos réflexions sur le développement économique des sociétés. Ceci requière le développement d'une théorie économique en archéologie qui propose une façon de lier les « traces » du travail humain à l'organisation sociale de la production et de la reproduction.*
A partir des principes proposés par la pensée économique classique, nous approchons les structures sous-tendant la production et la reproduction sociales. Une telle définition de l'économie nous oblige à considérer les formes d'appropriation ou de distribution des produits générés et, ultimement, à nous interroger sur les causes objectives de l'inégalité sociale. Un aspect crucial dans cette discussion est la division sociale du travail en tant que facteur décisif dans le développement des sociétés et la production de surplus.
Finalement, la discussion de la théorie économique en archéologie conclue que l'analyse fonctionnelle peut être comprise comme l'étude des changements auxquels sont soumis les sujets et les objets au travers de leur participation à la production sociale. A un niveau empirique, plutôt que des traces d'usage, ce sont des traces de productions qui devraient être identifiées, comprises comme les attributs physiques résultant de la vie sociale des objets aussi bien que des sujets. A un niveau analytique, le schème économique proposé nous permet de distinguer différents types de traces qui sont liés aux processus de production et de consommation en société.

Key words: Economic theory, social division of labour, functional analysis.

Since the publication of Semenov's *Prehistoric Technology* more than 40 years ago, functional analysis has come to occupy an increasingly important place in archaeology. While in Western Europe its use was mainly restricted to the study of flint tools from hunter-gatherer societies, recently, it has been applied to a growing variety of archaeological materials and to practically any type of social organisation.[1] Specific research methodologies have been developed in order to extend the use of functional analysis to artefact categories such as pottery, metals or wooden objects; an approach which had not been initially considered by Semenov. At an empirical level, conventional microscopic observation of the artefacts' surfaces is now increasingly complemented with experimental work, ethnographic information, contextual studies and residue analyses. The main result of this field of research has been the identification of a variety of work processes, activities and implements, which has allowed the recognition of the often unexpected complexity and diversity of technological devices developed by human societies.

In view of the increasing technical sophistication of functional analysis and the growing body of generally very detailed – metaphorically one could use the term "microscopic" – empirical information on artefacts, it has become necessary to raise questions about the position and relevance of this research within the framework of archaeology, as well as its relevance to our understanding of the history of society in general. While Semenov himself developed use wear analysis as an archaeological methodology within the theoretical framework of historical materialism, and considered technology to be a crucial aspect of the forces of production which determine the different modes of social production, recent trends have been, generally speaking, more empirically orientated, focussing mainly on the way tools were used in the past. A critical examination often reveals the mainly anecdotal character of the information obtained, as the relationship between the particular action carried out with an artefact and the context of social and economic organisation in which such an event would make sense remains unresolved. Such an approach limits functional analysis to becoming just another auxiliary technique, but justifies the common, although academically not uninteresting, claim to being considered a new field of highly specialised research with its own

[1] The diversity of archaeological issues which are starting to be addressed by functional analysis became clear during a recent conference held in Barcelona (Clemente *et al*. 2002).

need for staff, budgets, university courses, conferences, etc. It must be concluded that either the original expectations were unrealistic and methodologically weak, or that too little effort has been made to explore the heuristic value of this methodology for archaeology. In the following pages we will try to address this problem through a discussion of the theoretical implications of functional analysis.

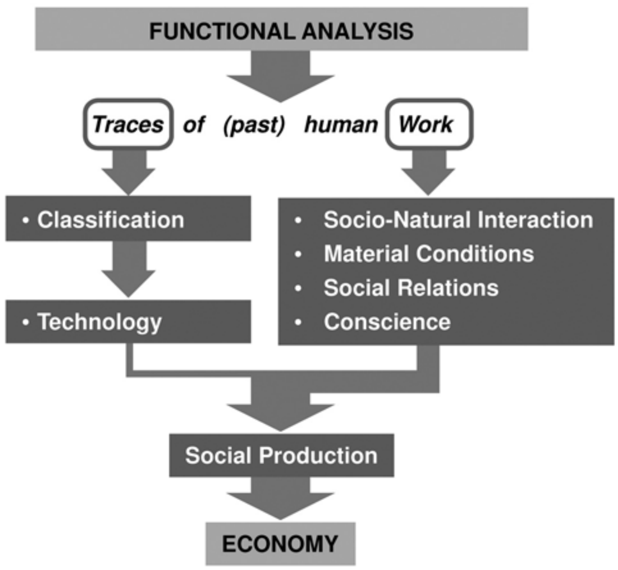

Fig. 1: The theoretical implications of functional analysis.

Archaeological research presupposes a capacity to define the object of study (the social and historical question), on the one hand, and on the other hand the physical objects (the empirical base), which helps us to address the first. Furthermore, any statement about the material realm requires a methodology that allows us to observe, define and order the reality perceived. That is to say, a methodology that establishes the inferential relations and the logical structure that link phenomenological observation and abstract conceptualisation, and vice versa. Of course, such concepts only make sense and have any heuristic value when they are set in a theoretical (ontological) framework that recognises a structure of causal relations (Fig. 1). With regard to Semenov's approach, we can suggest that the object of study of functional analysis is human work, while its empirical references are the traces visible on all objects that have been manipulated by people. Consequently if the emphasis is placed on the physical traces of human activity, research will centre on their classification and relation to specific operations. Such a positivist approach is capable of recognising repeated actions and sequences of operations, which in archaeology are commonly defined as *technology*. On the other hand, if the importance of human work is stressed, then the emphasis falls on processes, which are always located in an invisible past, rather than in a given object/product. From this necessarily theoretical perspective, a completely different set of issues becomes relevant, such as the social context in which the activity took place, the relationship between that society and its natural resources, or the resulting process of self-consciousness. Rather than discussing the epistemological strengths and weaknesses of each of these approaches, it would seem to be more promising to attempt a dialectical discussion between them by establishing the links between the abstract concepts we are using and the traits we observe. In my view, this exercise shows that functional analysis is not just another archaeological technique, but that it plays a crucial role in any attempt to understand the material conditions of human life, which can be called *social production* (Castro *et al.* 1998).

If functional analysis is defined as the study of labour processes by means of social matter (subjects and objects), it should enable archaeology to tackle three basic economic issues: 1. What is being produced? 2. How is it being produced? and, 3. Who produces it? These questions describe the process of production, but the acknowledgment of their historical implications in a given social organisation requires a solid body of economic theory. From this holistic perspective, functional analysis represents a basically archaeological methodology which allows the application of the postulates of economic theory to the study of social materiality. Unfortunately, most of modern economic theory focuses on market behaviour rather than on production processes. Its metaphysical orientation, based on the subjective notion of "scarcity"[2], hinders a historical explanation of pre-capitalist economic organisations, and this is partly the reason why archaeology has generally only adopted apparently value-free functionalist approaches to economic issues.

The question of economic explanation

The search for an economic theory capable of addressing the question of the material and energetic requirements for social development implies going beyond the paradigm of scarcity and the law of supply and demand introduced by the Marginalist approach at the end of the 19th century. This paradigm is used not only in the analysis of capitalist market economies, but more or less explicitly underlies most modern social sciences. When individual competition and maximisation is established as the universal law ruling human relations, the reduction of economies to the realm of prices and individual choice, rather than more tangible parameters such as natural resources, technology or social necessities, means that the modern economic school avoids facing any contradictions with the material conditions of human life.[3] Archaeology, still a materially bound discipline, is

[2] Menger, one of the "fathers" of the Marginalist school, defined economic goods exclusively as those goods for which individual necessity is greater than their available quantity (Menger 1871/1985: 84-94).

[3] While writing these pages, the American stock market is going up at the same pace as the magnitude of the destruction and casualties caused by hurricane Katrina become known.

therefore obliged to search for an alternative economic paradigm which allows the establishment of links between the conceptualisation of the notion of socially usable energy and socio-economic development.

One possible starting point is obviously Aristotle, considered to be the inventor of the concept of the economy. The well known definition he proposes in *Politica* emphasises that *oikonomia*, or house-holding, and not *hrimatismos*, or moneymaking, provides the necessary resources for social life. The basis of real and morally acceptable wealth can only rely on the cultivation of land. This paradigm maintained its validity in the Mediterranean through the ancient and medieval periods. In the 18th century, the first modern school of economic analysis, known as Physiocracy, was still presenting a model in which the total income of a country depended ultimately on the exploitation of the land. Manufacturing, trade or the national budget were only considered to be the consequences of a certain distribution of the initial wealth generated by primary production. Many peasant societies still operate with such a model in order to explain the material and energetic cycles underlying their subsistence economies (e.g., Gudeman and Rivera 1990).

The first radical paradigm shift occurred at the end of the 18th century, when Adam Smith intended to demonstrate in *The Wealth of Nations* that the key element in economic development was not natural force, but human labour and its "productive capacity". For more than a century, Political Economy made labour the abstract principle ruling economic theory. In *Das Kapital* Marx not only challenged the established academic position by questioning the value theory sustaining Political Economy, but also presented a thorough analysis of the importance of technology in any productive process. This paradigmatic breakthrough allowed Marx to formulate the first systematic account of the interrelation between productive forces and social organisation from hunter-gatherer societies to capitalism. The concept of "modes of production" was introduced in order to synthesise this dialectic interaction between the economic means and property rights that characterise each historical moment.

Each of these "classical" positions offers a different definition of the energy sources necessary for human existence in a given physical environment. Independently of how these sources or economic factors have been valued throughout history – before being excluded from liberal economic thought – they actually express the physical principles of any economic organisation and can thus be articulated in what we have called the *basic economic schema* (Fig. 2). Its variables are the labour objects (LO), first of all land, given its importance as an accumulator of energy, but also all other socially transformable materials, including their energetic values; the labour force (LF), understood as human labour; the labour means (LM), i.e. all the technical elements used in the economic activity; and the product (P) or final aim and result of the activity. Most work processes also generate by-products, but their consideration as residues or as materials which can be recycled and used in other production processes depends more on social decisions than on the technology available.

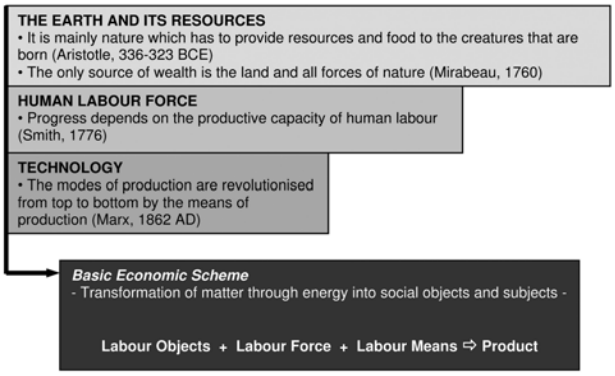

Fig. 2: Economic theory and the basic economic schema.

The basic economic schema represents an abstract formulation of the economic factors underlying the production of material goods. Yet, it has been one of the main contributions of feminism to show that many other vital activities have been excluded from modern economic analysis, such as the everyday care of people, storage of goods or the biological reproduction of society (e.g., Vogel 1983; Carrasco 1991). In order to overcome such a partial and unequal evaluation of the activities which warrant the material conditions of human existence, it is considered that all societies reproduce themselves through three types of production process (Castro *et al.* 1998):

a. *Basic Production* guarantees the biological reproduction of society. It is socially necessary work and can be carried out exclusively by women.
b. *Object Production* provides all the utilities a society requires and has been overvalued by classical economic schools.
c. *Maintenance Production* maintains or improves the physical, chemical, aesthetic or affective characteristics of social subjects and objects. It implies an increase in the social value of things without a modification of their original use value. As its aim is to avoid the exhaustion of subjects and objects, it represents an important part of the gross product of society, which historically has been provided to a large extent by women.

