Schriften des Seminars für Urgeschichte

der Universität Bern

Heft 7

Barbara S. Ottaway

EARLIEST COPPER ARTIFACTS OF THE NORTHALPINE REGION: THEIR ANALYSIS AND EVALUATION

1982

Seminar für Urgeschichte, Bernastrasse 7p, CH-3005, Bern

Vorwort

Früheste Metallfunde haben stets die Aufmerksamkeit der Forschung auf sich gezogen, denn die antiken Geschichtsschreiber, wie auch die heutigen Historiker haben darin den Beginn eines neuen Zeitabschnittes gesehen. Die Einführung des Dreiperiodensystems in der Urgeschichte durch Ch. Thomsen im Jahre 1836 trug dem zwar Rechnung, man verstand aber die Trennung zwischen "Stein-Zeitalter" und "Bronce-Zeitalter" zunächst nur als antiquarische Gliederung des Fundstoffes. Wohl als erster verband V.G. Childe damit einen epochemachenden Schritt in der Entwicklung der menschlichen Gesellschaft, indem er erkannte, dass früheste Metallbearbeitung die Entstehung einer arbeitsteiligen Gesellschaft bedeutet. Auch in Mitteleuropa galt das Interesse schon früh den ersten Metallfunden, wobei man erkannte, dass vor der Bronze lange Zeit hindurch lediglich Kupfer Verwendung fand. Diese Beobachtung führte in der Folge zu einer heftigen Diskussion über die Notwendigkeit der Einführung einer Kupferzeit.

In den letzten Jahren haben wichtige Funde in Südosteuropa völlig neue Aspekte über den Beginn der frühen Metallurgie eröffnet. Die zahlreichen längst bekannten Kupferfunde des nordalpinen Raumes fanden dagegen bisher keine Neubearbeitung. Allein das weiträumig angelegte Analysenunternehmen der Arbeitsgemeinschaft für Metallurgie des Altertums am Landesmuseum in Stuttgart untersuchte auch diese Funde und wartete mit vielen neuen Erkenntnissen auf, doch war dabei das Interesse der Forschung stets auf Gesamteuropa ausgerichtet; regionale Darstellungen konnten - obschon stets als unabdinglich hingestellt - nur angedeutet werden, wie dies z.B. E. Sangmeister in seinem Aufsatz über die Kupferfunde von

Burgäschisee-Süd versucht hat zu zeigen.

In der vorliegenden Studie wird diesem längst geäusserten Anliegen nachgekommen. B.S. Ottaway untersucht auf breiter Basis die Kupferfunde des nordalpinen Raumes nach ihrer Materialzusammensetzung und nach ihrem archäologischen Kontext und legt damit eine Pilotstudie für weitere Regionen vor. Dieses Gebiet ist bisher nicht zusammenhängend bearbeitet worden; auch insofern stellt die Arbeit ein Novum dar. Es lassen sich im nordalpinen Raum mehr Gemeinsamkeiten aufzeigen, als man erwartet hatte, und es wäre noch zu prüfen, ob diese durch die Metallurgie bedingt sind, oder ob es sich hier nur um eine tiefer wurzelnde gemeinsame Grundlage handelt.

Die Frage der frühen Metallurgie wird umfassend angegangen, der bearbeitete Raum als Teil der gesamten Entwicklung zum Metallzeitalter exemplarisch behandelt, so dass die hier sich deutlich abzeichnenden drei Horizonte wohl auch für weitere Regionen Geltung haben. Es wird deshalb zu Recht gefordert, dass in andern Gebieten nun ähnliche Studien folgen sollten, um die Anfänge der Metallurgie verstehen zu lernen, und damit den Beginn einer neuen Epoche in der kulturellen Entwicklung besser nachzeichnen zu können.

Die vorliegende Arbeit, die im Sommer 1980 abgeschlossen wurde, ist zwar nicht im Rahmen des Seminars für Urgeschichte der Universität Bern entstanden, steht aber mit unserem Interesse insofern in enger Verbindung, als ein grosser Teil der Kupferfunde, die hier vorgelegt werden, im Bernischen Historischen Museum aufbewahrt sind, und das Thema für die Erforschung des schweizerischen Neolithikums und der beginnenden Metallzeit von zentraler Bedeutung ist. Es scheint uns deshalb richtig, dieses Werk in unseren Schriften erscheinen zu lassen.

Bern, August 1982 — Die Herausgeber

LIST OF CONTENTS

PAGE

LIST OF TABLES

PAGE

LIST OF APPENDICES

ACKNOWLEDGEMENTS

The idea for this work originated with the author's thesis work for the University of Edinburgh, Archaeology Department; and with Professor Strahm's suggestion to publish the second, more technical half of it at the Seminar für Urgeschichte in Bern.

This work would not have been possible without the help, advice and discussion of many archaeologists and museum curators, members of museums, libraries and private collections throughout Austria, Britain, Germany and Switzerland.

My grateful thanks are due to all of them, and particularly to Dr. Hampl, Dr. Offenberger, Professor Pittioni, Dr. Reitinger and Dr. Ruttkay in Austria; to Dr. Gilmore, Professor Harding, Professor Piggott, Dr. Sakellaridis and Dr. Wellum in Britain; to Dr. Burger, Dr. Christlein, Dr. Pape, Professor Sangmeister, Professor Strahm and Dr. Uenze in Germany; and to Dr. Bill, Dr. Egloff, Dr. Gallay, Dr. Mottier, Dr. Osterwalder and Dr. Wyss in Switzerland.

Furthermore I am particularly grateful to Dr. Quitta (East Berlin) and Dr. Bakels (Leiden) for allowing me to include some vital, as yet unpublished radiocarbon dates in this work.

I would like to dedicate this book to my husband.

CHAPTER I. INTRODUCTION

I.1. GENERAL OUTLINE

The work presented here aims to study the earliest metal artifacts in the north alpine region in their cultural contexts. It falls naturally into two sections, 1 , the purely archaeological and socio-economic study, which provides the background and studies the effect and impact of metal on the prehistoric groups who used it, and 2 , a typological study, analysis of some metal objects and the evaluation of the resulting impurity patterns of these metal artifacts. This evaluation will, it is hoped, throw further light on the question of the development of early metallurgy, on how far this development could have been independent, or semi-independent, and on the spread of new technological processes. It should also help to elucidate the existence, or otherwise, of trade or pre-trade forms and contacts amongst coeval cultures. Only the second part of the entire study is presented here; the purely archaeological part, reviewing the present state of published research on distribution, settlement, and house patterns, economy, artifacts, burials, chronology and possible origins of the various cultures involved will be published elsewhere (B.A.R. International Series, Oxford).

For the purpose of this study the northern sub-alpine region covers the whole of modern Switzerland, Austria and part of southern

Germany. The natural boundaries of the area are the mountain peaks of the Alps themselves in the south, and the Danube in the north. To the west the Jura mountain range, although not as high as the Alps, is a very effective boundary because of its ruggedness. In fact, the Rhône was probably the only 'break' in this massif during prehistory and has been the gateway for successive influences. To the East the boundary formed by the end of the Alpine mountain range has been somewhat extended to include the whole of Austria.

The period covered, that is from the first appearance of copper to the beginning of the Early Bronze Age, ranges from approximately 3400 to 2000 bc. All dates (bc) are based on radiocarbon dates, using the conventional, uncalibrated dates calculated with the Libby half-life of 5568 years. Occasionally, corrected dates (BC) will be found in parenthesis following the uncorrected dates. The correction to calendar years will have been carried out with the aid of the MASCA correction curve (Ralph *et al*, 1973). The convention of using bc for uncalibrated radiocarbon years and BC for radiocarbon dates calibrated to calendar years was suggested in the Editorial of Antiquity (Vol. 46,1972,265) and has been widely adopted in English-speaking countries.

A study of the earliest copper metallurgy in the northern sub-alpine area should be viewed in the wider setting of the earliest European copper-using cultures in order to understand its full meaning. Thus in this Chapter some of the earliest southeast European copper finds and copper-producing sites will be reviewed briefly. A summary of the detailed archaeological, socio-economic and chronological information of all the relevant cultures in the northern sub-alpine region will then be presented to provide a background to the actual metal finds themselves. These are described and grouped from their morphological, chronological and cultural point of view in Chapter II. In the third Chapter attention turns to the metallurgical aspects of the earliest copper artifacts. This includes some 100 new metal analyses, for which a technique of measurement was adopted, developed and carried out by the author. The grouping of the results, together with results from other laboratories is also included in this Chapter. The fourth Chapter describes the actual methods of chemical and statistical analyses used, and the final Chapter contains a summary and discussion of all the data collected, and conclusions.

I.2. DEFINITION OF CULTURE

A study of this kind, which depends upon establishing relationships between various regions, requires a set of terms by which these relationships can be described. Unfortunately, there is no agreement about such terms or their conceptual content at present, and it is therefore necessary to define them solely for the present study. We may start by observing that occasionally there are artifacts which are worth studying in their own right, on stylistic grounds. However,usually the primary interest lies in the people who produced the artifacts, their development and their presumed relationships with others and with the world around them. In the study of pre-literate archaeological society, a whole nexus of features, i.e. assemblages of artifacts associated with structures, and economic, technological and environmental information, have of necessity to be used as evidence for the behaviour of a limited section of the society. The difficulties in finding suitable concepts and terminology have been discussed by Piggott (1965,7), Clark (1968,287), negatively by Hawkes (1973), briefly but lucidly by Hodder and Orton (1975,199) and very usefully by Doran and Hodson in the form of a flow chart (1975,T.2.1). The term that causes most difficulty is 'culture'. When Childe wrote his definition of a culture as being 'distinctive artifacts regularly found associated in graves and settlements over a given geographical area...' (1930, 41), this was an excellent and useful tool for archaeologists of the time. Inevitably, names used to refer to assemblages came to be used for populations or were 'assumed to have significance in human terms' (Piggott,1965,7) and continued to be used because ' it is an established shorthand virtually impossible to replace' (Piggott, 1965, 7). However, constant extension of methods used to ' decode ' the evidence, provided by constantly improving excavation methods, resulted in an increase in material from which much more detailed facts about human behaviour could be inferred. When finally anthropological and ethnographic as well as geographical concepts were borrowed to help explain archaeological data, the definition of 'culture' reached its limit and a total confusion of terms resulted. This confusion arises from the contrast between the extremely static definition used for 'culture' in Childe's sense, and the desire to link it to ideas of change, development or regression, i.e. to a dynamic use of the word. This notion of change and development is, of course, implicit in the study of human populations.

One of the aims of the whole study was to provide enough detailed information to make the step from a 'culture' defined in purely static or material terms to a dynamic 'culture' in the anthropological sense. This aim could not be achieved, because only in one or two cases (e.g. the Cortaillod culture) is sufficient information available. Fortunately, the static definition of 'culture' in terms of a nexus of features commonly occuring together within a limited spatial and temporal horizon is perfectly adequate when dealing with a set of data such as I shall be using, provided there is a reasonable chance of dating them fairly precisely, because I am dealing with the impact and development of a single technology, metalworking, on this otherwise static horizon. Logically, if the definition of culture as I have given it is correct, phrases such as 'the dynamism of culture change' can only be used to start a discussion of the development of a culture within a fixed geographical area, and ideally within a limited time horizon. Logically, the term ' spread of culture' has no meaning in the static definition of a culture, because the essential geographical element in the definition is being negated. Clearly, another term is needed to define the dynamic side of a culture. Doran and Hodson (1975) constructed a hierarchy of concepts (Fig.1) which I found most useful, because they relate closely to the stages of complexity which I found myself developing from the northern alpine material. A culture in the static sense defined above fits in between their level 3 and 4 (Table 1) between their 'culture complex' (or 'people') and a 'component class' (or social subgroup), reserving the term ' culture complex' for entities such as 'Chasséen' or 'Vinča' or the newly defined 'Saône-Rhône', which intuitively seem too large or too long-lasting to be homogeneous cultures. It is also important to stress that a culture must be defined in terms of several traits or features, not just one or

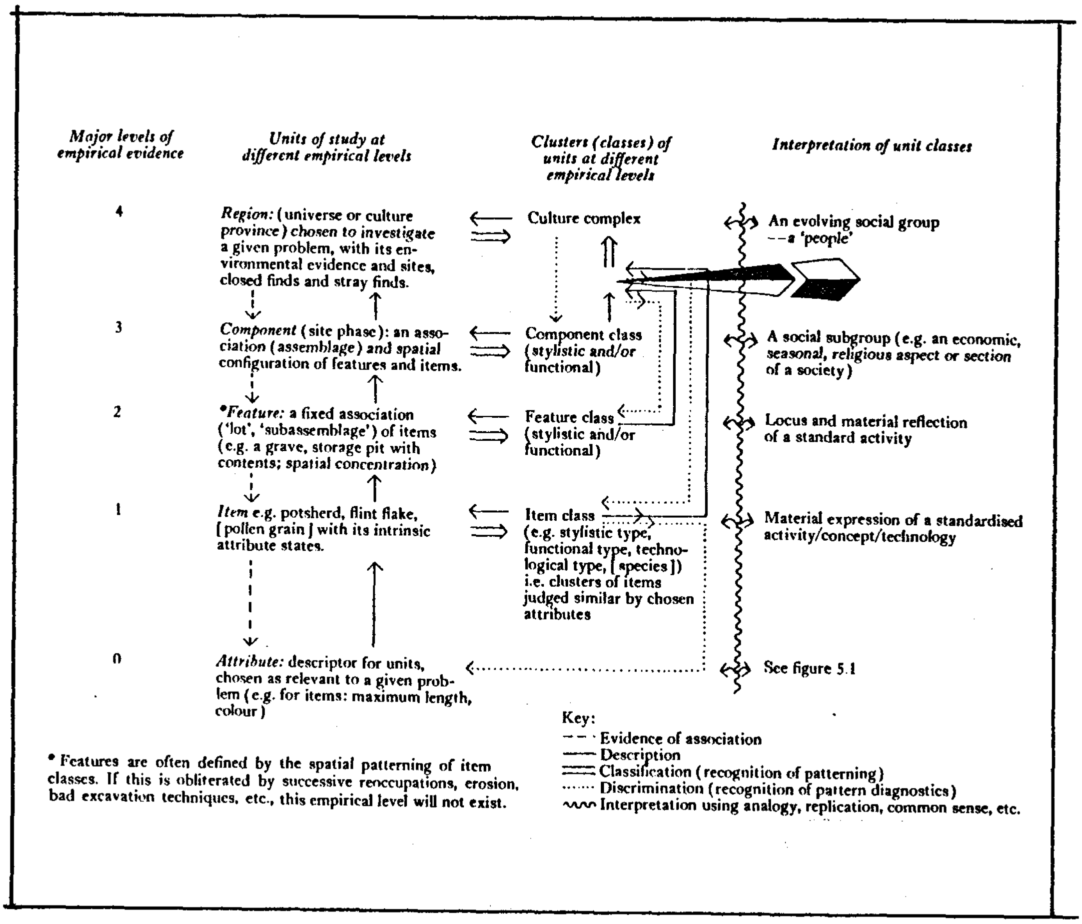


TABLE 1 The arrow shows the location of 'culture' as defined and used in this study. (After Doran and Hodson (1975,Fig. 1.2))

two common ones, even if, as in the case of the newly defined 'Lüscherz culture' a blind eye must temporarily be turned towards the lower limit of the definition. In summary, by 'culture' I mean throughout this study a nexus of associated features, i.e. assemblages of artifacts associated with structural, economical, technological and environmental features, in a geographically and spatially defined area.

I 3 BACKGROUND

i) SOUTHEAST EUROPE

A survey of southeast European early copper finds enables one to trace the following developments in this area: there is, in Bulgaria (Todorova,1973b,1978[+])

[+] All references marked with an asterisk are in the Addendum to Bibliography.

Romania (Filip,1966, Vlassa,1967,1970) and Jugoslavia (Ryndina,1971), a fully Neolithic period, in the early fifth millennium bc, where copper objects appear haphazardly as very scattered individual finds without evidence of local metal-working. This is followed by a period in which cultures,forming a continuum with preceding local Neolithic groups, were using copper objects as an extension to their normal tool kit. If the smelting of copper ore is used as the criterion (Tylecote,1976,5) the Copper Age begins at this point (see below). The artifact types - awls, fish hooks, beads and occasionally axes and chisels - show that the material was used to its best advantage while it was scarce. There is evidence in this period for local manufacture of copper artifacts by techniques which were complex and competent, as Russian investigations (Ryndina,1971) have shown. Finds come mostly from settlements, one of the exceptions being the cemetery of Vel'ké Raškovce where, unusually, heavy copper axes and chisels were found (Vizdal,1977[+]). Cultures and countries in which these finds occur include the earliest Tiszapolgár culture of Slovakia (Vizdal,1977[+]), the earliest Vinča-Pločnik culture of Jugoslavia (Brukner, _et al_, 1974, Jovanović and Ottaway, 1976, McPherron and Srejević, 1971), the Maritsa culture of Bulgaria (Todorova, 1978[†]), the Pre-Cucuteni III-Tripolye A cultures of Russia and Romania (Greeves,1973, 1975[+], Klejn,1968) and the Herpaly and Lengyel cultures of Hungary (Kalicz, pers. comm.).

A horizon followed in which there was a wider use of copper, implying that more raw material was available, indicated by the frequent occurrence of heavy copper tools in stratified deposits. Advanced techniques, such as casting, were used, and the first big hoards of copper artifacts appeared. Copper objects are now found in both cemeteries and in settlements. Cultures and countries in which this horizon is represented include the Vinča-Pločnik culture of Jugoslavia (Brukner, 1964, Grbic,1929, Jovanović,1971), the Cucuteni A - Tripolye B/I culture of Romania and Russia (Greeves,1973,1975[+]), the Dniepr-Donetz culture of White Russia (Chernych,1966, Telegin,1971), the

Gumelniţa and Karanovo VI cultures of Bulgaria (Ivanov,1978+ , Todorova,1978+), Sitagroi layers II and III in northern Greece (Renfrew,1969,1973a), the Slovakian (Šiška,1964) and the Hungarian Tiszapolgár culture proper (Bognár-Kutzian,1963, 1972) - the very last being somewhat tardier than the rest and still without large copper tools.

Added to this artifactual evidence is that provided by two sites where prehistoric mining activities had been established : one is at Rudna Glava, 22km east of Majdanpek in eastern Serbia, Jugoslavia, the other is at Aibunar, near Stare Zagora in Bulgaria. At Rudna Glava a row of vertical shafts, which are in fact empty ore veins, were discovered (Jovanović,1971). The shafts are 20 -25 m deep and vary in width between 0.5 and 1.5 m. The majority of the finds came from the access platforms which acted as small stores and/or preparatory work areas. Stone, bone and wooden tools as well as pottery had been inserted into the cracks, and some of the pottery was found in small hoards. The typological characteristics of the pottery are very clear and belong to the initial phase of the Vinča-Pločnik culture or slightly earlier, i.e. to the transition period between Vinča-Tordos to Vinča-Pločnik [1]. The extraction of the ore seems to have been by alternative heating and cooling and subsequent breaking up of the ore by bone and wooden wedges. The ore was then further broken up by massive hammer pebbles, sorted and lifted out of the shaft. Analysis of the remainder of the ore left behind in the bottom of the shafts showed it to consist mostly of haematite, that is iron ore, which was clearly discarded as unsuitable (Ottaway,1975). The copper ore which was used by the Vinča miners was probably malachite. The ore was found to be of rather high purity and is capable of giving high purity metal by quite simple smelting

---

[1] Vinča-Pločnik covers a very long period : 3950 - 3300 bc (4800 -4100 BC) but its floruit lies between 3900 and 3750 bc (4700 - 4500 BC) (Ottaway,1975b).

techniques (Tylecote,1977, 1977a).

Aibunar, the Bulgarian prehistoric copper mine, has similar tools and techniques; the shafts were wider than at Rudna Glava and the analysis of the ore has shown it to be malachite and azurite. The mining activities there have been dated to the Gumelniţa period (Chernych and Raduntcheva,1972) but could belong to an even earlier period, the Maritsa culture (Chernych,1975,1978[+]). It is clear then that copper was mined in the Balkan Mountains by the early fourth millennium bc and, as one would expect, numerous copper finds in contemporary sites attest this activity. However, one has to be cautious in automatically assuming that a mine always supplied settlements in the vicinity with raw material or finished products: studies of the impurity patterns have shown that the movement of ore and products could be very wide-spread indeed (Chernych,1975,1978[+], Ottaway, in press[+]).

The first known appearance of copper artifacts in Europe from the early fifth millennium bc, to the fully developed Early Copper Age of southeastern Europe in the fourth millennium bc, all lie within an area covered by the isochron shown in Map 1. If independent invention of copper metallurgy is to be found in Europe as suggested by Renfrew (1969), then the experimental stages, if they left any traces at all, should certainly be found within the area covered by this isochron.

However, before accepting - or rejecting - this notion finally, a thorough study of the Near Eastern material and new surveys in that area would have to be carried out. The present political and economic situation renders this a nearly impossible task in the near future. Judging by the existing material, the Near East appears to have the earliest evidence for the use of copper (De Jesus,1974, Mellaart,1975,Tylecote,1976, Wertime,1973) but the knowledge lay dormant for a long time. The sporadic early occurence of slag and ore does not seem to have supported a large production of metal implements and the real expansion of metal usage in the Near East belongs to a period when metal artifacts were also beginning to be seen in Europe; soon afterwards there is even evidence of copper mining in Europe.

Many writers have concerned themselves with possible areas of origin of metallurgy, and with early European metallurgy, but not so many have treated the shift and subsequent development of early metallurgy into the so-called Randzonen, i.e. border areas. Moreover, these Randzonen are rarely treated as units. The present study, while not claiming to present a huge corpus of material, does at least provide material collected by crossing several national borders.

ii) NORTHALPINE REGION

a) CHRONOLOGICAL ASPECTS

As in the southeast of Europe, there is in the northalpine area a fully Neolithic period, where a few pieces of evidence for the use of copper appears. These finds belong to the Münchshofener culture of Bavaria and the Bisamberg-Oberpullendorf group of Austria. Both form part of the 'Epi-Lengyel complex', which dates most probably to the middle of the fourth millennium bc and which stretches west to east from Bavaria to the Croatian Lasinja culture and north to south from the Silesian Jordanov to the Slovenian Lasinja culture. This culture complex unites groups most of which are not considered autochthonous and is thought to explain the manifold southeast European influences felt in them, amongst them the earliest copper finds (Ruttkay,1976).

This earliest, but scattered evidence of use of copper in the Epi-Lengyel complex - whose southeast European contacts may well turn out to be significant in relation to what follows below - is soon succeeded by a fully copper-using horizon which still belongs to the Early, Middle or Late Neolithic cultures, depending on the convention in the use of nomenclature of individual countries. The study of the northalpine region therefore starts with the appearance of the earliest copper finds. The latter are followed through the Neolithic period and the study is arbitrarily terminated with the appearance of the Bell Beaker and the Early Bronze Age cultures. Although considerable use was made of unalloyed copper in the EBA this is not treated fully here.

Radiocarbon dates for the entire period are not very equally distributed. Nevertheless, there are sufficient radiocarbon dates for the majority of cultures involved to provide a firm chronological framework which forms the basis for this study. The ranges of all these ^{14}C dates and their interquartiles can be seen in Table 2 (where n = the total number of radiocarbon dates available at present for each culture). This method of projecting dates by dispersion diagrams (Ottaway,1973a) has many advantages: it is very easy to construct, it is remarkably constant even when a considerable number of new dates becomes available and are added to it (for instance, neither the general culture sequence nor the interquartile ranges of the major cultures have changed significantly between 1978 (Ottaway[+])and now, despite a 50% increase in the ^{14}C dates available). It is also helpful in determining whether contact occurred between cultures, because if interquartiles do not overlap then the statistical probability is high that the population of dates are discrete; cultures with overlapping interquartiles may be assumed to be contemporaneous (cf also Sakellaridis,1979,42[+]). Thus the interquartile range, or the floruit, is taken as the probable duration of a culture, that is the time span when the culture's intensity was great enough for cultural transmission to have taken place with contemporaneous cultures.

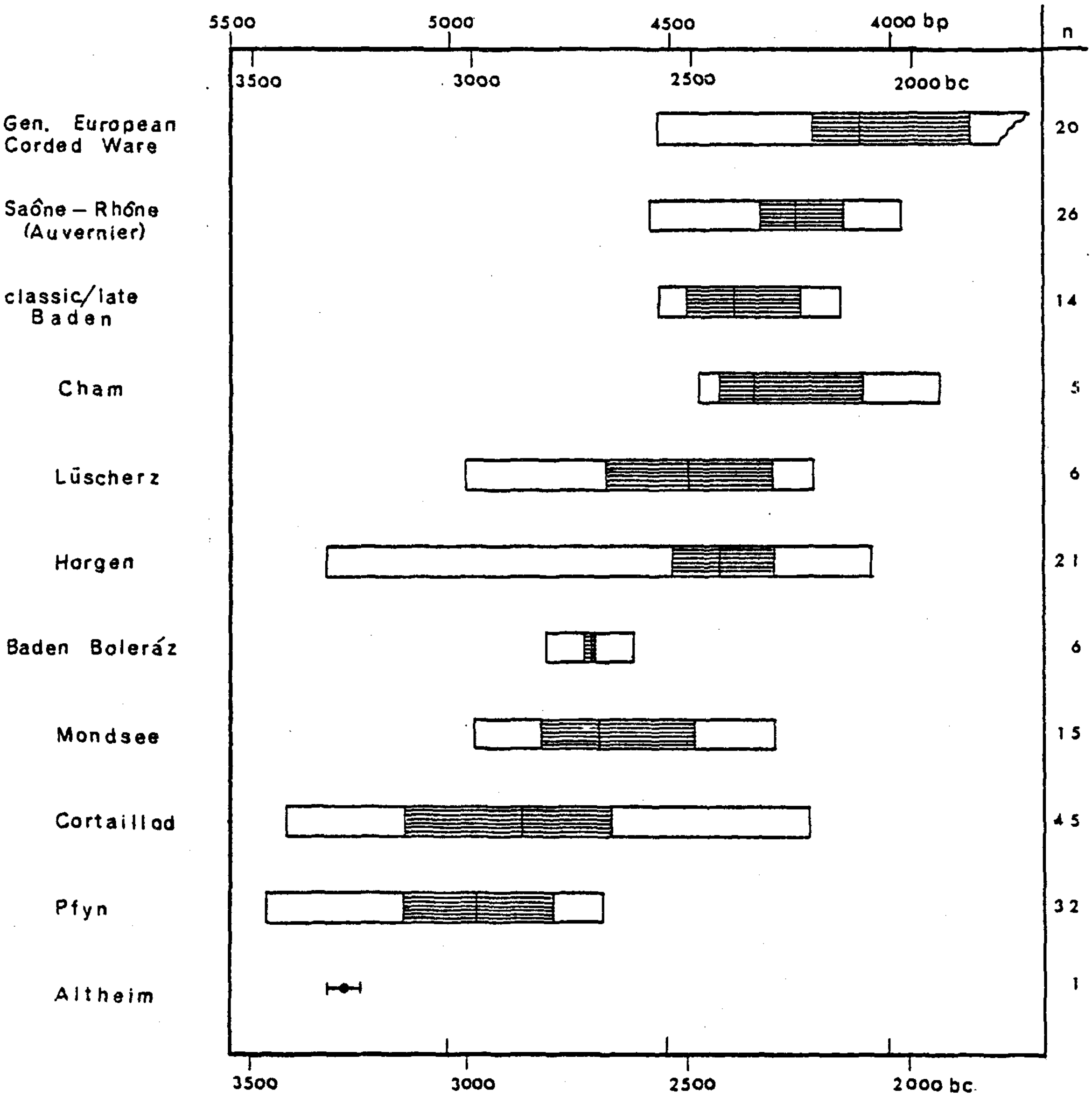


Table 2 Dispersion diagrams of ^{14}C dates for cultures discussed in this book. = interquartile ranges, or probable floruits of cultures. n = number of dates available at present and used for the diagrams.

Interquartiles and their construction are discussed in more detail elsewhere (Ottaway,1973a, 1973b). Most of the published radiocarbon dates used in Table 2 are already collated in Pape (1980+) who applied a method of dealing with ^{14}C dates suggested by Jaguttis (1977 $^{+}$); ^{14}C dates not mentioned there can be found in Appendix I.

From Table 2 a clear chronological succession of the early cooper-using cultures in the northern alpine region emerges, and this succession agrees with stratigraphical evidence where this is available. The inter-quartile ranges show that the Pfyn culture of eastern Switzerland (floruit 3150 - 2800 bc) almost completely overlaps the Cortaillod culture of western Switzerland (3150 - 2700 bc). This, in archaeological terms, provides the physical background to the extensive and long-lasting contacts between the two cultures which are attested by numerous archaeological finds.

The Mondsee culture of Upper Austria, whose interquartile range lies between 2850 and 2500 bc, is later, but still partly contemporaneous with the Pfyn and Cortaillod cultures. Both the Pfyn and Mondsee cultures have many stylistic links with the Altheim culture of southern Bavaria. These and other contacts have to be utilized, in the absence of sufficient radio-carbon dates, to deduce a time span for the Altheim culture. The Schussen-ried site at Ehrenstein, which has been suggested to be coeval to Altheim sites (Driehaus,1961, Lüning,1968), has an interquartile range between 3300 and 3200 bc. The floruit of the Michelsberg's culture lies between 3300 and 3150 bc. Thus the second half of the fourth millennium bc seems to be indicated for the Altheim culture and the only ^{14}C date now available (3290 $\pm$ 40 bc) fits this admirably.

I have associated the Altheim, Pfyn, Cortaillod and Mondsee cultures, after a close study of their archaeological material and contacts, to form the first copper-using horizon in the northalpine region, covering the area shown in Map 2 and dating to the last third of the fourth and the first third of the third millennium bc.

From the point of view of ^{14}C dates there then follows a heterogeneous middle phase, also archaeologically problematic. It is, however, united by one common denominator: all of them make very little use of copper. This latter fact is marked to such an extent that the cultures involved - namely the Horgen, Lüscherz, Cham and Baden-Boleráz cultures - have been thought to be 'metal rejecting'

The Austrian Baden Boleráz group is the westernmost part of the Boleráz culture, whose main concentration lies in the surrounding parts of Hungary, Slovakia, Moravia and Bohemia (Chropovsky, 1973). The six available dates (none of them from Austria) give an extraordinarily closely bunched interquartile region around 2725 bc (Quitta, pers. comm.).

The main concentration of sites of the Horgen culture is around lakes Zürich, Zug and Neuchâtel. The probable floruit of this culture lies between 2550 and 2350 bc and is thus clearly later than those of the first copper-using horizon. The same can be said for the Lüscherz culture, which overlaps to a large extent with the Horgen culture not only temporally but also geographically: its main concentration is around lakes Neuchâtel and Biel. It was separated from the Horgen complex by Strahm (1966) and 28 lakeside settlements (Sakellaridis, 1979+) have not yet been clearly assigned to either the Horgen or the Lüscherz cultures.

The lower interquartile ranges of the Horgen and Lüscherz cultures overlap with a considerable part of the interquartile range of the Cham culture. This culture is archaeologically coeval to the Horgen culture (Burger, 1978+) yet chronologically fits in better with the succeeding third copper-using horizon. The entire Cham assemblage has only one insecurely associated copper fragment, yet this culture appears to be the successor of the Mondsee culture in certain parts of Upper Austria.

Reference to Table 2 suggests that both these cultures are chronologically retarded in relation to the more precocious Altheim/Pfyn/Cortaillod and Horgen/Lüscherz/Boleráz cultures. If this is so, then in this rather isolated region there was no third horizon before the EBA. Nevertheless, it underlines the fact that however heterogenous this middle horizon may be, it is united by its lack of copper finds. Whatever the reason for this deficiency - whether a loss of supply or whether the cultures in the middle phase were conserving rather than innovating societies - copper was again being used to a considerable extent during the succeeding third horizon. This latter comprises the Baden Ossarn, Auvernier and Early Corded Ware cultures, covering the area indicated in Map 3 and dating to the second half of the third millennium bc.

The Austrian Baden Ossarn, or classical Baden culture, is only the westernmost part of the Baden culture, whose main concentration - like that of the Boleráz group - is in the surrounding parts of Hungary, Slovakia Moravia and Bohemia (Ruttkay,1973). A third phase, the Kostalac period, although not represented in Austria, has been included for dating purposes. The combined classical and late Baden dates (Quitta, pers. comm.) have a probable _floruit_ between 2500 and 2250 bc.

The Auvernier culture occupied the area around three lakes of the Swiss Jura, lakes Neuchâtel, Biel and Murten. It is part of a much larger Saône-Rhône complex (Strahm, 1975, Thevenot 1976^{+}). The dates in Table 2 show that the Saône-Rhône complex had its _floruit_ between 2350 and 2150 bc. After about 100 to 150 years the Auvernier culture was beginning to have contacts with, and be influenced by, the Corded Ware cultures. Tree-ring chronology from two settlements , stratigraphic evidence and further radiocarbon dates support this statement, and give the mixed Auvernier/Corded Ware phase a _floruit_ between 2250 and 2050 bc. Only after this time,when both Auvernier and Corded Ware cultures seem to have lived side by side, did the Corded Ware culture become the dominating partner.