All three production processes function according to the basic economic schema and they reveal that men, women and objects must participate in the production of social life in very different ways. Moreover, *the final aim of all production is consumption, while the production process itself implies a consumption process*. Raw materials or tools, for example, are the material result of given labour processes, and at the same time labour objects and labour means are consumed in new economic processes. Equally, the labour force needs to be first generated and

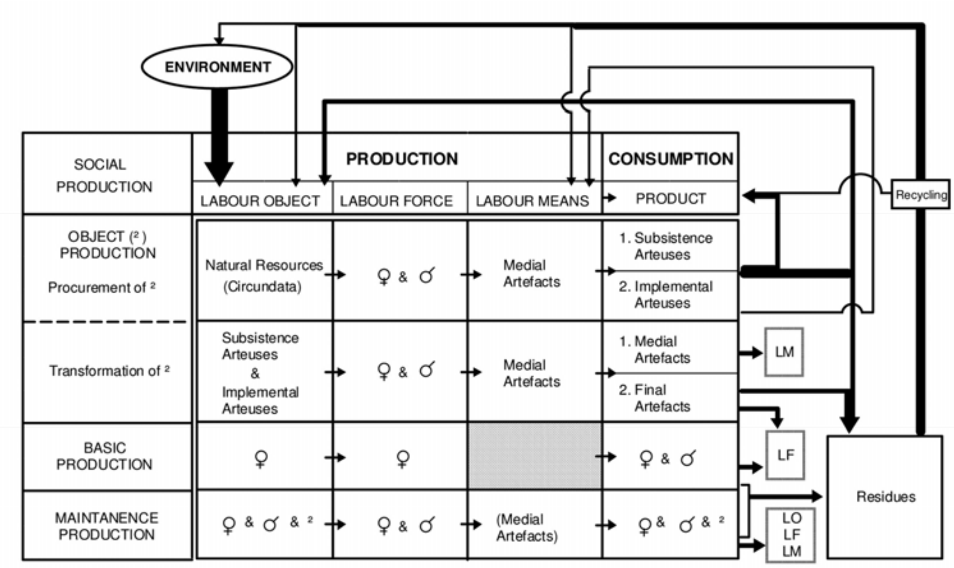

Fig. 3: The cycle of reproduction of social objects and subjects.

then maintained before entering the basic economic schema. This dialectical relationship between production and consumption, known as the paradigm of *social reproduction* (Marx 1857-8/1973; Sraffa 1960), implies, among other things, that every social object (and subject) is the result of a production process and is the condition for a different consumption process. As such, from an archaeological perspective we have to recognise that *all archaeological remains should be analysed from two different perspectives: firstly as matter that has been worked into an object; and secondly, as an object that has been used and consumed*. Moreover, the cycles of social reproduction imply a constant transformation of the social matter formed by men, women and objects, in successive production/consumption processes, until the complete exhaustion of the object has occurred, together with the replacement of its social value. The analysis of the economic organisation of society from this ontological standpoint requires the comprehension of the structure of the three forms of social production in terms of the basic economic schema (Fig. 3). Archaeologically, at least, this means examining the material implications of the reproductive cycle, and confirms that archaeological objects are not units of meaning, but rather represent a network of levels on which the dialectical relations between nature and society, and between at least two sectors of society – male and female – are expressed. Lull (1988), in his *theory of archaeological objects,* already proposed that the materiality of the archaeological object informs us about the environment it originally comes from (*circudata* or natural material); its dimension as a socially appropriated part of that environment (*arteuse* or used material); and about its dimension as an artificially transformed material (*artefact*). Depending on the function of an object in the economic cycle, one can further distinguish between subsistence, implemental, medial, final and residual used materials and artefacts (Risch 2002, pp.19-24).

The next step is to ask if this or similar sets of categories can actually be related to the archaeological record. One way of approaching this problem is by developing better definitions of the material properties of the objects through petrographic, botanical, faunal or other interdisciplinary methods. These “identifying” or denotative procedures can inform us about the source and the potential or probable utility of the archaeological remains, but they are inadequate for tracing their participation in a given production and consumption process. A common feature of the material transformation occurring throughout the reproductive cycle is the development of particular “traces”, i.e. attributes resulting from the working, consumption, handling, use, aging or simple exposure to a given environment of social matter. It is less the inner essence of things than the multiple aspects of their appearance that express not only the creation, but also the lifecycle of things. From this perspective, *“traces” are defined as all physical attributes resulting from the social life of subjects as well as objects*. The study of traces involves the totality of the archaeological record understood as *arteuses*, *artefacts*, *anthropological remains*, and those *circundata* associated with them. Given its concern with the observation of “traces” on materials, it is the responsibility of functional analysis to use the archaeological record to define how women, men and objects succeed (or not) in organising social reproduction. The main technical challenge of functional analysis lies in the identification of the archaeological materials as factors in the basic economic schema proposed or in any other economic model.

The economy in society

Having defined what we mean by economy, it becomes crucial to reconstruct what we previously deconstructed, and to link it to social organisation in general. Not only are we interested in describing the nature of the productive processes, and what material value they have generated, but we also have to understand their implications for social, political and ideological structures. The aim is to move from forms of production to relations of production and ownership.

The difficulty of organising a society’s economy resides in the fundamental differences between the stages it has to go through in order finally to satisfy individual necessities (Marx 1857-8/1973). *Production, as an*

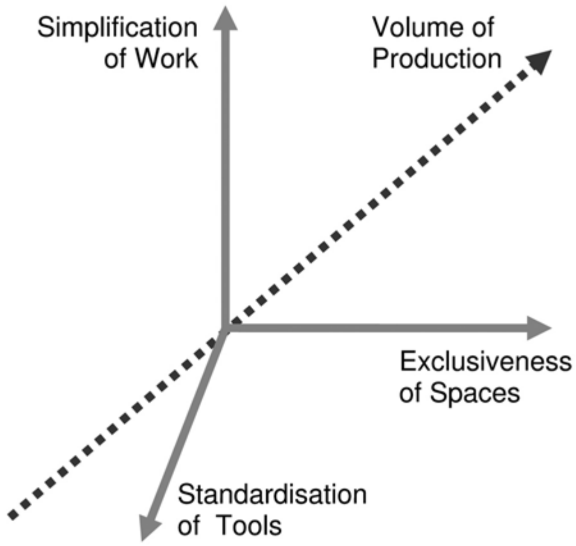

Fig. 4: The four economic parameters of the division of labour.

abstract category, is always a social action, given the social nature of the human species. Independently of the type of activity and how it is carried out, the meaning of production goes beyond the satisfaction of the needs of the individual worker to the general reproduction of the community he or she belongs to. Production not only generates the objects and subjects of consumption, but also generates the need for them. *At the opposite extreme, consumption, whatever its social or private context, is an act of individual appropriation, an existential necessity of each member of society.* Through consumption, new needs are created, which immediately produce the motivation for production. The responsibility for overcoming the opposition between social production and individual consumption falls to distribution. Gifts, tributes, theft or commodity exchanges are particular historical forms of organising individuals' share in production. Yet the social laws that enforce a given system of distribution are only the consequence of a previous organisation of production, and in particular of the distribution of labour objects and labour means in society. The power of Marx's introductory chapter to the *Grundrisse* still lies, in our view, in its emphasis on the relation between general production, particular distribution and singular consumption as dynamic elements of a socio-economic totality. History is not reduced to technology or production processes, but rather appears as the result of the changing relation between these elements of social production. Ultimately, this means searching for the economic as well as political and ideological structures responsible for the generation of material *wealth* and *surplus*, two of the motives underlying the development of our species.

Every society has to engage in a series of activities in order to satisfy its materials needs, but there is no predetermined form in which these tasks must be carried out. Throughout history, different societies have developed or adopted countless technical and social variants in order to organise their economies, so responding to changing needs and material conditions. The product obtained constitutes the material wealth of the society.

From a long-term historical perspective, social wealth has maintained an upward trend, although at very unequal rhythms depending on the geographical region and time period, and interrupted by periods of clear reversal. Such increases in production have been achieved by modifying, quantitatively or qualitatively, some of the factors of the basic economic schema, either by increasing the force of labour, or by improving, in material or technical terms, the means and objects of labour. While the former approach only permits an increase in production, the latter approach also achieves an improvement in productivity, understood as the quantity of value obtained per unit of labour.

The historical development of societies' material wealth and the means used in their production undoubtedly constitute one of the main economic issues in archaeology. Nevertheless, as we have seen previously, this analysis is partial, as it considers wealth as merely a natural result of production and not as an indispensable value for social, and as such, for individual reproduction. From the perspective of consumption, the other question which must be tackled is the access of all the members of a community to this material wealth; in other words, the distribution of social production.

If we approach this issue once again from a historical perspective, it can be seen that the degree of inequality in the distribution of production has fluctuated considerably over time, and does not follow a rising trend. In principle, the earliest state-like societies in Mesopotamia and Egypt do not seem to have followed more equitable redistribution systems than, say, the Greek city states, the Roman Empire or the Caliphate of Cordoba. Even within contemporary capitalism, there are important differences between some countries and others in terms of redistribution of production, although the tendency over the last few years has been one of an increasingly evident concentration of global wealth[4]. What seems clear is that increases in production and productivity are not inevitably associated with greater social inequality in terms of consumption, which is a source of hope for the majority of humanity.

When we take on the question of the unequal distribution of social production, we need to be able to establish when an object, produced according to the factors of the basic economic schema, becomes a surplus. *Surplus is defined*

[4] So, for example, the 200 richest people in the world have more than the combined income of 41% of the world's population (Informe 1999, p.38).

as the share of production which does not revert in any form to the group or individual that has generated it. As such, it always implies an unequal individual appropriation of social production. Surpluses appear when the appropriation of the material result of labour is socially restricted and becomes private property of an individual, group or class. To be sure, this is not just the result of an increase in production, as is usually suggested by functionalist archaeology, but is mainly the result of an unequal distribution of the material and energetic costs and benefits within society. To deny the social character of surplus production, and to confuse it with wealth, is an attempt by modern economic thought to obviate the economic causes of social exploitation, and to present technical and economic progress as neutral, value free processes. Yet, if we conceive surplus as profit or rent, as Smith or Ricardo still did, this negation becomes unsustainable. *To determine how surpluses are produced is a problem for economic analysis, but discovering the forms of appropriation and consumption used in its production relates directly to the study of a group's social organisation* (Risch 2002, pp.24-28).

The level of economic exploitation and social inequality of a community depends on the degree of asymmetry between social production and individual consumption. Surplus, property and social exploitation are interrelated concepts. Furthermore the institutionalisation of surplus as property is the consequence of a previous appropriation of one or several of the factors of production (LO, LF, LM and P) in any of the three spheres of social production. As such, *surplus is not the mechanical result of all economic development, but rather depends on certain social conditions which require a historical explanation*.

The same strategies that can increase social wealth can also be used to obtain surpluses: an increase in producers' labour time brings about *absolute surplus value*, while an improvement in the means of production and, as such, in productivity, generates *relative surplus value*. If increased wealth always requires an increase in production, the generation of a surplus, in principle, only implies that the appropriation of the product is no longer kept in proportion to the labour investment of all the members of the society. Its first physical expression is the appearance of people who do not work, or who work less, and the direct archaeological implication of this would be an unequal distribution of the means of production. A relative surplus is characterised, furthermore, by technical improvements in the means of production which, as such, should be possible to analyse archaeologically. Insofar as it has repercussions on consumption conditions, a surplus-generating economy also affects the material properties and energy values of the labour means and resources used in production, and of the social benefits obtained through their use. In any form of production, it can be suspected that, if the material and energetic characteristics of its factors of production produce negative consequences for the population's health, nutrition or habitat, then there are private interests underlying this situation, which somehow benefit from the worsening of society's living conditions. As such, the factors of production acquire qualitatively different forms and characteristics depending on whether a surplus is produced or not, and depending on how it is produced.

The economic conditions of surplus production involve variables which should be analysed archaeologically, such as the division of labour, the improvement of the technical means of labour and the volume of production. Functional analysis, understood as the recognition of all work traces left on all socially used material, as well as on anthropological remains, plays a key role in such a research programme. While the identification of traces presents information about technology and the organisation of production and consumption, the number of traces and the analysis of the degree of wear relates to the volume of wealth generated by a community.