Only recently has the Swiss Corded Ware group been treated as a separate entity (Strahm,1971). It may well be that the Bavarian and Austrian Corded Ware 'elements', to which numerous references have been made (Hell,1950, Maier,1963,1965c,1967, Pittioni,1954, Stroh, 1940) will only be synthesized into a coherent pattern after a thorough study, for which a beginning has been made by Reitinger (1969). The available dates for the entire European Corded Ware complex give an interquartile range between 2200 and 1850 bc, but it must be borne in mind that the Swiss Corded Ware dates constitute the earliest dates within this set. A recent suggestion that the Corded Ware complex is contemporaneous with the Horgen culture (Pape 1978[+]) does not seem to be supported by the evidence provided by the ^{14}C dates: the interquartiles indicate that they are discete sets of data.

b) <u>TYPOLOGICAL AND ECONOMIC ASPECTS</u>

The analysis of all archaeological material available for the cultures in this study allows certain generalized conclusions: the Cortaillod, Pfyn, Mondsee, Horgen, Auvernier and Corded Ware sites are found predominantly on or near lake sides, in bogs or on riverbanks, but mostly with a few outposts on hills or rocky shelters. Recent surveys in Austria have indicated that the number of lakeside settlements can be expected to rise considerably (Offenberger,pers.comm.). In the north of Austria, sites belonging to the Epi-Lengyel culture complex are only known to occur on hills, but in southern Austria lakeside settlements have been identified. This suggests that the complete pattern for this complex has not yet emerged, probably because it has only recently been established as a separate entity. For the same reason there remains a similar uncertainty about the overall Lüscherz settlement pattern. The Altheim and Austrian Baden sites, on the other hand, are situated mostly on hills, although some settlement sites also occur in bogs and on lakes. Most of the Altheim sites, particularly the newly discovered ones are situated on rivers and on gentle slopes (Christlein, pers.comm.).

Too little information is available at present to draw any but the most general conclusion about the economic aspects and utilization of resources of the South German and Austrian cultures studied here. The situation is radically different for the Swiss late Neolithic cultures, which have received considerable attention in the last decade or so (cf. Boessneck,<u>et al</u>,1963,Chaix,1976, Clason,1966, 1969, Guyan,1976, Hartmann-Frick,1969, Higham,1968a,1968b, Liese-Kleiber,1977[+] , Pawlik & Schweingruber,1976, Sakellaridis,1979[+] , Sauter,<u>et al</u>, 1971, Stickel, 1974[+]). Perhaps the most important point to be learnt from one of these studies, in which site catchment analysis, detailed examination of the environments, palaeoeconomies and climatic evidence of the individual lakes, as well as animal and plant resources were brought together, was that ' . . . a blanket statement of any economy of any culture is not realistic, for cultures adjusted to different environments to gain better food production rather than being tied rigidly to specific husbandry.' (Sakellaridis,1979,177[+]). Nevertheless, although she had many reservations, some cultural features could be distinguished by Sakellaridis: for instance, whereas the Pfyn and Cortaillod cultures seem to have used only small land clearances and had problems with overwintering of their animals, probable increase in summer pastures allowed the Horgen and Lüscherz cultures to have more successful cattle husbandry and keep more pigs. The Auvernier and Corded Ware cultures used larger clearances, had greater argrarian farming and used more varied legumes as well as keeping larger flocks.

It seems then that the Neolithic communities developed their economies in a rational yet empirical way. At the same time, we have to expect non-uniformity of response by prehistoric populations to their environment. Thus we have to study in as much detail as possible the modes of utilization of all likely resources accessible to a culture to deduce some of the socio-economic information.

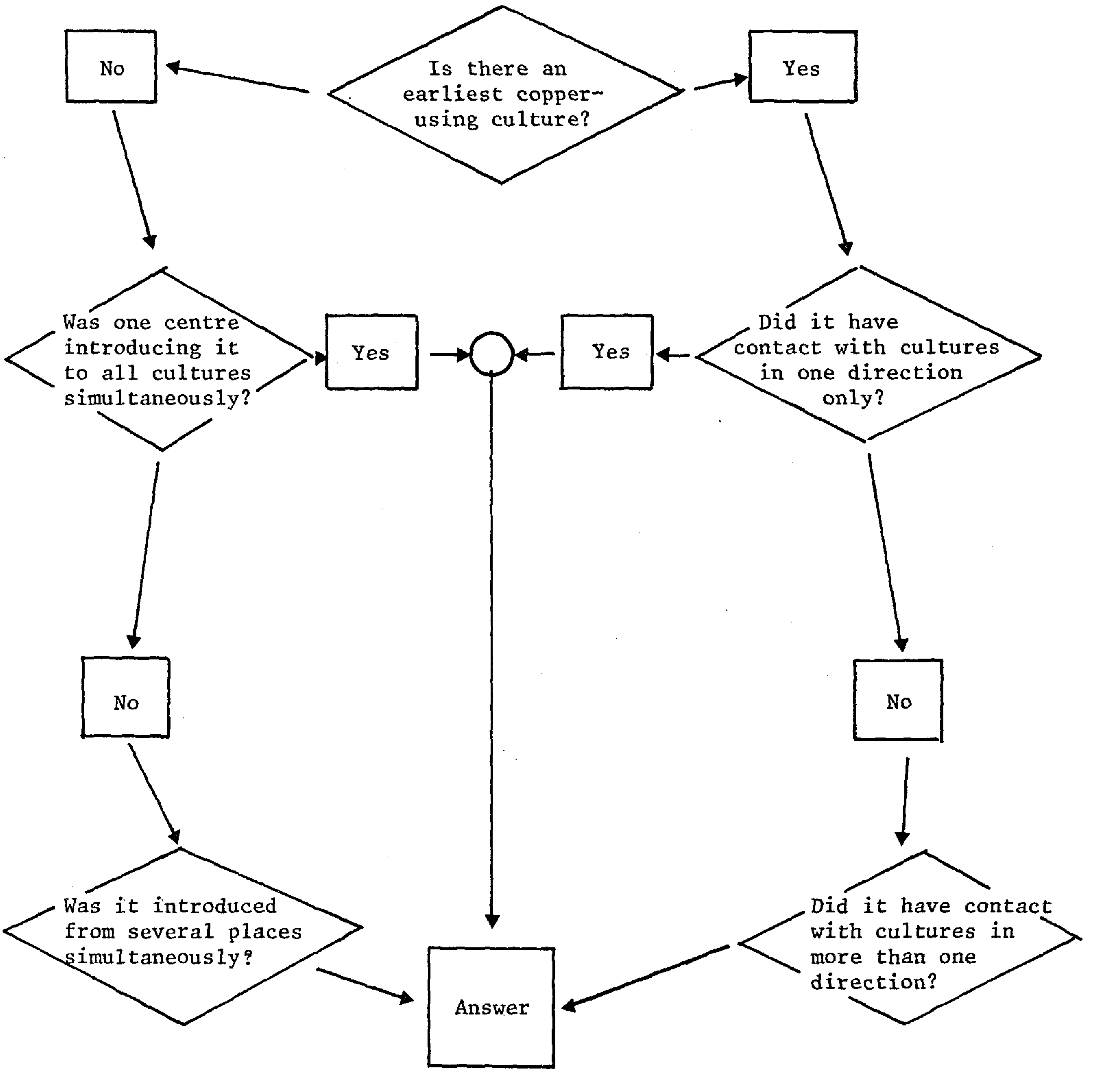
CHAPTER II. THE EARLIEST COPPER FINDS IN THE NORTHERN ALPINE REGION

II.1 INTRODUCTION

In the last chapter the existence of three copper-using horizons in the northern alpine region was suggested. Maps 2 and 3 show the spatial distribution of the two copper-rich horizons, i.e. the first and third. Of course, there are overlaps: cultures do not simply die out. The distribution maps are a necessary simplification of a three-dimensional time-space development which provides the basis for the following fundamental questions: can one distinguish any one of the cultures to be earliest to use copper? If the answer is 'yes': was there a later linear development throughout the area and was it one- or two-dimensional? If the answer is 'no' : was the use of copper introduced from some centre outside the area to all cultures simultaneously, or was it introduced simultaneously from different places? This can perhaps be better illustrated in the form of a flow-chart (p. 30) where each question has a yes/no alternative.

There are ideal situations which would enable one to answer all these questions quite clearly. These would be that 1) each copper artifact had been found under controlled conditions, i.e. that its exact provenence and cultural affinity was known, 2) that each culture had a precisely known time-distribution, and 3) that each metal object had been examined metallurgically. This last

Table 3


Is there an earliest copper-using culture?
No
Yes
Was one centre introducing it to all cultures simultaneously?
Yes
Yes
Did it have contact with cultures in one direction only?
No
No
Was it introduced from several places simultaneously?
Answer
Did it have contact with cultures in more than one direction?

specification is in order that one would be informed about the exact techniques employed in its production, both analytically, so that each had a known 'fingerprint' and could perhaps be traced to its source of raw material, and also typologically. This list of ideal conditions could, of course, be extended considerably, e.g. it could include the precondition that all analyses had been executed by one laboratory, that all excavations had been led with the same meticulous care, etc.. It is self-evident, that nowhere and probably never can all these ideal conditions be satisfied and that as usual when dealing with archaeological material we shall have to content ourselves with partial information.

It is proposed to use those copper artifacts which are securely associated to a known cultural assemblage and for whose time-distribution we have a good approximation, as a 'hard core'. This hard core of securely associated finds will also be referred to as 'first-order associated finds'. Since this hard core is mostly very small, the circle has to be widened by including artifacts which come from sites where Neolithic material only has been found. These will be referred to as 'second-order associated finds'. Swiss and Lake Constance sites from which only Neolithic finds are known are such a case. These include Burgäschisee-Süd, Dietikon-Senne, Egolswil, Hagnau, Lorze, Niderwil-Gachnang (Egelsee), Nussbach-Maurach, Thayngen-Weier, Vallon-des-Vaux, Vinelz, Wetzikon-Robenhausen, Yverdon, Yvonand and Zürich-Grosser Haffner. In Austria most of the material does not allow such a clear-cut division.

This chapter is devoted to the typological aspects of the metal finds of first and second order associations. I shall also group other single metal finds found in the northern sub-alpine region around this core on purely typological grounds - and include a brief study of coeval material from surrounding cultures in Italy, France, Germany, Czechoslovakia and Hungary. Only the briefest of references to other material evidence accompanying any of the metal finds will be made, since this will be dealt with elsewhere.

Unfortunately, the circumstances in which most of the metal finds have been recovered are far from ideal: over 90% are single or stray finds. This is mainly due to the fact that both Swiss and Austrian lake-side settlements provide the bulk of the material, which in both countries was obtained by indiscriminate treasure hunting during the end of the last and the beginning of this century. Many of these settlement sites were occupied for long periods either continuously e.g. at Mondsee: or with intervals of non-occupation in between (Egolzwil), and only rarely were they occupied for a well defined short period as at Burgäschisee-Süd. The development of modern techniques has enabled Swiss archaeologists to excavate sites up to 4m below water level (Egloff, 1972; Strahm, 1971c). They were thus able to ascertain at some of the lake-sites which groups were represented and which were not. In Austria the situation is made more difficult by the greater depth of the lakes, and consequently a greater depth of water above some of the lake-side settlements. However, there are sites which are not under deeper water than in Switzerland (e.g. Seewalchen: 2m depth), which could be excavated with the same care and rich results as in Switzerland, but this has not so far been attempted. Fortunately there are also some settlements on dry land in Switzerland, south Germany and Austria, all of them providing us with vital, securely stratified metal finds.

First and second order associated copper finds include the following types: flat axes, flat daggers, knives and daggers with midrib, awls, spirals, beads, small Ösenhalsringe, pendants, chisels, sickles, a spiral cylinder, a fish hook and several droplets of copper as well as crucibles. The cultures which produce most of these associated copper finds are the Pfyn, the Cortaillod, the Altheim, the Mondsee and the Baden-Ossarn cultures. The interquartile ranges of their uncorrected radiocarbon dates lie between 3100 and 2250 bc (cf. also Table 2, page 23). Based on this information, the Pfyn and possibly the Altheim cultures are the earliest, followed closely by the Cortaillod and the Mondsee cultures.

In the following sections of this chapter the individual types of copper artifacts found in association to the late Neolithic cultures will be discussed. Although the sample sizes in this and the following chapters may be criticised as being too small to allow valid conclusions to be drawn from them, it is the only extant material of its kind available to us. Valuable studies such as locational analysis have been carried out on very small samples (cf. Hodder and Orton 1976, 211-223).

II. 2 AXES

i) Flat axes securely associated to the Pfyn culture were found at Cham-St. Andreas, at Risch-Schwarzbach and at Zürich-Wollishofen. The former two were associated with typical Pfyn stone axes (i.e. 'Michelsberg' stone axes in the old terminology), the latter with a crucible which is now in Dr. Wyss' study collection at the Schweizerische Landesmuseum, Zürich.

Second-order associated flat axes were found at Egolzwil 4 and at

Hitzkirch-Seematte: both are Cortaillod sites. To these a few others with less reliable association but a high probability of belonging to the Pfyn horizon were added. A typical example is the axe from Wetzikon Robenhausen, which was not found during the excavation of the Pfyn settlement site itself but on the rubbish heap in 1882. However, this site contains Neolithic material only and the flat axe can therefore be included. A 'hard core' of 18 flat axes was thus established. (They are marked by an asterisk (*) in Appendix II.) Seventeen of these axes occur in a typological study by Sangmeister and Strahm (1974); fifteen were of their type Thayngen (cf. Appendix II under 'old grouping: T') and two of their type Bevaix (cf. Appendix II under 'old grouping: B'). Because my criteria were more stringent than those of Sangmeister and Strahm, twelve of their Bevaix-type axes are not included in my hard core of associated finds. Sangmeister and Strahm (1974) suggested that the Thayngen type axes were synonymous with the Pfyn culture: their distribution is almost exclusively in eastern Switzerland, i.e. the distribution of the Pfyn culture itself. The definition of this type was somewhat vague, sometimes even conflicting, thus indicating that perhaps it was not such a homogeneous group as suggested. I tried to define this group more precisely by taking measurements of the length, the widths at the butt, half way down and at the cutting edge, and the maximum thickness, (Fig. 1) as well as the weight. All these measurements for all flat axes in Switzerland were put into a datafile (cf. Appendix III).

The attempt to define the Thayngen group used cluster analysis (see Chapter III,p. 97). The objects used numbered twenty-eight; they included all my hard core of eighteen, and ten of the twelve

Bevaix-type axes defined by Sangmeister and Strahm; the two axes from Greng were left out because they are too corroded to provide reasonably accurate measurements. The numerical data was first converted into a similarity matrix (Pearson Product-Moment correlation coefficient) and then clustered with Olivier's option 7 (Nature's Group). Three major groups appeared and stayed relatively constant even when other clustering methods in the Bieber-Olivier package were tried. These three clusters (R,T,B in Fig.2) raised some interesting points. Above all: the three most securely associated axes, all of Pfyn association, fell within two well defined separate groups; they are axe numbers 01, 03 and 12 and are illustrated in Fig. 4a, 3b and 3e respectively. (The axe numbers are those used for discriminant and cluster analysis in Figs. 2, 6, 7 and 8, and correspond to those in Appendix II and IVa.) The results of the cluster analysis thus indicate that the old Thayngen type should be subdivided, but that both sub-divisions belong firmly to the Pfyn culture. Professor Strahm, in a discussion on the new group formed by the sub-division, suggested that it should perhaps be called 'Robenhausen type', after the axe from Wetzikon Robenhausen (Fig. 3 a). The distribution of this group is entirely in eastern Switzerland, i.e. a typically Pfyn distribution. Some axes formerly grouped under the Bevaix type now clearly belong to the new Robenhausen type, such as e.g., the axe from Risch-Schwarzbach (no. 12, Figure 3e). Others, such as the axes from St. Blaise (no. 46, Fig. 3f), Estavayer (no. 59, Fig. 3g) and Préfargier (no. 62, Fig. 3h) form a sub-cluster within this new group.

Axes of Robenhausen type (total number: 10) are small, with a mean length of 7.7 cm, a mean width at the butt (w_i) of 2.2 cm, mean width half way down (w_{ii}) of 2.8 cm, mean width at cutting edge (w_{iii})

of 3.7 cm and mean thickness of 6.5 mm and can be seen in Fig. 3. They were cast (Sangmeister and Strahm (1974) suggested in bipartite moulds, since their outline is very precise) - but not always very skilfully - as one axe from Zürich-Wollishofen, Haumesser, shows. It has several tears across both sides, probably indicating too rapid cooling.

The Thayngen type, comprising now twelve axes, still forms the largest group. The mean length is larger (11 cm, the other mean measurements are w_i 1.8 cm, w_{ii} 2.6 cm, w_{iii} 4.1 cm, t 11.9 mm) and the outline is more concave, as can be seen in Fig. 4.

The Bevaix type (now only containing six axes) is broader than the Thayngen type and at the same time is slimmer in profile (Fig.5). The mean measurements are length: 12.4 cm, w_i 2.7 cm, w_{ii} 3.9 cm, w_{iii} 5.1 cm and thickness 10.6 mm.

The grouping achieved by the clustering method was corroborated by discriminant analysis (cf Chapter III,p.106) the percentage probability with which each of the axes is allocated to the 3 groups was very high. It is therefore clear that the Pfyn culture used two types of axes: the Thayngen and the Robenhausen types - and these will provide the firm basis for further studies on flat axes.

Grouping of all Swiss flat axes was attempted next, and the result can be seen in Fig. 6. (All measurements used for the clustering are in Appendix III). Again three big groups appear. The first (upper) group (T) contains all of the securely associated Thayngen finds, defined from clustering the hard core, together with seven further axes, which can therefore tentatively be assumed to belong to the Pfyn culture. Two of these (Numbers 37 and 38) are from the lake-side dwelling Nussdorf-Maurach on Lake Constance, which contains almost certainly only Neolithic material. The Robenhausen group (R) remains a tight cluster, with several other axes clearly closely related to it. The third cluster includes all Bevaix-type axes, as well as all those not assigned by Sangmeister and Strahm (1974). The Robenhausen-Bevaix subgroup (p. 35) has moved back to the third group, but as Fig. 6 shows, is not very closely associated with it. This third cluster is indeed a rather heterogeneous cluster of axes; it includes some of the axes from Greng, which all have a very thick layer of patina attached to them (Schwab, 1970), and should probably have been excluded from the clustering. Bevaix-type axes cannot be firmly associated with any one culture in Switzerland but are most probably later than Pfyn-type axes.

None of the Austrian flat axes were found in secure association, even though some of them are quite recent finds, e.g. one at Lana-Gaulschlucht in Tyrol (Lunz, 1973), and one found during the extension of Linz harbour on the Danube (Pittioni, 1957). Nevertheless, all Austrian flat axes are compiled in Appendix IV; their numbers are all prefixed with 'A'. Their measurements are in the datafile in Appendix V. Cluster analyses of the data showed that there are basically four big groups, (D-G; Fig. 7). Examination of the axes in clusters F and G showed that they are large massive axes, mostly from Carinthia, Tyrol and the eastern Danube region.

Group D (Fig. 7), on the other hand, contains small axes of an appearance so strikingly reminiscent of the Robenhausen type that the similarity was tested by combining the data files of the Swiss axes of

Robenhausen type and of Thayngen type (groups R and T of Fig. 6) with groups D and also E of Fig. 7 . The combined data (62 objects) was clustered. Fig. 8 shows that three major clusters emerged. Cluster H is in effect the Swiss type Robenhausen, together with six of the small Austrian axes - no. A23 from Pölshals (Fig. 9 a), no. A17 and no. A15 from the Mondsee, nos. A10 and A22, also one from Altheim (no. A52). The similarity both visual and statistical, between the Austrian and Swiss axes in this cluster is considerable.

Cluster K contains all the Swiss axes of the type Thayngen, and three Austrian axes, whose similarity to the former is not, however, overwhelming.

Cluster L is basically the nineteen Austrian axes not so far mentioned, together with three Swiss axes. Almost all the Austrian group E (Fig. 7) are in this group, still tightly clustered; characteristic examples of this group come from the Attersee (Fig. 9 b) and are more elongated than the Robenhausen type, but broader than the Thayngen type.

Thus the effect of clustering was to show that most small Austrian axes are more similar to each other than to any Swiss ones, but a minority relate closely to types Thayngen and Robenhausen, especially the latter.

In order to achieve completeness, clustering was performed on the combined data formed from the large Austrian axes (groups F and G, Fig. 7) and the Swiss Bevaix axes, but no meaningful re-grouping, emerged. This is perhaps not surprising, since group G in Fig. 7 includes such axes as that for instance shown in Fig. 9d and 9e. Group F should indeed perhaps have been excluded from the study altogether, since four of the six axes - from the Austro-Hungarian Empire - might in fact, be of Hungarian or Slovakian origin.

Thus clustering, on a purely morphological basis, has helped to distinguish clearly between two types of Swiss flat axes, the types Robenhausen and Thayngen, both belonging to the Pfyn culture. The hope to attach unassociated flat axes, i.e. stray finds, to an associated type has, however, been only successful on a limited scale. Several stray finds from Switzerland could be grouped to the type Robenhausen. A close typological relationship between one group of Austrian flat axes and the Swiss type Robenhausen could also be shown to exist. Whether this is coincidental or constitutes a real contact can only be decided after further study in particular with the aid of metal analysis.

It also seems significant that the large heavy axes are from the southern and eastern and most accessible Danubian part of Austria, where contact with the neighbours and accumulation by trade might be assumed. The more one goes into less accessible regions and the further west one goes, the more uniform the groups become so that it was relatively easy to group the Swiss flat axes typologically. The homogeneity begins to appear in the Austrian lake district.

One might expect such a reduction in variability on geographical grounds if the underlying hypothesis assumes contact by trade and other social means with cultures more advanced, and richer in copper metallurgy, in the east and the south. Further away from these contacts, i.e. further west, cultures with access to copper might have made their own axes as copies of the larger ones, but with a more economical use of metal. This hypothesis seems to be supported by the uniformity of axes in the Mondsee and the Pfyn cultures. The distribution of the flat axes is shown in Map 4.

ii) Copper axes with shaftholes are not known in Switzerland or southern Germany and only a couple come from second order securely associated finds in Austria. One axe hammer comes from Zwerndorf and was found in 1931 with sherds of the Baden culture, other Neolithic sherds and wattle and daub (Willvonseder, 1937b). Its sides are facetted (Fig. 9f) and it has alternatively been grouped to Garasanin's type I,2 (Garasanin, 1954) or to Schubert's type III (Schubert, 1965). Another axe hammer from Linz St. Peter (Fig. 9g), was found close to the copper flat axe (cf. App. IVb) during the building of Linz harbour. This type of axe hammer is well known from the Hungarian Tiszapolgár culture and from Slovakia e.g. Vel'ke Raškovce or Tibava .

Two further axe hammers are thought to belong to the Baden culture. One was found at Puch and is unlike any found in south-east Europe. It is however, very similar to stone axe hammers found in Austria and is thought to be a copy of them (Pittioni, 1954; Fig. 136). The other axe hammer is very massive and large and was 'found' without site name in the museum at Mödling, near Vienna. It has again parallels in the Hungarian Copper Age culture of Tiszapolgár.

These axe hammers are listed in Appendix IVb and their distribution is shown on Map 4.

iii) There are no securely associated pronounced flanged axes in the area of study belonging to a late Neolithic horizon. The only possible exception is an axe from Vinelz which shows very slight flanges on one side (cf. Strahm, 1971a; Fig. 25,2). Pronounced flanges are thus clearly an EBA development.

II .3 DAGGERS AND KNIVES

The next types to be discussed are daggers, and knives. Of the former usually only the dagger blades are preserved, their hafts only very rarely. The hafts were probably made of wood; rivetted daggers requiring, of course, a different type of hafting from tanged daggers. One example of how the latter type was hafted is provided by the dagger from St. Blaise which has fragments of the wooden handle still attached to the blade by tar and both secured by a cord wound round tightly (Fig. 10a). A flint dagger from Vinelz of exactly the same shape and type of hafting (Fig. 10b, cf. also Strahm, 1962 Abb. 10,10) gives us an example of the appearance of the whole dagger. Wooden hafts of this kind and similar ones have been studied by Strahm, who came to the conclusion that tanged flint daggers - mostly made of Pressigny flint, were an imitation of tanged copper daggers (cf. Strahm, 1962 Abb. 7-10). Pressigny flint is close in colour and probably in value to the copper implements. Rivetted daggers were probably hafted in the manner suggested by the steles of Sion; on two of these steles a triangular dagger has a crescent-shaped pommel (cf . Gallay & Spindler, 1972, p.63 and p.51). Since these steles were re-used by Beaker people for some of their graves, and neolithic occupation of this site has been proven (Gallay, 1972c), it is clear that this kind of hafting was well known in our period.

Daggers in Switzerland as well as in Austria are often very small and their application as a stabbing tool is rather dubious, they were more likely used as knives. It is therefore often quite difficult to draw the line between small daggers and knives.

Basically the daggers fall into the following 3 groups: i) flat rivetted daggers; ii) rivetted daggers with a midrib on one or both sides, and iii) tanged daggers, which are all flat. Both types i) and ii) could be subdivided again into small and large and into those with round, straight or trapezoidal hafting plates. However, very often the graduation between these sizes is so imprecise that grouping based on those criteria would be quite artificial, particularly if one bears in mind that different castings even in the same mould could produce different sized objects (Tylecote, 1973), and that each time a dagger is re-sharpened it changes its shape somewhat.

The midrib is a more important distinction: Flat daggers could be manufactured by hammering - unfortunately, there are no metallurgical examinations to prove this, although the appearance of some of these daggers and knives would support such an assumption. Daggers with a midrib on one side only, were cast in open moulds, but those with midribs on either side were probably cast in a bi-valve mould and could thus be a more advanced type.

i) One securely associated find is a large flat rivetted dagger-blade (Fig. 1 1a). It was excavated in 1973, just a week prior to my visit to that area, at the site of Yvonand-La Peupleraie (Yvonand I) in Switzerland, together with a vessel belonging to the Auvernier group (Strahm, 1975a, 17). The dagger blade is elongated but still triangular, its point slightly rounded and its hafting plate straight. Its cutting edges were hammered to sharpen them; three square rivets forming a straight line are still in their rivet holes and Strahm suggested a shafting like those mentioned for the Petit Chasseur, Sion daggers. He also pointed out that one of the cutting edges is slightly convex, indicating its use as a knife i.e. a cutting implement rather than a stabbing tool.

At Vinelz, a site with Corded Ware material only, a dagger very similar in appearance and size was found (Fig.11 b). Morphologically similar, but smaller flat daggers also occur at Vinelz (Strahm,1971a, Abb.25). This indicates clearly that this type is typical for the late Neolithic Auvernier/Corded Ware groups. A list of typologically similar ones, e.g. those from Onnens, but also including small daggers with a straight hafting plate, can be found in Appendix VIa and their distribution (Map 5) shows them to be an entirely Swiss development.

It is not clear whether round hafting plates merit a distinction from daggers with a straight one. Certainly the size of the dagger from Sutz, Lattrigen (Fig. 11 c) is very similar to that from Yvonand. A small riveted flat dagger with round hafting plate (Kyrle,1918,Fig.9.1; Kneidinger,1942, T.IV,52) was excavated between 1914 and 1917 at the Langensteiner Wand in the Laussa valley in Austria. This site has, like several others in the area, produced Late Neolithic finds only (Kyrle,1918; Mitterkalkgruber,1954; Reitinger, 1968) but has not been fully published. However, it seems justifiable to include this small type of dagger blade with rounded hafting plate and two or three rivets parallel to the hafting plate (Fig. 11 d,e) in the late Neolithic assemblages. A group of morphologically similar daggers are all single finds from Austria and Switzerland (App. VIc and d), and their distribution (Map 5) shows that they occur widely scattered over the northern alpine area.

ii) Both small and medium sized daggers with midrib occur at Vinelz (Fig.11 f-h), so that we cannot automatically rule out the existence of midribbed daggers from the late Neolithic period. This is also supported by the presence of a dagger with a midrib in the Bygholm hoard

(Sylvest & Sylvest,1960,Fig.8) in Denmark which belongs to the TRB:C cultures of northern Europe (Ottaway,1973 d). Small daggers with midrib and round hafting plate (Fig.11 i), and large daggers with midrib and with trapezoidal hafting plates (Fig. 11 k) and also smaller daggers are fairly frequent in Austrian lakeside settlements of the Mondsee culture. Similar ones to these can only be found in secure association outside our area; in the Slovakian Ludanice group which is contemporary to the Hungarian Bodrogkeresztúr culture. A list of daggers with midrib can be found in Appendix VII a-c and their distribution is plotted on Map 5.

iii) Tanged daggers, belonging to the late Corded Ware phase of Utoquai (Strahm,1971a, 153) in Switzerland, occur at Lüscherz (Fig. 10 c), Colombier (Fig.10 d) and at St. Blaise (Fig. 10 e,f). At this latter site the large tanged dagger (Fig. 10 a) mentioned earlier was also found. Very similar daggers to those in Fig. 10 c-e have been found in the late Fontbouisse culture of southern France, which belongs to the very end of the Neolithic there (Strahm, 1971a, 153). The larger dagger from St. Blaise is so far the only one of its kind, and its context is problematic although the exact copy in flint at Vinelz suggests a Corded Ware date. In Austria at Wien XXII-Aspern, a flat tanged dagger (Fig.10 g) of similar size to that in St. Blaise has been found in a double burial of the Baden cultural group. Its shape, however, is not triangular, but has been broadened at the tip and then sharpened at the edges (Plate 1 a). It appears therefore that large as well as small tanged daggers occur relatively late in Switzerland and Austria, yet they are well known from the Bodrogkerestûr culture of Hungary (Hillebrandt, 1929, T. IV,5) and the Lažňany group of Czechoslovakia (Šiška, 1972, Abb. 35,3). Tanged daggers are not very numerous but they are listed in App. VIId and their distribution is shown on Map 5.

iv) Knives: As pointed out above, daggers were often used as knives and it is particularly difficult to distinguish between some tanged daggers and knives. This can be illustrated by the knife-daggers from St. Blaise or Monruz (Fig. 10h,i). There is one securely stratified knife in Switzerland from Erlenhölzli, lake Halwil, near Meisterschwanden. It is not symmetrical, less slim in outline than a tanged dagger and has a thickened edge (Fig.10 k). It was found in 1947 and belongs to the Horgen group (Itten, 1970). In Austria one knife and a fragment from another were found at Paura (Beninger, 1961), and one at the Langensteiner Wand; both sites as discussed elsewhere (Ottaway,1978[+]) belong to the Mondsee horizon. Twelve small knives were found in Seewalchen alone, (Willvonseder, 1968) but most of them are now lost. They were on the whole a rather heterogeneous group and less defined than those from Switzerland (Fig.10 l,m). Several of the knives could have been cast in an open mould, since they have a midrib on one side only, but again without metallurgical examination it is impossible to be sure. One of the ends of the knife was probably hafted. There are several very similar knives at the cemetery of Šebastovce, belonging to the Lažňany group in ČSSR (Fig. (Šiška, 1972, Abb. 35, 1,2). The knife is therefore a fully Neolithic artifact and a list (App. VIII a,b) as well as their distribution (Map 5) can be found at the end of the book.

In summary, it can be said that the knives are the earliest representatives amongst the stabbing / cutting implements - they are known from the Horgen and Mondsee cultures onwards. Next in chronological order appears the flat dagger with a round hafting plate which occurs on Mondsee land settlements and onwards in Austria and Switzerland.

Then follows the flat dagger with a straight hafting plate which is represented at the Auvernier culture and later, as well as tanged daggers which are known in Austria from the Baden period and in Switzerland from the Corded Ware period. Finally, midribbed daggers appear at Corded Ware sites in Switzerland and probably belong also to a similar time period in Austria.

II .4 AWLS AND PINS

The next artifact type to be discussed is awls and pins. The latter should really be discussed separately but since there are only two, perhaps three, pins in our entire area they will be included with awls. One pin, a Rollennadel, was found in Switzerland at Yvonand/Geilinger in 1974 in clear stratigraphic association with finds of the Horgen and the Lüscherz groups, such as pottery, antler axes, winged antler sleeves and rhombic arrowheads of flint (Strahm, 1975a). The pin consists of a long irregular square shaft which is pointed at one end and hammered flat and then bent over at the other (Fig. 12 a). Microscopic examination showed that it had several grooves running along its shaft and that it was probably hammered together from several pieces of metal.

In 1975 another similar Rollennadel - with square shaft, grooves and a slightly more bent head - was found at an excavation at Auvernier/Brise-Lame, and Strahm (1975a) suggested that we are dealing here with a specific type of pin of the Lüscherz group. This is a rather interesting suggestion since hitherto the Rollennadel was thought to be a typical BA object, and coeval parallels to the Swiss Neolithic pins cannot be found nearer than in the Ukraine. It seems likely therefore and indeed most plausible that this simple type of ornament was 'invented' in Switzerland. Whether we agree with Strahm's suggestion that it could have led to the BA Rollennadel or whether such a simple type could have been thought of several times is a matter of taste and cannot at the present be decided.

At Yvonand/Geilinger another smaller pin or awl (Fig. 12b) was excavated under precisely similar circumstances and associations as the previous pin. It too shows traces of having been hammered together from several pieces of metal. One end is pointed, the other flattened but it is only half the size of the Rollennadel. It has an almost exact counterpart in Austria at Seewalchen (Fig.12 c). A Rollennadel of similar size was found at Corcelles, Switzerland, but is a single find. Another stratified square awl was excavated at the settlement of Auvernier/La Saunerie (Strahm, 1965).

The four Swiss finds are the only securely associated ones. There are, however, quite a few second-order associated awls in Switzerland, South Germany and Austria. They can be divided morphologically into those with i) a square shaft and a rounded tip and those with ii) a round shaft. The first sub-type (i) has very good parallels in the Hungarian Bodrogkeresztur group, and a recent find of a small, thick awl with square shaft and oval tip was excavated at Schernau, Lower Franconia, Germany (Lüning, 1973). This awl had been cold-hammered and was found in late Rössen contexts (layer 6) in the south eastern part of a house floor together with a small spiral finger ring. Charcoal from layer 6 gave a radiocarbon date of 3260±65 bc (KN 726). Awls with round shafts (ii) occur in the Slovakian Lažňany group. We can therefore be sure that both sub-types can occur from Neolithic contexts onwards.

In Bavaria an awl was found during the excavation of a trial trench at Wallerfing-Bachling (Siegroth, 1972). This trench also produced a conglomerate of hitherto unsorted Rössen-Münchshöfener-Altheim elements and could therefore belong to either of those three groups. It is quite likely to belong to the Münchshöfener Wallerfing phase (Maier, 1972), which I would suggest - disagreeing with Maier - is coeval with the Austrian Bisamberg-Oberpullendorf group recently worked out by Ruttkay (1976), since they have several elements, amongst them the handled jugs and enlarged herringbone patterns of incised lines, in common. The awl - or is it a pin? - is 12.6 cm long and has a similar pitted and hammered appearance to the pin from Yvonand. Its shaft is round at one end - just as that from Yvonand - and is otherwise square.

In Austria, at the Neolithic settlement site of Prücklermauer both a copper awl and a copper pin were found (Mitterkalkgruber, 1954) but the only illustrations (both finds are in private hands) are so poor and without scale that it is impossible to decide whether they really are an awl and pin. In Switzerland, at the site Zürich/Grosser Hafner, which contains Neolithic material of the Cortaillod and the Horgen culture only, an awl with a square shaft but pointed and round on both ends was found in the last century (Antiqua, 1885). It belongs therefore to the Neolithic period, although it is not clear to which cultural group.

At the south German site of Altheim three 'awls' were found (Driehaus, 1960, T. 34, 3-5). They are very small (2.8, 2.7 and 1.4 cm, Fig. 12 d & e) and of irregular, rectangular cross-section. They are more like rivets than awls and are listed in the Munich Staatssammlung as '2 Kupferstifte and 2 Fragmente' (one of the latter is now missing).

Finally, at the Corded Ware site of Vinelz, several awls with round, and half round and half square, shafts were found. The most common type is a basically square shaft which has been smoothed and thereby rounded at the tip (Figure 12 f). It is also common in Austria e.g. at Seewalchen (Figure 12 g). It is possible that the one end was deliberately left square to facilitate fastening into a bone, wood or antler handle with the aid of tar, in a manner demonstrated by one of the Vinelz awls (Fig. 12 h). The manufacture of these awls can be followed closely by the very rough awl (Fig. 12 i) which has several sheets (up to 5) folded inside each other. Their seams are hardly worked over and only the tip has been smoothed. There are also some very small awls and these can have either square or round shafts.

Thus, there is evidence that the square, roughly hammered awl with a rounded tip was the earliest type - belonging to the Münchshöfener culture. A similar type - only rounded at both ends - could belong either to the Cortaillod or the Horgen group. It was followed by small round awls in the Mondsee culture. Both types were carried through to the Corded Ware period when they are represented at Vinelz. By then the awl with a square shaft and round tip is worked with more care and - presumably understanding of the raw material - and there is little evidence of the rough hammering found earlier. This latter handling of the material was still practised in the Lüscherz group from which we know the Rollennadeln.

A list of the two types of awls including the securely associated and the single finds can be found in Appendix IX a-c, and their distribution is plotted on Map 6.

II.5 CHISELS

The type to be discussed next is the chisel. None were found in Austria. In Germany a few occur around lake Constance but in Switzerland they are numerous and several come from second-order secure contexts: one is the chisel from Burgäschisee-Süd (Fig. 12 k), found at the start of the excavation in 1952 during cutting the surface humus. It was treated as a stray find at the time but later the cultural layer was found to reach up to the surface in this field, and there is therefore no reason to doubt that it belongs to the Cortaillod culture as all other finds from this site do (Sangmeister and Strahm, 1974, 191).

The others all come from the Corded Ware site of Vinelz and are of varying size and shape (Fig. 12 l-h). All chisels that could be compared to those mentioned above as well as all smaller ones are listed in Appendix X and their distribution is shown on Map 6.

II.6 BEADS

The next type to be discussed is beads. These occur in our period in Switzerland only and can be divided into two clear groups: ring-beads and biconical beads. The former occur in an absolutely secure stratified context, the latter in a (second-order) secure association.

Ring-beads were found in the Cortaillod settlement Burgäschisee-Süd during the 1967 excavation. A total of 56 beads belonging to two strings, some still on a cord, were excavated from a shallow pit, where they had been carefully deposited. A detailed study (Sangmeister and Strahm,1974) proved that they were made from 5 rods, with triangular cross-sections, four of them about 30 cm long, the fifth somewhat shorter. These rods had evidently been cut and the short pieces then been bent together until their ends met. Each bar can be clearly separated from the other (Ottaway & Strahm,1975, cf. Fig. 12) and the suggestion was made by the latter authors that the beads were currency rather than ornaments.

Ring-beads were known from the Cortaillod through to the Corded Ware period (Fig. 13 a-f) but they are rare. In areas outside Switzerland roughly contemporary parallels are just as scarce (cf. Ottaway & Strahm,1975), Brešč Kujawski being the only site where they occur in any larger number. In Southern France there are about 8 beads which could be called ring-beads (Sangmeister, 1971, Fig. 4) belonging to the French Chalcolithic, which according to Sangmeister is roughly coeval with the Horgen culture in Switzerland.

Biconical beads are known from the Corded Ware site of Vinelz (Fig. 13 g) but also from a few other sites (Fig. 13 h-l). The 46 beads from Vinelz were first mentioned in Antiqua (1885), but the site also produced some ring-beads of the type known from Burgäschisee Süd. In areas outside Switzerland there are only a few coeval parallels to biconical beads: in Kelsterbach, a site belonging to the south-German Corded Ware period, a necklace of biconical beads was excavated. The biconical, facetted type of bead found in the Chalcolithic of France was, according to Sangmeister (1971) another very local development of the type.

A list of all ring-beads and biconical beads can be found in Appendix XI and their distribution on Map 7.

II.7 TUBES OF SHEET COPPER

Beads made of sheet copper, also called tubes of sheet copper, are very numerous in northern Europe, particularly in Germany during the Neolithic period prior to the Corded Ware (cf. Ottaway,1973,Fig. 12) yet in the northern alpine area they are exceedingly rare and only one was found in a relatively secure (second-order) association. It is the tube of sheet copper from Vinelz (Fig. 13m) which, therefore belongs to the Corded Ware culture. It seems that this type of copper artifact was not at all popular before this period, and only started to be used at the changeover from late Neolithic to the EBA.

A list of tubes of sheet copper (App. XII) and their distribution (Map 7) can be found at the end of the book.

II.8 SPIRAL CYLINDERS

A similar lack of securely associated finds is true for spiral cylinders of copper. They are often called beads, or salta leoni. Again they are quite frequent in northern Europe in various Neolithic periods (cf. Ottaway, 1973, Fig. 11), i.e. the late Lengyel, the northern TRB:C, the Salzmünde, Baalberg and Walternienberg-Bernburg as well as in the Corded Ware cultures. The only secure find (of the second-order) comes from the Corded Ware site of Vinelz (Fig. 13 n). The band width of the Swiss spiral cylinders varies between 1-3 mm and the band used for these spirals was usually flat. Those from the lake-side settlements of Sumpf, Zug and from Chevroux have a triangular profile which gives the spiral cylinders a biconical appearance reminiscent of the Corded Ware beads at Vinelz and elsewhere. In Austria most of the spiral cylinders come from the Stollhof hoard and are of a quite different type. They are much larger, much more regularly executed and have a very constant band width within each individual spiral cylinder. The method of production for spiral cylinders has been briefly touched on before (Ottaway,1973).

A list of all probable spiral cylinders is given in Appendix XIII and their distribution is plotted on Map 7.

II. 9 i) SINGLE SPIRALS

The next type to be discussed is a very intriguing one: Until quite recently it had always been assumed that the many single spirals which had been found in lake-side dwellings were fragments of spectacle spirals. However, when Kalicz excavated a spiral earring at Zalavar (Kalicz,1969, Abb. 2), a site belonging to the Balaton culture of Hungary, and when a similar one was 'excavated' in the Vienna museum and found to belong to the excavation of Wien 21, Leopoldau (Jirawetz) (Pl.1b) - a dwelling pit, containing sherds decorated with Furchenstich and other pottery similar to that of the Balaton group (Ruttkay,pers. communication), I re-examined all objects which I had previously classified as spiral spectacles or fragments therof. It was found that all those that come from relatively secure (second-order) associations in Switzerland as well as in Austria were, in fact, single spirals. This is true for one found at the Pfyn site Niederwil Gachnang on the Egelsee (Pl.1c), of which there is a copy in the Zürich Landesmuseum. Unfortunately, the spiral was not found during the Dutch excavation but afterwards on the dump. It was for a time with the finder, who wore it - set in gold - as a necklace (I am much indebted to Prof. Waterbolk and Dr. Butler for their information and illustration of this important find and to Dr. Wyss for the permission to publish it here). The enlarged illustration (Pl.1d) shows that we are not dealing with a cast wire of smooth cross-section, but one which was probably made of several strands of metal wound and rolled together.

Another 'spiral' is mentioned by Sitterding (1972,32 & 86). It was ...' a tiny piece of a spiral, which was the only metal found at this site...'. The site is Vallon des Vaux and contained Cortaillod material only. Unfortunately,no illustration is available, and the 'spiral' is so very small, that the excavator (pers.comm.) is uncertain as to its exact type.

All these three single spirals came from our earliest horizon, which is coeval with phases 2-3 of the Balaton culture. There are two radiocarbon dates for the Balaton culture, from Keszthely-Fenékpuszta of 2830$\pm$ 80 bc and 2940$\pm$80 bc (Bln 500 and 501, Quitta & Kohl, 1969), which fit in very well with Pfyn and Cortaillod ^{14}C dates. There are other single spirals from Austria , e.g. from the Mondsee.

One further relatively securely associated spiral comes from our next horizon: it was found at Baden-Königshöhle, together with late Neolithic pottery (Ladenbauer-Orel, 1954); Kyrle (1924) just noted that a 'fragment of a spiral' was found. Another spiral is somewhat larger than the Austrian spirals, and made of a flatter broader band. It is a single find from Lüscherz (Fig.13 o). Appendix XIV lists all single spirals and their distribution is shown on Map 8. Once one accepts the idea of spiral earrings one could include pieces of 'wire' which have been found occasionally, as part of this artifact type. One such 'wire' was found at Ossarn, together with typical Ossarn pottery; another at Seewalchen, Attersee, might well have had a spiral attached to it.

It is also interesting that a single spiral of lead is exhibited in the museum at Zug (Inv. No. 400).

II .9 ii) SPECTACLE SPIRALS

Spectacle spirals create quite a different problem. There is not a single (even second - order) securely associated example in the whole of our area, yet for the first time we are assisted by their depiction within Switzerland on two steles at Petit-Chasseur, Sion (Gallay, 1972c, PL. 50 & 51). These two steles are still somewhat of an enigma but we can be certain that they were re-used in Bell Beaker times for graves when they were roughly be-headed - whether for purely functional or superstitious reasons is, of course, not known. They had originally been made in pre-Beaker periods (Bocksberger, 1971; Gallay, G. & Spindler, K. 1972; Gallay, A. 1972c).

We have further proof for the early date of spectacle spirals by their presence at the graves in Brešč Kujawski and elsewhere in northern Europe (cf. Ottaway, 1973, Fig. 12), e.g. at sites on the Oder and the Bohemian part of the river Elbe, as well as in graves of the Bodrogkeresztúr culture. But the northern European examples are made mostly of flat copper ribbon (cf. Ottaway, 1973, PL. 31 a & b), whereas the Swiss ones are all mostly of rounded or oval 'wire'. One spectacle spiral, from Font in Switzerland (Fig.13 p) is made of such perfect round wire that it might be a forgery, because no true wire has been found in secure association in northern Europe or in our alpine area (cf. also Section 15, this Chapter). However, Schwab does not consider it to be a forgery, though the circumstances under which it was found are somewhat obscure (personal communication; I would like to thank Dr. Schwab for her kind help and the drawing of this interesting find). Other Swiss and lake Constance spectacle spirals are less carefully executed (Fig. 13q) as is one made of gold from Mörigen. In Austria, the only spectacle spirals - of much larger size and made of even, hexagonal wire all come from Stollhof. There are six of them and they have been compared to those found at Malé Levâre (Spindler,1971), although the loops of the latter are different: they are bent over to form a hook.

The entire question of spectacle spirals will have to be reviewed again when more securely stratified examples are found. Nevertheless, all spectacle spirals are listed in Appendix XV and their distribution is shown on Map 8.

II. 10 PENDANTS

The next type - pendants - include all those objects which were worn on a string. This is indicated either by a perforation or a turned-over end. One found at the settlement site of Altheim (Fig. 13 r) is very similar to the copper sheets with turned-over ends from Preusslitz, belonging to the Baalberg culture (Ottaway, 1973, Fig.5). It is the only intact one of its kind known to me in the northern alpine region and might indicate contacts of the Altheim with its northern neighbours. Fragments of flat sheet copper have been found at Vinelz as well as 6 triangular pendants (Fig. 13 s-u). Unless one wants to make a rather far-fetched comparison to very similar pendants at Inowroclaw in Poland belonging to the late Lengyel period, one has to assume that this type is an independent development. Considering its simple shape I find it not so unlikely.

A very interesting shape of pendant comes from St. Blaise; it is a metal copy of an animal claw (Fig. 13 v) (Munro,1890, Fig.8,11,

12) mentions two of these pendants, but only one is left in the Neuchâtel museum). Another pendant, from Gemeindeberg, Vienna, is in the shape of a slim flat axe but the material used is a banded slate and is perforated in the centre.

A list of pendants and their distribution can be found in Appendix XVI and Map 8 respectively.

II. 11 ÖSENHALSRINGE

The next type to be discussed is ingot torcs, commonly also called Ösenhalsring or Ösenhalsreif. They are a well known BA artifact and therefore, particular care was taken to include only those whose secure association was undisputed. Nine examples belong to the Austrian Baden culture, eight out of these nine come from burials. They are different from the well known Bronze Age torcs: they are smaller and thinner and, as will be discussed in Chapter III their impurity pattern is totally different from the very characteristic so-called Ösenhalsring-copper. Moreover, all the sites on which they were found (Map 9) are very close to each other so that we can be sure to have found the centre of a local development.

One from Baden-Königshöhle (Fig.14 a) was found in a settlement deposit in a cave together with 3 jugs with handles of typical Baden appearance, flint and other material, including the spiral which was mentioned previously (Ladenbauer-Orel, 1954; Kyrle, 1924).

One Ösenhalsring and a fragment of another were found at Leobersdorf during the building of the water mains into Vienna in 1876. Two graves were accidentally uncovered; grave 1 was found to contain one crouched inhumation. At his foot were the skulls of 5 children. As grave goods a channeled jug, fragments of a further four jugs, and 20 animal teeth, a flint arrowhead as well as the Ösenhalsring and the fragment were found. Unfortunately we do not know for certain the exact position of the Ösenhalsring on the body (Willvonseder, 1937a).

In 1933 a mass burial containing 8 skeletons (3 youths and 5 adults) was uncovered in Lichtenwörth. They were accompanied by 5 arrowheads of flint, and 2 shafthole axes of serpentine. Near 6 of the skulls, close to the neck, one Ösenhalsring each was found (Willvonseder, 1937a). Pittioni illustrated four of these still intact (1954, Fig. 137). However, in 1973 only three intact objects (Fig. 14 b and PL. 1e) were found in the museum at Asparn an der Zaya. The three intact examples are remarkably similar to each other as well as being similar to those from Baden-Königshöhle and Leobersdorf: they are made of round irregular 'wire' which has been flattened at both ends and then bent-over to form the hook - or Öse. One of the Lichtenwörth rings has split open near the end and reveals that they - like the pins and awls in Switzerland, had most probably also been rolled together from several strips of metal and then smoothed.

A similar, but smaller, Ösenring was found in the Denk collection at Wieselburg. It had been found in a grave with a crouched inhumation which had automatically been labelled 'Early Bronze Age', presumably because of the presence of this artifact. Unfortunately, no other circumstances of the Ösenring could be found.

Two Ösenhalsringe were found at Maxglan, but since this site contains EBA as well as Neolithic material we have to treat these finds with caution (Hell, 1952b; Hell, 1975), although as we shall see in Chapter III metal analysis will be able to help us somewhat further here.

Seven Ösenhalsringe from the Mondsee which were supposed to be in the Museum in Vienna but were found to be missing in 1973 were analysed by the Stuttgart group (Junghans et al., 1968) and by Otto & Witter (1952). Their analyses suggest a different type of metal - they are made of the typical Ösenhalring-metal - and they are of the typical later, heavier EBA type.

Nothing exactly like this early type is known in Switzerland and the only artifact approaching it is the so-called Ösenband of which two are known. One, from Concise (cf. Strahm, 1971a, Abb.35,2), is made of a flat ribbon of copper with bend-over ends. Strahm suggested that this is a Corded Ware imitation of coeval bronze 'diadems' which was first of all copied in bone then later, when metal was more easily obtainable, in metal (Strahm, 1971a, 156). The other is from the museum at Neuchâtel (Fig. 14c) but its exact location is unknown.

A few less circular crescent-shaped sheets of copper are known from northern Europe (cf. Ottaway, 1973, Fig. 12) and the Swiss Ösenband is really more like those than the Austrian early Ösenhalsringe.

As before a list (Appendix XVII a & b) and the distribution of Ösenringe and Ösenbänder (Map 9) can be found at the end of the book.

II .12 SICKLES

Of our next type - the sickle-knives - only one has a secure stratification. It was excavated by Beninger (1961) at the Paura on the river Traun, Austria. In field $\alpha 1$ and $\gamma 1$ a sickle and a fragment thereof, were excavated in layer M (Fig.14 d). This layer M is below a firm stone paving which separates the Bronze Age finds from late Neolithic and Neolithic (layer T) finds (Beninger, 1961, 55). Together with the first sickle in field $\alpha 1$ the following artifacts were found:

a triangular flint arrowhead, a bladelet of rock crystal, a copper fish hook, 2 spindle whorls with deeply incised decorations, and a serpentine axe. The other field in which a sickle was found, $\gamma 1$, again contained serpentine axe fragments, sherds decorated with deeply incised circular patterns, typical of the Mondsee group and 'a piece of crude metal' (Beninger, 1971, 73). (Several such pieces of crude metal are mentioned in Beninger, but they are not illustrated, nor, to my knowledge, analysed metallurgically.) It seems then that there is no doubt about the correctness of including sickles in the inventory of late Neolithic finds, and several others from Austria are listed in Appendix XVIII. All of them seem to have been cast in an open mould, but no metallurgical examination is available.

Those from Micheldorf (e.g. Fig. 14e) come from a limestone quarry where late Neolithic finds also occurred; and the Rainberg has already been mentioned as a likely candidate for late Neolithic settlement.

This distribution of these sickles (Map 9) shows it to be of local importance - another local development - which only became more wide-spread with the Bronze Age.

II .13 FISH HOOKS AND UNIDENTIFIABLE METAL PIECES

There now remains one securely associated artifact: a fish hook (Fig. 14f) from the Paura, Austria (Beninger, 1961). It was found together with the sickle just discussed. One would expect this type of artifact to be very numerous indeed on settlements near water, yet it is extremely rare. One fish-hook from Cortaillod is mentioned in Munro's guide to lake-side settlement material (Munro, 1890, Fig. 10,2). Others are also illustrated (e.g. Fig. 32,13 and 19). None of these could, however, be found in any of the museums visited, but they are listed (Appendix XIXa) and plotted on Map 9.

The only other securely associated copper objects found in the area of this study are pieces of metal, unidentifiable bits of sheet-copper, or fragments of objects whose shape is long lost. Sometimes, particularly from those four notorious sites - Langensteiner Wand, Mühlbachgraben, Rebensteiner Mauer and Sonnbichl, (Mitterkalkgruber, 1954) - we have only the excavators' remarks that '... a few unimportant metal objects...' had been found, and have to await a further publication patiently (personal communication, Reitinger). All these objects are - for completeness' sake - listed in Appendix XIXb and their distribution too can be found on Map 9.

II . 14 CRUCIBLES, (BUN) INGOTS

Having discussed all the artifacts which with some probability belong to the northern alpine earliest horizons of metal-using groups, we shall now turn our attention to some of the other evidence left behind of smithing and smelting activities. These are in the form of crucibles and similar containers of clay, and pieces of raw material or 'ingots'. The German terms are often confusing and not always correctly used. For instance Gusskuchen is a bun ingot but Schmelzgut can mean anything from a rough piece of metal to the typical early type of 'bun-ingot' which is just a lump of raw material usually with one semicircular and one flat surface (Fig. 14g). This is the form obtained when the copper melted out of the ore during smelting into a shallow pit of sand or similar material. As the discussion in the next Chapter will show these pieces of raw material can be quite pure or they can still contain quite a large amount of iron and other bits of slag so that we are not always justified in calling them 'ingot'. Two other terms in German usage are Gusslöffel and Gusstiegel. The latter is our crucible, the former is really also a crucible, but with a perforated handle into which a (wooden) rod was inserted to act as a convenient way of holding the hot container safely. This by implication means that the ordinary crucible was held by some sort of tongs - perhaps of green wood as used by the primitive smelters in Africa (personal communication, J. Brown) - whereas the handled version was better adapted to pouring the molten metal into some kind of mould and they do, in fact, sometimes have spouts. By implication the handled version is the later type. It is hoped that the forthcoming study of the Swiss crucibles (Wyss, pers. comm.) will elucidate their exact function considerably. Further evidence of the smelting or melting activities on a site can sometimes be in the form of a droplet of metal, as for instance the one from the Mondsee (PL. 1 f).

The oldest material of this kind comes probably from the settlement at the Bisamberg, near Vienna. Unfortunately, the Bisamberg assemblage, which belongs to the Epi-Lengyel Complex of Lower Austria has not yet produced any metal finds. There are, however, several fragments of a crucible (Ruttkay, 1976 and in press).

The Pfyn culture of Switzerland has - as mentioned above - quite a number of crucibles; 5 of them are securely associated and come from Wetzikon-Robenhausen, Niederwil Gachnang (cf. Waterbolk & Zeist, 1966), Zürich-Breitinger Strasse and two from Horgen (Drack, 1969, Abb. 8).

At Prücklermauer, Austria, a fragment of a crucible and a droplet of raw copper were found. At Paura, Beninger found at least 8 pieces of Schmelzgut (Beninger, 1961). The piece of metal from Altheim, mentioned before, could also be some raw material. At any rate it is clear that melting if not smelting, that is local manufacture but not necessarily local smelting, was carried out at several sites belonging to our first and second horizons of alpine early metal work.

A list containing bun ingots, crucibles etc. will be found in Appendix XX a and b, and their distribution (Map 10) shows that all sites are close to the northern alpine edge.

II .15 DISCUSSION

We have now discussed all the metal artifacts in the northern alpine region for which securely stratified parallels within the area could be found. It was possible to group most of the objects, with a few notable exceptions: neither for arm rings, nor spiral arm rings could securely associated parallels within our area be found. I do not think that this is accidental; it means that we have come to the limits of the metal smith's ability in the late Neolithic period. This might at first sight seem rather astonishing, after all the smiths were capable of casting objects like flat axes, possibly starting in the Corded Ware period to cast flanged axes, daggers with and without midribs, knives, and possibly, again at the Corded Ware horizon, awls. Yet all these objects are more solid, shorter or less vulnerable than the length of 'wire', which would be required to manufacture a spiral armring. This 'wire' would undergo further stress and tension when being wound. The production of real wire has always been regarded as a difficult and late process (cf. discussion of this point in Ottaway, 1973) and although very primitive methods of wire-drawing are known (personal communication, J. Brown) they usually involve iron and not copper (Lindblom, 1939). The reason why 'wire' has always been used in quotation marks in this study, is that the northern alpine area did not know the method of true wire-production, nor did most of the rest of northern Europe in Neolithic and late Neolithic periods know it. Areas where copper had a much longer tradition of being worked (cf. Chapter I) probably provided the few scattered single finds and hoards, such as those found at Stollhof, N.Ö., and Bygholm, all of which contain wire of round, half-round or oval cross-section. There are some spiral arm rings and ordinary arm rings which are made of flat copper ribbons, belonging to the Late Lengyel and the Salzmünde cultures of northern Europe (Ottaway, 1973, Fig. 11). It is possible that the spiral arm ring from Lichtenwörth (Fig.14h) as well as rings from the Rainberg (Hell, 1943) do belong to our Neolithic horizon. The Lichtenwörth spiral ring, although coming from the same site as the Ösenhalsringe, was found in a different pit during gravel digging, i.e. it is a single find. It was not mentioned by Willvonseder (1933, 1937). In Hungary, these flat ribboned spiral arm rings occur in the Tiszapolgár culture and in Czechoslovakia, they are known in the Lažňany culture (Šiška, 1972, Fig. 34).

Foreign to our area, are also the bars with triangular cross-section, which provided the material for the Burgäschisee-Süd beads. It is not surprising that no parallels for similar beads could be found - they may well be a manifestation of a short-lived import.

Other artifacts for which no parallels with secure associations within our area exist are axes with a semicircular cross-section and double axes. With one exception the former are finds from unknown sites, in the museum in Vienna, which had - as so many other museums - bought from a wide circle of people and places. The axe from Spitz on the Danube ,Austria, is said to have come from a hoard (museum catalogue) but all the other axes have disappeared. Three double axes are known from Switzerland, but neither in Austria nor in south Germany have any been found. None of the three Swiss examples were found in securely associated circumstances, although the one from Küssnacht (Fig. 14i) was found as recently as 1970. Their function and distribution in central Europe - mainly on the Saale/Elbe and the Rhine - have been well discussed, and since they cannot be included in this study under the stringent pre-conditions laid down earlier in this Chapter (p. 31) I shall refer the reader to Wyss' publication (1974).

At the end of this Chapter we have thus come to a realization of the remarkably broad variety of types which were in use during what is commonly called the 'Late Neolithic' period. We have been able to distinguish three copper-using horizons. Before these there are a few stray copper finds from the Münchshöfener and the Bisamberg-Oberpullendorf cultures of southern Germany and Austria, respectively. The types include awls, pieces of copper and crucible fragments. The first copper-using horizon is represented by copper finds from the Pfyn, the Cortaillod, the Altheim and Mondsee cultures. Types in these cultures were flat axes, spirals, beads, knives, chisels, and crucibles. It was possible to increase the variety of finds belonging to the Mondsee culture by a very large extent after analysing the land settlement sites belonging to it. Thus the following types are known to be represented in the Mondsee-culture: flat daggers with rivets, knives, awls, fish hooks, sickles, pieces of metal and crucibles.

In the second copper-using horizon - represented by copper finds of the Baden Boleráz, the Lüscherz, the Horgen cultures, but probably also by the Cham culture (cf. p. 24) - the amount of metal used decreased and only pins, awls and knives are known. However, only a few years ago these groups were thought to be 'metal-repelling'. This judgement has now been slightly altered but the fact remains that there is very little metal in the second horizon.

The third copper-using horizon is again very rich in metal types. Flat daggers and those with midribs, both rivetted, as well as beads, pendants, spiral cylinders, flat axes, spirals, Ösenringe and pieces of 'wire', other fragments and crucibles are known to belong to it.

It is very interesting to compare these three metal-using horizons of the northern alpine region with their neighbours. The horizon, where the first scattered copper artifacts appear, has coeval eastern neighbours which are in the fully fledged Copper Age. The Ludanice culture of western Czechoslovakia has daggers; at the slightly earlier eastern Czech site at Vel'ke Raškovce heavy shafthole axes and massive rings were in use, which is also true for the Hungarian Bodrogkeresztur culture, where smaller objects such as awls, knives, pins beads were also made in copper.

South-eastern neighbours in Jugoslavia represented by the Lasinja group in Slovenia (N. Jugoslavia) do not seem to have used copper, although earlier further south-eastern groups (Vinča) in Jugoslavia did. But then the Lasinja group has only very recently been outlined (Leben, 1973) and it might still be too early to make positive statements about it. In the south the only coeval group which has any use of copper at all is the last phase of the Bocca Quadrata group; the Rivoli-Castelnovo site at Bocca Lorenza at which 3 trapezoidal axes were found (Barfield, 1971, 49).

The first true copper-using horizon of the northern alpine region has coeval neighbours such as the Lažňany group of Czechoslovakia using knives, daggers, arm rings made of broad ribbons with a midrib, flat axes and awls. The coeval western Hungarian Balaton II group has spirals, and is also smelting or at least melting its copper since a crucible has been found in this only recently defined culture. In the southern Po valley - late Neolithic (Lagozza) culture several copper objects have been found at Attiggio, and a hoard of flat axes from Isolino might also belong to it (Barfield, 1971, 52).

To this horizon also belongs the Brjuni-Skocjan group around Trieste, which used copper in the form of flat axes and daggers. Further south-east, in Jugoslavia, there is as yet no group which would exactly correspond to our horizon.

Our second horizon is a highly interesting one; there is a general impoverishment in the use of copper. This is felt in Hungary, (in the Boleráz culture) as well as right across our alpine region into Switzerland; but it witnesses the first appearance of copper in France: the late Chasséan in the Rhône area is now beginning to use awls, blades and slag (Phillips, 1975, 125). The 'Chalcolithic' period of southern France begins.

The third horizon witnesses another change: the northern alpine region again begins to use a great deal of copper; Switzerland as much as in Austria. The eastern neighbours, during the period of the classical Baden culture, are still poorer in copper than our region. On the other hand, France and Italy, the former represented by the Saône-Rhône culture complex, the latter by the Remedello complex, are now fully copper-using cultures.

We have thus traced a complete reverse of a situation in which cultures that were familiar with the use of metal and had obviously rich supplies of it at hand - note the heavy type of tools e.g. shafthole axes - gradually came to be without the metal. On the other hand, cultures who had been very slow and hesitant in taking up this new raw material made increasingly more use of it until a time arrived when they became independent of its original suppliers and produced their own supplies. This change-over can, of course, be explained in several terms, such as exhaustion of ore supply, or transfer of power to control the exploitation of the ore sources. But in view of the closeness of local alpine supplies which - as we now collect more and more evidence - the northern alpine population knew well how to exploit, the latter explanation is rather unlikely. The early copper users in the south east may have lost control over their supplies but not to the northern alpine region.

This change-over began to make itself felt at the end of the first and during the second horizon, which expressed in terms of uncorrected ^{14}C dates is around the middle of the third millennium bc.

CHAPTER III: METAL ANALYSIS OF THE EARLIEST NORTHERN SUB-ALPINE FINDS

METHODS

The next two chapters deal with the analysis of trace elements in the earliest copper finds. This chapter describes the methods used on samples obtained from museums in Austria and Switzerland, whereas the next chapter deals with the problem of grouping these and other available results in a meaningful way.

This chapter has been divided into two main sections, one on physico-chemical methods, and one on the techniques of classification and statistical treatment of the data that were used. Since basic criticisms, both of metal analysis and of statistical classification of the analyses, have been voiced from time to time, both sections are prefaced by a short introduction. Neither of these is intended to be exhaustive, since it is not intended to be a book on purely metallurgical and statistical questions.