The social character of surplus production is expressed physically through the relations between spaces of production and spaces of consumption and, clearly, in agents involved, their injuries, illnesses and nutritional conditions. The location of the types of traces and, as such, of the activities undertaken in space and time allows a better understanding of the distance between the places and the agents of production and consumption. In short, these are the main archaeological issues to be addressed by the study of the economic development of societies and their drift towards surplus production.

Division of labour and surplus

The *division of labour* has played an extremely important role in the economic analysis of societies, being understood as one of the fundamental mechanisms in the production and increase in wealth and/or surplus (examples in archaeology are provided by Childe 1951; Friedman and Rowlands 1977; Renfrew 1982; Lull 1983; Vidale 1992). Often, a direct relation has been established between specialisation on the one hand and the production of surpluses and increases in productivity on the other. Nevertheless, both approaches are problematic, since the existence of a surplus is linked to social exploitation, and productivity depends much more on the labour means than on the labour force.

By contrast, the generation of more products, or of new types of objects, that is to say, an intensification of production in a society, always implies an increase in the labour force or of productivity, which can imply the division of labour, but not necessarily the generation of a surplus. In this sense it is convenient to distinguish between strictly technical divisions of tasks, intended to increase production, and the social division of labour, which generates social differentiation and asymmetry and whose goal is to obtain a surplus (Castro *et al.* 1998). The complexity of the notion of the division of labour makes a precise definition of its strictly economic implications necessary, while its social nature refers once again to the problem of the distribution of material and energetic costs and benefits in the community.

The merit of having recognised the role of the division of labour in the improvement of productivity goes to Adam Smith. The mechanisms implied in this economic phenomenon are: 1) the specialisation of labour, understood as a means to allow the simplification of manufacturing processes; 2) the improvement of the spatial organisation of production; and 3) mechanisation (Smith 1776/1994). As such, productivity only increases if the labour specialisation includes a technical and spatial division of the labour processes and/or if the instruments and raw materials used are made more efficient. *The first physical consequence of this type of division of labour is a reduction in the variability of all or some of the factors of the basic economic schema* (homogenisation of labour movements, spaces of production, the instruments and material and energetic resources used). Given that the degrees of specialisation in each of these factors are variable and are not technically correlated, the division of labour can be organised in many ways. *Secondly, the volume of production is the variable required for quantifying the division of labour and its productivity* (Risch 2002, pp.31-33).

In short, the division of labour should be defined in terms of:

1. S*implification of work*;
2. E*xclusiveness of the spaces of production*;
3. S*tandardisation of the means of production* (raw materials and means of labour).
4. *Volume of production*.

It is important to underline that *labour specialisation* is not equivalent to an increase in the technical sophistication of the activities involved, as has frequently been argued in archaeological studies. Rather, it relates to *an exclusive activity in a particular space and time, which is expressed in a multiplication of exclusive production spaces, and results in a higher volume of production than is required by the consumption needs of the individual or domestic group*. As a consequence of the greater division or individualisation of the production processes, there is also an increase in the productive exclusivity of the spaces of labour. The degree of specialisation of these spaces varies to an inversely proportional extent to the number of different activities carried out in them, and is expressed materially in the diversification and/or dominance of the technical conditions of those spaces.

Another recurrent postulate in archaeology has been the existence of a positive relationship between labour specialisation and the standardisation of the products obtained. It is implicitly assumed that the formal and physical characteristics of the products are determined exclusively by the technical processes, and that they lack any other social significance. This is clearly not a valid premise, as consumption objects ("final" artefacts), frequently act as political and ideological mediators in numerous social practices. Nor in the case of tools ("medial" artefacts) is there any evident direct relationship between specialisation and standardisation, given that there is generally not a single technological approach available to obtain the majority of products (e.g., Lemonnier 1993). Instead, if a *specialised labour instrument is defined as a tool which is always used to perform the same task*, there seem to be three levels at which specialisation and standardisation can be interrelated:

1. *Functional standardisation of the artefact*; as the result of the use of the object, is expressed in the standardisation of the working or active surfaces in terms of size, shape and types of wear traces.
2. *Material standardisation of the artefact*; as the result of the appropriation of the raw material, is expressed in the physico-chemical characteristics of the object.
3. *Morphometric standardisation of the artefact*; as the result of the selection of the raw material and the production process, is expressed in the reduction of the metric and formal variability.

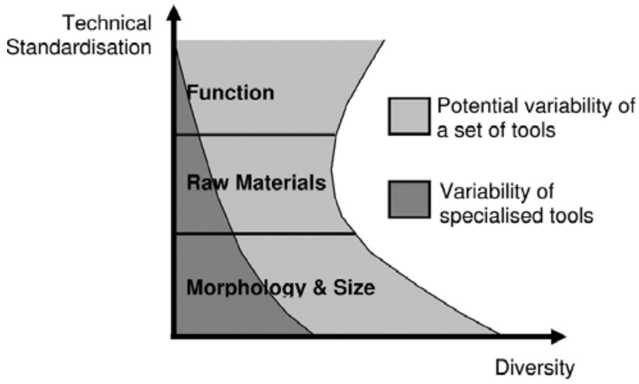

Fig. 5: The relation between standardisation and technical specialisation.

The importance of these three levels of standardisation is proportional to the degree of specialisation of the artefact (Fig. 5). The greater the regularity of the labour action, the greater the standardisation of the work surface. To increase productivity, an attempt would be made to improve and regularise the raw material used. There is often a range of alternative materials available for the satisfaction of the same requirement. Ultimately, the regularity of the work will result in a normalisation of the form, size and weight of the tool. Here, the possibility of extra-economic factors coming into play is even greater. Once again, how this schema can be applied to archaeology depends on the level of development of the functional analysis, not just when determining the use of the objects, but also in order to understand the technical conditioning of their production and consumption processes.

In summary, we feel that these three qualitative parameters (simplification of labour, exclusivity of the spaces of production and standardisation of the means of production) and one quantitative parameter (volume of production) allow the definition of the different historical expressions of the division of labour as a decisive factor in the economic development of societies and of the production of surpluses.

Functional analysis and the study of production and consumption processes

We have seen previously that production and consumption form the continuous cycle through which society reproduces itself. Consequently, *functional analysis can be understood as the study of the material changes subjects and objects experience through their participation in social production.* These changes originate from basic production, maintenance production and object production, as well as from the lifecycle, employment and exhaustion of the subjects and objects generated.

At an empirical level, we can recognise the production/consumption processes by means of different *traces,* understood in a broad sense as *the physical attributes resulting from the social life of objects as well as subjects* (from a microscopic scale – for example a scratch – to a structural scale – for example, an accumulation of charcoal and ashes), using different experimental and analytical techniques (microscopy, residue analysis, chemical analysis, paleoanthropology, etc.). As a starting point, we can relate these traces to the ways material has been used, which enables us to recognise the human remains, artefacts and all other socially used materials as factors in the basic economic schema of the different social production systems.

A second level of functional analysis consists of the location of the production traces in space. The combination and association of traces gives us information about the socio-economic practices carried out in a given space, and, most importantly, allows us to establish the distances existing between production and consumption. Finally, the traces left by individuals' activities to be found among the anthropological remains are an indispensable element for determining if this spatial distance corresponds to a social and/or spatial asymmetry.

From the economic model outlined above, it can be deduced that the traces we observe, even leaving to one side post-depositional processes, have been produced by different types of activities according to the economic structure of the societies. In this sense, it is clearly insufficient to refer to the traces and marks left by social production on an object or subject, as "use wear". Instead, we should talk about *production traces, understood as all physical and chemical transformations that have taken place during the circulation of any subject or object in society*. Epistemologically, the concept of *production traces* goes beyond the identification and description of wear traces (stigmas) and establishes their relationship with particular activities. In agreement with the structure of social reproduction, it is possible to differentiate between the following types of *production traces*:

1. *Manufacturing and gestation traces*: Transformations brought about in objects during the production process and in subjects during basic production, respectively. Except in the case of some raw materials obtained through direct appropriation, these traces tend to be present in all the factors of the basic economic schema (LO, LF, LM and P).
2. *Maintenance traces*: Traces resulting from maintenance production, potentially appearing in all factors, but principally in the agents (men and women) and in the means of labour. The analysis of manufacturing and maintenance traces are the indispensable condition for the archaeological identification of an object as an artefact, as well as allowing us to determine the production value of social matter.
3. *Use traces*: In a strict sense, the term use traces only refers to those traces brought about in the means of labour and the force of labour as a result of transformation, generation or intentional maintenance of objects, women and men. Its presence in objects delimits and characterises that which is normally known as active surfaces, which, in turn, distinguish medial artefacts, or tools. In the case of anthropological remains, it covers both the use of parts of the body as productive instruments (for example, teeth) and indications, in the bones, of occupational stress.
4. *Wear traces*: In general, these are a range of signs of physical wear and/or chemical alteration produced by the use and consumption of any social materiality, separately from the generation of other goods. These traces are produced intentionally or inadvertently during the lifetime of use of all social objects. Materials that only have wear traces and no use traces are final artefacts. Use traces and wear traces provide information about the use value of social objects.

Such differentiation of *production traces* not only allows the identification of a given material as a social object, but it also relates the multiple signs of wear to economic factors in each of the different spheres of social production. These traces appear on artefacts and other socially used materials, as well as on residues generated by production and on the anthropological remains of the social subjects. The abstract classification of traces does not automatically mean that we will be able to identify them technically, but it allows us to become aware of the different social practices that can lead to the features that we are looking at, as well as the relevance of particular observations to a general economic theory.

Production Traces \ Economic Factors	LO +	LF +	LM ⇨	P
Manufacture traces	(+)	+	+	+
Maintenance traces	(+)	+	+	(+)
Use traces	-	+	+	-
Wear traces	+	+	+	+

Fig. 6: Production traces and their economic meaning.

This paper has attempted to discuss some aspects of the general structure of human economies and to draw attention to the historical questions that derive from it. By disarticulating the cycles of social reproduction into economic factors, moments and spheres of social production, it has been possible to reflect on a series of material implications which, in principle, can be approached archaeologically. To this end, functional analysis appears to be the only archaeological methodology which has the heuristic potential to place the different material remains and traces in their social context. The shift of focus from traces to production and its social organisation opens up new perspectives in the research into the historical development of human societies, and, in this sense, recovers the intention of Semenov's original proposal.

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Tool functions and ethnographical analogies

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Summary. *The use of ethnographic parallels for the explanation of ancient tool functions is widely adopted in various archaeological studies. For instance, some ancient tools received their names by analogy with ethnographically known implements. However traceological data show that morphologically identical tools could have been used for different functions, and ethnography gives examples of morphologically different tools with identical functions. Therefore our functional interpretations should be confirmed by the traceological study of both archaeological and ethnographical objects.*

Résumé. *Le recours aux parallèles ethnographiques pour la compréhension de la fonction des outils anciens est largement répandu dans les études archéologiques. Par exemples, certains outils reçurent leur nom par analogie avec des instruments ethnographiques. Cependant, les données tracéologiques montrent que des outils identiques peuvent avoir été utilisés de façons différentes, tandis que l'ethnographie donne des exemples d'outils de morphologies différentes mais aux fonctions identiques. C'est pourquoi nos interprétations fonctionnelles devraient être confirmées par l'analyse tracéologique à la fois d'objets archéologiques et ethnographiques.*

Key words: tools, morphological study, use-wear analysis, ethnographic analogies.

Ethnographic records are often used in archaeology both for interpreting isolated finds and for constructing broad generalizations. First of all this applies to the materials dated to the Stone Age. Even the terminology used in typological descriptions of various archaeological artefacts is often based on their comparison with ethnographic objects. For instance, the names of many ancient tools, signifying their functions, go back to ethnographic records (e.g. borers, scrapers, burins, and so on). The use of ethnographic data has numerous limitations, but they still allow us to "revive" archaeological facts when modelling various aspects of ancient human life.

Russian archaeologists differ in their approaches to the use of ethnographic data. Some of them question the reliability of ethnographical analogies because of the big chronological gap separating the latter from archaeological finds. In addition, they point to the singularity of most analogies and impossibility to verify them by statistical methods.