III. 1 PHYSICO-CHEMICAL METHODS

i) INTRODUCTION

This book is concerned with the present state of knowledge of the artifacts of the northern alpine region. There is no doubt that examination of the crystal structure of artifacts could give valuable (although not unambiguous) additional evidence about the manufacturing techniques used (Allen *et al*, 1970; Slater, 1972,21), but there were various reasons why this was not possible. As already implied , attempts to distinguish metallographic features that unambiguously identify objects made of native copper have failed to stand up to rigorous testing (cf. Maddin, 1978). In the event, to have put great emphasis (Coghlan, 1962) on this technique would have been useless, since only one of the museums I approached to take samples for analysis would have been ready to allow the surface of any object to be prepared for micrographical examination. Even permission to drill holes for sample material was only given after assurances as to the smallness of the sample, which is understandable since all the early artifacts are rare, and usually extremely fragile and thin (other than axes).

Thus the data which I have collected is of impurity patterns only. The impurities measured could have included sulphide, which in theory could give an indication of the type of ore used for making the raw copper (Tylecote, 1962, 27 ff).

The quantitative analysis of metal objects, particularly those based on copper, has a long history. It began about 1860, at first with the limited object of distinguishing bronze, brass and copper from one another by analyses of tin, zinc and later lead, but before the turn of the century a considerable corpus of analyses had been published. Early work, notably by Hampel, Helm, Montelius and Much, has been well reviewed by Otto & Witter (1952, 1 ff).

Analyses continued to accumulate throughout this century, but the rate of growth has increased enormously since the beginning of the systematic study of the composition of European copper and bronze objects by Junghans et al (1960,1968,1974), (hereafter also referred to as JSS) which at the beginning also included tables of data published by Otto & Witter (1952), of Coghlan and Case (1957), of Briard and Maréchal (1958) and Novotná (1955b).

The number of multi-element analyses of copper and bronze objects extant must now be of the order of 40,000 (probably more, if the multitude of unpublished Russian analyses were to be included). It is therefore rather startling to read, as recently as 1975, that '... while thousands of analyses of archaeological bronzes have been reported in the literature, the basis for comparing them, especially those from different laboratories, is shaky' (Chase, 1975, 148). The underlying causes of these doubts seem to me to be three, and I propose to discuss them in order.

ii) <u>THE SENSITIVITY OF THE ANALYSIS</u>

It is only to be expected that the lower limits of detection for the various elements have been lowered during the century in which archaeological metal analysis has been in existence, sometimes perhaps by 100-fold. The spark spectrograph uses an image of a spectrum on a photographic plate as the basis for measurement. When the existence of a spectral line can be detected, but is too faint to be quantitatively compared with the standard, most authors use a qualitative symbol: JSS actually use seven symbols - 'less than' ($<$), much less than ($\ll$), trace (Spur), ++ and +, more than ($>$) and much more than ($\gg$). Although it is troublesome to convert these and other symbols into reasonable quantitative equivalents (cf. Appendix XXIII), the objection that lower limits are not concordant is not, in the present work, a serious one. The lower limit stated in the earlier work of Otto and Witter (1952) was, for several elements, lower than that of JSS and more like my own, while JSS have re-determined arsenic, antimony and bismuth (for samples 1-10,040) by more sensitive techniques and published them as an Addendum to Volume 2,4 (1974). The differences in the lower limits between the three sets of analyses is therefore not great.

The more important reason for thinking this objection a minor one is the very wide range of analytical values encountered; for example for cobalt, values range from 0.0002% (my analyses, Appendix XXI) to 'much greater than 0.5%' (cf. Gemeinlebarn coppers, in JSS). In consequence, whether an analysis is 0.0002%, or 0.002%, it still means that the element in question is present only as a tiny trace of impurity. Furthermore, the raw data is normalized before cluster analysis as is discussed in section 2.iv of this Chapter. One would only need to worry seriously if one were trying to use earlier analyses which consistently showed an indicative element to be absent when it was, in fact, present in traces.

iii) REPRODUCIBILITY OF THE ANALYSES

This question has two facets: the index of precision for a single laboratory - that is, the likely range within which an estimate of a single sample would be likely to fall if it were repeated - and the consistency between analyses of the same sample made by different laboratories.

I was not well placed to form an estimate of the index of precision for most of my own analyses, because the method used was neutron activation analysis, and there was no way of getting replicate analyses done, although each estimate is already the mean of a number of intensity peaks of that element (see below). The reproducibility of estimates of standard solutions by atomic absorption spectroscopy was in general, very good, perhaps ±10%, but I was more interested in the consistency between estimates made by different methods on the same sample, and this is discussed in Section 1.x of this Chapter.

Other laboratories have hardly been more forthcoming about their index of precision. A range of 8-16% as the mean percentage error for the five elements used by JSS for classification purposes is quoted by Junghans, Klein & Scheufele (1954, Table 2 & 3). No other statement has been made in later publications from this laboratory, to my knowledge.

When Chase made the remark quoted above, he had in mind chiefly the lack of agreement between estimates of the same element in the same sample, made by different laboratories specializing in metal analysis, which led him to set up the 'Comparative Analysis of Archaeological Bronzes Programme' to improve the inter-laboratory consistency. It should be remarked that poor consistency between results from different laboratories is a general phenomenon in chemical analysis. When accuracy is a matter of life and death, as in clinical chemistry, quality control may be established by sending unknown samples every month to hundreds of laboratories all around the world.

Comparison of my own results with the inter-laboratory standards is dealt with in Section 1.xi of this Chapter.

iv) INHOMOGENEITY OF THE ARTIFACTS

This is probably the source of error in metal analysis that has caused most discussion among archaeologists. For reasons which are fairly obvious, but described more fully in Section 1.v of this Chapter, it is rarely possible to take more than one sample from an artifact. Unless the composition of the copper is absolutely uniform throughout, the result given from analysis of a second sample would not be identical with the first. How, then, can the results from a single sample be relied upon as an indicator of the composition of an artifact?

It seems that no one has ever thought this problem through to its logical conclusion. I have deliberately avoided using the word 'error' in the previous paragraph. If the artifact is genuinely inhomogeneous, then both sets of analyses might be correct for their local region of the artifact, but neither would be 'correct' for the object as a whole. How many samples would one have to take to get an average that was 'correct', or is the only satisfactory procedure to reduce the whole artifact to fine turnings, mix these to ensure homogeneity, and analyse samples of this mixture?

There are good reasons for expecting some inhomogeneity in copper artifacts of any size. These reasons range from segregation of bismuth and lead, which have a very limited solubility in copper (Slater and Charles 1970), to differential solidification, i.e. micro- or macrosegregation during cooling (Richards & Blin-Stoyle, 1961 ; Charles, 1973), mechanical displacement or squeezing out of a lower melting point phase during hot working (Slater, 1972 , Charles, 1973), and enrichment - or depletion - of surface layers, whether due to leaching (Hall, 1961) or inverse segregation (Werner, 1970; Charles, 1973). Quantitative figures are hard to come by, but Richards and Blyn Stoyle reported differences of 10% for several elements between butt and tip of an Irish axe. Charles (1973, Fig. 7) found enrichment of about 6% in tin in the surface layers of a chill-cast slab with an average tin content of 5.09%.

In the following argument I shall try to prove that the element of error due to causes outlined in Sections iii and iv, although real, is not a cause for alarm. Let us suppose that we have 30 artifacts (say axes) coming in equal numbers from each of three sites, and that we are trying to establish whether the axes differ from site to site on the basis of an analysis of one element only (say nickel). The best way to proceed would be to use a statistical technique known as the One-Way Analysis of Variance.

To do this one would first calculate the mean nickel content of all the axes, and then the sum of the squares of all the deviations of the individual analyses from this mean. This sum of squares is then divided, by algebra that need not concern us here (see Colquhoun, 1971, 182) into a component assigned to the variation between the three groups of axes, and one assigned to the variation within each group. The significance of the differences between the groups would be estimated by dividing the <u>mean</u> sum of squares for between groups, by the <u>mean</u> sum of squares for within groups. The ratio ought to be about four for significance.

It is the word <u>mean</u> that is important here. The mean is calculated by dividing each component of the total sum of squares by the degrees of freedom (cf. Section 2.vii of this Chapter). For between groups the number is $(3-1) = 2$, but within groups (between axes) it is $(10-1) = 9$. Thus the total sum of squares could be partitioned into two components of equal size, and the difference between groups would still be significant.

Further the component assigned to 'between axes' can obviously in principle be broken down into sub-components related to experimental error (including non-comparability between laboratories), inhomogeneity of each axe, and real differences between the composition of each axe within one group. Of these three, the last would be expected to be by far the largest, because until the EBA, it is unlikely that objects which have been retrieved and analysed come from anything but small-scale smelting operations. All those who have analysed the composition of ore samples even from a single vein have commented on the large variability in their composition (Pittioni 1957,1959,1971). Pittioni indeed was so impressed by this that he refused to express the results of his analysis in quantitative terms, which unfortunately makes it impossible to compare his results with anyone else's. This difference in ore composition must undoubtedly be reflected in the composition of individual artifacts. For the present purpose the point to be taken is that, because one is not assigning individual objects, even quite large variations in comparability between laboratories, and inhomogeneity of artifacts, are likely to make up only a small fraction of the 'within groups' sum of squares. Providing the number of groups is not too great, and the number of objects within each group is quite large, we need not fear that errors due to causes listed under iii. and iv. will give rise to a failure to classify objects into separate groups - what statisticians call 'an error of the first kind'. Of course, one should take every care that errors due to causes indicated under iii. and iv. are minimized wherever possible.

What statisticians call 'an error of the second kind' is misclassification into a wrong group. This could happen if one were using a limit value of a single element as a guide to classification. This is the basis of the criticisms that have been levelled at the classification used by JSS, but here I am on safer ground, because the method of classification that I used makes simultaneous use of all 11 elements that were analysed. It was my experience that even when one or two important elements were left out of the classification (i.e. were masked), the groupings usually did not change significantly. Moreover, in the first analyses of the data that I collected, I used the original values quoted by Junghans _et al_ (1960,1968), whereas those which are now in this book have been corrected by reference to the supplement (Junghans et al, 1974, p.362-382), already referred to. The corrections are in many cases substantial, but I have been astonished to find how little the classification has been affected. Thus one may say that providing a sufficient number of objects is being studied, and providing the analyses are being used for a suitable purpose, errors perhaps inherent in any large-scale analytical investigation need not deter us from making use of the results. The question 'what is a suitable purpose?' needs a brief discussion.

Doran and Hodson (1975, 251) wrote ...'It should be possible to distinguish clusters that represent common, natural and widely distributed combinations of elements from those that have at least some regional significance. Within the latter it might then be possible to distinguish highly distinctive workshop clusters from more general ore-clusters that reflect no more than well-known major ore-types...'. This quotation puts forward a hierarchy of significance levels for groupings based on metal analysis, but two major, and different, aims stand out clearly: to obtain clusters (or groups) that have 'some regional significance' for their own sake, and the relationship of copper objects to ore-types. The latter aim has been frequently stated as a major aim for metal analysis, but it has on the whole been tacitly abandoned for the present, since many more years of research are needed. In particular the ore analysis programme still has to be widened (Tylecote 1970), and the monumental survey being prepared at the moment by Rapp at the University of Minnesota (1977) should be an important step in this direction. Other workers are studying the behaviour of various elements during experimental smelting and are thus providing valuable information. For instance, Tylecote

& Boydell (1978) have found that recovery of silver during smelting is 100% and that of nickel nearly so, i.e. silver and nickel are copper-related, whereas manganese and cobalt, for instance, are iron-related. It is to be hoped that more studies of this kind are forthcoming.

It has been shown that relationships between ore and artifact can be achieved; Coghlan: (1958, Coghlan et al, 1963) related Irish halberds to ores analysed by Biek (1957). There will, however, always be serious drawbacks, because there are considerable variations of composition within an ore body and thus within the artifacts, as pointed out earlier, and also because there is the strong possibility that prehistoric metal was often obtained from sources which are now exhausted. In order to distinguish the output of a workshop, on the other hand, one might well have to concentrate on a particular type of artifact. In an earlier study of ornaments (Ottaway, 1973), I was in fact able by using the methods of manufacture - ranging from simple sheet-copper pendants to spectacle spirals made of 'wire', in conjunction with impurity patterns - to establish cluster types which are of general usefulness, at least in Denmark (Randsborg, 1979). The present study, however, is concerned with all artifacts; the only simple distinguishing mark of a workshop (if physical examination is ruled out) would seem to be a characteristic alloy. This is easier to establish for tin-bronzes than for coppers. The rather widespread use of lead in bronzes in western Switzerland, which is not characteristic in EBA bronzes of Austria (e.g. Gemeinlebarn cemetery) is one such example. The possibility that arsenic was used for alloying during the time studied here, is a complex matter which will be discussed in detail in the next Chapter.

v) PREPARATION OF SAMPLES

Having thus established that analysis of metal artifacts is still a very useful approach to certain problems concerning early metallurgy, I found that several of the important early Austrian and Swiss metal finds had not been analysed. I therefore undertook the task of analysing these, since the Stuttgart team has stopped its programme of analyses. Over 100 artifacts were sampled and several Bronze Age objects were included, partly because the typological/ chronological study was then only at a preliminary stage, and partly because a few museums wanted to have as many artifacts analysed as possible.

The main methods used for analysis were neutron activation and atomic absorption spectroscopy. Neither of these methods are new in themselves, but they have here been used for the first time for such a wide range of elements and on such small samples, and this necessitated several alterations in the commonly used methods (Shaw and Ottaway, 1974; Chase, 1975; Hughes et al., 1976). Copper was analysed by a method developed by Felsenfeld (1960). On some of the samples Sn and Zn were analysed both by neutron activation and atomic absorption spectroscopy. In about 25% of the samples Sn was measured by a recently developed method using catechol violet (Corbin, 1973). All these methods are described in Sections vi-ix below. Inter-laboratory comparisons as well as measurements of standards are also outlined.

All samples were in the form of fine powder and had been obtained by drillings taken from prehistoric copper or copper-based artifacts. For this purpose, a portable dental drill with high-grade, nickel-free drills was used. The purity of the drills was examined by passing samples over a magnet and comparing the result with samples which had not been passed over a magnet. Before the drilling was started the corroded surface was removed on a small area with special attachment to the drill. The drilling was then carried out to a reasonable depth which depended on the size of the object. In this way the samples were, if at all possible, free from corrosion products and possible surface enrichments (Werner, 1970). The drillings were collected on clean filter paper and transferred into tared polypropylene microcentrifuge tubes, with attached lids (purchased from Sarstedt,U.K) These lids were covered by zinc-oxide plaster and the tubes then labelled. Permission to sample the artifacts was sometimes only obtained when assurance was given that a hole of not more than 1 mm in diameter would be drilled and that only one side would be 'defaced'. This is sometimes quite difficult since many of the earlier finds are small, very thin and fragile. On other occasions there was no such restriction on sample size and it would have been desirable to have had a stronger drill.

The samples were weighed and then subjected to neutron activation analysis (Section vi). After sufficient time had elapsed for the radioactivity to reach an acceptably low level - this time depends mainly on the activity of copper and antimony, and was usually 4 to 6 months - the samples were dissolved in a solution of 4 M fluoroboric acid and 3 N lead-free nitric acid (1:1, V/V) (Hwang and Sandonato, 1970). This mixture was found to dissolve 60 mg/ml copper or bronze readily and hold it in solution indefinitely. Above 15% Sn, however, a small volume of concentrated hydrochloric acid had to be added to redissolve the metastannate. The samples were kept in the polypropylene tubes mentioned above which have the added advantage that they are not attacked by hydrofluoric acid, which attacks glass. Moreover, unlike glass, polypropylene hardly adsorbs metal ions (Struempler, 1973). It is also convenient to weigh the samples into polypropylene centrifuge tubes, because the powdered sample concentrates at the point of the tube, which does not contain impurities. Milar containers, which were used at East Kilbride, were found to contain 214 ppm (0.214 mg/g) Sb. It is also important that the plastic containers should survive exposure to high temperature because temperature in the neutron flux apparatus is about $100^{\circ}C$ (Gilmore, personal communication). Polypropylene survives exposure to $130^{\circ}C$. Most tubes survived the exposure to high temperature in the neutron flux but some became brittle, and it was necessary to put the samples into new polypropylene containers after irradiation, and before atomic absorption analysis. Re-weighing then resulted in a slight loss of sample.

The dissolution of the samples was aided by an automatic test tube shaker and after complete solution part of the sample was diluted, mostly 1:1000 times, and was then ready for atomic absorption spectroscopy.

vi) NEUTRON ACTIVATION ANALYSIS

In neutron activation analysis the weight of the required element in a sample is determined by measuring the intensity of induced radioactivity. This intensity is directly proportional to the weight of the required element and is independent of its state of chemical combination. Most elements can be converted into artificially radioactive isotopes by appropriate neutron bombardment or 'activation'. The process of neutron bombardment of a weighed sample, normally together with a standard, followed by measurement of the intensity of the induced radiation, constitutes neutron activation analysis. The mass of the required constituent, Y, in the sample is finally calculated by the equation:

$$\text{Mass of Y in sample} = \text{mass of Y in standard} \times \frac{R_{Y_{\text{sample}}}}{R_{Y_{\text{standard}}}}$$

where R = Radiation intensity (Jenkins & Smales, 1956).

Optimisation of a multi-element neutron activation analysis involves a compromise between the conflicting requirements of the various isotopes produced. The problem is even more severe when, as in my case, the sample matrix itself is activated. Table 4 shows some of the typical impurities contained in copper, as well as the tin and copper itself, all with their radioactive isotopes and their half-lives. The effect of activation of the sample matrix is to raise the lower limit of measurement of the minor activities in the sample. Sensitivities of detection of all elements can be improved by increasing the neutron flux of the irradiation, but this is ultimately limited by the reactor facilities available. The optimum irradiation and decay times will be different for each isotope, depending upon their respective half-lives and the half-lives of the matrix activities, but in practice the irradiation time is limited by the high ^{64}Cu and ^{66}Cu activity produced by the copper matrix. Ideally, an irradiation time of less than two minutes should be used if short-life trace isotopes are to be measured, but longer irradiations are necessary to determine longer-lived

TABLE 4

ELEMENT	ISOTOPE(S)	ENERGY	INTENSITY OF PEAK	HALF-LIFE			
				YEARS	DAYS	HOURS	MINS.
Fe	^{59}Fe	1099.27 1291.58	5600 4400		45		
Co	^{60}Co	1173.23 1332.48	9988 10000	5.2			
Cu	^{64}Cu	1345.50 β^{+}511	10000			12.8	
Zn	^{65}Zn ^{65}Zn	1115.51 438.7	50000 10000		243.8	 13.9	
As	^{76}As	55.1 657.04 1216.25	10000 1500 1000			26.5	
Ag	^{110m}Ag	657.6 884.5	10000 7400		253		
In	^{113m}In	391.7	65400				99.99
	^{116m}In	1417.0 1097.1 1293.4	3000 5300 8000				54
Sn	$^{113}Sn/^{113m}In$	391.688	60000		115		
	^{117}Sn	158.4	83000		14		
	^{123}Sn	160.2	10000				42
	^{125}Sn	1070	10000		9.4		
	^{125m}Sn	331.7	10000				9.7
Sb	^{122}Sb	564.0 692.5	66300 3300		2.8		
	^{124}Sb	602.7 1691.0	10000 5100		603		
Au	^{198}Au	411.8 675.88 1087.68	99000 1000 200		2.7		

Typical impurities which can occur in copper with their isotopes, energy (KeV), intensity of peaks (where the intensity is the number of γ rays emitted per 10,000 disintegrations) and half-lives.

isotopes adequately. In this case, a delay of 4-5 days is needed to allow the ^{64}Cu matrix activity to decay sufficiently to prevent overloading the detector.

In recent times the value of epithermal neutron activation as a means of improving selectivity in instrumental neutron activation analysis has been realized (Gilmore, 1976). Unfortunately, the research reactor centre at East Kilbride, Glasgow, where most of my neutron activation analyses were carried out, had not then adopted this improvement. Thus, when planning analyses, certain practical considerations had to be taken into account. They involved availability of the irradiation facilities and of time to use the high resolution gamma spectrometer necessary for instrumental activation analysis.

The determination of relevant elements had to be considered in the light of these factors, and the conditions were as follows: Irradiation: 6 hours in a high-flux mixed neutron spectrum. Decay period: 3-5 days; Count period: 10 minutes. The elements so determined were As, Sb, Au and Sn. After a long decay period of 1-3 months, the sample was counted again for 60 minutes and the elements determined in this count were Ag, Co, Zn and again Sn and Sb. The long decay period allowed the radioactivity of the copper to decay, but any trace of the short lived isotopes had vanished. Peaks belonging to ^{76}As, ^{198}Au, or ^{122}Sb cannot be expected, but peaks belonging to the isotopes ^{124}Sb, ^{110m}Ag, ^{60}Co, ^{65}Zn and ^{113}Sn may be identified more clearly. Figure 15 shows the γ-spectra of a 10 mg sample after short (a) and after long (b) decay.

The amount of the trace elements in the sample is calculated from the ratios of the peak areas to those of the standard. The latter is always irradiated along with the sample so that conditions are exactly comparable. At first all eight elements were included in one standard, but it was found that the idendification of all peaks in the trace from one standard is rather difficult. Two standards were used instead, one contain containing Au, Sb and Fe; the other As, Sn,Ag, Co and Zn. Identification was also aided by including a radium calibration count, because under the particular conditions at East Kilbride Reactor Centre, the multichannel analyser was used by several people for different projects and the setting of the analyser was therefore changed frequently. The peaks shown in Figure 15 are the visual output,the actual counts were punched on paper tape and later read into a computer.

The elements measured by me are shown on Table 5, where a) shows the elements estimated after a short decay period and b) those estimated after a long decay period. For elements such as antimony and tin, where peaks after short and long decay periods may both be used, the result is the mean of all measurements.

TABLE 5a: ELEMENTS USED FOR COUNTS AFTER SHORT DECAY PERIOD

ELEMENTS	GOOD PEAK (KeV)	MEDIOCRE PEAK (KeV)	COMMENTS
^{65}Zn	-	1115	-
^{76}As	559	657	Interference from ^{110m}Ag/peak at 657 KeV.
^{110m}Ag	884	(937)	Interference from ^{76}As peak at 657 KeV.
^{117m}Sn	-	158	Interference from copper matrix.
^{124}Sb	603	1691 (723)	-
^{198}Au	676 412	1087	-

TABLE 5b: ELEMENTS USED FOR COUNTS AFTER LONG DECAY PERIOD

ELEMENTS	GOOD PEAK (KeV)	MEDIOCRE PEAK (KeV)
^{60}Co	1173 1332	-
^{65}Zn	1115	-
^{110m}Ag	885	(1504) (1384)
^{113}Sn	-	391
^{124}Sb	603 1691	(1436) (1367) (713) (706)

Figures in parenthesis were used only for identification, not for counts.

vii) ATOMIC ABSORPTION SPECTROSCOPY

The elements Pb, Bi and Ni cannot be determined by neutron activation analysis, and determination of Fe may not always be feasible, depending on the conditions and instruments available. All these elements can be estimated by atomic absorption spectroscopy.

In atomic absorption, atoms of the element to be measured are caused to emit light (nowadays a hollow cathode lamp is used). This incident beam is passed through an air space containing atoms of the element. These atoms absorb light of the characteristic wavelength of the incident beam and in so doing reduce its intensity, but no other element will absorb light of precisely this wavelength. Therefore the element in question can be measured in the presence of any other element, and the method is absolutely specific, although there can be matrix effects (see below).

The intensity of the light source, measured with a photomultiplier, is set at some arbitrary point on a scale. The diminution in intensity caused by the presence of atoms of the element in the sample space can be measured for various concentrations of the element, and from this a calibration curve can be drawn, which enables the concentration of the element in samples of unknown composition to be estimated.

The only technical difficulty in the method is to get the sample vaporized, so that the atoms of the element are not in chemical combination. If they are, excitation by the incident beam will not take place, and the method does not work. Originally a solution of the sample was sucked into a gas flame by a Venturi tube, but in the last few years it has been found that greater sensitivity can be obtained if the sample is vaporized by being placed in a depression in a graphite rod or block, which is heated to a white heat for a second or two by a large electric current passed through it. This is the so-called 'graphite furnace' or 'flameless atomization'. With the use of this device, concentrations as low as 10 nanograms/ml (0.01 ppm or 0.00001 mg/ml) can be estimated, and the sample volumes can be as low as 5 μl.

Although the technique is simple in principle, attention to detail is important. The precautions to be observed will only be briefly mentioned here. The graphite rod must be surrounded by a stream of nitrogen gas, to prevent it burning when the current is passed through. A rigid schedule of waiting for the rod to cool down must be observed between each analyses. Even so, each rod only lasts for 60 - 100 vaporizations. Each new rod, which is very fragile and easily broken, must be accurately positioned in the incident light path, and 'purged' of contaminating salts before it is ready for use. The optimum temperature and duration of the vaporization flash have to be worked out empirically for each element, and although these conditions usually hold for all rods in a batch, they tend to vary from batch to batch. Nevertheless, it was found to be possible to measure the concentration of one element in about twenty samples, in duplicate, together with the intercalated standards and blanks (bidistilled water) in a working day.

There are also certain difficulties that arise from the nature of the sample. Copper itself readily dissolves in dilute nitric acid, but many impurities, particularly tin, do not, and the standard solvent for bronze is aqua regia. However, the halides of many metals vaporize only at very high temperatures, and even then the atoms of the salt may not be dissociated in the vapour phase. Thus it is best to avoid hydrochloric acid whenever possible. This was achieved by the use of the solvent described in Section v, p.80. Another problem is that at the very low concentrations used, the ions readily precipitate or are adsorbed on the walls of the container in which they are stored. Glass is particularly bad in this respect, and all containers used both for standards and samples were made of polythene. Although there is a finite adsorbance of some metals (notably Pb) on this material (Struempler, 1973) it is very much better than glass.

The most serious difficulty, however, is the 'matrix effect' referred to above. While atoms vaporized from a standard solution may stay isolated for some time, or at worst recombine with the counter-ions of the salt from which the solution was made, an unknown solution will probably contain a high concentration of another element - copper, in the case of bronzes, or iron in the case of steels. The atoms of this base or matrix element have a great tendency to form lattices, or in some cases chemical compounds, with the element to be measured. This is to be expected, since the latter was at least in solid solution in the matrix before the sample was vaporized. The 'matrix effect' varies not only with the element being measured but also with the proportionate relationship between it and the main component of the metal. This can be seen in Fig. 16, where nickel in concentrations between 0.1 and 0.5 μg/ml (Fig. 16b) was measured at varying concentrations of copper. No general relationship can be found from these graphs, and this is also true for the other four elements measured by atomic absorption spectroscopy. For the best results, a series of standards ought to be made up for each sample, each standard containing the same concentration of copper that there is in the sample solution. This would have been altogether too time-consuming, and in practice, three or four sets of standards, each containing differing concentrations of copper, were run for each element. An empirical algebraic relationship between the inhibition of absorption and the copper concentration was found by manipulation of the calibration graphs, and this was used for evaluation of the data.

It may be mentioned that the Absorption Spectrometer manufactured by Perkin-Elmer has a different design of graphite furnace with a larger block. In this apparatus the atoms of the sample remain separate within the vapour phase for several seconds, and the matrix effect does not occur.

viii) DETERMINATION OF COPPER

Copper was determined by a method developed by Felsenfeld (1960). For this method test tubes had to be cleaned consecutively in hydrochloric acid, ethelene diamine tetra-acetic acid and distilled water. To 20 μl of the sample and 2 ml water were added 50 µl hydroxylammoniumchloride solution (5% weight per volume) and the solutions were gently mixed. 2 ml of 2'2'-biquinoline in glacial acetic acid (50 mg 2'2'-biquinoline in 100 ml glacial acetic acid) was added from a burette and the solution was shaken vigorously. It was then put into a waterbath at 30°C for 10 minutes. After leaving overnight, the depth of colour was read in a photometer at a wavelength of 545 nm against a reagent blank. A series of standard solutions, containing 4,8,12,16 and 20 µg/ml of copper, was treated in the same way, and gave a perfectly straight calibration curve (Fig. 17) from which the readings of the samples were evaluated.

ix) DETERMINATION OF TIN

Tin was determined by neutron activation analysis (cf. Section 1, vi) and in some of the samples also by atomic absorption with a Perkin Elmer apparatus (cf. Section 1, x). However, some of the results were so high that it was thought wise to check the results by yet another method. For this purpose a recently developed colorimetric method which uses the pH indicator pyrocatechol violet was employed (Corbin, 1973). The method depends on the colour change (from blue to red) which takes place when Sn^{4+} complexes with the indicator. The concentration of the sulphuric/citric acid mixture necessary to prevent precipitation of metastannate, and to keep the pH constant, has to be carefully watched. Moreover, it is possible to use up almost all the indicator in the reagent mixture by adding too much Sn^{4+}, and the curve relating Sn to absorbance will then no longer be linear. However, by careful choice of catechol violet concentration it is possible to find a range in which the calibration curve is perfectly linear (Fig. 18). The reproducibility is good, and the analysis itself is very simple. The absence of interference from Cu^{2+} in the sample, even in concentrations 1000 times those of Sn^{4+}, was checked by direct experiment. Fig. 19 shows that the results obtained by the catechol violet method (CV) and by neutron activation analysis (NAA) show very good correlation. The scatter around the lower part of the graph is not as serious as it looks, since this is a double logarithmic scale, and the absolute deviations are not great.

x) SOME COMPARISONS OF RESULTS OBTAINED BY ATOMIC ABSORPTION AND NEUTRON ACTIVATION ANALYSIS

Fig. 19 also shows,that the results obtained by atomic absorption, for tin, represented by open squares (AA) are in good agreement with both the methods mentioned in the previous section. It is clear therefore, that the high tin values obtained in some samples - sometimes as high as 34% Sn - are correct.

Occasionally, I was able to use a Perkin Elmer apparatus, to carry out atomic absorption spectroscopy. This was done to check results obtained on an EEL apparatus where the 'matrix effect' was very marked. Preparation and dilution of the samples was exactly the same as for the atomic absorption measurements outlined earlier and the only difference was the sample size of 50 µl (even this can now, in the latest models,be as small as 5 µl). Besides Sn (Fig.19) a few of the Ni, Bi and Zn results were checked and found to be in generally good agreement with previous estimations (cf. Fig. 20 for Zn).

xi) COMPARISON WITH 'WASHINGTON STANDARDS' AND WITH STUTTGART ANALYSES

To check my own results, I included the 'Washington standards' in my analytical programme. These are the basis for a comparative analysis programme instigated by Gettens in 1965 and supervised by Chase (1975). For this purpose two ancient bronze objects of different composition have been taken, half of each object has been reduced to homogeneous filings and samples drawn from these filings have been circulated to various laboratories which have routinely analysed archaeological bronzes or who have wanted to participate in the programme.

The results have been tabulated and reported (Chase, 1975). The goal was to test the comparability of the results from each laboratory using its usual method under routine conditions. (I would like to thank Dr. Carriveau, Metropolitan Museum of Art, New York, for pointing out the existence of this project to me, and Dr. Chase, Smithsonian Institution, Washington, for sending me samples, internal reports and offprints.) A third sample which was included in the Chase project was from the National Bureau of Standards, Washington (NBS). Fig. 22 gives an indication of the large standard deviation of these interlaboratory comparisons (blank bars represent results published by Chase, diagonally hatched bars are my results from neutron activation analysis and squares those from atomic absorption analysis). They show that my results lie comfortably within this standard deviation on the whole, although antimony values are somewhat low and nickel values slightly high. For atomic absorption results only two values were available and therefore no standard deviation could be calculated.

Direct comparison was also achieved by including 5 samples of bronze objects which had previously been analysed by the Stuttgart team. These samples were obtained from the Museum at Elgin, Scotland. Fig. 21 shows that the correlation between analyses from Stuttgart and my own is very good, and integration of the two sets of results is therefore possible.

III .2 CLASSIFICATION AND STATISTICAL TREATMENT OF THE DATA

i) INTRODUCTION

Having outlined the methods by which the analytical results were obtained, and checked that comparison of my own results with those of other laboratories is possible, this section deals with the treatment of the data so obtained. The raw data of my own analyses can be found in Appendix XXI, the combined data in Appendices XXIV (bronzes) and App. XXV (copper artifacts).

About 60% of all the metal objects associated to late Neolithic cultures in Austria or Switzerland or included on typological grounds (cf. Chapter II) have been analysed, either by the Stuttgart team (Junghans et al, 1960,1968,1974) by Otto and Witter (1952), by myself (cf. Appendix XXI) or (in one instance) by Angeli (1953). The analysed objects are broadly representative of the whole, although ornaments, apart from beads, are under-represented. For instance, of a total of about 400 tools, 240 were analysed; of the total of just over 300 ornaments, about 150 were analysed, although 90 of these were beads. The associations within these analysed artifacts, purely in terms of their chemical components, were explored by a statistical technique that must be briefly discussed.

There is no doubt that much information can be picked out by the eye of an experienced metallurgist, without sophisticated mathematical techniques, as can be seen very clearly in the 'Handbuch der ältesten vorgeschichtlichen Metallurgie in Mitteleuropa' (Otto and Witter, 1952). It is unfortunately not possible that many archaeologists should be experienced practical metallurgists and it is also true that few metallurgists have a really sound archaeological background.