In his works, alongside with other issues, S.A. Semenov considered the question of the possibility to use ethnographic observations for identifying ancient tool functions and reconstructing past economic behaviour. He believed that this is, firstly, necessary, since ethnographic data may help to reveal types of economic activities and to characterise specific features of ancient technologies "in concrete technical details" (Semenov, 1968:7), and, secondly, possible, because traditional culture is very conservative and tends to retain archaic things, whereas later elements can be easily identified. To illustrate this point he referred to the stability of the everyday use of objects in the Shoshon Indians during some hundreds of years after the discovery of the New World.

S.A. Semenov thought that ethnographic information about various methods of tool manufacture can be useful for the reconstruction of ancient technologies after archaeological materials. For example, the information about the methods used by Australians to grind and polish wooden artefacts led to the discovery of abrasive wood-working tools in the Neolithic of Eurasia (Semenov 1968:110).

Experimental-traceological analysis uses ethnographic analogies both at the initial stage, when formulating hypotheses on the functions of artefacts, and for the verification of the results of such studies (Semenov 1957, 1968; Semenov, Korobkova 1983; Skakun 1981,1985,1993, 1993, a; Aleksashenko 1999). Many experiments devoted to the study of ancient tools are based on the imitation of technologies known from ethnographic descriptions of economic activities in traditional societies. Subsequently the results of these experiments are compared with archaeological facts. Not infrequently such experiments allow to correct ethnographic records. In many instances archaeologists, by means of experiments, were able to prove that in reality ancient tools and technologies had been more effective, than it was testified by travellers and ethnographers. For example, in one of Semenov's experimental expeditions a log canoe was hollowed out in 10 days, whereas S. Krasheninnikov wrote in the 18th century that it took the Kamchadals 3 years to make such a boat. To verify his functional definitions Semenov, when possible, compared use-wear traces on archaeological and ethnographical objects. With this purpose he microanalysed Australian, Oceanic and Siberian stone, bone and wooden tools from the ethnographic collections of St. Petersburg museums.

As a result of these works it was established that tools of different forms could be used for the same function and that tools of identical forms could have different functions (Semenov 1968, pp.4-5). The shape of the working edge and use-wear traces should be considered the major criteria for the determination of tool functions.

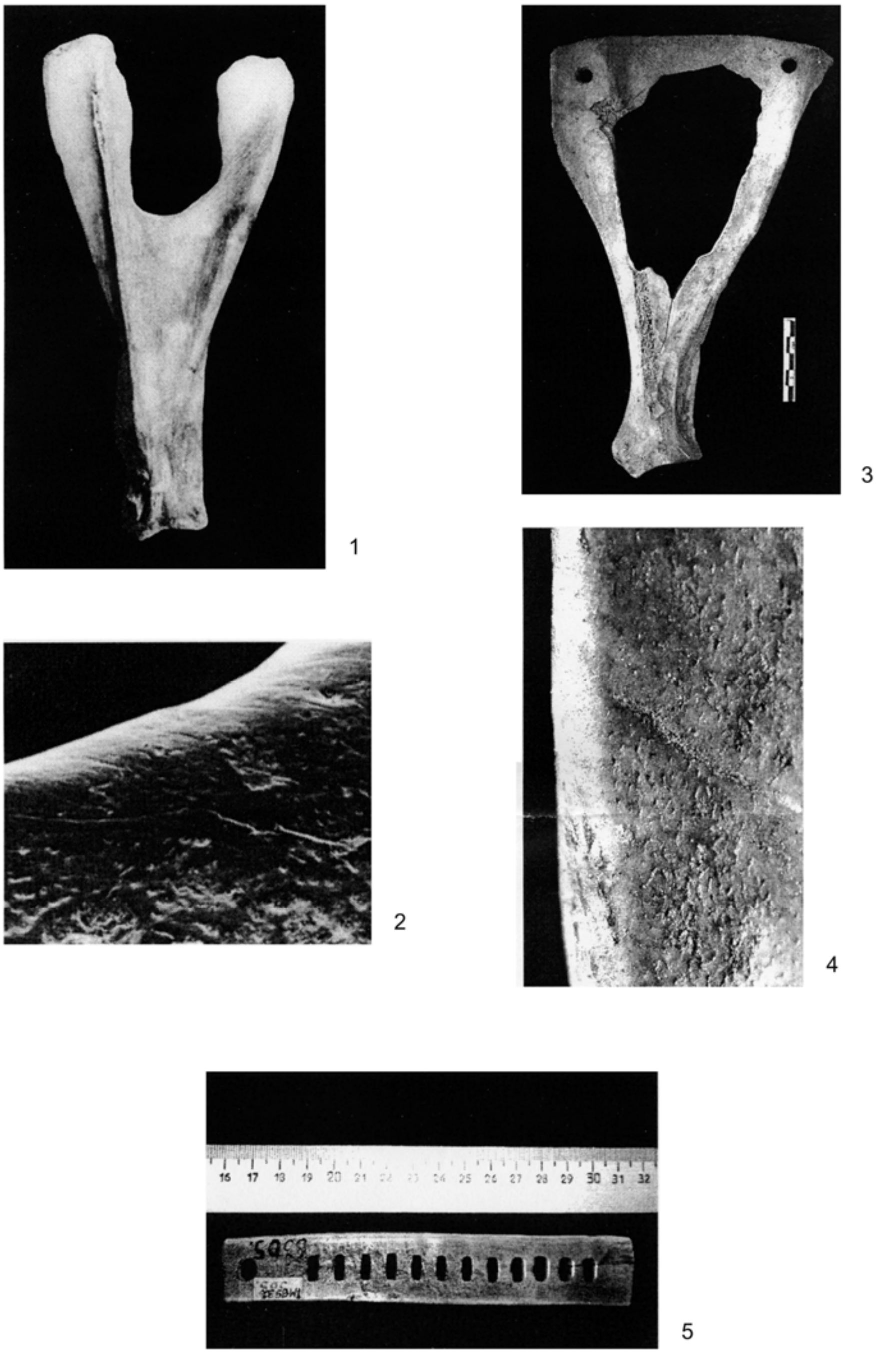

Fig. 1: 1) Tool from Ezerovo II; 3) Tool from Yarte VI; 2) Use-wear traces on the working edge of the tool from Ezerovo (x 32); 4) Use-wear traces on the working edge of the tool from Yarte VI(x 32); 5-6) An ethnographic implement used to stretch out raw hide belts (the Ethnographic Museum of Tobolsk, Siberia).

The outward resemblance between ancient artefacts and those known from ethnography should be treated with a great caution. For instance, Semenov's study of such categories of objects as end-scrapers and tools used on hides, demonstrated a considerable variability of their forms in archaeological and ethnographic collections.

In our paper we would like to dwell on some questions related to the use of ethnographic parallels for the identification of tool functions. Some interesting observations pertinent to the subject were made by us when we studied tools made of animal shoulder-blades, which were similar to each other in shape, but came from archaeological sites of different age situated in different geographic regions. Some of them, dated to the Early Bronze Age, come from the territory of Bulgaria where agricultural economy had existed since early times, while the others, dated to the Iron Age, are from the regions of northern Siberia populated by hunters and reindeer-breeders. In both cases the shoulder-blades had intentionally cut U-shaped or V-shaped openings (Fig 1, 1,3).

The tool from Bulgaria comes from the destroyed settlement of Ezerovo II (Fig. 1, 1), situated on Lake Varna shore (Tonceva 1981). In as much as the tool was used for a long time it is impossible to say now how the opening was made and how the edges of the shoulder-blade were cut and rounded. The maximum degree of wear is observed at the bottom part of the U-shaped opening (Fig. 1, 2). Here the edge is rounded due to its use, and both surfaces are heavily polished as can be easily seen with the naked eye. The polish goes far from the edge, and in its intensity it resembles the mirror-like shine on the edges of flint sickles or on their bone handles. Easily seen are also linear traces going parallel to each other and at right angles to the working edge (Skakun 1993). Similar tools made of animal shoulder-blades, with V-shaped openings and semicircular small holes on their lateral sides, were found by P. Anderson in the materials of one of the Near Eastern Neolithic sites (Stordeur and Anderson-Gerfaud 1985). Judging on the character of wear, these implements were used to hull seeds from the ears. Experimental work has confirmed this traceological conclusion.

Analogous tools of shoulder-blades were found on the Medieval settlement of Yarte VI on the Yamal peninsula in the north of Siberia (Fig. 1, 3) V-shaped openings were made in their centre, and the edges of these openings, like those of the Varna tool, were rounded due to utilization. However, both the character and position of the linear traces and polish are quite different (Aleksashenko 2002). The tools from Yarte VI have dense short striations on the bottom part of the opening, which go across its edge and sometimes reach adjacent areas. One can see here also a narrow stripe of rich shine (fig. 1, 4). Similar tools with U-shaped openings, made of elk shoulder-blades, are found in the Mesolithic of north-eastern Europe (Oshibkina 1997, p.92, Figs. 65-6).
Ethnography of different peoples gives numerous examples of various use of animal shoulder-blades. Sometimes they were used for utilitarian purposes, sometimes served for fortune-telling. The highest degree of similarity with the archaeological specimens is demonstrated by the tools that are still used by the Khanty to dress and stretch raw leather belts. Traceological analysis has shown the identity of wear traces on the tools from Yate VI and on the ethnographic specimens. This type of wear was described by S.A. Semenov in one of his earliest works, devoted to the bone belt-softeners from the Medieval settlement of Rodanovo (Semenov 1947, 1957, pp.223-225; 1968, pp.168-169).

The comparison of wear traces identified on archaeological and ethnographical specimens has allowed us to prove that tools made of shoulder-blades from the settlement of Yarte VI were used to stretch narrow leather belts. Of interest is the fact that in the course of work with ethnographic collections the same traces were found on an object of quite different shape. This is a bone blade with 12 holes (Fig. 1, 5), through which belts were put when being stretched (Aleksashenko 1999). This fact demonstrates once again that tools of different shapes could well have been used for the same purposes.

Thus the study of shoulder-blade implements with openings from Ezerovo II and Yarte VI has shown that similar tools had quite different wear traces and different functions. On the other hand, ethnography gives examples of bone tools which have nothing in common shape-wise, but still are used for the same purpose.

By focusing on these examples from our practical experience, we would like to emphasize, firstly, the inadmissibility of straightforward ethnographic parallels in archaeology, and, secondly, the necessity to use only those ethnographic analogies which come from a close environmental and economic milieu. In addition, to prove the identity of functions of archaeological and ethnographical tools it is particularly important to undertake comparative traceological analysis on them.

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S.A. Semenov and his outstanding discovery in 20th century archaeology

Galina F. Korobkova

Summary. *After "Prehistoric technology" was published in English, simultaneously in London and New York in 1964, Semenov's discovery became known and acknowledged all over the world. S.A. Semenov succeeded in distinguishing and classifying the most common use-wear traces characteristic of different groups of tools, what became a critical step in the creation of the experimental-traceological or functional method. The importance of this work can hardly be overestimated. It is thanks to it that tools became an independent source of information about ancient economy. This paper reviews the most significant works of S.A. Semenov and starts to explore further developments introduced in Russian traceological research by Semenov's pupils.*

Résumé. *Après que "Prehistoric Technology" ait été édité en anglais, simultanément à Londres et New York en 1964, la découverte de Semenov devint notoire et reconnue partout dans le monde. S.A. Semenov maîtrisa la distinction et la classification des traces d'usage les plus courantes de différents groupes d'outils, ce qui fut une étape déterminante dans la création de la méthode tracéologique expérimentale ou fonctionnelle. L'importance de ce travail peut difficilement être surestimée. C'est grâce à lui que les outils sont devenus une source propre d'informations sur l'économie ancienne. Le présent article examine les travaux les plus significatifs de S.A. Semenov et regarde les développements ultérieurs introduits dans la recherche traceologique russe par ses anciens élèves.*

Key words: S.A. Semenov, traceological method, microanalysis.

The discovery of the traceological method in the 1930s was a real revolution in archaeological science. Archaeologists obtained a key to understand functions of ancient tools. Stone, bone and antler tools, which had seemed speechless before then, suddenly began to tell us not only about their functions, kinematics, and manufacturing technologies, but even about the material they had been applied to, the same material often absent on archaeological sites. This event turned out to be an important link in the chain of studies devoted to the economic activities of ancient societies, since it is tools with their functional content, kinematics, and connection to the worked raw materials, that lie at the foundation of economic reconstructions. In addition, when studied in relation to their distribution within a site, tools can shed an important light on the inner structure of ancient settlements. It is not surprising that the discovery of the traceological method by professor Semenov had revolutionary consequences for archaeology. After his work "Prehistoric technology" was published in English, simultaneously in London and New York in 1964, Semenov's discovery became known and acknowledged all over the world. S.A. Semenov succeeded in distinguishing and classifying the most common use-wear traces characteristic of different groups of tools, what became a critical step in the creation of the experimental-traceological or functional method. The linear traces of wear were considered by him one of the most important diagnostic traits.

His scientific career started in the 1930s, and the results of his early research devoted to the method were described in his degree dissertation "*A study of functions of Upper Paleolithic tools and their traces of utilization*", which was successfully defended in 1937. The importance of the newly created method can be compared to that of typology. The former became an important addition to the latter, since it made it possible to obtain information about functions of ancient tools and opened the way for paleo-economic reconstructions.

In the 1940s Semenov published his first papers on the application of microanalysis to Upper Paleolithic and Neolithic artefacts.

In 1957 S.A. Semenov published "*Prehistoric Technology*", which marked the beginning of a new stage in the development of archaeology. The methods described in this book allowed archaeologists to determine functions of different tools, to make correct assessments of ancient technologies and economies, to widen the interpretation of the archaeological record. In this work Semenov describes the theoretical foundations of his methodology, the methods of laboratory analysis of artefacts, he gives numerous examples of how microanalysis can be applied to particular archaeological materials of different periods. The text is supplemented with numerous microphotographs and graphic drawings illustrating different kinds of use-wear traces. The book for the first time explains the beginnings of the experimental-traceological method, opening a new direction of research in archaeology: the study of tool functions through the use of microscope and by means of experimentation.

The importance of this work can hardly be overestimated. It is thanks to it that tools became an independent source of information about ancient economy. Before the appearance of the new methodology they had served as a mere supplement to the information obtained by palynologists, paleobotanists, paleozoologists, etc. The judgements on the character of their use were based exclusively on their morphology, which, as we know now, often does not coincide with their function.

At this point, one would think, most projects materialized and it was possible to take a rest. But Semenov did not stop. He continued to develop his methodology and ideas. A result of this was his new monograph "*The development of technology in the Stone Age*" (Semenov 1968). In this book he uses archaeological, experimental and ethnographic data to consider different ways of stone raw material acquisition and working. The book contains also a detailed description of the Stone Age wood-working and bone-working, as well as game cutting and processing. The second part of the book is devoted to the development of fire-making, building, and means of transportation. In addition, Semenov acquaints the reader with the problems of the study of ancient hunting and fishing practices. On the basis of both archaeological and ethnographic data he describes different ways of hunting and fishing in Australia and Oceania, in the tropical zone and in the North, and dwells on the general regularities in the development of these branches of economy. He discusses at great length the problem of technological progress in the initial stages of human history.

After he discovered the method of experimental-traceological analysis of stone tools, retraced the evolution of stone-working and other production activities, demonstrated the possibility of paleo-economic reconstruction through the functions of ancient implements, S.A. Semenov worked hard on the development of new approaches to the study of tools. In 1971 he and V.E. Shchelinsky created the method of micrometric analysis of stone artefacts, designed to determine functions of weakly worn or little known tools by means of quantitative study of use-wear traces (Semenov and Shchelinsky 1971). Unfortunately, this method did not become widely adopted because of the complexity of the analytical procedure.

A special place in Semenov's works was occupied by the problems of early agricultural technologies, including the question of farming tools functions and efficiency. Results of his research devoted to this subject are described in his seminal work "*The origins of farming*" (Semenov 1974). In this monograph he considers various questions associated with the origins of farming and gives the description food gathering economy, characteristic of the earliest world centres of agriculture, reconstruction of the ancient farming systems and techniques, as well as the dynamics of ancient farming tools and agricultural cycles. A particular attention is paid to harvesting and cereals processing technologies. Semenov studied use wear traces on reaping implements and explained how the polish could have formed on their surfaces.

Experiments were of crucial importance for Semenov's research. They were very diverse and thematically differentiated. His experimental studies prompted the revision of many traditional paleoeconomic and cultural views, especially those related to functions and efficiency of ancient tools. The numerous experiments, which were carried out by him in 16 expeditions, convincingly demonstrated the importance of the experimental method for the study of ancient tools and technologies and for our understanding of the early economic and production systems.

Experiments became for archaeologists an important source of new information, a means for identification and verification of tool functions and reconstruction of production processes, a basis for the development of the methodology of micro- and macroanalysis. Results of the most important experiments were described in a number of Semenov's papers and in the joint monograph "*Technology of the oldest productions. Mesolithic-Eneolithic*" (Semenov and Korobkova 1983). The chapters of the monograph written by Semenov are devoted to the characteristic of the Upper Paleolithic and Mesolithic tools, as well as to the processing of fibrous material in primitive societies, spinning and weaving, technology of wood, bark and skin working, pottery making, sewing of fur clothes. Special attention is given to the progress of tools and techniques, which allowed people to exploit new land resources inaccessible before, and to develop new and more diversified and specialised forms of economy (Semenov and Korobkova 1983, pp.236-237).

S.A. Semenov constantly and tirelessly worked on the problems of theory and methodology of the experimental-traceological studies, as reflected in his last paper "*New methods in the study of ancient technology and economy*" (Semenov 1978).

Though the last page of Semenov's creative biography closed a long time ago, we still remember his works and gratefully use his inheritance. Forty years have passed since Semenov's main work was published in England, USA and Spain, but this monograph still remains to be an indispensable manual for modern traceologists. Semenov founded the Russian tracelogical school. His first pupils were G.F. Korobkova, V.E. Shchelinsky, A.K. Filippov, A.E. Matyukhin. Later they were joined by N.A. Kononenko, T.S. Shirinov, T.M. Mirsaatov, K. Stiyanov-Kinchev, N.N. Skakun. Among the pupils of the first alumni of Semenov's school are V.V. Kileinikov, G.V. Sapozhnikova, K.M. Esakia, O. Lollekova, N.A. Aleksashenko and many others.

In the last 40 years many significant changes have taken place in the realm of traceological studies. They consist in the diversification and further elaboration of our methods and approaches, in the use of new techniques of microanalysis, in a considerable broadening of the range of artefacts and raw material analysed within traceological research. Traceologists have started to pay particular attention to the reconstruction of ancient economic systems and production activities and to the revelation of the inner structures of human settlements. Traceological analysis can be applied now to material of different periods: from the Oldowan to the Middle Ages. Traceology enabled archaeologists to make a number of important inquiries into the past. The elaboration of the functional typology (Korobkova 1987; Korobkova and

Shchelinsky 1996) contributed to our reconstructions of the ancient economic systems. The combination of traceology with site planimetric data allowed us to reconstruct the production structure of the Neolithic and Bronze Age settlements (Korobkova 1969, 2001). Of equal importance is the popularity of traceological studies and training of professional traceologists. All this is to a large extent based on the rich scientific inheritance left by professor S.A. Semenov.

Experimental archaeology: the Italian experience

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The international congress, organised by the Natural History Museum and University of Verona (Italy), if on one side can be explained as the results of the strong efforts made by the Prehistory Department of the Museum, on the other hand it has to be said that falls in a very favourable international framework: the title itself which recalls the 40th anniversary of what can be considered the founding of the functional analysis S. A. Semenov, it has an important effect.

It has to be pointed out that for almost 150 years the study of human artefact production has concentrated on the observation, classification and study as means used by the archaeologists to demonstrate the presence of human groups in a given period. It is a kind of information which cannot be replaced with any other source, this is particularly true for the period before writing appearance; nonetheless it is worth to say that chrono-typological methods, together with hard sciences ones, need to be continuously developed. But the history of last forty years studies demonstrates the risk of not considering the material production from the point of view of ancient people production necessities but only from the chronological and topographical one of the archaeologist.

To enlarge the range of data that a human product can provide, we should start first of all from the fact that whatever is deriving from cultural evolution must be considered an attempt, more or less experienced and developed, to solve a problem. Just this issue becomes the guide-line of the research. When the topic regards material culture, such as survival production to solve or improve the quality of life, we do not consider “material” as the essence of culture, not even in the sense of the culture of primitives, poors, or just craft productions, but in the sense that in this case the knowledge acquired by means of attempts and corrections and corresponded among the human society, are related most of all with the material technical characteristics and of the environment in which they lived.

In this sense artefacts function becomes of fundamental importance and use-wear analysis together with experimental archaeology represent the principal investigative heuristics. As well archaeometry widens its fall out if employed with the logic of material culture of how it is possible to learn and transmit the “know how”. It is important to know if the material utilized to produced an artefact, with a given function, was actually the most suitable for the purpose, on the base of technical characteristics, among the ones available in the given environment, or if it was necessary a certain displacement in order to procure it. Or if the sudden appearance of a new type of artefact in a society was possible, without any previous attempt, due to simple mocking of imported products or if it is simply based on exchange.

Studies on the artefacts recovered in Otzi tool kit represent a striking example: nothing was useless or produced by chance; to any necessity corresponded one or more objects devoted to that functioning. It is also evident, on different artefacts, the normal activity of specialized craftsmen compared with some clumsy retooling. It is not possible to speak about archaeology of production if we are not considering the consumption archaeology or that of possible exchange, which results more frequently and widely of what is possible to imagine.

Typology, function, use-wear and context: where is the common vision?

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Summary. *The paper presents an interesting category of the flint tool repertoire: denticulated blades. In the context of Bulgarian Bronze Age, it is a diagnostic and characteristic type of tool, combining techno-typologically and functionally determined parameters. Denticulated implements appear as innovation in the flint tool-kit sporadically in the late Chalcolithic and in large numbers in the Bronze Age. They are quite similar to a special kind of tool coming from the flint assemblages of the epic site of Troy which have already been studied by the author.*

The most typical features of these tools are their impressive dimensions and intentionally denticulated working edges showing typical or more particular use-wear traces of cereal processing. The external and formally typological similarity of flint implements are obvious, but on the level of the detailed use-wear analysis and comparison, there are some particularities and differences, which wait for deeper and adequate interpretation and understanding, based on wider experimentation and parallels. One of the crucial and not finally resolved problems consists in the correct identification of the use-wear traces linked with different treatment of cereals – harvesting, threshing, simple straw cutting, etc. In the frame of prehistoric subsistence activities, different particular and local agricultural approaches could be attested, as part of evolutionary macro regional changes in crop husbandry. One of the challenging purposes and perspectives of further studies on this topic is the resolution of this particular problem related to Bulgarian Bronze Age.

Resumé. *L'article porte sur une catégorie intéressante des outillages en silex: les lames denticulées. Dans le contexte de l'Age du Bronze en Bulgarie c'est type d'outil assez diagnostique et caractéristique, qui possède des paramètres technico-typologiques et fonctionnels bien déterminés. Les spécimens denticulés apparaissent comme innovation parmi les outillages en silex sporadiquement pendant le Chalcolithique récent, et déjà régulièrement à travers de l'Age du Bronze. Ils sont très comparables et similaires avec un type d'outil distingué par moi pendant mon étude sur les assemblages lithiques du site épique de Troie.*

Les traits les plus typiques de ces outils sont leurs dimensions impressionnantes et les tranchants qui sont intentionnellement modelés par la retouche denticulée et les traces du traitement de céréales. La ressemblance visuelle et typologique de ces artefacts est évidente, mais au niveau de l'analyse tracéologique détaillée, on remarque certaines particularités et différences dont l'interprétation et compréhension adéquate demande expérimentation et parallèles supplémentaires. L'un des problèmes cruciales et non pas encore résolu c'est de pouvoir identifier correctement les traces d'usure liées avec des différents traitements des céréales : moisson, battage, découpe de la paille, etc. Dans le contexte des activités de subsistances préhistoriques il est possible d'attester les démarches locales et spécifiques dans l'agriculture, à part des changements évolutifs macro régionaux que l'agriculture a pu subir. En ce qui concerne la Bulgarie, un des objectifs des recherches futures envisage l'étude approfondie sur les outillages en silex de l'Age du Bronze.