For the rest of us, a method of grouping which does not rely on subjective judgement is highly desirable.

Three statistical techniques have been used within the last 15 years to detect groups in collections of analytical data. The first is the statistical frequency analysis developed by Klein (Junghans, Klein & Scheufele, 1954) in which an object is assigned to a group on the basis of whether an analytical result is larger or smaller than a particular value for a single element.

This division was based on Klein's observation, originally on 400 analyses, that the frequency distributions within four basic groups (A-D) were normal. He checked this by plotting the frequencies against the concentrations of the 'most important elements' (Ag,Ni,Sn,As,Sb,Bi and Pb), on log/log paper, on which normality appears as a straight line (cf. Section 2, viii). Deviation from a straight line was taken as evidence that a sub-division within the group was necessary (e.g. group D was sub-divided into one with low and one with high Sn contents). After each of the groups contained only normally distributed (Gaussian) components, checked by the graphical method, a Table with the border values of each element in each of the groups was constructed (cf. Table 4, Klein, 1954). This led to the now famous Stammbaum in Junghans et al (1960, 210).

The method has been severely criticised (Butler and van der Waals, 1964; Waterbolk and Butler, 1965 ; Slater and Charles, 1970). The chief grounds are the possibility of error in analysis, which could put an object irretrievably in one major group with no possibility of re-assignment, on the basis of the result for a single element; and the fact that the element chosen for the first division into two groups was bismuth. This element has only a low solubility in copper, and segregates badly (Slater and Charles, 1970), and was therefore a very unfortunate choice. This method of grouping has now been replaced (Sangmeister, personal communication) but this does not detract from the value of the analyses themselves.

In 1965 Waterbolk and Butler, in the course of a review criticising Klein's grouping technique, proposed a method which depends essentially on visual display. It has the advantage that it uses all the elements for which analyses are available, and there are no preconceived cut-off values. A series of histograms is constructed, one for each element, in which the number of objects with analyses falling between certain limits, is plotted against the concentration of the element. Waterbolk and Butler used a logarithmic scale in which the common logarithm of the concentration spanned a range of 0.25 for each block of the histogram, or in the terms which they used, the concentration rose by $(10)^{\frac{1}{4}}$ from one boundary to the next. A separate convention was used for zero and trace values.

The limit for each block was probably set too narrowly, because an object can move from one block of the histogram to the next if the error in analysis is as low as 10%, but this does not affect the validity of the method, because for each element the values tend to be distributed within 3 or 4 blocks, rather than a single one, in a pseudo-Gaussian fashion. The sorting of objects into groups is done by eye, removing objects which give outlying values for any element, until a characterisitic pattern results, for a group of analyses, which can be visually distinguished from all others.

I used this method - or rather a computer program sorting objects on the basis of this method - elsewhere, in a study of copper ornaments of the Neolithic period in northern Europe (Ottaway, 1971). The program sorted the objects on the basis of four elements - arsenic, antimony, silver and nickel - although histograms were drawn by hand for all the other elements. I found that the method worked satisfactorily provided that the number of clusters was not too large, and the pattern of elements was not too complex. For the topic mentioned above, this was so, and a useful grouping was obtained, which has proved to be of more general usefulness (cf. Randsborg, 1979). However, when I later came to look at more complex material - the Wessex bronzes analysed by four different laboratories (as compiled in Ottaway, 1974, Appendix A), I found that the Waterbolk-Butler method was not sufficiently powerful, and seems hardly suitable for inter-regional studies (cf. also Doran and Hodson, 1975, 247).

If a grouping method is to keep pace with fast developing and improving techniques of analysis it needs the following attributes: a) it should be reasonably easy to handle the data, b) it should be able to take account of all measured trace elements so that no information is wasted, c) it should be able to deal with missing values and d) it should stand up to testing by an independent grouping method. The method to be described fulfills these criteria.

ii) <u>CLUSTER ANALYSIS</u>

This fast developing method of analysing multivariate data has been applied in a wide range of studies, including zoology, biology, sociology, language and many others.

Ball (1971) has given seven possible uses of clustering techniques and of those two or three are of particular interest to archaeologists: namely, 1) finding a true typology, b) data reduction,

c) data exploration. Everitt, in his useful Social Science Research Council review on cluster analysis (1974, p.4) puts it very lucidly: '... in many fields the research worker is faced with a great bulk of observations which are quite intractable unless classified into manageable groups, which in some sense can be treated as units. Clustering techniques can be used to perform this data reduction, reducing the information on the whole set of say N individuals to information about say g groups (where hopefully g is very much smaller than N). In this way it may be possible to give a more concise and understandable account of the observations under consideration. In other words simplification with minimal loss of information is sought...'.

By using cluster analysis on two kinds of data - i.e. on physical measurements of flat axes (cf. Chapter II , p.33) and on chemical composition of metal artifacts - I found the resulting clusters provided me with a basic framework from which I could start the interpretation of the data.

In 1969 Hodson published the first experiments with a clustering technique for copper objects, based on the construction of a similarity matrix for all the objects, using all results for all the elements. My own experience with this technique has been very satisfactory, but the choice of clustering method used in this study needs to be justified.

It goes without saying that all cluster analysis techniques depend on computer programs both for establishment of the similarity or dissimilarity matrix, and for the 'nearest neighbour' comparisons, which produce the actual dendrogram. Since I am not capable of writing such a program, and would think it a waste of time to try to do so, I must necessarily depend on those available to me. The first clustering program that I used was part of a suite of programs written by Wishart

(CLUSTAN, E.R.C.C. Manual 1973). The program worked satisfactorily, producing the clusters used for the Wessex bronzes. It has the great advantage that it produces an estimate of the coherence, or density, of each cluster, and a measure of the distance of the centroid of each cluster from all the other clusters. From these numerical values a diagram can be constructed, showing graphically the relationship of the clusters to one another (Ottaway, 1974, Fig. 3). However, the Wishart program had two grave defects from my point of view, one local and one basic. The local defect was that the graphics subroutine of the suite has never been implemented in Edinburgh, so that it is impossible to get the computer to print out a dendrogram. The basic defect (which is in many ways a virtue) is that the program is both hierarchical and relocatory, i.e. iterative. Left to itself, it starts with a large number of small clusters, and successively relocates objects until all end up in one single cluster. In order to get the details of intermediate clusters printed out, the user has to specify a minimum number of clusters that should remain when the program stops itself. There is no way of identifying 'natural clusters'. This introduces an element of subjective judgement that I found unsatisfactory. I was therefore interested to try out a non-relocatory program written by Olivier of the National Bureau of Economic Research in Boston, Massachusetts which had been used by Bieber et al (1976) (and also by Hammond, Harbottle and Gazzard, 1975). The program is called ACCLUS and offers seven options for the clustering method, each of which can work with any similarity matrix (Olivier, 1973). In practice I used a program for calculating similarity matrices written by Bieber of the Department of Nuclear Energy, Brookhaven National Laboratory, Upton, New York, U.S.A. (to whom I am greatly indebted for help in obtaining a copy of this program). It provides seven different formulae for calculating the similarities.

I tested the programs exhaustively by using all seven similarity matrices, and all clustering options (49 variants in all) on the Wessex bronzes, and comparing the results with those I had already obtained by using Wishart's suite of programs. Both methods were compared with a completely different technique, Discriminant Analysis (see Section vi of this Chapter). The results of these studies were presented to the Archaeometry Symposium at Oxford in March 1975; there were no adverse comments. Briefly, the clustering method which gave results most in agreement with both Wishart's suite and Discriminant Analysis was one called by Olivier 'Nature's Clusters' (cf. Fig.23a). Unfortunately, there is no reference to the details of the method in Olivier's preliminary publication (Olivier, 1973) but judging from the program it appears to have some approaches in common with a method available in Wishart's suite, called 'Ward's' method, which is quite well-known, and which I had found to give good results. I also found that the method of forming the similarity matrix had a much more decisive effect on the success of the clustering, than the clustering method itself. The similarity method that was far superior to the other options, for my data, was Pearson's Product-Moment correlation. This is referred to in more detail in a subsequent paragraph. Bieber <u>et al</u>)1976) who were clustering analytical data from Aegean ceramic material, used the more common General Euclidean Distance matrix. Although they discussed the clustering technique in some detail the authors did not make it plain whether they had tested all possible alternatives.

The terms 'success', 'good results', and 'satisfactory', when applied to clustering of metal analyses, are hard to define objectively. The most desirable results are that the data should not split up into a large number of very small groups; that the groups, once selected, should be stable - that is, objects should not move from one to another group if the system is perturbed either by corrections to the analyses or by the addition or deletion of a few objects; and that objects whose similarity can be detected by the Waterbolk-Butler method should end up in the same group. That the clustering should make 'archaeological sense' is an added bonus, because if the archaeological meaning of the objects could be extracted without metal analysis and subsequent statistical treatment, one might spare oneself the labour. However, in the case of the Wessex bronzes, the results of cluster analysis did agree reasonably well with the relationships expected on typological grounds.

By the purely scientific criteria ennumerated in the previous paragraph, ACCLUS behaved very well when used with the data in Appendices XXIV and XXV. A stringent test was the correction of the values for As, Sb, and Bi for about 20% of the data, when new determinations of these elements for objects 1-10,040 in the Stuttgart analysis catalogue became available (Junghans et al, 1974, 363). The corrections were in some instances substantial, but they affected the clustering remarkably little, although they did, of course, change the mean values within the clusters.

Fortunately, I was also able to test the cluster analysis on some numerical data involving archaeological relationships. This test was the clustering of the Swiss flat axes on the basis of physical measurements, already described in Chapter II. Not only did the cluster conform extraordinarily closely to the purely typological grouping previously established by the traditional archaeologists (Sangmeister and Strahm, 1974), the results indicated the existence of a new group (type Robenhausen) which had not been previously recognized, although suspected.

The following paragraphs deal with some technical points of cluster analysis which are important.

iii) SIMILARITY MATRIX

This is the lower triangular matrix which records the similarities between each pair of objects in the file of data. For the Pearson Product - Moment coefficient the normalized data (see below) are used as follows. For objects i and j, with k being the number of elements (in the study: 11) for which analyses are available:

$$II = \sum_{1}^{k} (C_i)^2$$ (the sum of squares of values for all elements for object i).

$$JJ = \sum_{1}^{k} (C_j)^2$$ (the sum of squares of values for all elements for object j).

$$IJ = \sum_{1}^{k} [(C_i) \times (C_j)]$$ (the cross-correlation).

$$\text{Distance } (i \rightarrow j) = \frac{IJ}{[II \times JJ]^{\frac{1}{2}}}$$

iv) NORMALIZATION OF DATA

The program written by Bieber for calculating the product moment coefficient automatically normalizes the data beforehand. The normalization (or standardization) of a group of observations so that their mean value is zero and their variance is 1.0 (Doran & Hodson, 1975, 39), is carried out by subtracting from each of the observations the mean value of the group and then dividing the result by the standard deviation of the group.

This has the effect of compressing extreme values of the group (cf. probit plot), as the following example will show. Suppose two minimal values for one element in a group of analyses are 0.002% and 0.005%. One is more than 100% greater than the other, and we may suppose that they represent the limits of detection for that element reported by two laboratories. However, suppose that the mean of the analyses for that element is 0.55% and the standard deviation 0.9% (the range being 0 - 4.1%). The transformed value for the first analysis is:

$$\frac{0.002 - 0.55}{0.9} = -0.6089$$

and for the second result the transformed value is:

$$\frac{0.005 - 0.55}{0.9} = -0.6055.$$

Both these values, when used for computing a similarity matrix, will give very similar results when combined with, say, an uncorrected value of 4.1%, whose transformed value is:

$$\frac{4.1 - 0.55}{0.9} = +3.94.$$

(This can be shown by putting the values in the formula at the bottom of p.102). Thus the absolute value of the limit of detection becomes relatively unimportant after transformation, which is a very desirable result.

The effect of taking logarithms of the analytical values before constructing a similarity matrix - another possible way of standardization and an option provided by Bieber's program - was also tried. It is necessary to add a small constant to all zero values before transformation, since it is not possible to express zero on a logarithmic scale. The result was not satisfactory and the preparatory computations are tedious, so this option was not pursued.

v) IDENTIFICATION OF CLUSTERS

In the dendrogram printed out by the ACCLUS program, each object is accompanied by a 'value'. The method of calculating this number is not precisely explained in Olivier's manual (1973), and I have been unable to elucidate it completely from the study of the program, but basically its meaning is as follows:

The program works by running through the similarity matrix to find two objects with a high similarity for each other. These form the nucleus of a cluster; if the similarity is absolute, the 'value' attached to the second object is zero, in other words the 'distance' between the objects is zero. This aggregative process goes on until the 'distance' between the object next to be added in and the centroid of the cluster is greater than that between the object, and the object most similar to it, remaining in the similarity matrix. These latter two form the nucleus of a new cluster, and the 'value' opposite the first of the two objects records the distance between the first cluster and the beginning of the second. An advantage of the clustering option and similarity matrix used was that the numerical size of the 'values' varied greatly. In the major cluster of 362 objects, the 'values' varied from 0.000 to 84, and it was possible using a series of arbitrary limits for the 'values', to break the dendrogram up into a series of clusters. The details are shown in Table 6, p.116. The practical limit to this dissection was easily ascertained, because the less coherent clusters eventually began to break up into more and more numerous sub-clusters, while the major clusters remained unaffected. The limit was therefore set at a point just before this occurred, except as described in the next paragraph.

Doran and Hodson (1975, 246) have pointed out that all cluster methods have difficulties in dealing with objects which are relatively pure, because their similarity coefficients in the method are not very distinctive. The ACCLUS program is no exception to this generalization, and the clustering produced one large cluster - about one-third of the total objects - with very similar 'values', separated by a very distinct break from all the other clusters. It was, nevertheless, very important to subdivide this cluster: in particular to try and separate objects possibly made of native copper. There seemed to be two ways of achieving this. One was to re-cluster, using as raw data only the objects in the large cluster of 'pure' objects. When this was done, the cluster sub-divided, with breaks indicated by satisfactorily large values. The other method, which was adopted here, was to retain the complete dendrogram, but to use very much lower values to indicate breaks in the 'pure' cluster than for the other clusters. Table 6 p.116, (at the bottom) shows how this was done. Both methods gave essentially the same results, but the advantage of retaining all the objects in one single dendrogram - apart from that of space - is that it was possible in a second run to mask an element, e.g. arsenic, (that is to omit analyses for arsenic when forming the similarity matrix), and thus to study the effects of this one element in the distribution of artifacts within the clusters.

vi) TESTING THE COHERENCE OF THE CLUSTERS (DISCRIMINANT ANALYSIS)

For this purpose, and also to check the validity of the clusters themselves, the Discriminant Function routines of the IBM Scientific Subroutines Package (SSP) were used. Discriminant analysis is a mathematical technique, the purpose of which is to examine how far it is possible to distinguish between members of various groups on the basis of observations made upon them. It is really an extension to multivariate observations of the ordinary analysis of variance within and between groups. It has been adequately described by Marriott (1974, 32). Here it is only necessary to say that the IBM routine contains an algorithm for calculating the probability that any object belongs to any of the groups that have been fed into the program, on the basis of the discriminant functions that may be calculated for it. It was therefore only necessary to run the appropriate subroutines, using as groups those provided by breaking up the dendrogram as described in the previous paragraph, and to study the 'Most Probable Groups' and the 'Percentage Probability' columns of the output (cf. Print-out D, at the back of the book). Objects which were not assigned a high probability of belonging to the cluster in which they were found were provisionally re-assigned. These were very few, and in general it was found that their adherence to the new cluster was not greater than to that from which they had been transferred. In the interpretation of the individual clusters, objects which had only a low probability of belonging to that cluster were not used for archaeological evaluation.

In the course of investigating the validity of the clustering techniques described in Sections 2, ii-v of this Chapter (p. 97 ff), discriminant analysis was used in a slightly different way. The results of the investigation were reported at the Archaeometry Symposium at Oxford (Ottaway, 1975a) but as only the abstracts from these meetings are published, it has been thought desirable to reproduce the substance of the argument here.

In its orthodox use discriminant analysis is used fo find the measurements that are most significant in discriminating between a number of pre-defined groups. These measurements are then used to allocate fresh objects to one or other of the existing groups. However, if the algorithm mentioned at the beginning of the Section is used to relocate objects, discriminant analysis can be used actually to find groups (or clusters). For this purpose the objects are first fed in in a series of clusters formed at random, and the program is run iteratively, relocating the objects to their most probable groups each time, until the largest Mahalanobis D^2 is achieved. Clusters which become very small (≤ 2) are eliminated. It was of course necessary to start the process several times with different initial random grouping; however, it was found that the iteration converged reproducibly to almost identical groups each time. It is a limitation of the method that the number of groups cannot be greater than the number of measurements.

When the groups obtained by discriminant analysis are compared with the clusters obtained by Wishart's cluster analysis - using the Wessex bronze analyses (as in Ottaway, 1974) as test data - it can be seen (Fig. 23b) that there is very good correlation between all groups, particularly when account is taken of the fact that discriminant analysis converged to six rather than to seven groups. The same excellent agreement can be seen in Fig. 23c where tin was masked in both cluster analyses and discriminant analyses. On the basis of the good agreement between cluster analysis, using either Wishart or Bieber's programs, and discriminant analysis, I became confident that clustering could be used for grouping analytical results. It may be recalled here that cluster analysis and discriminant analysis were also used to group Swiss flat axes discussed in Chapter II , p. 36. In this instance it was possible to use a third independent method of checking the techniques, namely that of comparing the typological allocation to groups made by an experienced archaeologist by visual inspection, with the grouping methods. Correlation was again extremely good.

vii) CONTINGENCY TABLES, THE Chi-SQUARED TEST, AND THE EXTENSION OF THE MEDIAN TEST.

Very considerable use is made in the next Chapter of contingency tables. These are tables which may be drawn up to discriminate between objects on the basis of two different attributes which each object may simultaneously possess, for example, one may draw up a Table in which the nature of the object - dagger, bead , etc. - is used as one criterion, while the cultural group to which it may be assigned is the other. The object of drawing up such tables, which are not unfamiliar to archaeologists, is to assess whether there is any correlation between the two sets of attributes. This may be done by statistical testing. Since the only numerical information available is the number of objects in each cell (row x column), i.e. the frequency distribution, the chi-square test is the only one that can be used (Siegel, 1956, 175). Chi-square (χ^2) is a measure of dispersion, it estimates the extent to which the observed frequencies of distribution among the cells differ from the expected frequencies. The null hypothesis (H_0) is that there is no difference between observed and expected frequencies; it is not usually possible to construct, in advance of testing, an alternative hypothesis about the distribution. The formula by which chi-square is calculated is as follows:

$$\chi^2 = \sum_{1}^{k} \frac{(O-E)^2}{E}$$

where k is the number of cells, O is the observed value, and E the expected value, for each cell. Clearly if O=E for every cell, χ^2 will be zero. Conversely, the larger χ^2, the more likely it is that the null hypothesis - that the frequency distribution is the expected one - is untrue. The critical value is looked up in Tables for the appropriate degrees of freedom (see below).

The calculation of the expected frequency for each cell is usually done from probability theory. If the total number of objects is N, and the total number of objects in a single row of the contingency table is p, then the expected frequency with which an object will turn up in that row is p/N. Similarly, the expected frequency for an object to turn up within one column is q/N, where q is the total number of objects in that column. The probability that an object will be placed within one cell, at the intersection of a row and a column, is

$$p/N \times q/N, \quad \text{or} \quad \frac{pq}{N^2}$$

This is the expected value that is calculated for each cell.

The chi-square distribution is an approximation that is true for large numbers. If the expected frequency in a cell is small, χ^2 may over-estimate the probability that the null hypothesis is untrue. To guard against this, rows or columns may be amalgamated, to arrive at a minimum value for the expected frequency. The traditional advice is that the expected frequency should not be less than 5 for more than 20% of cells (Siegel, 1956, 178), but later research (Snedecor and Cochran, 1967, 235) has suggested that this is too restrictive, and that the minimum value for the expected frequency should be 1. Again, this should not occur more frequently than once in five cells. This less conservative view was certainly of great help in this study, where it would have been impossible to study the expected distribution of infrequently analysed finds, such as chisels and awls, if an expected frequency of 5 for each cell had been obligatory.

The only other point to consider is the calculation of the number of degrees of freedom. For each row (or column) of the contingency table the total number of objects is fixed (that is, it is an observation). The objects can be distributed among the cells belonging to the row or column in any way, except for the last cell, where there is no freedom of choice, because the total for all cells must be equal to the observed value. Therefore the number of degrees of freedom for each row is (n_p-1), and for each column is (n_q-1). The total number of degrees of freedom, used for looking up the critical value of chi-square, is $(n_p-1)(n_q-1)$.

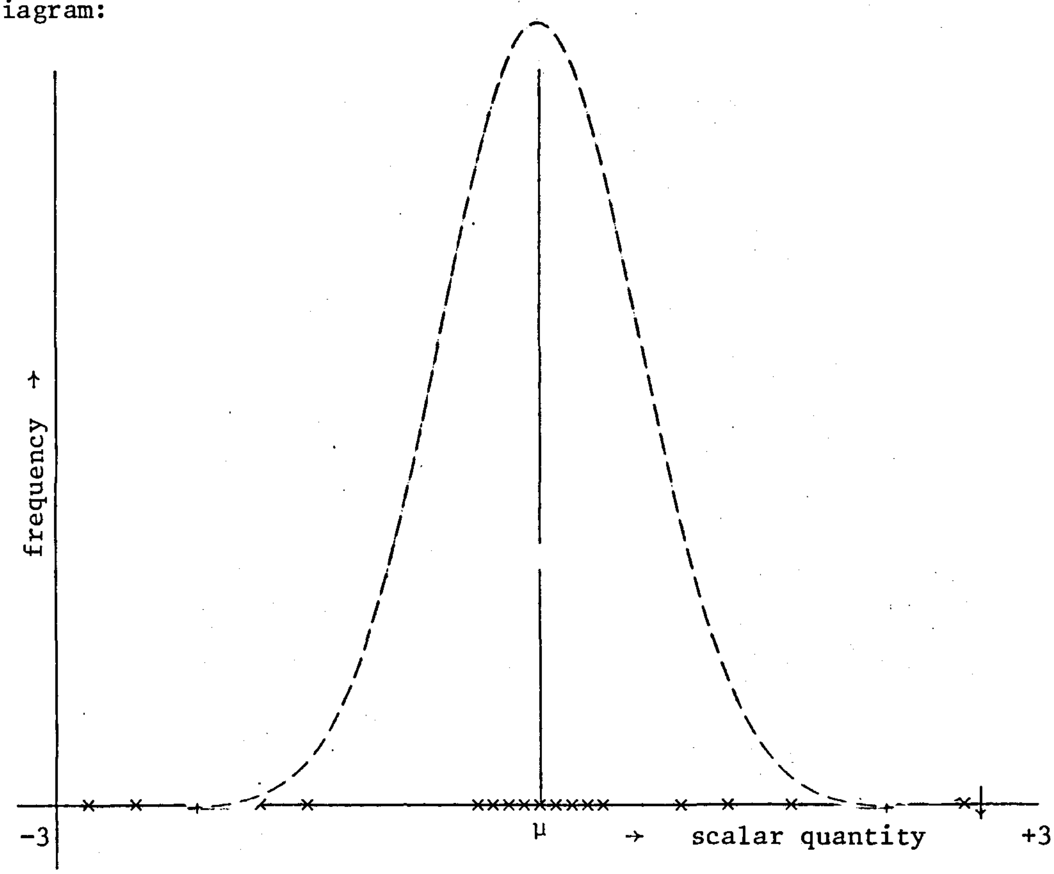
The rule is also true for the Extension of the Median Test (Siegel, 1956, 179), which was used for testing whether the geographical distribution of three clusters was uniform. This is a 'ranking' test, which involves finding the median rank for all the objects to be tested, on a suitable scale (in this case the E-W distribution of the find-sites within the region). For each cluster, the number of objects with ranks below, and above, the median is counted, and the results for all the clusters to be tested are entered in a 2×n contingency table. The correct number of degrees of freedom is (2-1)(n-1), or one less than the number of clusters to be tested.

The extension of the Median Test was found to be better than the Kruskal -Wallis test (Siegel, 1956, 184), for the case where one of the clusters was much smaller than the others.

viii) THE RANKIT TEST

It is sometimes very difficult to decide whether a distribution is normal, i.e. Gaussian, or not, and various statistical methods exist to test this. One used by Klein (in Junghans, Klein & Scheufele, 1954, 106), has already been mentioned. Another is the Rankit test (Colquhoun, 1971, 80), which uses 'expected normal order statistics'.

The principle of this may be most easily explained by the following diagram:



The normal (Gaussian) distribution curve is a plot of frequency against some scalar quantity. If the latter is normalized, to zero mean and unit standard deviation, the curve shown above will result. Any sample of finite size from a normal population will tend to be distributed along the scalar abscissa in the way shown in the diagram, bunched more closely around the mean (μ). It is possible to calculate, by statistical formulae, a precise numerical value for any member of the sample in terms of the normalized mean and standard deviation. Tables for sample sizes up to 60 are given by Colquhoun (1971), and for samples up to 400 by Harter (1961).

To make use of the Tables, the sample to be tested is ranked in order of size of the scalar variable whose distribution is in question. Each member of the sample is then plotted on a graph, using ordinary graph paper. On one ordinate is the variable to be tested, and on the other is the expected normal order statistic. If the sample is normally distributed, a straight line will result. Deviation from the straight line indicates a non-normal distribution (cf. for instance, Fig. 31, Cluster 10).

CHAPTER IV. METAL ANALYSIS OF THE EARLIEST NORTHERN SUB-ALPINE FINDS: INTERPRETATION

IV. 1 INTRODUCTION

Using the grouping method described in Chapter III, most analytical results obtained by the methods described in that chapter were clustered, together with all the relevant analyses carried out by the Stuttgart team (Junghans et al, 1960, 1968, 1974), and by Otto and Witter (1952). It has been shown that comparison of analytical results of these teams is possible (cf. Chapter III,p.92). It remained to decide which analysed objects should be included. First of all, artifacts which are securely associated with any of the relevant north alpine cultures were included. These were very few in number, and consequently artifacts which on typological grounds (cf. Chapter II) could be assumed to belong to the period under discussion, were also included. In addition, certain artifacts have been considered which either have a typological or a temporal association. For example, certain daggers have been included which have some typological similarity to late Neolithic types. Also considered are spiral cylinders which as a type are not found in association in the late Neolithic period of the region studied here, but do occur in the Stollhof hoard. In general, however, the artifacts included are limited to those discussed in Chapter II.

In this way some 450 analyses - including most of my own 100 - were collected, and stored in data files on the ERCC computer. The data had been amended by inserting the re-analysed values of the elements arsenic, antimony and bismuth for Stuttgart analyses numbers 1 - 10,040 (Junghans et al, 1974, 362-382) when appropriate.

(Incidentally, great care had to be taken in correcting the old values, i.e. when inserting the new results, because the new analysis numbers up to 860 are not the same as the old ones.)

Elements merely presented as 'trace' or by other non-numerical symbols such as 'larger than' , etc., pose a problem in quantification. Appendix XXIII shows which values have been used to replace these non-numerical symbols.

The first step in handling this set of 440 analyses, each with 11 element determinations, was to remove those that contained a significant amount of tin. This was taken to be larger tha 2% of the element (Witter, 1938, 121; Forbes 1964,144). In this way, 80 analyses of artifacts which were certainly alloyed with tin were removed (cf. data file, Appendix XXIV). The data file for the remaining 362 copper analyses can be found in Appendix XXV.

IV.2 THE COPPER CLUSTERS: GENERAL DISCUSSION

i) CLUSTERING AND REPRESENTATION OF RESULTS

The 362 copper objects, i.e. those containing less than 2% tin, were clustered using the clustering programs NADIST and AGCLUS which were described in Chapter III, p 97. Ten basic clusters can be discerned from the dendrogram (Print-out A, pages 342 - 345). using a boundary value of -6.1. Table 6 gives an insight into the hierarchical breakdown of the one large, initial cluster into smaller ones, and makes it clear that a number of clusters are stable from boundary value -16 onwards, and the last cluster is stable until breakdown was stopped. It is therefore only a minority of analyses which form denser clusters as the boundary constraints are increased.

TABLE 6: ILLUSTRATION OF HIERARCHICAL FORMATION OF COPPER CLUSTERS WITH INCREASING BOUNDARY CONSTRAINTS.

BOUNDARY VALUE	NUMBER OF OBJECTS IN CLUSTER	NUMBER OF CLUSTERS
	362	1
-80.0	181 181	2
-50.0	181 116 65	3
-22.0	181 84 32 65	4
-16.0	136 45 84 32 65	5
-15.0	136 45 32 52 32 65	6
-10.0	136 45 32 34 18 32 65	7
- 6.7	136 45 32 21 13 18 32 65	8
- 6.6	136 45 32 21 13 18 12 20 65	9
- 6.1	136 45 12 20 21 13 18 12 20 65	10

BOUNDARY VALUE	NUMBER OF OBJECTS IN CLUSTER	NUMBER OF SUB-CLUSTERS OF CLUSTER 1 FROM BOUNDARY VALUE -6.1
- 2.0	46 90	2
- 0.8	46 67 23	3
- 0.6	46 60 7 23	4
- 0.5	46 50 10 7 23	5

Discriminant analysis performed on these clusters showed which of the analysed objects do not fit so well into each of the clusters. On the whole, the probability that each of the individual analyses belong to the cluster assigned to them by the cluster analysis is very high (cf. Print-out D, pages 348-351). Only cluster 1 was less homogeneous. This is the largest cluster (136 artifact analyses are contained in it) and it does contain objects made of relatively pure copper, which do not readily form clusters. It was decided, therefore, to break up this cluster 1 into smaller sub-groups, by decreasing the boundary calue further, in fact, down to -0.5 (cf. Table 6). Five sub-clusters resulted and I named them 1.1 - 1.5, to help in remembering the fact that they are all sub-groups of the 'purest copper' cluster.

Since the aim of using cluster analysis is to reduce the data to manageable groups, it is desirable to use the smallest number of clusters which makes sense archaeologically and geographically. Preliminary checks showed that no information was lost, and no more detailed information could be gained, by either reducing or increasing the number of clusters from those shown in Table 6. It was therefore decided to use the nine basic clusters of copper objects plus the five sub-clusters of the first cluster, for final evaluation.

A list of the analyses numbers (i.e. laboratory numbers), contained in each of these clusters, can be found in Appendix XXVI.

For each cluster the mean concentration for each element was worked out by computer together with the percentage coefficient of variation, referred to also as V. These values can be found in Table 7 (for sub-clusters 1.1-1.5) and in Table 8 for the remaining

TABLE 7 : **MEAN VALUES AND THEIR PERCENTAGE COEFFICIENT OF VARIATION (V) FOR EACH ELEMENT IN COPPER CLUSTERS 1.1 - 1.5**

CLUSTER NO.	IM-PURITY	Sn	Pb	As	Sb	Ag	Ni	Bi	Au	Zn	Co	Fe	NO. OF OBJECTS IN CLUSTER
1.1	Mean	0.0002	0.0001	0.007	0.002	0.003	0.1	0.0002	0	0	0	0.001	46
	V	678	678	553	587	410	28	432	0	0	0	665	
1.2	Mean	0.001	0.0003	0.011	0.007	0.013	0.003	0.0001	0	0	0.0002	0.004	50
	V	495	400	407	324	165	344	295	0	0	511	356	
1.3	Mean	0	0.01	0.003	0.014	0.022	0.016	0.0066	0.0004	0.007	0.0006	0.022	10
	V	0	143	238	110	146	112	40	165	211	148	166	
1.4	Mean	0	0.001	0.114	0.01	0.139	0.006	0.004	0.0001	0	0	0.001	7
	V	0	192	113	150	25	90	63	265	0	0	218	
1.5	Mean	0.0004	0.001	0.212	0.020	0.021	0.002	0.001	0	0	0	0.0002	23
	V	480	203	21	78	89	141	97	343	0	0	480	

Mean values are given as per cent per weight. Elements with low values of V (i.e. highly significant) are denoted by heavy outlines.