Key words: denticulated blades, Bronze Age, crop husbandry, functional analysis, typology.

Morphological and typological diversity versus restrictive functional application, use-wear traces variations, raw material variability: these are some of the quite common features of the Holocene flint assemblages on a large contextual scale. A crucial question arises in the frame of the whole mosaic of general and particular cases/problems: what is the right balance of the complementary approaches such as archaeological case studies, ethnographic references and experimental reconstruction? There is neither a definitive answer, nor a valid and commonly used approach. Each site has its own history and its specific network characteristics. Each site is a specific unit and offers a spectrum of common and concrete problems. Each of these problems deserves particular attention. And just as any kind of a specialized exploration, the use-wear analysis of prehistoric flint implements has an important role, which permits a correlation of a functional database on various (intra-/inter-settlement) levels.

I chose to present what I believe it is an interesting topic focused on a particular category of the flint tool repertoire: denticulated blades. In the context of Bulgarian prehistoric flint assemblages I conceive these artefacts as a diagnostic and characteristic type of tool, combining both techno-typologically and functionally determined characteristics. Denticulated implements appear sporadically as an innovation in the flint tool-kit in the late Chalcolithic (Fig.1: 4), but it is during the Bronze Age that they become a characteristic feature of the chipped stone industry. Their appearance and functional identification have already been treated in the specialized literature concerning Bulgarian prehistory (Gurova 2001b, 2002, 2004, 2005). It is worth remembering, retrospectively here, that from the beginning of the Neolithic period in Bulgaria a completely evolved Neolithic package is present: in terms of domesticated plant and animal species, as well as of the revealed agricultural tool-kit. The entirely preserved sickles from Tell Karanovo and other Thracian Neolithic tells with obliquely inserted flint segments in arched antler handles are well known and often used as a reference and example for the reconstruction of prehistoric sickles used in harvesting. It should be stressed that almost all sickle inserts identified among the numerous assemblages from the Neolithic and Chalcolithic periods in Bulgaria possess a diagonal polish that indicates the angular fixation in arched handles. Single examples with a narrow lateral polish suggest parallel hafting or even use without a handle. Within the frame of the studied assemblages these

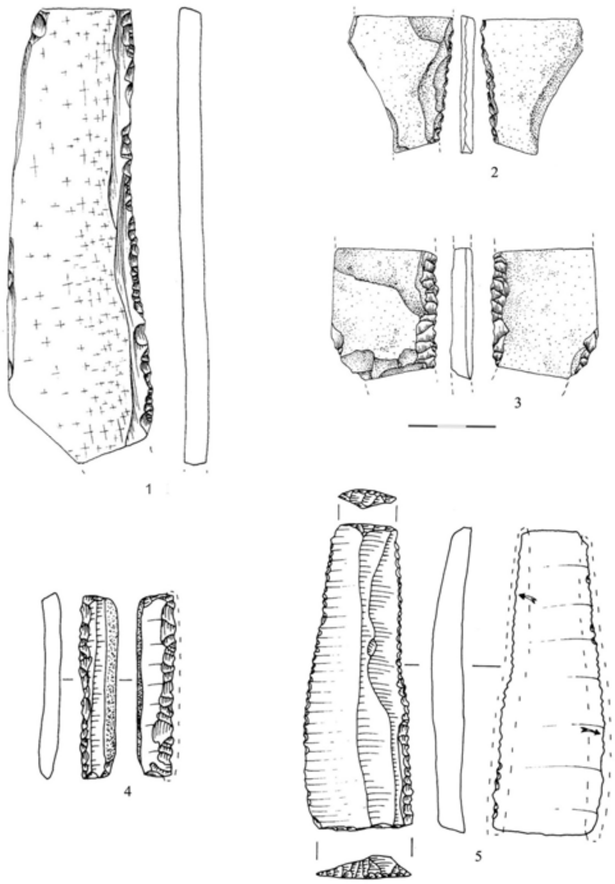

Fig. 1: Sickle blades from the sites: 1-3) Troy VI and VII (according to Gatsov 1998, fig.14-1, 5; fig.15-1); 4) Drama-Merdjumekia (Karanovo V chalcolithic culture); 5) Lepitsa (Early Bronze Age).

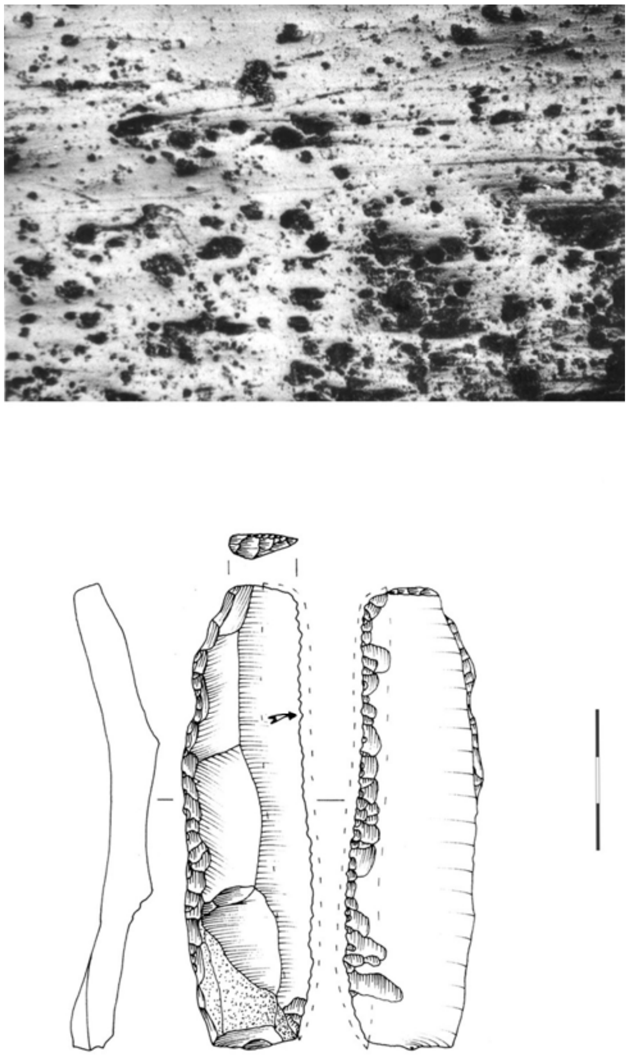

Fig. 2: Late Bronze Age site Kamenska Čuka: sickle blade with a microphotographe of the use-wear traces (x 100).

examples cannot be interpreted as preceding the "Karanovo sickle" type, but as reaping knives, the use of which was rather sporadic but simultaneous with the typical sickle.

Until quite recently there has been insufficient evidence about the material culture dating to the Bronze Age period in Bulgaria. This scarcity of archaeological records is being successfully overcome through extensive contemporary surveys and excavations on a wider scale.

In the context of my research, the most intriguing point with regard to the quite radical changes between the Chalcolithic and Bronze Age material culture is the change in the flint tool repertoire. As already mentioned, the denticulated implements are one such innovation. They consist mainly of blades with different dimensions and rarely in blade-like flakes. From the techno-typological point of view the most characteristic feature of these artefacts is the intentional denticulated retouch varying from fine and delicate to shaped and pronounced bifacial notches on the working edges. That retouch undoubtedly served to improve the efficiency of the cutting tools. The micro-wear traces of the denticulated specimens show a typical so called 'cereal polish' parallel or lightly angular to the edges. Morpho-metrical parameters of the artefacts suggest at least two options for usage: insertion in the composite sickle as well as simply hafting or working without a handle. Among the studied denticulated implements from Bulgarian assemblages the most interesting and representative of these tools are several items coming from the following sites: Lepitsa (north Bulgaria - EBA period, excavation in progress) (Figs. 1-5), the multilayer Tell Iunatsite (south Bulgaria – LBA – finished exploration), the ritual site of Perperikon in the Rhodopes mountains (Fig. 3) and the LBA site at Kamenska Čuka (south Bulgaria – this project is still in progress) (Fig. 2). This last site is quite a particular settlement interpreted by its investigators as goods exchange '*emporium*' on the strategic route connecting north Greece and the Danube region. There have been found about 30 big *pitoi* with victuals (food provisions, including different types of grains).

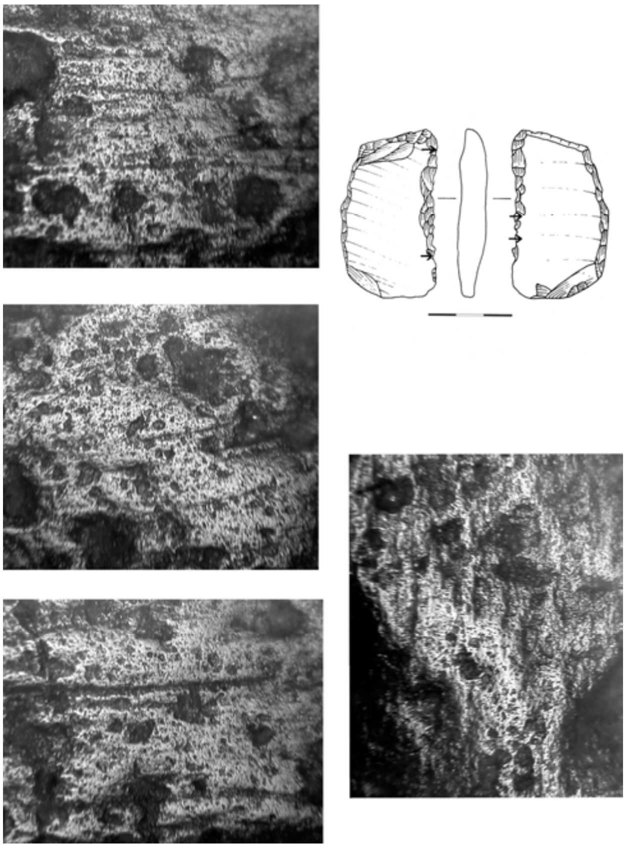

Fig. 3: Ritual site Perperikon: denticulated tool with a microphotographs of the use-wear traces (x 100).

The flint industry is considered to be one of the most conservative elements of material culture. For the prehistoric population it was normal practice to keep, maintain and reproduce for long periods a range of efficient tools for household and subsistence activities. Such a tool for Bulgarian prehistory represents the traditional Karanovo type of sickle, successfully used for more than two millennia. The question that inevitably arises is what was the reason for this innovation and partial change in harvesting implements from the beginning of the Bronze Age?

A quite convincing answer comes from the palaeobotanical studies. The data about crop husbandry do not show radical changes in the cereal taxa, but rather a misbalanced ratio between them. Einkorn *(Triticum monococcum)* predominates in combination with barley (*Hordeum vulgare* var. *vulgare*). During the Late Bronze Age sensibly grows the rate of millet (*Panicum milaceum*) (Popova 1995). All these taxa are more resistant towards the climate and environment changes due to their stronger stems. This fact, as well as the appearance of new weed species (*Setaria* sp*., Poligonum.*sp*, Agrostema githago, Cheponodium type, Carthamus* sp. etc.) (Stefanovich, Bankoff 1998, p.275) could be considered as a probable explanation of this change in the harvesting tool-kit and gesture.

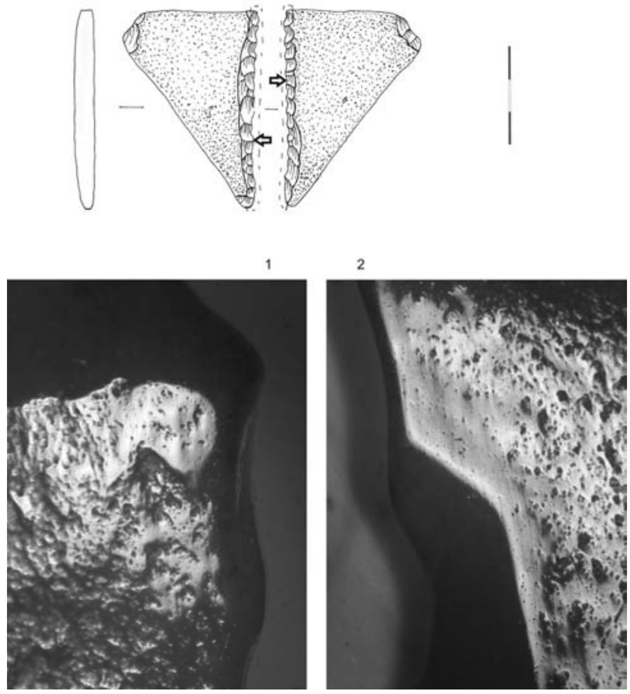

Fig. 4: Late Bronze Age Troy (phase VI-VII): denticulated cortical sickle blade with a microphotographs of the use-wear traces (x 100).

My study on the flint assemblages from the Bronze Age site of Troy in Turkey (Çanakkale district) allowed me to identify a type of tool, made mostly of blades or thin blade-like concretions with bifacial cortex. (Fig. 1: 1-3). The most typical features of these tools are their impressive dimensions and intentionally denticulated working edges with detectable use-wear traces of cereal processing preserved particularly on the teeth of the denticulation (Fig. 4). Apart from this particular category of denticulated implements, among the Late Troy assemblages there are some rather massive blades, as well as blade-like flakes with partial and variably pronounced denticulated retouches and parallel bilateral cereal polishing. The third category of sickle artifacts consists in truncated and simply retouched blades, backed pieces (including geometric segments) with parallel to lightly diagonally located polishes suggesting insertion in a curved handle. It is worth stressing here that the palaeobotanical data from late Bronze Age Troy does not differ noticeably from the above mentioned data from Bulgarian Bronze Age. Barley was the main crop in Troy I and VII b, whereas in Troy VII a einkorn and emmer were the relatively preferred cereals (Riehl 1999, p.60).

The formal typological similarity of some of denticulated tools from Troy with the flint implements from Bulgarian Bronze Age mentioned above, are obvious, but in a detailed comparison (including use-wear and raw material analysis), there are some particularities and differences, which require deeper and adequate interpretation and understanding, based on wider experimentation and parallels. It seems difficult to presume that the denticulated blades were used as threshing sledge inserts. Their morphology and the retouch of the working edges would support the argument for sickle blade usage. It remains crucial, and as yet unresolved, the problem of differentiation of the use-wear traces caused by the different case-treatments of cereals – harvesting, threshing, ground straw cutting, etc. (Anderson, Inizan 1994; Anderson, Chabot 2004; Chabot 2002; Gurova 2001a). One of the very significant facts for the ambiguity in our reading of the use-wear traces is the interpretation of the comet-shaped features that were long considered as an attribute of the sickle use-wear picture (Korobkova 1996). At the first Semenev congress at St.-Petersburg, I put the matter precisely, if we have to distinguish and consider the comet-shaped figures as a feature attributable to some unique microwear complex, then to what must we associate these comet-like figures – to sickle inserts or to threshing sledge inserts? Recently a reliably argued solution was presented by the team Anderson, Chabot, van Gijn on the basis of Canannean blades study (Anderson, Chabot, van Gijn 2004). But on the other hand I feel certain that the interpretation of Prof. Korobkova and many other colleagues about the comet-like figure on sickles is also valid. So the enigmatic point is possibly hidden at the cereal taxa used in different conditions and states of ripeness, or at the different devices and approaches for achieving the agricultural practices in different contexts. Some of the implements I have mentioned, possess traces of a kind of combined mixture between harvesting and threshing segments. In fact my own experimentation for ground cutting straw of barley with a massive especially made denticulated blade was not sufficiently successful. It was perhaps because of the short duration of the experimental work, that no diagnostic use-wear traces were produced. In the frame of the prehistoric subsistence activities, different (maybe local) agricultural approaches can be attested, apart from some evolutionarily determined changes in crop use and diversity. One of the challenging purposes and prospective expectations of the further studies on this topic is the resolution of this particular problem related to the Bulgarian Bronze Age. My efforts in this field have led for now to co-operation with the paleobotanist E. Marinova. In the larger scale I am having a very fruitful and efficient collaboration with an international team of colleagues who are working on the multiaspect investigations of agricultural tool-kit.

It is quite tempting to invoke the quotations of one scholar as an introduction to the concluding remarks. This scholar, S. Rosen is not a use-wear analyst, but has succeeded to catching the complexity as well as the evident and potential pitfalls of the sickles problematic.

***S. Rosen**:* "However, the equation *gloss + morphology = sickle* leaves open the question of morphologically appropriate pieces without gloss….. However the archaeological context may also play a role. At sites where glossy blades of a particular morphology are found, it is reasonable to assume that there will be sickles that have been used for differing lengths of time….. If the precise difference in functions can not be identified without experimental work, certainly the differences in form are recognizable and may correspond, at least partially, to functional variability" (Rosen 1997, p.57).

"Sickle segments as a class span a long period, covering numerous archaeological periods beginning in the Epipalaeolithic and terminating in the Iron Age. This long spam allows examination of a great range of typological variability, long-term perspective on typological and stylistic change… There are found in a range of geographic areas and environmental zones, crosscutting ethnic and state boundaries and varying forms of agricultural exploitation…. Sickle types can be well defined, varying both chronologically and geographically, and providing ample opportunity for evaluating archaeological models attempting to explain that variability. Notably, intertype variation can also be examined" (Rosen 1997, pp.135-136).

In my opinion our understanding and knowledge about this rather banal and, at the same time, challenging tool is still moot. Sometimes even a meticulous polish analysis is not sufficient to determine the sickle function. At the initial stage of its development the polish is not diagnostic enough to identify plant species; at the last stage of utilisation of the sickle inserts they (depending on their position in the handle) could obtain the striation features resembling the *tribulum* inserts pattern. More complicated are situations derived from multiple uses of the flint implements, e.g. a sickle insert reused in *tribulum* insert, which seems to be the case of some of the Canannean blades. Any attempt at a precise, adequate and unambiguous reference is only partially successful, but none is complete and final. The reasonable issue of this scientific puzzle is somewhere in our personal highly cautious professional approach, the efficient and reliable team co-operation, and, in taking into consideration the inherent contextual background.

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9. Functional analysis: Lewis Binford and his contribution

Functional analysis: Lewis Binford and his contribution

I am greatly honoured, in this important academic occasion, to introduce Professor Lewis Robert Binford, one of the most prominent scientists who deeply contributed to the advancement and substantial progress in Anthropological Archaeology in the last four decades.

Lewis R. Binford was born in 1930 in Norfolk, Virginia, and graduated from the University of North Carolina. He then attended the University of Michigan in Ann Arbor were he earned his Ph. D in Anthropology. His formation at the University of Michigan - where, at that time, taught well known anthropologists, such as Leslie White and his students Elman Service and Marshall Sahlins – was in my opinion, of paramount importance for his theoretical background. This may be seen from the "systemic" approach and the evolutionary perspective of several of his scientific contributions, such as, for instance, *Comments on Evolution*, published in his book "An Archaeological Perspective" in 1972.

Lewis Binford then taught at Ann Arbor, Chicago and in the Universities of California of Santa Barbara and Los Angeles. From 1972 to 1991 he taught at the University of New Mexico in Albuquerque, where he became professor of Anthropology and from 1991 at the Southern Methodist University (Dallas, Texas). Since 2000 he is at the University of Washington in Missouri.

The well known article *Archaeology as Anthropology*, published in "American Antiquity" in 1962, may be considered as the pioneering work of the movement called "New Archaeology", the starting point of ethnoarchaeological research and of processualism. The relations (and challenges and debates) with European and especially French archaeologists, such as François Bordes, started during the excavations of Neanderthal sites in France in the 1960s which produced the famous functional analysis debate of the lithic industries of some Mousterian assemblages in *A preliminary Analysis of Functional Variability in the Mousterian of Levallois Facies*, published with Sally Binford in 1966 on a special issue of "American Anthropologist". This paper was strongly criticized by traditionalist European archaeologists, notably by François Bordes, even with some good arguments, and was widely considered by many of them as a classical example of the "danger" that new theoretical approaches, such as the "New Archaeology", could constitute for the "old, secure and trustable" empiricist (not simply empirical, in my opinion) chronostratigraphic traditional approach in Palaeolithic archaeology. In particular, this position is still now strongly supported, for instance, by most of the old fashioned Italian archaeologists, as can be seen also in some widely used handbooks published until recently in Italy, where all the more "modern" research (starting from the late 1960s and early 1970s!) by Lewis Binford are totally ignored.

In fact, after the experience in France and the following debate, Lewis Binford realised he needed to know more about how contemporary hunter-gatherers used their knowledge of environment and animal behaviour before he could say anything about Neanderthal's behaviour vs. the one of modern humans (one must however recognise that even F. Bordes learned something from Binford's 1966 article: see the discussion in the article *Des buts, problèmes et limites de l'archéologie paléolithique*, published with J. P. Rigaud and D. de Sonneville-Bordes in 1972 published on "Quaternaria").

He thus carried out field studies among the Navajo of the south-western United States, the Australian aborigines and most of all among the Inuit-Eskimos of Alaska. In the Introduction to the book *Nunamiut Ethnoarchaeology* (Academic Press, 1978), a cornerstone of any research in Ethnoarchaeology, he writes recalling the functional argument on the Mousterian assemblages:

Although I was "impressed" with the results of the 1966 study I was very uncomfortable with the situation. I was proposing that tool frequencies varied with activity differences. Clearly what was needed was some way of identifying activities, some concepts with linked definitions that would permit me to recognize a past activity from empirical techniques that could be used for isolating activity areas. I hoped that if we could see such areas then we might be able to develop concepts and definitions sufficient to identify activities (*Nunamiut Ethnoarchaeology: 6-7).*

The book focuses mainly on detailed studies of faunal assemblages (caribou and mountain sheep, in this case), and together with the later one, *Bones: Ancient man and Modern Myths*, published in 1981 again by Academic press, constitutes the essential basis of any modern research on taphonomy and zooarchaeology of the archaeological assemblages.

As regards studies on the activity areas, it is worth noting that, for instance, the analysis of the Mask site in *Dimensional Analysis of Behaviour and Site Structure: Learning from an Eskimo hunting stand*, published in 1978 in "American Antiquity" has been used subsequently as a typical case-study for testing statistical techniques of spatial correlation analyses, such as the ones presented in the books *Intrasite Spatial Analysis in Archaeology* edited by H. Hietala, in 1984 and published by Cambridge University press and *Intrasite Spatial analysis in Theory and Practice* by H. P. Blankholm, published in 1991 by Aarhus University press. The importance of identifying site formation processes was further stressed by Binford in some fundamental papers, as for instance, *Willow smoke and Dog’s Tails: Hunter-Gatherer Settlement Systems and Archaeological Site Formation*, published in 1980 in “American Antiquity”, where he introduces the categories of “foragers” and “collectors” as two extreme cases of settlement and subsistence strategies of hunter-gatherer groups. This argument is further developed in the article *The Archaeology of Place*, published in 1982 in “Journal of Anthropological Archaeology”. Shortly after, Binford came back to the African Hominids in *Human Ancestors: Changing Views of their Behavior*, again in “Journal of Anthropological Arcaheology” (1985). At the same time, he resumed the interest in lithic industries, with three important papers on ethnoarchaeological observations derived from field work done in 1974 among the Alyawara Australian aborigines: *An Alyawara day: The Stone Quarry; An Alyawara day: Flour, Spinifex Gum and Shifting Perspectives*, both published in 1984 in “Journal of Anthropological Research” and *An Alyawara day: Making Men’s Knives and Beyond*, in “American Antiquity” (1986). These articles, notably the first one, are particularly interesting, since they describe some actual examples of lithic reduction processes, starting from the quarry, with multiple and fractioned partial sequences (e.g. “curated” tools made immediately at the quarry, in contrast with preforms of cores carried to the residential camps and then shared between men and women for more expedient tools). These articles were written practically in the same years when Europeans, mostly French, archaeologists started to show great interest in the investigation of reduction processes in the lithic industries, even if often seen as unique continuous chains, rather than in the customary strictly typological analyses.