CLUSTER NO.	IM-PURITY →	Sn	Pb	As	Sb	Ag	Ni	Bi	Au	Zn	Co	Fe	NO. OF OBJECTS IN CLUSTER
2	MEAN V	0.0002 671	0.004 288	0.566 23	0.024 131	0.02 117	0.004 325	0.0047 172	0 387	0.001 671	0 473	0.004 495	45
3	MEAN V	0.003 181	0.001 235	0.046 229	0.009 307	0.009 125	0.447 21	0.0006 226	0.0002 167	0 0	0.0018 182	0.004 223	12
4	MEAN V	0.003 190	0.015 166	1.322 80	0.197 124	0.151 138	1.453 50	0.0087 201	0.0004 233	0.007 447	0.0062 164	0.469 182	20
5	MEAN V	0.11 395	0.089 128	0.317 119	0.587 124	0.126 195	0.198 161	0.0086 84	0.0155 166	0.284 145	0.0249 179	0.122 122	21
6	MEAN V	0.64 100	0.368 198	0.162 122	0.215 124	0.089 123	0.041 99	0.005 132	0.0006 341	0.0208 361	0.003 306	0.005 218	13
7	MEAN V	0.006 114	0.013 191	0.130 163	0.022 180	0.024 166	0.25 172	0.008 169	0.0002 271	0.007 326	0.0032 96	1.075 97	18
8	MEAN V	0.0008 346	0.0004 346	1.200 64	1.493 47	0.736 66	0.004 298	0.1131 75	0 0	0 0	0 0	0.0001 346	12
9	MEAN V	0.003 315	0.023 185	0.266 196	0.615 89	1.399 72	0.083 199	0.011 140	0.0005 268	0.0025 447	0.004 282	0.026 331	20
10	MEAN V	0.001 290	0.022 220	1.693 54	0.019 157	0.034 129	0.019 233	0.008 338	0.0003 606	0.004 480	0.0002 408	0.016 516	65

TABLE 8: MEAN VALUES AND THEIR % COEFFICIENT OF VARIATION (V) FOR EACH ELEMENT IN COPPER CLUSTERS 2-10.

clusters 2-10). The coefficient of variation is used here rather than the standard deviation because the absolute values for each element are so very different. To keep this in proper perspective the standard deviation (SD) is transformed to be a proportion of the mean. V, which is dimensionless, is calculated as follows (Hodge & Seed,1972,77):

$$V = \frac{100\ SD}{mean}$$

Thus the coefficient of variation can be used as a measure of relative importance for each element in the formation of a cluster. In Tables 7 and 8 those elements which have a significantly low value of V, i.e. a low standard of deviation of that element within that cluster, are stressed visually by heavy outlines.

A graphical representation of these mean values of the impurities contained in each of the copper clusters can be found in Figs. 24-27. Here the mean values were coded on a logarithmic scale, i.e. the ordinates represent logarithmic concentrations starting from an arbitrary base for each element. For instance, code 1 means that the element is present only in trace amounts. Code 3 for the elements lead, arsenic,antimony, silver, nickel,zinc and iron, for instance, is less than 0.03% whereas code 4 for the same elements is less than 0.1%. A complete key to the codes is given in Appendix XXVIII. The importance of the coefficient of variation is represented in the Figures by shading: the darker the shading, the lower the value of V, and consequently the lower the standard deviation of that element within the cluster. Two diamonds show that the value of V equals zero, that is, all measurements of that element have the same value within the cluster. This absolute agreement only occurs when the element in question is completely absent.

ii) CHRONOLOGICAL CONSIDERATIONS

Before the metal composition of each of these copper clusters is discussed in detail, the cultural affinities of the artifacts contained in the clusters will be examined, since they provide chronological information which is relevant to the discussion on the clusters.

In Table 9 the copper clusters are plotted against the cultures to which the securely associated artifacts in each cluster can be assigned. The chronological basis for the culture sequence was provided in Chapter I (p.20ff & Table 2,p22), where the existence of three distinct horizons of coeval cultures in the region under study was deduced (cf. p. 23-26). Only first- and second-order associated finds (as assigned in Chapter II) are included in the Table, which is therefore a good indication of the relatedness of these copper types to the cultures. Artifacts which were included in the main cluster analysis only on the basis of their typological similarity to securely associated finds, are not included in this Table. The number of beads was divided by ten - on the assumption that one bar of copper provided enough material for about 10 beads (cf. Ottaway and Strahm, 1975) - to avoid overweighting the results (as a result of this, not all numbers in the Table are integers). The number of associated artifacts in each cluster (in the column headed Σcol), the number of all artifacts - associated and un-associated - in each cluster and the percent of associated objects in each copper cluster are also given. Thirty-one percent of all analysed artifacts are associated finds, although the percentage was very variable for individual clusters, e.g. 100% for cluster 1.5, but only 5% for cluster 5.

TABLE 9: COPPER CLUSTERS 1-10 PLOTTED AGAINST THE CULTURES. Row Σ_{col} indicates the number of associated artifacts in each cluster; the row below that gives the total number (associated and unassociated) and the last row the % of associated objects in each cluster.

		NUMBERS OF COPPER CLUSTERS														
		1.1	1.2	1.3	1.4	1.5	2	3	4	5	6	7	8	9	10	TOTAL
CULTURES	Altheim					1									2	3
	Pfyn	1	1		3		1							1	1	8
	Cortaillod					1	3								2.7	6.7
	Mondsee		2		1	9	8								14	34
	Lüscherz						1					1				2
	Auvernier									1				1		2
	Baden		3	2		1		1							1	8
	Corded Ware	9.4	1	0.1				3	4					1	1	19.5
Σcol.		10.4	7	2.1	4	12	13	4	4	1	0	1	0	3	21.7	83.2
No. of objects in each cluster (beads 1/10)		15.4	41	9.1	7	12	27	12	20	20	13	18	12	20	49.7	276.2
% of associated objects in each cluster.		68	17	23	57	100	48	33	20	5	0	6	0	15	44	31.14

This variability made inference slightly hazardous. Nevertheless, in view of the fact that almost all the artifacts of cluster 1.5 are associated with the first copper-using horizon, i.e. to the Altheim, Pfyn, Cortaillod and Mondsee cultures, it appeared to be worth while to test statistically the probability that the copper types identified by the clusters are, in fact, related to the cultures. In Fig. 28 the clusters are re-arranged in what appears to be the chronological order. A distinct association between copper of clusters 2, 1.5 and 10 and the Altheim, Pfyn, Cortaillod and Mondsee cultures, i.e. the earliest copper-using horizon, is visually suggested. On the other hand, copper of clusters 1.3, 3, 4 and 1.1 does not seem to have been used until the later Auvernier, Baden and Corded Ware cultures. It is impossible to test statistically Table 9 or Fig.28 as they stand, because the expected frequency is too low in too many of the cells (cf. Chapter III, p.110). By merging several cultures into an early horizon and a late horizon (the early corresponding to the first - the later corresponding to the third copper-using horizon) as well as by grouping two related copper clusters together and leaving out altogether groups with too low values, I was able to test the relatedness of copper clusters to cultural groups statistically (Table 10). It would have been desirable to keep the Lüscherz culture as a separate middle period, but the numbers of associated finds in it are too small.

The χ^2 test (cf. Chapter III, p.108) tests the goodness of fit to the model, which assumes that there is no relationship between copper clusters and cultures, i.e. that the copper clusters had the same chance of having been used by either early or late cultures. This model, or null hypothesis, is tested against the alternative hypothesis

TABLE 10: TWO-WAY CONTINGENCY TABLE FOR TESTING THE RELATEDNESS OF CULTURES TO COPPER GROUPS

		NUMBERS OF COPPER CLUSTERS						
		2	10	1.5	1.2	1.1	3&4	Σrow
CULTURES	Early copper-using groups.	12 (8.4)	19.7 (14.3)	11 (7.8)	3 (4.5)	1 (6.5)	0 (5.2)	46.7
	Late copper-using groups.	1 (4.6)	2 (7.8)	1 (4.2)	4 (2.5)	9.4 (3.5)	8 (2.8)	25.4
Σcol.		13	21.7	12	7	10.4	8	72.1

Degrees of freedom : $(r-1)(c-1) = 5$

Probability under H_0 that $\chi^2 \geq 15.09$ is 0.01

computed $\chi^2 = 45.32$

Expected values in parentheses.

that there is a probability of certain kinds of copper being used by certain cultures. The values in parentheses in Table 10 are the expected frequencies, the degrees of freedom are 5 and the significance level of 1% was chosen, i.e. the probability under the null hypothesis that $\chi^2 \geq 15.09$ is 0.01. Since the computed value for χ^2 is 45.32, the null hypothesis is rejected and the alternative hypothesis is accepted, that is, there is a better than 99% probability that copper types are related to cultures. Thus the probability that some of the copper types were used in the early copper-using horizon - as suggested visually by Fig. 28 - whereas other copper types have a tendency to have been used by later copper-using cultures, is high. Most outstanding is the observation, that the three earliest copper types 2, 1.5 and 10, are all arsenical coppers. This will be discussed in detail later. Most of the sub-groups of cluster 1, i.e. 1.2, 1.3 and 1.1, and to some extent cluster 2 and 10, have an early/late pattern of occurrence; i.e. they occur in the early as well as in the late copper-using horizon. The remaining clusters, in particular 5, 3 and 4, appear in the late copper-using horizon only. Unfortunately, the proportion of securely-associated finds which were analysed and which belong to the later copper-using horizon is very small, but I think the general trend is clear.

I propose to deal with the copper clusters not in numerical order but in terms of the order shown in Fig. 28 and thus follow, as far as possible, its chronological indications.

Since the arguments are involved, I shall briefly outline the major conclusions of this Section here. They are:

i) The earliest types - or clusters - of copper contain arsenic in varying amounts.

ii) There are two, possibly three groups of ingots from the region under study. Their distribution as well as their composition suggest that several copper sources in the Salzach region of Austria were worked, probably at slightly different periods.

iii) Some artifact types, in particular daggers, correlate with certain copper types, but others were made of any type of copper.

iv) Native copper is notably absent from the early copper-using contexts.

v) The types of copper used for tin bronzes are completely different from any of the types not alloyed with tin. (This conclusion is mentioned here, although it is arrived at in Section 4 and 5 of this Chapter.)

All these conclusions refer, of course, only to the northern alpine region during the period under study.

IV.3 DISCUSSION OF THE INDIVIDUAL COPPER CLUSTERS (IN SEQUENCE AS LAID OUT IN FIGURE 28)

i) CLUSTER 2

This is a rather large cluster, containing 45 artifacts which stayed constant from an early stage onward in the clustering (cf. Table 6). The artifacts in it were made from a metal which contained appreciable amounts of arsenic. The average arsenic value (Table 8) is slightly over 0.5% - code 6 in Fig. 25 - with a very low coefficient of variation of 23%. This remarkably low value of V indicates a very coherent cluster (cf. section 2, of this Chapter p.120). Relatively low coefficients of variation are also found for antimony and silver which are present in low concentration. Bismuth is also present, but has a rather high coefficient of variation of 172% which means that the scatter is too large for the element to be of indicative value for this cluster. In general, tin, gold, zinc and cobalt are not present - the positive values for tin and zinc reflect a very few analyses. Nickel has a wide scatter but occurs more frequently than the four previous elements.

Table 9 and Figure 28 show that this copper cluster has a tendency to appear in the earliest copper-using horizon in the northern alpine region. Almost 50% of the artifacts in this cluster are securely associated finds. This is largely due to the number of beads from Burgäschisee-Süd (SAM 2977-3020, App. XXV), belonging to the Cortaillod culture. However, the cluster also contains ten flat axes, two of which belong to type Robenhausen, which, as we saw in Chapter II (p. 35) belongs to the Pfyn culture. The other axes come mainly from the Mondsee and Attersee. The distribution of this type of copper is therefore, not surprisingly, mainly around the Swiss and Austrian lakes (Map 11).

All three early arsenical copper clusters on Fig. 25 will be discussed in more detail on p. 130.

(ii) CLUSTER 10

This large cluster (65 artifacts) was again very stable from an early stage in the clustering (cf. Table 6). It includes all artifacts made from metal with the highest arsenic content of all the copper objects studied here. The average value for arsenic is 1.7% with a low coefficient of variation of 54%. Of the other elements only silver, and to a lesser extent antimony, have low coefficients of variation (cf. Table 8 and Fig. 25). Most of the other elements are present in very low amounts with a fairly large scatter, indicated by the large values of V.

The chronological indication of this cluster is, like cluster 2, early, i.e. the artifacts which are securely associated and are made from metal of type cluster 10 (44% of the total in the cluster), come from the early Altheim, Pfyn, Cortaillod and Mondsee cultures (cf. Table 9 and Fig. 28). Two analyses, securely associated to the later Baden and Corded Ware cultures, suggest that this copper was also in use in later periods.

Again ten of the Burgäschisee-Süd beads are included in this cluster (SAM 2990-3026, Appendix XXV) as is a bead from Baulmes, also belonging to the Cortaillod culture (SAM 21674). The inclusion of a further six beads from Gerolfingen (SAM 3092-3100, Appendix XXV) means that almost a quarter of objects in the cluster are beads from Switzerland. However, an equally high number of flat axes (22) and daggers (13) are made of this copper, and the finds are almost equally distributed between Austria (28) and Switzerland (35). Perhaps significantly, two of the south German finds are also included in this cluster (cf. distribution map Map 11). Quite a large number of the Burgäschisee-Süd beads could almost equally well fit into cluster 2, as suggested by discriminant analysis (cf. Print-out D, pages 348 351) and this stresses the fact that these clusters are closely related.

iii) CLUSTER 1.5

This is the smallest (23 artifacts) of the early arsenical copper clusters. When cluster 1 was further sub-divided, cluster 1.5 separated out at an early stage and stayed constant in size (cf. bottom of Table 6). Incidentally, sub-cluster 1.1 was also constant from an early stage in the sub-division (cf. Table 6) and only sub-clusters 1.2, 1.3 and 1.4 were less stable. This is particularly interesting in view of the fact that each of these three main sub-groups (i.e. 1.1, 1.2-1.4, and 1.5) have different chronological implications (cf. Table 9 and Fig. 28). This will be discussed in more detail at a later stage (p. 140).

Cluster 1.5 has the lowest average arsenic content, about 0.2%, of the early arsenical copper clusters, with a very low coefficient of variation of 21%. This is not particularly surprising, since it is a sub-group of the 'purest copper', cluster 1. The elements antimony, silver and bismuth are present at very low concentration with a low coefficient of variation (cf. Table 7) and the concentration of nickel is even lower. The absence of zinc and cobalt is highly indicative; (cf. Table 9), no object in this cluster contains either of these two elements. Tin, gold and iron have too wide a scatter to be indicative.

All artifacts in this cluster either come from excavated sites or can be linked typologically to artifact types discussed in Chapter II , i.e. they can be considered associated finds (Table 9), either of the first or the second order (Chapter II , p. 31). Thus the correlation of this type of copper with the early copper-using horizon is highly significant and particularly interesting from the archaeological point of view (cf. Fig. 28).

The remaining beads from Burgäschisee-Süd are included in this cluster (SAM 2988-3025). Thus all beads from this site were made of one of the three arsenical copper types discussed so far, and this will be commented on later. Copper of cluster 1.5 was also used to produce 8 flat axes, some of definite Robenhausen type (e.g. SAM 4345 and 14465). The cluster also includes the flat axe from Altheim itself, again of type Robenhausen (cf. No. A52 in the typological study in Figure 8). This axe has been analysed both by Otto & Witter (1952, An. No. O & W 278) and by Stuttgart (SAM 8) and since the results differed slightly (cf. Appendix XXV) they were both included here as a check. Both stayed together in cluster 1.5. This underlines a point made at an earlier stage (cf. Chapter III, p. 76), that slight individual differences in the analyses need not distort the overall result, if an appropriate grouping method is used.

Artifacts of this cluster are mainly found in Austria (cf. Map 11) ; ; only Altheim and Burgäschisee-Süd are sites at which copper of this type was found outside Austria.

There is only one object which does not belong to the early horizon: it is a small torc from Leobersdorf (SAM 3731, Appendix XXV), belonging to the Baden culture (cf. Chapter II , p. 57).

iv) DISCUSSION OF THE THREE EARLY, ARSENICAL COPPER CLUSTERS 2, 1.5 and 10.

Cluster analysis was repeated on the data with the arsenic values masked. It was interesting to note that all three early arsenical clusters merged into one big cluster which contained a few other artifacts as well, and which had the impurity pattern shown in Figure 29 . This suggests that basically one similar type of copper - or copper ore - was used in the early horizon.

In two of the clusters - those with low arsenical contents, cluster 1.5 and cluster 2 - the arsenic was normally distributed. In cluster 10, however, this is not the case, as can be seen on

Figure 30, where the arsenical contents of cluster 2 and 10 are shown in histogram form. It is always difficult to decide whether a distribution is normal or not, and the Rankit test (cf. Chapter III p.111 for description of this test) was used to test the normality of arsenic values in these three clusters. Figure 31 shows that the individual arsenic values of clusters 1.5 and 2 are normally distributed (i.e. on average they lie on a straight line) with a low standard deviation, indicated by the slope. The arsenic of cluster 10, on the other hand, is normally distributed up to about 1%, but then has a sharp break after which it again forms a straight line, but with a much steeper slope, i.e. a much larger standard deviation.

It is, to my mind, significant, that this break occurs at an arsenic value just above 1%, the value most often associated with arsenical alloying (Otto and Witter, 1952, 47; Tylecote, 1962, 39; Sangmeister and Strahm, 1974; Doran and Hodson, 1975, 250, Eaton and McKerrel, 1976). It is therefore possible that arsenic was added deliberately to those objects which contain more than 1% of it. This is supported by the silver values in cluster 10 which, when subjected to the Rankit test (Figure 32) are seen to be normally distributed.

Alloying might have been achieved by smelting arsenic sulphides in conjunction with the copper ores, as suggested by Slater (1972, 101), although there is no way of proving that early alloying was done by this method. Another possible source of arsenic is indicated by two bun ingots from Zihl, Switzerland, one of which contains 10% tin, the other 3% arsenic and 2% nickel, suggesting the use of a metal arsenide (nickel arsenide) for alloying, at least by the Bronze Age. This source of arsenic could not have been used for the three early arsenic clusters 2, 1.5 and 10, since they hardly contain any nickel at all (cf. Tables 7 and 8 and Figure 25), but the use of other arsenides might have been feasible.

On the other hand, arsenic can occur naturally in some copper ores, although it is not always present in quite such high amounts as in the well publicised Azerbaijan ores (Selimchanov, 1962). The wide variation in the high arsenic contents of cluster 10 could be due to varying smelting conditions and to the original content in the ore. For instance, arsenical copper can be the result of retention of arsenic from the ore. This has been demonstrated by Tylecote (1977) by smelting experiments with <u>artificial</u> oxide ores, where arsenic contents of 4.4% in the ore produced a raw smelted metal with an arsenic content of 4.2%. Experiments with naturally containing arsenic oxide ores have yet to be carried out. On the other hand, experiments with smelting of sulphide ores showed a severe loss of arsenic: an arsenic content of 1.4% in the ore gave an arsenic content of only 0.26% in the matte. The loss of arsenic into the fumes was 82% of the original content of arsenic. Further experiments with different ores under differing conditions will be needed to show whether this is a general phenomenon.

Looking again at the distribution of the three arsenical copper clusters (Map 11) one finds that they reflect reasonably accurately the settlement pattern of the period involved. I wanted to test whether the artifacts clustered in these three groups geographically belong to one population and used for this purpose the Extension of the Median Test (cf. Chapter III, p.111 for description of this test). The sites were plotted on a linear distribution (Map 12) and ranked in order of their west to east distribution. From the ranks a two-way contingency table about the median rank (Table 11)

TABLE 11: CONTINGENCY TABLE FOR 'EXTENSION OF MEDIAN TEST' FOR THE GEOGRAPHICAL DISTRIBUTION OF COPPER CLUSTER 2,10 & 1.5

	COPPER CLUSTERS		
	2	10	1.5
-	14 (13)	26 (23)	2 (6)
+	12 (13)	20 (23)	10 (6)
Σ_{col}	26	46	12

computed χ^2 = 6.27

Degrees of freedom = 2

Probability under H_0 that $\chi^2 \geq 5.99$ is 0.05

was made and the test carried out as described in Chapter III(p.108). The null hypothesis (H_0), that there is no difference in the distribution of these three clusters, was tested against the alternative hypothesis, that there is a difference in the distribution. The degrees of freedom are 2 and a significance level of 5% was chosen, i.e. the probability under H_0 that $\chi^2 \geq 5.99$ is 0.05. Since the computed value for χ^2 is 6.27 the null hypothesis is rejected and the alternative hypothesis is accepted.

The contingency table (Table 11) shows that the expected values (in parenthesis) are roughly equal to the observed values for clusters 2 and 10, but that those for cluster 1.5 differ markedly. We can thus deduce that there is a strong possibility that copper of cluster 1.5 came from a different population (used here in the statistical sense) than those of clusters 2 and 10. This very limited distribution of copper cluster 1.5 in Austria - which consists of associated finds only, as shown earlier, and contains on average about 0.2% arsenic - could suggest exploitation of a local source and might help to explain why there are two different clusters of low arsenical coppers, which have nonetheless normally distributed arsenic contents within themselves.

To suggest a possible local source of copper of cluster type 1.5 is one thing. To say, however, that clusters 2 and 10 are coppers from similar local sources is somewhat speculative at the moment. Only if it could be shown by future research that there is no similar copper outside the artificial boundaries of this study, might one be justified in assuming a source within this area. In the west the boundary has been found to be a true one, because there are few copper artifacts belonging to French cultures coeval with our early copper-using horizon. None of these French artifacts which have been analysed have similar impurity patterns to those in our region.

There are Slovakian copper artifacts which typologically and chronologically have excellent parallels to the first- and second copper-using horizons of the northern alpine region, namely the knives mentioned in Chapter II (p. 45), which belong to the Lažňany culture of Slovakia (Šiška, 1972). Later periods in Switzerland, such as the Corded Ware culture, continued to use this particular type of dagger/knife. However, the copper of these Slovakian artifacts - if one can take the seven analyses published in Šiška's paper (1972, Table II) and carried out by Selimchanov, as a representative sample - is rather variable. When these analyses were added to the data file and re-clustered together with the northern alpine analyses, they grouped with several copper clusters (e.g. with clusters 4,6,7,8 and 10) rather than with a particular one. No direct connection between the copper types of the two regions can thus be found, at the moment. A detailed study of the Slovakian material is envisaged and would be highly interesting, but would go beyond the scope of this book.

In the south, typological links between Italy and Switzerland belong to a later period, e.g. Remedello type daggers were found in the Corded Ware site of Vinelz. Twenty-two analyses of Remedello artifacts were added to the data file and re-clustered with the northern alpine data (the analyses were those of Junghans _et al_, 1960 and of Otto and Witter, 1952). Half the Italian analyses clustered with copper cluster 8, a further seven with the 'pure copper' (sub-clusters 1.2-1.4) and the remaining ones with copper clusters 6 and 10. As will be shown later, cluster 8 probably belongs to the EBA and is very atypical for the copper-using horizon of the region, and clusters 1.2 to 1.4 have a mixed early-late chronological association. None of the Italian analyses were found in cluster 1.5. The clustering suggests that Remedello artifacts were made either from a fahlerz - or of a pure type of copper, without, in all probability, sharing sources with the northern alpine region.

In the east, particularly in south-east Austria and northern Yugoslavia, the state of research is too patchy at the moment to allow any definite statements to be made, and further research is needed before final conclusions can be reached.

A further interesting observation was made when all artifacts of cluster 10 containing arsenic values higher than 1.5% were studied. Of the 27 objects so abstracted from the cluster, nine were associated finds, belonging to the Altheim (SAM 10), Pfyn (SAM 7293), Cortaillod (SAM 3090, 3095), Mondsee (SAM 4351, 14466 & O & W 256) and Corded Ware cultures (SAM 2842), i.e. they are not exclusively early, a fact born out by some of the unassociated artifacts, particularly daggers, in this group, typologically belonging to the late horizon. Table 12 shows the types of artifacts with arsenic present in amounts larger than 1.5% (under column 'Observed'). The expected values (under the middle column), i.e. assuming that artifacts were indiscriminately made of either of the three arsenical types of copper, were calculated as a proportion of all artifacts of this type in the three arsenical clusters (shown in the last column). These expected values show quite clearly that there are twice as many daggers as expected made from copper with more than 1.5% arsenic. Flat axes seem to have been

TABLE 12: CONTINGENCY TABLE RELATING ARTIFACTS OCCURING IN CLUSTER 10 WITH ARSENIC CONTENTS HIGHER THAN 1.5% TO ARTIFACT TYPES.

	ASSOCIATED OBJECTS		
ARTIFACTS	OBSERVED NO.	EXPECTED NO.	TOTAL NO. OF ARTIFACTS IN CLUSTERS 1.5, 2 & 10
FLAT AXES	10	8.9	40
DAGGERS	10	4.9	22
CHISELS	2	2.0	9
BEADS	1	10.4	47
PENDANT/RING /INGOT	4	0.9	4
TOTAL	27	27.1	122

made in equal numbers of high and low arsenical copper. On the other hand, only one tenth of the expected number of beads were made of the high arsenical copper. It seems that the properties of arsenical copper, for instance its increased strength after cold hammering (Tylecote, 1962, 42; 1976, 8) might well have been recognized and utilized, whatever its mode of production from the ore. It is unfortunate that this observation cannot be supported at the moment by metallographic studies of the artifacts involved.

Summarizing, one can be reasonably certain that one or more types of copper containing arsenic as dominant element were used in the northern alpine area before any other type of copper was used in any appreciable amount.

It must be pointed out that the proviso 'dominant element' is important. Arsenic is a very usual contaminant of copper, and occurs to some extent in almost all the clusters. However, only in clusters 2, 1.5 and 10 is it both the impurity present in highest concentration, and also the impurity with the lowest coefficient of variation (only cluster 4 (cf. below, Section xi) has arsenic with a similarly low coefficient of variation). The term 'arsenical copper' seems justified, since it has already been used by Otto (1973) and also by Sangmeister and Strahm (1974), who pointed out the early occurence of arsenic-containing copper artifacts in Switzerland. One of the reasons for the confidence that I placed in the clustering method was the coincidence between their conclusions, obtained by visual inspection of SAM data, and my own.

It is likely, although it cannot be proven, that at least some of the objects in cluster 10, containing the highest amounts of arsenic, were alloyed. This inference is based mainly on the fact that the silver contents of this cluster are normally distributed, whereas the arsenic contents have a bimodal distribution, and that this copper was preferentially used for the production of daggers where the properties of the alloy were particularly useful.

It is likely, that the arsenical copper was at first imported into the region, which after all had no previous experience in the use of metal. At a slightly later time, copper ores containing some arsenic were perhaps also found and exploited locally. The localized distribution of cluster 1.5 suggests one possible source.

In general the notion of a local development - after an initial contact with fully metal-using groups - is supported by the fact that the bars with plano-convex cross-section of which the Cortaillod beads were made, and indeed the beads themselves (cf. p. 51) are totally foreign to any other coeval culture not only in the region studied but also outside (cf. Ottaway and Strahm, 1975). As was shown earlier (p. 134) it is very difficult to find, in the immediately neighbouring regions, an arsenical copper that matches that used in the northern alpine areas, implying that the initial import came from much further afield. More detailed research will have to be carried out to confirm the implications of this.

v) SUB-CLUSTERS 1.2-1.4

As mentioned earlier, these three sub-groups of cluster 1 were the least stable of that cluster (cf. Table 6). The sub-division of cluster 1 could have been stopped at a boundary value of -0.8, but it was felt that since none of the coefficients of variation was lower than 165 at this stage in the proto-cluster 1.2-1.4, a further sub-division would be beneficial. In fact, as can be seen in Table 7, the coefficients of variation had dropped drastically at a boundary value of -0.5, so that we find that sub-cluster 1.2 has zero coefficient of variation for both gold and zinc which are absent, sub-cluster 1.3 has no tin, and a low V for antimony, silver, nickel and bismuth. Sub-cluster 1.4, the smallest of them all, with only 7 artifacts, has a low value of V for practically all elements except for gold and iron (cf. also impurity patterns Figure 24), with notable absence of tin, zinc and cobalt. As the actual average values in Table 7 show, all elements in all three sub-clusters, if present at all, are there only in traces, only nickel, arsenic and silver, with average values of about 0.1%, being present at slightly higher amounts (in sub-cluster 1.4).

Sub-cluster 1.4 has the best cultural association (cf. Table9), almost 60% of objects being associated. From Figure 28 it can be deduced that all associated finds in this cluster belong to the earliest copper-using horizon. However, since this cluster has such a small number of artifacts (7), this can only be a tentative conclusion.

Of sub-cluster 1.2, which contains 50 artifacts, only about 20% are associated finds (Table9). These few associated finds are almost equally distributed between the early and the late copper-using horizons (cf. Figure 28). This means that small amounts of this type of copper, which is not too dissimilar from that of sub-clusters 1.4 and 1.5 (cf. Table 7), reached the early copper-using Pfyn culture of Switzerland (e.g. at Schwarzbach, Hüneberg, (SAM 2845)), but it was also used in the later Corded Ware site at Vinelz as well as at sites near Vienna. At Vinelz, this type of copper was used to produce ten biconical beads. In Austria, three artifacts of this type of copper belong to the Baden culture (SAM 3730, 4638 and 6080). In view of the fact that so few of the small number of Baden metal finds are analysed, this must be important. The fact that all of the artifacts of the Stollhof hoard are included in this cluster, suggests that the Baden culture either had access to copper resources similar to those available to the producers of the objects in the hoard, or that the Baden population re-used some of the huge artifacts of the hoard, which still has not been satisfactorily dated (for a review on this problem see Angeli, 1967).

Mention of the Stollhof hoard brings up the point that the controlled disintegration of basic cluster 1 did not bring to light the expected sub-cluster of 'native' copper, of the type so frequently found in Copper Age artifacts from Hungary (Bognâr-Kutzian, 1963, 500; 1972, 164). The question of native copper is a rather complex one. Tylecote (1976, 1) has shown that copper known to be native can contain one of a number of impurities; on the other hand, by collating all the then extant analyses, I was able to show (Ottaway, 1973, Figure 6) that the most frequent impurity in native copper was silver, present in low concentration and not usually accompanied by any other impurity. It therefore seems reasonable to assume, as do for instance, Otto and Witter (1952, 45), and also Tylecote (1976, 1) that copper artifacts containing only a trace of silver as impurity have been made from native copper.

The majority of objects from the Stollhof hoard have this composition, and it would have been very satisfactory if they had been found in a sub-cluster of objects which could have been identified as being made of native copper. The fact is, however, that by visual inspection of the datafile (cf. Appendix XXIV and XXV) one can see that there are practically no objects, other than those from the Stollhof hoard, which contain only silver as an impurity, whether alloyed or not with tin. Native copper is remarkable for its absence from copper-using contexts in Austria and Switzerland, which contrasts strongly with its appearance in Early Bronze Age bronzes in the Gemeinlebarn group of cemeteries (Boomert, 1975).

In order to have produced a sub-cluster containing only the Stollhof objects, one would have had to break down cluster 1 to a much greater extent, which would have been generally unwelcome. This explains the 'masking' of the Stollhof hoard in sub-cluster 1.2 and indicates that the hoard should not really have been included. (Inclusion was done on typological grounds, although rather hesitantly, since all its objects are so much bigger than those known from the copper-using horizons of the region).

Sub-cluster 1.3, which has only 10 artifacts, is distinct from the others by its slightly higher average values for bismuth (0.006%) and the presence of zinc, gold and cobalt (cf. Table 7). Again only 20% of the artifacts are associated finds and these belong to the late copper-using horizon (Figure 28, Table 9), such as the small torcs from Lichtenwörth (SAM 4636, 4637). One biconical bead from Vinelz was also grouped with this cluster (SAM 2881) as well as one of the two flat axes from the Stollhof hoard (SAM 4926).

vi) SUB-CLUSTER 1.1

As Table 6 shows, sub-division of cluster 1 produced sub-cluster 1.1 at a very early stage, and this sub-cluster remained stable down to the final sub-division. Its relatively large size (46) and its high percentage of associated finds (about 70%, cf. Table 9) makes this an important sub-group. The impurity pattern (Figure 24 and Table 7) shows that absence of gold, zinc and cobalt, the presence of nickel (at about 0.1%) are the indicative elements in this cluster.

Such a copper, containing only nickel, is quite probably a native copper of an unusual kind, and it is interesting to see that most of the associated finds in this cluster belong to the Corded Ware culture (cf. Figure 28) which is largely due to 37 beads, awls, daggers and pendants from Vinelz. It seems that this site used this very specific type of copper which is only found in a very few other settlements nearby, such as Lüscherz, Grandson and Estavayer, but not anywhere else (cf. Map 13.).

The distribution of the sub-clusters discussed in the last two sections (Map 13) shows that, whereas at Lake Constance only one type of pure copper - sub-cluster 1.4 - was used, at Vinelz three of the sub-clusters were known. Apart from cluster 1.1, with its very local western occurrence, the distribution of sub-clusters 1.2-1.4 is approximately even throughout Austria and Switzerland.

The question arises, whether a sub-division of the first basic cluster was justified. In my opinion, the fact that the different sub-clusters coincided with different chronological, geographical and possible metallurgical implications is important, and fully justifies the procedure.

vii) CLUSTER 9

With this cluster, comprising 20 artifacts, we enter a different phase of the metal-using era: the impurity pattern indicates that a more complex copper ore was used, the concentration of the impurities present rise, and the chronological indications are that coppers of the types to be discussed from now on were used at later periods than the purer ones discussed above.

Table 8 and Figure 27 show that the indicative elements of copper cluster 9 are antimony (with an average value of about 0.6% and a coefficient of variation of 89%), silver (which is present on average at about 1.4%) and bismuth (present on average at about 0.01%). Gold and zinc are present in trace amounts, other elements slightly higher, but all of these latter elements have a large scatter within this cluster and are not indicative.

Only 15% of the artifacts in this cluster are associated finds, and they fall either into early or later copper-using cultures without giving an indication for any preferred association. Since these few associated finds (SAM 2787, 22223 and O & W 120) do not fit with 100% probability into this cluster, as indicated by the discriminant analysis (cf. Print-out D, p.348-51 , at end of the book), but could possibly belong to cluster 1, this cluster is virtually unassociated to any particular period within this study and the information that can be obtained from it is very limited. The inclusion in this cluster of one of the two double axes (AXX1) might indicate that this type of copper belongs to an early BA period and has perhaps a more north central European distribution (cf. distribution map of double axes, Wyss, 1974, 7).

The predominantly Swiss distribution of this cluster could be explained in this way. Another possible indication for a BA date for this cluster comes from the inclusion of two heavy ingot torcs from Lake Mondsee and of an unassociated find from the Rainberg near Salzburg. (cf. Map 14).

viii) CLUSTER 7

This cluster is the result of an experiment in which I included all the bun ingots and metal pieces of this area in the cluster analysis. One group of bun ingots (cluster 7) remained almost un-associated with other artifacts.

Table 8 shows that the most characteristic elements of this cluster (which contains 18 objects) are iron, cobalt and a very low concentration of tin, all with coefficients of variation of around 100%. The high iron content (cf. Figure 27) of this cluster (around 1%) is characteristic for smelted ores which either had contained iron which was removed by the addition of silica, or conversely which had contained silica which was later removed by slagging with iron (cf. Tylecote, 1976, 6 and 1978). The presence of cobalt should help to identify a source of this copper since it is a somewhat unusual marker. This type of copper also contains on average some arsenic (0.13%) and nickel (about 0.25%), but the value of V is slightly high for them to be used as indicative elements.

There are only three artifacts - two awls and one axe - in this cluster, apart from the bun ingots. Figure 28 and Table 9 show that one of these was an associated artifact (BAR 90) which, however, did not fit very well into this cluster, as shown by discriminant analysis (cf. Print-out D, pages 348 - 351). The fact that it belonged to the middle copper-using horizon is therefore too tentative evidence to be taken any further. The cluster remained unassociated with others, even when cobalt and iron were (separately) masked, which suggests that it does not relate to any of the other copper types in this study.

The distribution of this copper type is a very interesting one: most of the bun ingots (Figure 15) come from the area along the Salzach valley, but also along the Enns, and several were found at the point where the Enns debouches into the Danube. The occurrence of some bun ingots of the same type of copper in Switzerland might suggest that the metal in the form of bun ingots was transported down the rivers Salzach or Enns, and thence along established 'flow patterns' (Chang 1975), into Switzerland. It is in Switzerland, close to where some of these ingots were found, that the three artifacts of this type of copper were found.

In this connection it may be interesting to point out that in the early copper-using horizon, the Pfyn culture had occupied the area in which two of the Swiss bun ingots were found and that this is the culture for which there is evidence of metal working, in the form of crucibles (cf. Map 10). The culture was known to pass its products on to the Cortaillod culture which occupied territory immediately adjacent to it in the south-west (cf. Ottaway, in prep.). This established flow pattern may well still have been operative during later periods.

ix) CLUSTER 5

This cluster, which contains 20 objects, is characterized by a large number of indicative elements (cf. Figure 26 and Table8), all present in higher amounts than hitherto found. For instance, lead (average 0.09%), arsenic (average 0.32%), antimony (average 0.6%), silver (average 0.13%), nickel (average 0.19%), bismuth (average 0.009%), gold (average 0.016%), zinc (average 0.28%) and iron (average 0.12%) all have a coefficient of variation around 100%. Bismuth has the lowest coefficient of variation (84%).

Unfortunately, only one artifact, a dagger from Yvonand, belonging to the Auvernier culture of Switzerland, (BAR 88, cf. App. XXV) was found in secure association, and it is only loosely attached to the cluster as shown by the discriminant analysis (cf. print-out D, pages 348 - 351).

Most of the other artifacts in this cluster also come from Switzerland (cf. Map 14) , and the larger proportion of finds on Lake Geneva might indicate a new influence from the West.

Two analyses (BAR 86 and 93) are from the same flat dagger from Auvernier; they were samples from differently coloured zones of the artifact. The two flat axes from Hungary (BAR 43 and 44) should not really have been included in the cluster analysis, but had originally been incorporated because a number of finds in the Vienna museum came from the 'Austro-Hungarian Empire'.

Fifty percent of this cluster are daggers, which are of three types (early - flat daggers with round hafting plate, middle - flat daggers with straight hafting plates, or late - midribbed daggers). A spectacle spiral from Concise, unfortunately without clear association, was also included in this cluster.

x) CLUSTER 3

This cluster, which was the last to separate from the dendrogram (cf. Table 6), is also one of the smallest clusters (it contains 12 artifacts). It is characterized by the absence of zinc and by a very low value of V for nickel, whose average concentration is 0.5%. Silver (average 0.009%) and trace amounts of tin and cobalt are also present (cf. Figure 26 and Table 8).

The chronological indications for this type of copper are slightly more secure than for the last three clusters which have been discussed: it clearly has a predominant association for the late copper-using horizon. It was used in the Baden and the Corded Ware periods in the region under study. At the Swiss Corded Ware site of Vinelz, awls and a dagger were of this copper (SAM 2835,2837,2839), as was one of the small ingot torcs of the Baden culture found at Lichtenwörth in Austria, (cf. Chapter II , p. 58). The second analysed double axe from the region is also included in this cluster and the probable EBA date of these artifacts has been mentioned under cluster 9.

Two Austrian bun ingots, one from the Salzach and the other from the Mondsee (cf. Map 16), which segregated in this cluster could indicate that the east alpine copper zone supplied this type of copper to Switzerland too, as was suggested for copper of cluster 7.

xi) CLUSTER 4

This cluster, which contains 20 objects, is differentiated from cluster 3 by higher arsenic (about 1.3%, with a value of V of

80%) and higher nickel (average 1.5% with a V of 50%). The other indicator elements in this cluster are antimony and silver (with average values of 0.2 and 0.5% respectively) which both have relatively low coefficients of variation. Iron is high (on average about 0.5%) but not as high as in cluster 7 (cf. Table 8 and Figure 27). Cluster 4 contains almost all those bun ingots added to the data file before clustering which did not end up in clusters 7 or 3. It is very interesting to see that although there are slight differences between the composition of the bun ingots and the artifacts, they were similar enough to come together in one cluster. For instance, it is particularly interesting to note that only the ingots, but not the artifacts, contain traces of tin (cf. Table 13). Also lead , bismuth and iron are higher in the ingots, yet the basic composition is similar enough for them to be in the same cluster, and the cluster as a whole is quite dense, as can be seen in the discriminant analysis (cf. Print-out D, pages 348 - 351). This print-out also shows that only one dagger (SAM 2834) might be closer to cluster 3 than to cluster 4.

Three of the ingots (SAM 2939, 3027, and 3063) were found in Switzerland and three in Austria (O & W 1269, 1296, 1297); yet the composition of all six is remarkably similar (cf. Table 13). All artifacts except one were found in Switzerland around Lake Neuchâtel and Lake Biel (cf. Map 17).

Looking at the mean values of the ingots and of the artifacts in this cluster (cf. Table 13) an interesting question arises: Loss of iron, bismuth and lead during the manufacture of the artifacts from the ingots can be explained by hot working and melting prior to casting (cf. Slater, 1972, 38), but can the concentration of

TABLE 13: RELATIONSHIP BETWEEN MEAN VALUES OF INGOTS AND ARTIFACTS IN CLUSTER 4

	Sn	Pb	As	Sb	Ag	Ni	Bi	Au	Zn	Co	Fe
ARTIFACTS	0	0.012	1.35	0.196	0.191	1.5	0.0037	0.0005	0.0093	0.0067	0.09
SD	-	±0.02	±0.91	±0.19	±0.22	±0.73	±0.004	±0.0009	±0.03	±0.01	±0.16
BUN INGOTS	0.01	0.022	1.25	0.19	0.058	1.355	0.0195	0.00003	0	0.0075	1.3
SD	±0.006	±0.04	±1.27	±0.32	±0.1	±0.64	±0.03	±0.00007	-	±0.0018	±1.06

silver and nickel be increased during this process? Tylecote, in recent smelting experiments (1978) has shown that recovery of silver is 100% and recovery of nickel is nearly as high. It is therefore a possibility, but so far we have not enough data, since metallurgists are only beginning to carry out the extensive experiments that are needed. It is, of course, also possible that the rather low number of ingots which survived and which were analysed, and included in this study, may not be representative for the entire population of ingots used. But one thing seems clear: that the Swiss population had access to metal mined, and probably also smelted, in the Austrian Salzach region.

The proportion of daggers made of the copper of cluster 4 is extremely high (cf. Table 14, p.157), so that it can be deduced that this type of copper was preferentially used for daggers. It may well be that the relatively high amount of arsenic was the determinant factor, as we have seen in cluster 10 that twice as many daggers than expected were made of copper containing more than 1.5% arsenic (Table 12). Presumably the improved properties of arsenic-containing copper, such as increased hardness, mentioned earlier, and easier working without cracking, greater strength and rigidity than pure copper, and possibly the recognition that this material could more easily be hardened under hot forging (Böhne, 1965 and Slater 1972, 30) than pure copper, had been recognized and utilized.

In view of the high amount of nickel in the copper of this cluster, it must be pointed out that nickel is also an element which increases the hardness of copper; the possibility of an addition of nickel, or of nickel arsenide, must not be forgotten.

Four of the artifacts (20% of the total) in this cluster belong to the Corded Ware site of Vinelz (SAM 2834,2838,2843 and 3088) although as was mentioned above, the first of these does not fit as closely into this cluster as the others. Nevertheless, the chronological implication is clear: this type of copper belongs to the late copper-using horizon and not a single artifact comes from an earlier period (cf. Fig. 28 and Table 9 underneath Fig. 28).

There is an even stronger case than that made out for cluster 7, for a direct link - by whatever means - between the Austrian copper mines in the Salzach valley and the Swiss copper-using population, this time belonging with rather higher probability to a known prehistoric period - the Corded Ware. In other words, it is possible that some of the copper of the Salzach valley (Map 15) was mined by a group belonging either to the Swiss Corded Ware population or one in close contact with it. This would be procurement. Alternatively, it is possible that copper mined in certain parts of the ore deposits along the Salzach valley, and presumably smelted nearby, was traded along earlier established flow patterns directly to Switzerland.

Considering all three clusters which contain bun ingots (clusters 7, 3 and 4), it is striking that hardly any artifacts made of this type of copper occur in Austria, the probable source area of the ore. Of course, later (that is, BA) artifacts may well have been made of it, and would not have been included in this study. At any rate, it seems likely that at a period during which the Corded Ware and Baden cultures flourished, and possibly earlier, ingots were transported to Switzerland and worked there into artifacts. It is, of course, not known whether the smiths travelled to Austria or the miners travelled to Switzerland, or whether an indirect trade was involved. All three variants are possible, but the very localized distribution of the three copper clusters, and their absence in intermediate regions, would to me suggest a direct contact between smiths and miners. The absence of hoards during this period suggests that these were not travelling smiths but local metal fabricators who collected their own supply.

xii) CLUSTER 6

We finally come to two small clusters (6 and 8) which contain no securely associated artifacts (cf. Table 9), and are therefore somewhat floating in this present study, and seemed better not represented in Figure 28 . The impurity pattern of cluster 6 (cf. Figure 26 and Table 8) shows that this is the first cluster which contains appreciable amounts of tin (average value of 0.6% with a coefficient of variation of 100%). The other indicative elements are arsenic (average 0.16%), antimony (average 0.2%), silver (average 0.09%), nickel (average 0.04%) and bismuth (average 0.005%) all with coefficients of variation around 100%. The high level of lead (average 0.37%) might be characteristic, but since the group has no chronological indications, and has only 13 objects of which several are not very closely connected to the cluster (cf. Print-out D, p.348 - 351) as indicated by the discriminant analysis, it has no great value for archaeological interpretation.

Its distribution, mainly around Lake Neuchâtel, can be seen on Map 14.

xiii) CLUSTER 8

This, in contrast is quite a dense cluster, and only two flat axes, which do not seem to belong to the area under study anyway (SAM

3633 and 6373), do not relate closely to it, as indicated by discriminant analysis (cf. Print-out D, p. 348-51). This leaves us with 10 objects. The impurity pattern (cf. Figure 27 and Table 8) has a striking similarity to the well-known 2:2:1 proportion of arsenic to antimony to silver (on average 1.2 : 1.5 : 0.7 % respectively), which is characteristic of a copper smelted from the fahlerz type of ores. The absence of gold, zinc and cobalt all with a coefficient of variation of zero, is also characteristic for this cluster. It contains analyses with the highest bismuth values (on average 0.11%, with a value of V of 75%) in all the 362 copper artifacts included in the cluster analyses.

Waterbolk and Butler (1965, Figure 7) give a diagram of 51 Ösenringe whose composition they regard as characteristic. The composition is identical to that of cluster 8, and we may thus regard the objects made of this type of copper as fabricated from 'Ösenhalsring' copper, which is widely distributed throughout Austria, Bohemia and Moravia at the beginning of the EBA. (It is distinguished by the absence of nickel from the otherwise similar fahlerz copper found at Singen, which the Dutch call 'Singen metal'). The fact that so few objects in my group of 362 were fabricated from this type of copper increases confidence in the original choice of objects, whether securely associated, or included only on typological grounds.

Cluster 8 includes seven heavy ingot torcs of the type well-known for the EBA, mostly from Lake Mondsee (SAM 3772-6, and 4439), and two spiral bracelets, which were only included because they were similar to those of the Stollhof hoard. It seems therefore that copper of this cluster really belongs in the EBA and is yet another demonstration of how well the cluster analysis has worked on the data.

Only the flat axe from Cham St. Andreas (SAM 2844) is somewhat puzzlingly included in this cluster. It is an axe of type Thayngen and belongs to the Pfyn culture. Its presence here can, however, be explained when the actual analysis of the axe is inspected: it is made of virtually pure copper containing only a high concentration of antimony (2.7%), and silver (0.086%). No other artifact with a similar analysis has been found in the region studied here and those in cluster 8 are clearly the most similar. We must therefore consider the possibility that during the early copper-using period not only arsenic-alloyed, but also antimony-alloyed artifacts, or metal, came into the northern alpine region, but so far this axe is the only evidence for this hypothesis. We should perhaps regard it as a sporadic, somewhat precocious occurence, just as tin bronzes have been found to appear sporadically in the Copper Age of central Europe. Artifacts containing very high concentrations of antimony (about 5%), but also containing several percent of nickel and arsenic are known from Switzerland, e.g. from Salez (cf. analyses BAR 80,81, Appendix XXI, and also SAM 2768,2779-2784,3761-3762). They are flanged axes and are usually taken to belong to the EBA.

The distribution of cluster 8 is almost exclusively Austrian (cf. Map 14), but it is clear that if artifacts of EBA types had been included, this cluster would be far larger in size than it is now. It should also be remarked that the most homogeneous group of the Remedello analyses (cf. Section iv, of this Chapter, p.135) segregated with this cluster.

xiv) CORRELATION BETWEEN ARTIFACT AND COPPER TYPE

It has already been shown that several of the types of copper were used preferentially for the fabrication of daggers. This was found to be particularly true for cluster 4 and for artifacts in cluster 10 with arsenic values larger than 1.5%. In an attempt to find out whether there is a general correlation between types of copper and types of artifacts, a contingency table was constructed (Table 14), and the χ^2 test was carried out (cf. ChapterIII, p108). The null hypothesis, H_0, that there is an equal chance for any type of artifact to be made of any type of copper was tested for significance. The degrees of freedom are 21 and the significance level of 1% was chosen, i.e. the probability (of random association) under H_0 that $\chi^2 \geq 38.9$ is 0.01. Since the computed value for χ^2 is 130.03, the null hypothesis is rejected and the alternative hypothesis, that copper types do correlate with certain types of artifacts, is accepted. The expected values (in parenthesis) in Table 14 give a clear indication where the correlations are to be found. For instance, it is apparent, when comparing the observed with the expected values, that far fewer flat axes than expected were made of copper of type 1.1 (observed 1; expected 12.1) whereas this type of copper was preferentially used for beads (observed 34; expected 17.8). On the other hand, daggers were made preferentially from copper of types 3, 4 and 5 (observed values for both 12 and 10 respectively, expected values 3.8 and 2.6 respectively) and not of copper type 1.2 (observed 0; expected 5.2). The earlier observation, that the number of daggers with arsenical contents higher than 1.5% within cluster 10 tended to be twice as high as expected, does not come out in Table 14, since all artifacts in the clusters are considered here. Clearly, more detailed

TABLE 14 : CONTINGENCY TABLE; ARTIFACTS AGAINST COPPER CLUSTERS

		COPPER CLUSTERS								
		2	10	1.5	1.2	1.1	9	5	3&4	Σrow
ARTIFACT TYPES	Flat axes	10 (10.8)	22 (15.2)	8 (5.2)	13 (7.2)	1 (12.1)	6 (2.8)	2 (3.6)	0 (5.2)	62
	Daggers	5 (7.8)	13 (11)	0 (3.8)	0 (5.2)	3 (8.8)	2 (2)	10 (2.6)	12 (3.8)	45
	Awls & Chisels	4 (4.7)	3 (6.6)	1 (2.3)	3 (3.1)	6 (5.3)	2 (1.2)	1 (1.6)	7 (2.3)	27
	Beads	20 (15.8)	17 (22.2)	10 (7.7)	10 (10.5)	34 (17.8)	0 (4)	0 (5.3)	0 (7.7)	91
	Σcol.	39	55	19	26	44	10	13	19	225

computed $\chi^2 = 130.03$

Degrees of freedom = 21

Probability under H_0 that $\chi^2 \geq 38.9 = 0.01$

information can at times be extracted when single elements within a cluster are studied, e.g. as in Section iv of this Chapter, by the Rankit test. Cluster analysis, which deals with the distribution of all eleven elements in space - or better in hyper-space - cannot, and indeed should not, focus attention on one element alone, and has difficulty in distinguishing very impure, as well as very pure, analyses.

Table 14 shows that beads were preferentially made of copper types 2 and 1.1 (observed 20 and 34 respectively; expected 15.8 and 17.8 respectively) but not of copper types 5 and 3/4.

Awls and chisels tended to be made of copper types 3/4 (observed 7; expected 2.3). Other, but less significant differences can be seen on inspection of the contingency table.

xv) CORRELATION BETWEEN ARTIFACT TYPES AND CULTURES

Having established that there is a correlation between the copper types and the cultures and also between the copper types and the artifacts, it is hardly surprising to find that there is an implied correlation between the artifact types and the cultures (Table 15). This contingency table was constructed - of necessity using only associated finds - to test the null hypothesis, H_0, that there was a random association between artifact types and the cultures which used them, against the alternative hypothesis, H_1, that certain types of artifacts were preferred by certain cultures. The degrees of freedom are 4 and the significance level of 1% was chosen i.e. the probability under H_0 that the $\chi^2 \geq 13.28$ is 0.01. The value computed for χ^2 is 39.57 and therefore we must reject the null hypothesis and accept the alternative hypothesis. In other words, there is an association between

TABLE 15: CONTINGENCY TABLE OF ARTIFACT TYPES AGAINST CULTURES

		ARTIFACT TYPES					
		FLAT AXES	DAGGERS/ KNIVES	AWLS	BEADS	INGOT TORCS	Σ row
CULTURES	Early copper-using cultures.	33 (19.3)	7 (7.4)	2 (6.2)	47 (52.2)	0 (4.0)	89
	Late copper-using cultures.	1 (14.7)	6 (5.6)	9 (4.8)	45 (39.9)	7 (3.0)	68
	Σcol.	34	13	11	92	7	157

Degrees of freedom: 4

Probability under H_0 that $\chi^2 \geq 13.28$ is 0.01

computed $\chi^2 = 39.57$.

certain cultures and certain types of artifacts. This, of course, is one of the basic principles of archaeology, but not always easy to prove. In this instance we may note that the early copper-using cultures preferred flat axes (observed 35; expected 19.3), whereas the later ones did not (observed 1; expected 4.7). On the other hand, early copper-using cultures did not have ingot torcs, whereas the later ones did. Beads occur in both early and late horizons; but no distinction was made in Table 15 between cylindrical and ring beads on the one hand - as known from the Cortaillod settlements, and biconical beads on the other - as occur at the Corded Ware site of Vinelz.

This raises the question of the meaningfulness of testing association between copper types and artifact types. I would say that in the early horizons the association between artifacts and copper types is secondary - that is, artifact types known to an early culture (e.g. flat axes) can only be made of one (or a few) kinds of copper, because that culture only had access to one (or at most a few) types of copper. On the other hand, in the late horizons the association is probably primary, because these cultures had access to several different types of copper, and if artifacts were made preferentially from one type, the presumption is that this was a deliberate choice.

IV.4 THE BRONZE CLUSTERS

The analyses of the eighty artifacts which were detached from the main data file, because they contained more than 2% tin, were clustered using the same clustering programs as those used for the copper objects. It was felt that by masking tin, the underlying types of copper would emerge, and this would indicate whether they were similar to the copper clusters discussed in the previous Sections. This was done first. Six main clusters, A-F, can be discerned from the dendrogram (Print-out B , page 346), using a boundary value of -5.1. The number of objects in each of these clusters is of necessity smaller than when 360 objects were grouped, and inferences drawn from them may not hold true if more data were to be included. The mean values for each element together with their percent coefficient of variation, for each of these six clusters, can be seen in Table 16, and their visual representation is shown in Figures 33 and 34. A list of the analysis (i.e. laboratory) numbers contained in each of these six clusters is given in Appendix XXVII.

The clustering was then repeated, using un-masked data for all elements. The resulting dendrogram (cf. Print-out C , page 347) shows that the number of clusters, and indeed the objects in most of the clusters, remain the same, regardless of whether tin was masked or not. The mean values for each element and the percent coefficient of variation for these six clusters (a-f) are given in Table 17, where again the low values of V are stressed by heavy outlines. It can be seen when comparing the two tables (16 and 17) that the compositions of clusters A-D and F, and of a-d and f, are very similar, in fact, clusters B and b are identical. Only cluster e, which now contains all analyses with tin values larger than 10%

(which had been assigned the value of 15%) has changed.

Only very few of the bronze artifacts in all these clusters come from securely associated finds. One of them is the awl from Sion, Switzerland, which I was allowed to sample (analysis BAR 50, Appendix XXI) and which could either belong to the Bell Beaker (so-called 'Neolithique final') or to the Early Bronze Age I phase (Gallay 1972c). The other is an awl or rivet from Altheim (SAM 7) which must be assumed to have been found together with the other metal finds from Altheim itself (Driehaus, 1960, Figure 35). The ring from Unterwölbling (O & W 177) comes from an EBA type site and should perhaps have been excluded from the study. None of the other finds are associated to any of the copper-using cultures studied here, yet they were included, as pointed out earlier, on the basis of their typology. There are 4 awls and 2 daggers made of bronze from Seewalchen, Attersee and it is not clear whether they belong to the Neolithic Mondsee culture or to a later BA occupation of the site. Their copper does contain relatively high arsenic contents (cf. Appendix XXIV) as did most of the analysed Neolithic Mondsee artifacts, but at least one of the daggers (SAM3616) is of totally different copper and contains lead and high amount of iron.

Some of the copper clusters discussed in the previous sections had shown a tendency to occur in late copper-using horizons only, and others a very tentative tendency to be linked to EBA, such as copper cluster 8. It now appears that none of the bronze clusters can be securely linked to the earlier horizons, and when the impurity patterns of the copper clusters (Figures 24 - 27) and those of the bronze clusters (Figures 33 & 34) are compared, it becomes clear that they are totally dissimilar. The bronze clusters have much

TABLE 16: MEAN VALUES AND THEIR % COEFFICIENT OF VARIATION (V) OF EACH ELEMENT IN BRONZE CLUSTERS A-F (WHEN TIN IS MASKED).

BRONZE CLUSTER NO.	IMPURITY →	Sn	Pb	As	Sb	Ag	Ni	Bi	Au	Zn	Co	Fe	NO. OF OBJECTS IN CLUSTER
A	MEAN V	(9.08) (48)	0.097 207	0.773 38	0.237 82	0.076 102	0.505 96	0.0038 161	0 424	0.001 424	0.0011 253	0.1 148	18
B	MEAN V	(6.41) (53)	3.898 129	1.055 36	1.759 47	0.692 64	0.878 80	0.0435 218	0 316	0 0	0.0145 209	0.003 156	10
C	MEAN V	(8.96) (26)	0.744 57	0.876 79	0.457 55	0.107 85	0.436 56	0.015 85	0.0106 39	0.037 265	0.2414 54	0.067 62	7
D	MEAN V	(10.26) (76)	0.288 181	0.162 92	0.228 127	0.082 112	0.137 116	0.0088 143	0.0156 419	0.001 566	0.01 234	0.034 172	32
E	MEAN V	(12.83) (42.5)	0.219 108	0.291 73	0.23 112	0.043 124	0.295 91	0.0084 87	0.0025 166	0.02 245	0.0127 81	1.477 62	6
F	MEAN V	(12.81) (81)	0.19 113	0.348 112	0.161 110	0.052 133	0.082 88	0.033 172	0.0021 112	0.435 63	0.012 135	0.127 159	8

TABLE 17: MEAN VALUES AND THEIR % COEFFICIENT OF VARIATION (V) OF EACH ELEMENT IN BRONZE CLUSTERS a-f.

BRONZE CLUSTER NO.	IM-PURITY	Sn	Pb	As	Sb	Ag	Ni	Bi	Au	Zn	Co	Fe	NO. OF OBJECTS IN CLUSTER
a	Mean V	8.43 48	0.087 183	0.833 29	0.23 90	0.051 103	0.246 45	0.0047 150	0 0	0 0	0.0008 252	0.092 139	12
b	Mean V	6.41 53	3.898 129	1.055 36	1.759 47	0.692 64	0.878 80	0.0435 218	0 316	0 0	0.0145 209	0.003 156	10
c	Mean V	8.31 34	0.776 52	0.766 93	0.55 64	0.125 79	0.431 53	0.0189 85	0.0543 228	0.033 283	0.2204 61	0.063 65	8
d	Mean V	8.52 45	0.282 194	0.172 91	0.216 112	0.066 103	0.108 109	0.0062 123	0.001 271	0.001 520	0.0059 318	0.022 201	27
e	Mean V	15.99 63	0.185 126	0.334 66	0.199 95	0.098 106	0.505 102	0.008 150	0.0074 315	0.021 223	0.0129 142	0.565 148	18
f	Mean V	8.08 68	0.134 145	0.372 123	0.144 143	0.043 185	0.092 89	0.0415 154	0.0019 115	0.538 43	0.006 99	0.147 159	6

higher contents of impurities and one of the clusters, cluster B, indeed seems to have had lead added to it. I shall therefore only briefly discuss the individual bronze clusters in the following Section.

IV.5 DISCUSSION OF THE INDIVIDUAL BRONZE CLUSTERS (A-F, CLUSTERED WITH MASKED TIN)

i) CLUSTER A

Table 16 and Figure 33 show that this second largest cluster contains moderately high amounts of arsenic (average about 0.8%) with a low coefficient of variation, and high amounts of nickel (average of 0.5%) again with a low value of V. Other indicative elements in this cluster (expressed by their low values of coefficient of variation are antimony, silver and iron (present at about 0.2, 0.08 and 0.1% respectively). This cluster apart from containing the Altheim artifact mentioned in the previous section, also contains 9 daggers, i.e. 50% of the cluster are daggers. The distribution of this, and all the other bronze clusters, can be seen on Map 18.

ii) CLUSTER B

This cluster contains on average almost 4% lead, an amount of this element too high to occur naturally in the ore, and the metal was therefore alloyed with lead - a characteristic occurence in LBA of, e.g., Britain (cf. Tylecote, 1968, 48). The basic copper in this cluster is of the fahlerz type with high arsenic, antimony and silver (average values of 1.06, 1.7 and 0.7% respectively, all with low values of V), but also with a high content of nickel (on average about 0.9%, coefficient of variation of 80%)(Fig. 33). Zinc is absent with a coefficient of variation of zero. The distribution of this cluster is entirely around the area of Lake Neuchâtel and would suggest that either a source of copper with nickel was locally exploited, or that this area had now contact with an eastern supply of this distinct type of metal.

iii) CLUSTER C

In this cluster - the second smallest, containing only 7 artifacts - almost all elements have a low coefficient of variation (cf. Table 16) the only exception being zinc. The concentration of lead is quite high (average of 0.7%) and so are the concentrations of arsenic and nickel (on average 0.9 and 0.4% respectively, Fig.33). Again its distribution is confined entirely to the area around Lake Neuchâtel (Map 18).

iv) CLUSTER D

This is the largest of the bronze clusters and contains 32 analysed artifacts. It has considerably lower contents of arsenic, silver and nickel than those mentioned above (0.16, 0.08, and 0.14% on average respectively, all with a low value of V). Further indicative elements are antimony and bismuth (present on average at 0.23 and 0.009% respectively). This type of bronze (Fig.34 can, like that of clusters A and E, be found in Austria as well as in Switzerland (Map 18).

v) CLUSTER E

This is the smallest cluster, containing only 6 analyses. It is not surprising that it is very coherent, with low coefficient of variations for all but one element (cf. Table 16). The high amount of iron (on average 1.5%) is indicative for this cluster.

vi) CLUSTER F

This again is a rather small cluster, containing only 8 analyses and the coefficient of variation is small for most elements (cf.Table 16 and Figure 34). The high amount of zinc (on average 0.4%), together with the very localized distribution, partly in the Vallais and partly around Lake Neuchâtel, might indicate again exploitation of a small local source (Map 18), but the number of artifacts included in this cluster is too small to allow more than tentative conclusions.

vii) SUMMARY OF BRONZE CLUSTERS

Although this book is almost entirely devoted to describing the earliest copper-using horizons, some bronze objects, whose analyses I have just discussed, were included. Their inclusion was based largely on typological similarities to the late (third horizon) artifacts. There is no evidence for alloying with tin in the first or second copper-using horizons. In Switzerland, typological and settlement evidence points to an overlap of the EBA and the latest copper-using horizon, and it is likely that the use of tin bronze and the use of copper went on side by side for some time. The extraordinary nature of the bronze analyses just described must be stressed in this context; their unusual character can best be appreciated by comparing them with others.

In the EBA the area under study together with others in Central Europe witnessed a great increase in the use of copper-based artifacts. For the present purpose, we may refer to two sites: Singen, which is only a few kilometers to the west of Lake

Constance, and the cemetery sites of Upper Austria, such as Gemeinlebarn. The finds from both sites have been discussed and their analyses classified by German and Dutch workers (Junghans, et al, 1960, Christlein, 1964,* Waterbolk & Butler, 1965, Boomert, 1975).

It is often not recalled how many EBA artifacts were made of copper. In Gemeinlebarn, the frequency of objects with little or no tin was 52%, in Singen it was much higher, about 80%. Almost all the Singen metal artifacts were made of copper from a fahlerz ore, which contained typically about 1.5% nickel, high arsenic and antimony and 0.5 - 1.0% silver. The more common variant of this copper contains very little nickel but is otherwise similar. Many of the Ösenhalsringe of the EBA are made of this latter copper, which is here for convenience called Ösenhalsring copper (cf. also p.154).

One might expect that in making bronze, the local coppersmith would add tin to the local copper; or if copper was imported from a distance, that the suppliers would do the same. In either case, the composition of the bronze would be basically the same as that of the copper. At Singen in 6 of the 9 true bronze objects that have been analysed, this simple expectation is true. It is not, however, true either for Gemeinlebarn or the north alpine region studied in this book.

At Gemeinlebarn the copper objects were made either of 'Singen' or of Ösenhalsring copper. A curious feature of the objects made of the latter, in Gemeinlebarn, is the prevalence of cobalt in high concentrations (up to 1.25%). This element is a very rare contaminant of prehistoric copper, and is a significant marker when it occurs.

The bronze objects of Gemeinlebarn,like those in the sample of bronzes discussed in this book, were not made of the same copper as the copper artifacts. About half were made of rather pure copper, containing at most 0.06% of any contaminant. The rest were made of two kinds of copper, probably smelted from sulphide ores, but not identifiable with any of the Gemeinlebarn copper groups; for instance, none of the bronze objects contained any significant amount of cobalt.

I should say at this point, that the preceding summary is based on re-clustering of the Gemeinlebarn analyses by my own method (I would like to thank Dr. Butler for providing a listing of the analyses that were used by Boomert). I did this in order to facilitate comparison with the analyses in Appendices XXIV and XXV; however, the conclusions drawn above are broadly similar to those of Boomert (1975).