I might go on and remind many other interesting and important papers and books written by Lewis Binford but I will stop here my introduction, remembering only two of the most recent books: *Cultural Diversity Among Aboriginal Cultures in Coastal Virginia and North Carolina (The Evolution of North American Indians)* (1991) and *In Pursuit of the Past: Decoding the Archaeological Record* (2002).

I met Lewis Binford for the first time at the Annual SAA meeting at Denver in 1985, and was present to his invited speech on that occasion. I was already familiar with several of his important papers and was very impressed by the scientific perspective he presented in the processual approach. My previous scientific formation taught me the need and the importance of a theory for the interpretation of the data, against which the evidence of the data should be tested: I felt therefore that the processual approach advocated by Binford went exactly in this direction in the field of prehistoric archaeology.

At Denver in 1985, I met as well two very brilliant students of Binford, S. Kuhn and M. Stiner, and starting in 1986 we worked together on a Mousterian excavation in Italy (Grotta Breuil) for several years. In particularly M. Stiner taught taphonomy and zooarchaeology to some of my students. In the last four years I have collaborated again with Binford’s former students for an excavation in Italy: R. Whallon, Ann Arbor Museum of Anthropology, Michigan.

In a way or in another, I am always involved with Lewis Binford and/or his students: I must say that at this point I may well consider myself as a sort of “virtual” former Lewis Binford’s student!

Amilcare Bietti

THE ITALIAN REPUBLIC

IN THE NAME OF THE LAW, WE, ALESSANDRO MAZZUCCO, PROFESSOR OF CARDIOSURGERY, CHANCELLOR OF THE UNIVERSITY OF VERONA, IN CONSIDERATION OF THE DECISION TAKEN ON 3 JUNE 2004 BY THE FACULTY OF HUMANITIES, AWARD THE 'LAUREA HONORIS CAUSA' IN HUMANITIES TO

LEWIS ROBERTS BINFORD

BORN IN NORFOLK (VIRGINIA, USA) ON 21 NOVEMBER 1930 FOR HAVING ESTABLISHED, IN THE 1960s, A NEW FIELD OF STUDIES (NEW ARCHAEOLOGY) OF CRUCIAL IMPORTANCE FOR THE RENEWAL OF THE DISCIPLINE OF ARCHAEOLOGY, BASED ON THE ACQUISITION OF METHODS EMPLOYED IN OTHER DISCIPLINES (FROM ANTHROPOLOGY TO STATISTICS, FROM GEOGRAPHY TO LOGISTICS, FROM CYBERNETICS TO ECOLOGY), AND FOR HAVING SIGNIFICANTLY CONTRIBUTED, IN THE FOLLOWING YEARS, TO THE DEVELOPMENT OF ARCHAEOLOGICAL THEORY. BASED ON A LONG FIELD RESEARCH PERIOD, HE HAS BEEN THE FIRST TO DEMONSTRATE THE POTENTIALS OF THE ETHNOARCHAEOLOGICAL APPROACH (THE STUDY OF THE MATERIAL CULTURE OF PRESENT-DAY NON – INDUSTRIALISED SOCIETIES APPLIED TO ARCHAEOLOGICAL METHODS), TO HAVE UNDERTAKEN EXPERIMENTAL RESEARCH IN ORDER TO RECONSTRUCT THE BEHAVIOUR OF PREHISTORIC HUNTER-GATHERERS AND TO HAVE FORMULATED DIVERSE AND INNOVATIVE HYPOTHESES. ALSO THANKS TO HIS KNOWLEDGE OF PALEONTOLOGY HE HAS BEEN ABLE TO EXPLAIN THE FORMATION PROCESSES OF THE ARCHAEOLOGICAL RECORD.

WITH THE APPROVAL OF THE MINISTRY OF EDUCATION, UNIVERISITIES AND RESEARCH, NOTIFIED WITH NOTE No. 247, 24 JANUARY 2005, IN CONSIDERATION OF ARTICLE No. 169 OF THE UNIVERSITY EDUCATIONAL LAW, APPROVED BY R.D. 31 AUGUST 1933, No. 1952, WE CONFIRM THE AWARD TO LEWIS ROBERTS BINFORD OF THE

LAUREA 'HONORIS CAUSA' IN HUMANITIES AND HEREBY ISSUE THE PRESENT HONORARY DEGREE CERTIFICATE, ACCORDING TO THE LAW IN FORCE.
ISSUED IN VERONA ON 22 APRIL 2005.

HEAD OF FACULTY	CHANCELLOR	ADMINISTRATIVE DIRECTOR

8. Recalling friends

Amilcare Bietti (1937 - 2006)

During the conference "*Prehistoric Technology*: 40 years later. Functional Studies and the Russian Legacy", held in Verona 22-23 April 2005, Amilcare Bietti gave his last speech in front of the national and international scientific community. He was invited by the conference Organising Committee to introduce an outstanding American scholar, Lewis Binford, who was awarded the *Laurea ad honorem* on behalf of the University of Verona. After the event, due to an incurable illness, Amilcare's health deteriorated dramatically, and one year later, on 28 July 2006, he died in Rome, aged 69.

Amilcare concluded his speech in Verona by saying: "I may well consider myself as a sort of "virtual" former Lewis Binford's student!". Amilcare's personality is fully reflected in these few and simple words, uttered with modesty but also with the proud enthusiasm of one who has worked not only with competence, originality and professionalism but above all, with passion.

In 1980 he was Visiting Professor of Ethnology at the former Anthropology Institute of the Università "La Sapienza" in Rome. In 1983 he became Associate Professor of Prehistoric Ecology in the Department of Animal and Human Biology of the same university where, in 2004, he became Full Professor. He was president of the 4th UISPP Scientific Commission (1991-1996) and as such a member of the UISPP Permanent Council and Executive Committee. In addition, Amilcare for a long time lectured the course entitled: "Mathematical and Statistical Methods applied to Archaeology and Prehistory" at the Scuola di Specializzazione in Archeologia of the University of Rome. From 1991 to 1999 he was the General Secretary of the Italian Institute of Human Palaeontology, of which he became President during the last years of his career. A complete bibliography is available in the Proceedings of the 15th Scientific Meeting of the Istituto Italiano di Preistoria e Protostoria (Firenze 2007).

In the field of prehistoric archaeology he grew academically with the guidance of Mariella Taschini, developing a profound knowledge of the typological method (see Taschini & Bietti 1972 and Taschini, posthumous work by Amilcare, 1979). At the same time, he sensed from the very start, the limits in the application of the typological method and foresaw its interpretative weakness for the understanding of archaeological evidence. For instance, on different occasions, he pointed out the difficulty in identifying cultural *facies* through the traditional typological classification of Upper Palaeolithic material in central-southern Italy (e.g. Bietti 1976-1977, especially the discussion on the term "evolved Epigravettian" on p. 367; Bietti 1990, for a "behavioural" view of the main Epigravettian archaeological evidence).

Amilcare's approach is not only characterised by open criticism (Bietti 1978): through the processing of mathematical methods, probably for the first time systematically applied in Italy (e.g. Bietti 1974-1975), he also produced alternative models and theories to those traditionally adopted by the Italian scientific community. The use of multivariate analysis, T-test, Chi-square and other mathematical tools allowed him to propose hypotheses on site occupation patterns (Bietti 1981, 1985, 1989, 1994) and raw material procurement and exploitation (e.g. Bietti 1980, Bietti & Grimaldi 1991), clearly following the "processualist" perspective and methods. Amilcare proposed themes and interpretations of extraordinary originality as regards the necessity to establish a theoretical and methodological framework within which to contextualize archaeological data or, in other words, to define Prehistory as a scientific discipline (e.g. Bietti & Bietti Sestieri 1985, Bietti 1986, 1991).

Despite his illness, Amilcare continued to work, publish and deliver his university lectures, for as long as he could. Owing to the stimulating intellectual power and genuine warmth which were the typical traits of his personality, Amilcare will for a long time be a reference figure for future research on the Palaeolithic. All those who either worked with him or simply had a chance to know him, are left with a fond and indelible memory.

Galina Fedorovna Korobkova (1933 – 2007)

Galina Fedorovna Korobkova was one of the brightest representatives of the Russian archaeological school. Being a leading expert of world-standing reputation in the field of traceological research and the first disciple of S.A. Semenov (who created the traceological method), she, for a long time, headed the Experimental-Traceological Laboratory at the Institute for the History of Material Culture (Russian Academy of Sciences) in Leningrad/St. Petersburg. It was due to her organizational capabilities, scientific erudition and pedagogical talent that the Laboratory became an important international centre where many Russian and foreign scholars were trained. She should also be given the credit of continuation of the experimental-traceological expeditions that had been started by her teacher S.A. Semenov. This work resulted in the creation of a unique reference collection of experimental replicas of ancient tools, which has no analogies in the world. Korobkova's publications, which include several monographs and over 150 papers, demonstrate an extremely broad geographic and chronological scope of her research, as well as its originality and innovativeness. Of great importance for the development of use-wear studies are her works devoted to the complex technological, morphological and functional analysis of mass materials and to the elaboration of functional classification. Equally important are her studies devoted to the theory of paleoeconomic reconstructions. It should be stressed that it was thanks to these works that tool assemblages of many archaeological sites were published for the first time and became a basis for wide historical generalizations.

Galina Fedorovna was an indefatigable worker, talented experimenter, energetic popularizer and propagandist of traceology. She devoted a lot of time to the training of young researchers, and many traceologists working now in different archaeological centres of Russia and other countries were her students.

G.F. Korobkova made a very significant contribution to the study of the prehistory of humankind.

Thomas Harold Loy: 1942-2005

Dr Tom Loy collapsed and died at his home in Brisbane, Australia, where he was found on 19th October. His discovery of blood and other residues on prehistoric stone tools challenged scientific convention and prompted new directions in functional studies. Tom had wide interests in arts and science, and was an inspirational teacher. A Buddhist memorial service was held at the University of Queensland on November 7 to celebrate his life among family, colleagues and friends.

Born in Chino, California, USA, Tom took a BSc in Geology, at Redlands University, and later studied anthropology and archaeology. While Associate Curator at the Royal British Colombia Provincial Museum, Canada, Tom published the famous article in *Science* (1983) in which he identified blood residues on ancient stone artefacts. He moved to a research position at the Australian National University in Canberra (1987-1995) where he was awarded a PhD, and then to a joint appointment at the University of Queensland in the Centre for Molecular and Cell Biology and the Department of Anthropology and Sociology. In 1999, he was offered the first lectureship in Archaeological Science in the School of Social Science, University of Queensland.

Tom was invited to work in Australia, Africa, Europe, Middle East, Americas and Pacific Islands on projects of high significance. His research on Ötzi, the 5300 year-old glacial mummy, is widely known. Many congress participants will remember our visit to Ötzi in Bolzano and the museum presentations of Tom's discovery of blood and DNA on artefacts, and his re-interpretation of how Ötzi died. Those working on plant processing will also recall the remarkable publication in *Antiquity* (1992) of starch grains on 28,000 year-old stone tools from Kilu Cave, Solomon Islands. In 2004 he convened the 7th Ancient DNA and Associated Biomolecules (International) Conference, held at the University of Queensland. Tom was also closely associated with Aboriginal people in northwestern Queensland. He is survived by his six children, Inge, Curtis, Kim, Adam, Max and Emma, and his only brother, Gareth.

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