Close comparison of the composition of the Gemeinlebarn bronzes showed that, with one exception, none of the groups resembled any of the clusters A - F described on pages 161 - 167. Nor were they similar to any of the copper clusters 1 - 10. Vice versa, none of the copper of the bronze clusters A - F was identical with any of the groups of the Gemeinlebarn copper objects. In general, the bronzes described contained characteristic traces of gold and zinc, as well as rather more lead than the Gemeinlebarn coppers.

The single exception was that the composition of a group comprising about 20% of the Gemeinlebarn bronzes was similar to the composition of bronze cluster A. Objects of this cluster occur with roughly equal frequency in Austria and Switzerland.

An equally important point is that the composition of the copper artifacts of the three copper-using horizons and the copper base of the north alpine bronze alloys was totally different. As we have seen, the evidence brought together in this volume, suggests that well before the end of the period under study important groups located in the north alpine region were making their own copper. The inference must be that they had no access to sources of tin in this period. In this respect they had reverted, as it were, to their status at the beginning of the first copper-using horizon, that is complete dependence on outside sources.

Thus, on some sites, such as Singen, an abundance of elaborate copper artifacts attributed to the EBA is associated with almost complete absence of bronze, but the few bronzes that do occur, are made of the same copper as the copper artifacts.

In other regions, such as the north alpine region and also Gemeinlebarn, bronze and copper objects co-existed but the bronze was not made by the persons who made the copper. We may conclude that tin was not imported as the metal. Rather, bronze was imported, either as finished objects or as ingots. The typological similarity of many of the bronze objects in clusters A - F to comparable copper artifacts of the late copper-using horizon, and of the Gemeinlebarn bronze and copper artifacts also, suggest the import of raw bronze, which was then worked to artifacts within the respective regions.

Analyses of the bronzes has thus provided indirect evidence of a complex situation. The central place model (Renfrew, 1975) which has been used to try and explain the distribution patterns of copper objects in the Balkans and in particular around the copper mine of Aibunar (Ottaway, in press*) , might fit many of the facts. On this hypothesis raw material e.g. copper ore or ingots, could be brought from many outlying sources to a central place where it was converted into bronze. The crucial factor here would be that the people at the central place would be the only ones who had access to the scarce resources: tin. From the evidence of the analyses, there might have been two, but probably more such central places in operation in the EBA supplying the upper Danube valley and the north alpine region either with bronze or, more likely, with bronze ingots.

V.6 SOURCES OF THE COPPER ORE

It is of great interest for the tracing of patterns of movement, contact and trade, to find the sources of ores from which the raw materials were made (Lamberg-Karlovsky, 1975). Basically, three approaches are possible:

i) the distribution of objects of a particular copper type in geographical areas;

ii) the empirical approach, i.e. detailed analysis of a large number of ores and artifacts from a restricted area; and

iii) the geological approach.

Since both of the first two approaches have hitherto not been entirely successful, I shall discuss the last one first.

Pelissonnier and Michel (1972) have studied the distribution of existing and perhaps undiscovered copper ores throughout the world. In doing so they discussed exhaustively the previously published classifications of these ores and produced a relatively simple classification of their own, which related ore types to the surrounding rocks. This work should enable one to introduce an new conceptual idea of basing groups on geomorphological evidence . Although Pelissonnier and Michel's interests lean heavily toward industrial exploitation of copper resources, their division of the majority of all deposits into 13 groups might well prove suitable as a theoretical basis for grouping of prehistoric copper analyses, when more work on the exact relation between the ore and the smelted metal has been carried out. Their classification shows up strong correlations between certain types of copper deposits and the type of rock in which they are usually found (Table 18). It is also flexible enough to allow for variation within the vertical layers of one deposit, thus eliminating one of the basic criticisms of other grouping methods. It may bring us ultimately closer to the original aim of all metal analyses, i.e. to try and trace the metal back to the original source of raw material. It will probably also enable us to view prehistoric centres of metallurgy with a critical eye by inspecting the surrounding geology and allowing us to make

TABLE 18

TYPE	MAJOR ELEMENTS	MARKER ELEMENTS	TYPICAL ASSOCIATED ROCKS	PER CENT OF TOTAL WORLD Cu DEPOSITS
1	S, Fe	Zn, Pb, Ag, Au, Se, Fe, Ba.	Massive pyrite deposits in volcanic tuffs and agglomerates.	10
2	[S]	Ag, Zn	Lavas and tuffs (no pyrite).	~1
3	(native Cu)	Ag	Basalt lavas	2
4	-	Ag, Co	Sedimentaries - sandstones, clays (some native Cu).	27
5	[S]	$\boxed{\text{Sn}}$ Bi, W, Ag	Cu-bearing tin deposits in subvolcanic granites	<1
6	[S]	$\boxed{\text{Mo}}$ Au, Re	Porphyry, subvolcanic granodiorites.	48
7	S, [Fe]	$\boxed{\text{As}}$ Ag, Pb, Zn	Enargite in subvolcanic granodiorites	4
8	Fe, O	Co, Ni, Au	Basic intrusive rocks; diorite, gabbro, diabase sills.	2.5
9	S, Fe	$\boxed{\text{Ni}}$ Pb, Co	Basic and ultrabasic intrusions.	2
10	[S]	Co, Au	Quartz veins in schists and carbonates.	0.05
11	[Fe] [S]	$\boxed{\text{Co}}$ $\boxed{\text{Fe}}$ $\boxed{\text{Sb}}$ Ni, Ag, Bi, Hg Ba.	Siderite - no typical country rock. Tetrahedrite veins.	<0.1
12	Fe, S	$\boxed{\text{As}}$ Au, Ag, Bi.	Schist, sandstone, sometimes lava. Mispickel.	~1
13	-	$\boxed{\text{Ge}}$ $\boxed{\text{As}}$ Pb, Co, U, V, Mo, Ag, Cd, Zn.	Tennantite in carbonate rocks.	<1

'informed guesses' as to whether copper deposits, which are now exhausted, might have been present in prehistoric periods.

It would go beyond the scope of this study to do more than outline briefly the 13 types put forward by Pelissonnier and Michel (1972, 129-223). They were obtained by distinguishing three domains for the major elements iron, sulphur and oxygen, and by using the minor elements as sub-characteristic markers. There are a number of types which can be excluded for early prehistoric use in Europe, leaving us with the types represented in Figure 35. Both types 7 and 11 occur in Austria , type 11 also in restricted locations in Switzerland. Type 7 is of particular interest in that it is a possible source of a natural alloy of copper and arsenic. It is not, however, at all widely distributed in Europe, and it is not known whether the only major deposits there (at Bor in eastern Serbia), were worked before modern times. Types 11 and 12 can according to Pelissonnier and Michel often not be clearly distinguished from one another. They are characteristically found in shallow,quickly exhausted deposits near the surface (Mitterberg with its deep layer being the exception). In spite of the small proportion of the total world copper ore deposits which they form, they are widely distributed throughout Europe,particularly in the eastern Alps, and in the Carpathians. The best known deposit is at Mitterberg but there are several other deposits in Austria.

The large scale experimental study by Rapp (see Chapter III, p.77) and also further experiments by Tylecote on smelting native copper, copper carbonate and sulphide ores, coupled with the determination of their impurity patterns, may also bring us a large step nearer to the provenancing of copper ores.

The second approach has been followed by Otto and Witter (1952) and by Pittioni (1957, 1959, 1964, 1965, 1966, 1967, 1971). Since it has been established in this book that the Salzach region in Austria supplied the northern alpine area with some of its raw metal, possibly even during the middle copper-using horizon in Switzerland, it seemed desirable to make use of the studies of Pittioni. He has repeatedly pointed out that the reason why he cannot accept Witter's results is that no allowances were made for the variations in composition of differing lodes of the same mineral deposit (Pittioni, 1957, 3). This is perhaps a reason why Otto and Witter's work has not been followed more closely by later workers, because basically their grouping method was more meaningful than that of Junghans _et al_ (1960,1968,1974) which is purely statistical. However, Pittioni's semi-quantitative analyses, which - though perhaps more sensitive in detecting the lower concentrations of impurity than Stuttgart's quantitative method - do not facilitate objective comparison with other analyses. Pittioni's results are subdivided into 7 arbitrary, unequally large subgroups (not detected, not certainly detected, trace, + and ++ and +++,and main component).

Neuninger & Pittioni (1962a) compared 37 artifacts which had been analysed by both Pittioni's and Stuttgart's methods. From this work it is evident that there is a considerable degree of overlap in 3 of the 4 groups (Table19).This is particularly noticeable for the elements lead, silver, arsenic and bismuth (cf. Neuninger and Pittioni 1962a, Figure 1) where for instance, a value of bismuth of 0.01 (according to

TABLE 19: CONVERSION OF NON-NUMERICAL SYMBOLS USED BY PITTIONI TO NUMERICAL SYMBOLS: USING 37 ANALYSES CARRIED OUT BY BOTH PITTIONI'S SEMI-QUANTITATIVE AND BY STUTTGART'S QUANTITATIVE METHOD (NEUNINGER & PITTIONI, 1962a)

	Sn	Pb	As	Sb	Ag	Ni	Bi	Au	Co	Zn
++	1-10	0.08-5	0.5-3	0.08-1.15	0.01-1.0	-	0.004-0.051	?	?	whole %
+	0.05-1	0.008 -0.02	0.01-0.7	0.06-0.69	<0.01-0.05	0.05-1	0.004-0.021	?	?	tenth and hundredth %
trace	-	0.008 -0.02	-	<0.03-0.03	<0.01	<0.01-0.09	0.003-0.004	?	?	?

Stuttgart's determination) could belong to any of two groups + or ++) in Pittioni's scale; an arsenic value of $\sim$0.5% could belong to either + or ++, and a silver value of <0.01% could be either trace or +, whereas a silver value of 0.02 could be + or ++. The authors say that '... a slight overlap cannot be avoided, because the eye cannot measure as accurately as the photometer' (1962a, p.99). They propose a reasonable agreement for the two laboratories for the four main elements tin, silver, arsenic and nickel (cf. 1962a Table 16), but suggest that one cannot compare the results of the two methods without due consideration.

Bearing these restraints in mind, I have nevertheless attempted to give quantitative values to Pittioni's three basic types of copper ore: the east-alpine type, the Bertha Grube type (Tyrolean) and the East copper (Ostkupfer), and have shown this in Table 20 and Figure 36 because it seems a great pity to leave such valuable material unused. However, the variations within each element - indicated in Figure 36 by the vertical bars - in each of the groups are so big that only a very rough approximation indeed can be obtained.

Nevertheless, none of the copper clusters described in the previous pages agree with any of Pittioni's alpine groups of copper, which is very unexpected in view of the distribution maps (cf. Maps 15-17). Only copper cluster 8, which has, as pointed out earlier, a typical Fahlerz composition, resembles at all closely Pittioni's East copper (Ostkupfer). The high amounts of arsenic, antimony and silver, and also of bismuth are found in both the Ostkupfer and cluster 8; the absence of lead in cluster 8 could also lie within Pittioni's East copper group with its range of lead from zero to 0.02%. Pittioni thought that the east copper was probably of Slovakian origin, and it

TABLE 20 : ATTEMPTED CHARACTERIZATION OF PITTIONI'S 'EAST-ALPINE', 'BERTHA GRUBE' AND 'EAST-COPPER'.

PITTIONI'S COPPER TYPES		Sn	Pb	As	Sb	Ag	Ni	Bi	Au	Co	Zn
	East alpine	trace –	0-trace 0-0.02	0-trace 0-0.7	– –	trace – + <0.01-0.05	trace – + <0.01-1.0	– –	– –	trace –	– –
	Bertha Grube	trace –	+ – ++ 0.008-5	+ 0.01-0.7	trace <0.03-0.03	+ – ++ <0.01-1.0	trace – + <0.01-1.0	trace – + 0.003-0.021	0-trace –	trace –	0-trace <0.01
	East copper (Ostkupfer)	0-trace –	0-trace 0-0.02	+ 0.01-0.7	trace – + <0.03-0.69	++ 0.01-1.0	– –	+ 0.004-0.021	– –	– –	– –

is interesting to note the almost entirely eastern distribution - within the region studied in the thesis - of cluster 8 (cf. Map 14). The typological indications of this cluster pointed towards the Bronze Age rather than earlier periods, although none of the finds were associated to the Bronze Age, and this could agree with Pittioni's finding of this type of copper. He pointed out that the bulk of Early Bronze Age material was not supplied by the east alpine mines, but came from further east. He showed that in 37 Ringbarren hoards, which were usually taken as an indication of EBA east alpine copper mining activities, 87% of the 1053 analysed artifacts were made of his 'East Copper' (Ostkupfer), and only 3% were made of east alpine and Tyrolean copper (Pittioni, 1964). As a source for his 'East Copper' Pittioni suggested Slovakian or Hungarian copper ores. So far, however, ancient Slovakian copper mines have not been found, although the area is rich in copper-bearing minerals.

According to Pittioni, a few artifacts from the Attersee and Rainberg near Salzburg are made of 'East Copper'. I found his distinctions sometimes difficult to follow, but have been able to trace the analyses of some 10 artifacts which were specified by Pittioni to have been made of Ostkupfer, but which had also been analysed by Stuttgart. The resulting average impurity pattern is depicted in Figure 36 d.

In general it is remarkable how few associated early artifacts of this type of copper there are. This suggests that it is a later appearance in the northern alpine area, which was what Pittioni had suggested in the first place.

Returning now to the first approach, that of tracing a pattern of movements of the metal, and finding possible sources of ores from which the raw material might have come; this was the approach adopted by the Stuttgart team (Junghans, et al, 1960), in their ambitious attempt to provide a system embracing the Eneolithic and Early Bronze Age of Europe as a whole, using statistical methods to provide groups which were obtained without taking archaeological judgements into account. This method was rightly criticised by Waterbolk and Butler (1965), who suggested using a graphical method for classification of analyses, starting with archaeologically homogeneous groupings. Their method which has been discussed in Chapter III (p. 96) worked well for small groups but is extremely tedious for large numbers of analyses, as has been pointed out by Doran and Hodson (1975, 247).

By using basically a combination of these two approaches, i.e. by confining myself to a very precise time and space horizon and applying statistical methods to provide the groupings, I have been able to obtain information on some of the sources. However, the difficulties I found in tying more than a few of the copper types to any particular source area indicates how futile this attempt would be if undertaken on too large a scale, geographically and chronologically. This difficulty is furthermore increased by the probability that raw material was re-used after the onset of the full Bronze Age. However, a deep insight into the pattern of movements and contacts of the copper-using populations was obtained, and this in itself is a considerable achievement.

IV.7 CONCLUSIONS

A complex pattern has thus been elucidated for the period immediately preceeding the Early Bronze Age in the northern alpine region. The pattern is more complicated than can be covered by a simplistic explanation or model.

The early copper-using horizon - which included the Altheim, Pfyn, Cortaillod and Mondsee cultures - had a few very distinct types of copper, mostly containing arsenic, and some possibly alloyed with it. Sites like the Cortaillod settlement of Burgäschisee-Süd have a particularly clear pattern: no types of copper other than of clusters 1.5, 2 and 10 were used (cf. Figure 28) for the production of their tools and ornaments. Similarly, for Altheim implements, only copper types 1.5 and 10 were used. But here the situation is made less clear by the fact that one of the small awls or rivets from Altheim is made of bronze, whose copper is totally unlike that of the copper clusters.

Considering the Pfyn culture as a whole, a study of the analysed artifacts indicates that far more than just one or two basic types of copper were used. They can be made of copper clusters 1.1, 1.2, 1.4, 2 and 10. This, together with the large number of crucibles found exclusively at Pfyn sites in Switzerland (cf.Map 10), some of which have traces of metal still inside, is, to my mind, a clear indication that a part of the Pfyn population were metal workers who obtained their raw, but perhaps smelted, material from various sources, whereas the inhabitants of settlements such as Burgäschisee-Süd were recipients of finished and semi-finished objects which they perhaps fashioned themselves into some of the final products - e.g. such as the ring and cylinder beads known at that period nowhere outside the Cortaillod culture - but who did not have contact with as many metal-using or producing centres as the Pfyn culture did.

The very localized distribution of copper cluster 1.5 has been taken to suggest, tentatively, that this type of copper was mined or worked in the Mondsee and Attersee area and that trade or exchange patterns of this type were on a limited scale only.

Moving to the middle copper-using horizon, which included the Boleráz, Horgen and Lüscherz (and ? Cham) cultures and which was shown to be much poorer with regard to copper finds, only one of the copper types used on the earlier horizon continued to be used: cluster type 2. Other types such as cluster 5, 7 and 9 also began to be used at this time.

The late copper-using horizon - which included the Baden, Auvernier and Corded Ware cultures - presents quite a different, and wider, spectrum of types of copper used. The population at the Corded Ware site of Vinelz, for instance, used cluster types 1.1, 1.2, 1.3, 3, 4, 9 and 10 for their implements. Further east, at the Baden site of Lichtenwörth, copper types 1.2, 1.3 and 3 were used.

We have thus in this late horizon a predominance of types of copper which were rarely, if at all used in the early horizon (cf. Figure 28). Moreover, copper of cluster 4 can be safely assumed to have been mined in the Salzach region as was shown by the analyses of bun ingots from this region (cf. Map 17).

It has been explained that the bun ingots, although they are commonly taken to be of Bronze Age date, were included as an experiment. The results, in my view, justify the venture. It is significant, that only for copper types used in the later copper-using horizons are there bun ingots of comparable composition (i.e. clusters 3 and 4). A number of bun ingots remained in a group by themselves (cluster 7) indicating that this type of copper was not in use during the period studied here. The absence of any ingots of the early arsenical copper of clusters 2 and 10 could indicate that this material came from outside the region, although a search for similar copper has so far failed to find areas in which artifacts made of this type of copper are concentrated, in the coeval cultures of the immediate neighbourhood to the south, west and north-east.

Thus a combined study of the possible ores, the bun ingots and the distribution of the copper clusters in the region under study has shown that the Austrian Alps were very likely sources of some of the raw material for artifacts of this book. This was particularly marked for copper of the types of cluster 1.5, 3 and 4. Of these clusters 1.5 and 4 could be linked to a definite period - to the Mondsee and the Corded Ware periods respectively. The former link was based on the very limited distribution of artifacts of this type, whereas the latter is more definitely linked to the actual mining area by the occurence of ingots of very similar composition as artifacts in Swiss Corded Ware sites. The complex impurity pattern of cluster 4 suggests that a sulphide ore was mined.

None of Pittioni's Austrian copper types were found to occur in the region during the period under study. This implies that Mitterberg itself, and the Bertha Grube, were exploited after the period under study here. Pittioni had at first (1957,56) put forward the idea that mining activity began at Mitterberg and related mines in the area before the EBA, but in 1964 he changed this to the beginning of the

EBA. It seems from the work reported here, that there are strong indications that some of the mines of the area around Mitterberg, but not Mitterberg itself, were worked before the EBA, particularly during the Baden and Corded Ware periods.

Pittioni's 'East Copper' (Ostkupfer) was represented by my cluster 8 which had, however, no secure links to any pre-Bronze Age period in this region. According to Pittioni this Ostkupfer probably had a Slovakian origin, and this might indicate a flow pattern from Slovakia to Austria. Contact with Slovakia in an earlier period has been suggested on typological grounds (cf. Chapter II ,p.44) but there is no evidence that this contact existed with regard to copper.

It could be shown that a correlation between copper types and artifacts existed. This was particularly marked for daggers, which were made preferentially of a type of copper containing relatively high amounts of arsenic, particularly clusters 3, 4, 5 and 10.

The bronze clusters, which were formed from analysed artifacts which had been included on a typological basis only, were found to be totally different in composition from any of the copper clusters, even when the tin contents were masked before clustering. Nor did they resemble any of Pittioni's copper types. Their distribution is predominantly a western one and could indicate the beginning of local exploitation of small copper sources in Switzerland during the EBA, or alternatively, mark the beginning of influence and contact with France.

The continuation of a few types of artifacts, foremost among them daggers, awls and chisels, from the copper-using phases into the EBA, is marked in Switzerland, whereas in Austria only the Attersee site Seewalchen has a similar trend. This supports the hypothesis of a discontinuity of a large number of settlement sites of the Mondsee cultures in the Austrian lake district (Reitinger, 1968, 61) on the one hand, and the continuum of lake site settlements (cf. Strahm, 1977) in Switzerland, on the other hand.

CHAPTER V . CONCLUSIONS

1. TECHNICAL CONSIDERATIONS

The investigations which I have reported in this book required a good deal of purely scientific research, as well as the archaeological studies which have been discussed in Chapter I-II. It does not seem appropriate to discuss this technical work in greater detail than has been done in Chapter III. Most of it will be published (Gilmore & Ottaway,+in press) ,or has been briefly reported elsewhere (Ottaway, Archaeometry Conference, Oxford,1975). It is nevertheless desirable to recapitulate briefly the work that has been accomplished. This can be dealt with under three headings.

i) Analytical Methods. The techniques of neutron activation and atomic absorption spectroscopy are already well established, but they have, in the main, only been applied in archaeological research for the determination of a few individual elements, not for the whole range of elements determined by Otto and Witter (1952) or by the Stuttgart team (Junghans *et al*, 1960, 1968, 1974). Furthermore, in a number of instances, the complete objects weighed only a few grams, and it was difficult to obtain more than a few milligrams of sample. Neutron activation analysis had therefore to be scaled down to micro-level and all possible measurements had to be obtained from the irradiation of a single sample. Epithermal neutron activation, which minimizes the inference of the copper matrix, improves tremendously the sensitivity and certainty with which traces of some elements can be determined (Gilmore,1976). For the elements which cannot be determined by neutron activation, namely, lead, bismuth, nickel (and iron only with difficulty) flameless atomic absorption spectroscopy was the method of choice, but many technical problems had to be solved, such as the choice of solvent, and allowing for the effect of the copper matrix on the shapes and gradients of the calibration curves for each element. Most of these problems again were connected with the smallness of the sample size.

ii) DETECTION OF SIMILARITIES BETWEEN ANALYSES

The hundred or more sets of analyses which I carried out in some insstances filled important gaps in our knowledge, but they represent only a small fraction of the metal analyses now in existence. The latest volume of Junghans et al.(1974) carries the number of analyses of copper and bronze objects, primarily from Europe, beyond 22,000 and there are more analyses to be published. How can similarities be detected within this vast mass of material?

Very occasionally this can be done by simple inspection. For example, Professor Müller, of the Instituteof Egyptology, Munich, provided me with a copy of analyses of Egyptian copper and bronze objects from pre-dynastic to Roman times. Even a superficial glance showed that, alloying apart, the copper source was very unlikely any with which I have become familiar from European sources, and moreover, that the impurity pattern remained amazingly constant over the whole period of several millennia.

This kind of conclusion is, however, exceptional. Figs. 24-27 show that the impurity patterns of the copper objects found in the northern alpine region do not show this homogeneity, and that the patterns for the bronzes are not only just as bewildering, they are also completely different from the coppers.

When the number of analyses was no more than a thousand or so, as for Otto and Witter (1952), it was possible for a trained metallurgist to come to some valuable conclusions by visual inspection of impurity patterns. I do not think that this is any longer possible. Certainly, when I tried to find similarities by eye in analyses which arrived too late to go into the computer, I found myself making the most subjective and non-repeatable distributions. Some kind of automated sorting, based on statistical probabilities, is a necessity.

I have found cluster analysis to be a very reliable technique for the following reasons: a) it uses similarity coefficients between objects which are obtained from all impurities simultaneously, in contrast to sequential sorting, which is the basis of the sorting technique employed by the Stuttgart team. b) both in the present work and in a previous study (Ottaway, 1974) analyses which were entered into the computer more or less blindly were sorted into groups which mostly made archaeological sense in terms of location or typology. c) Cluster analysis of Swiss axes purely in terms of size and shape produced clusters which not only agreed almost exactly with the visual sorting of an experienced archaeologist, but also indicated a new and important group (flat axe of type Robenhausen).

It is probably as well that the size of computer at Edinburgh limited the number of objects which could be clustered to something over 300, or one would have been tempted to be over-ambitious. I feel that progress can be made in interpreting metal analyses, but only by taking relatively small groups of analyses from an area restricted in time and space, and analysing them in detail. This has already been done for the Early Bronze Age material from Gemeinlebarn (Boomert, 1975). Eventually, the groupings relevant to each area will be linked up to give regional patterns, but probably not on a pan-European scale. The problem of controlling the time-scale, which is discussed briefly in the next paragraph, will always remain important.

iii) DATING

The interpretation of the analyses which have been collected can only sensibly be done in terms of a firm chronological framework of the cultures, and this must mean radiocarbon dating, for the period of the northern alpine region with which we are concerned. For defining the relationships between the cultures more precisely the interquartile method (Table 2) was used (cf. also Sakellaridis, 1979*). In certain instances this method shows up the present lack of a necessary minimum number of radiocarbon dates. This is particularly true of the Altheim culture, the essential link between the western and eastern halves of the northern alpine region. This is especially sad, because the evidence from numerous stray and chance finds (Maier, 1965a), as well as unpublished field surveys and surface finds in the region of Lower Bavaria, shows that settlement of this culture must be much more densely distributed than indicated by the distribution map of Driehaus (1960). The lack of detailed chronological information is entirely due to the fact that few sites belonging to this culture have been excavated since before the Second World War. It is to be hoped that the German archaeological authorities remedy this defect at a not too distant time in the future.

V .2 LOCATIONAL CONSIDERATIONS

In an area where natural geographical constraints such as the Alps play such an important role, one has to be careful to make allowances for their existence in the interpretation of one's findings. This is why the lack of recent excavations of Altheim sites has been stressed repeatedly. On the other hand, the correction of the Jura waters in Switzerland must also be borne in mind, and must not be allowed to overweight results in that area. However, there is a part of southern Germany which seems genuinely to have been sparsely populated during the whole of the Neolithic period. This is the area between the rivers Lech and Iller, and one asks oneself why this gap exists. One of the possibilities is that, as with the Inn valley, sedimentation could be a very late and slow process, so that there was not enough suitable soil for sizeable settlement sites much before the Bronze Age (Paschinger, 1957). However, it is equally possible that the area was very inhospitable, because it was covered either by bog and swamp vegetation or consisted of barren glacial debris, which even today will only support sparse growth, unless heavily fertilized.

V .3 GENERAL CONCLUSIONS

In the northern alpine region the first copper-using horizon was preceded by some evidence of earlier use of copper (see below). This is a repetition of the process as seen in south-eastern Europe where the true Metal Age was also preceded by individual finds of copper consisting of no more than a bead or a small trinket. The interquartile ranges of the first copper-using horizon in the northern alpine region lie between 3300 and 2500 bc, that of the south-east European Metal Age, e.g., in Jugoslavia, the Pločnik culture, between 3900 and 3700 bc. The priority of south-east Europe over the northern alpine region cannot be denied with respect to the development of metallurgy. Nobody disputes that development in the former preceded and influenced the northern alpine area, which later became independent.

The question arises, as an offshoot of the study proper, can one conclude from a similar chronological priority, in terms of copper finds, of the Near East with respect to south-east Europe, that the former area influenced the latter? This question is more complicated, because in the Near East there is no evidence to support the suggestion that the true Metal Age there, with large-scale mining and smithing activities, started at a period very noticeably earlier than in south eastern Europe. It is possible that a few copper artifacts came from the Near East into south-east Europe where the new material imparted information which aroused the curiousity of the receivers and prompted them to start to experiment. This is, of course, only another - and more clumsy - way of expressing the phenomenon in terms of a flow of ideas. Whether or not one should call the subsequent local developments 'independent invention' is still open to discussion.

At any rate, in the northern alpine area, as in south-east Europe, the start of the true metal-using horizon is very soon followed by local mining and smithing activities. A similar time lag was observed for local bronze manufacture in the northern alpine area (cf.p.167 ff), which probably mirrors the lag between the use of alloyed copper objects and the acceptance of alloying techniques by local smiths.

The earliest evidence of the use of co per in the northern alpine area comes from the Münchshöfener and the Epi-Lengyel cultures. It consists of one awl and pieces of crucibles. The time at which they occur is roughly coeval with the Italian Bocca Quadrata culture, in which copper also occurs (Chapter II). None of the northern alpine copper of this period has been analysed and we cannot say where it came from.

The next period at which copper finds occur, and which I have called the first copper-using horizon, since only then the real use of this material started, is the Pfyn, the Cortaillod, the Altheim and the Mondsee horizon. This is coeval with the Po-Valley-late-Neolithic of Italy, from which there is copper in small amounts. It is also approximately coeval with the northern European TRB:C, SE Polish TRB, Salzmünde and Baalberg cultures, which are known to have used copper (cf. Ottaway, 1973d). In the east, the Lažňany culture of Slovakia, the Balaton 2-3 culture of western Hungary, and the Bodrogkeresztúr-B culture of eastern Hungary are all coeval. All these eastern cultures use copper and this is, indeed, a very rich copper-using horizon in south-eastern Europe as well as in the northern alpine region. It is, however, also coeval with the Chasséan culture of France which did not use copper until later. The copper types which were used in the northern alpine area are mostly arsenical copper of types 2 and 10, and of the type 1.5 which has a very localized distribution around the Attersee and Mondsee (cf. Chapter IV p. 134). Some pure copper (types 1.1 and 1.2) also occurs. The artifacts include types such as flat axes, beads, flat daggers, knives, chisels, awls, spirals, fish hooks, metal pieces and crucibles. Techniques employed were cutting, hammering and probably also annealing (but metallographic analysis has still not been employed on any of the objects), hammering together of several pieces or strands of copper, rolling and casting, and, of course, smelting and melting. The objects were largely for use and not for display or decoration, but the absence of graves may distort the interpretation here.

The following (second) horizon in which the use of copper is attested in the northern alpine region, is a very interesting one, because neither the Lüscherz, Horgen, Cham nor the Boleráz cultures used very much copper and the only types known to belong with certainty to this period are simple, roughly hammered awls, pins and knives. The coeval Boleráz culture of the ČSSR shows a similar absence of copper, yet the late Chasséan culture of France for the first time has a few copper artifacts. At the same time, new types of copper - 5,7 and 9 - are used in the northern alpine region. The early arsenical copper (type 2) is represented by only one analysis (Fig. 28).

The third copper-using horizon, however, witnesses a return to a rich copper-using phase. The Auvernier, the Early Corded Ware and the Baden cultures have the same types of artifacts as the first copper-using horizon, i.e. flat axes, daggers (but now these daggers can be either flat or have a midrib), biconical beads and crucibles. A few new types also appear, namely pendants, spiral cylinders and Ösenringe.

The types of copper used for these objects are rarely those used in the earlier horizons (cf. Table 9 & 10 and Fig. 28) and represent a much wider spectrum. The pure copper types 1.1-1.3, but also copper types 3,4, and occasionally types 9 and 10, were used in the western area, whereas the eastern area of the region under study only used types 1.2, 1.3 and 3. Copper of type 4 and possibly 3 can be safely assumed to have been mined in the Salzach region (cf. Map 17) but most of it was used in the western area (cf. Map 16 and 17).

At this time eastern (Baden) as well as western (Saône-Rhône culture complex of France) and southern cultures (Remedello-Rinaldone cultures of Italy) all use copper, but interestingly, of different impurity patterns from those of the northern alpine region. The latter remains a unit in this sense. The techniques with which these copper artifacts were produced did not change greatly from those used in the first horizon, except perhaps that casting became more commonplace. This can be seen in the fact that awls from this horizon are now cast and not rolled together from different strands of copper as before, and that perhaps the bivalve mould is beginning to be used as can be seen from the appearance of daggers with midribs on both sides.

The Mondsee culture is often thought to form a continuum right through to the Early Bronze Age, yet neither the interquartile range of all its ^{14}C dates (Table2) nor the types of copper found in the Mondsee area support this idea: of the 40 analysed Mondsee artifacts 31 are made of the early arsenical copper types 2,10 or 1.5 and only 6 are of bronze. Since most of the Early Bronze Age sites seem to be differently situated from the late Neolithic ones in the Austrian lake district (Reitinger, 1968), a discontinuity between late Neolithic and Early Bronze Age occupation is suggested by the available evidence. The fact that so very little of the copper from its immediate neighbourhood resources (i.e. of types 4, 3 and 7) was used suggests that this discontinuity happened during the second and third copper-using horizon when the exploitation of these types of copper started. The

Neolithic Mondsee population used mostly arsenic-containing copper of types 2, 10 and 1.5, of which there is suspicion of local origin, but not yet cogent proof.

It seems that bronze was not used to any great extent in the northern alpine region until after the period studied here: of the 80 artifacts which contained more than 2% tin and which were included in this study purely on their typological relation to Neolithic finds, only those six from the Attersee mentioned above and one from Altheim were associated Neolithic finds.

Thus we are now in the position to answer at least some of the questions posed at the beginning of Chapter II and in the flow chart (Table 3 p. 30). We can say that there was not one single culture which was the earliest to use copper in the northern alpine area, but an entire 'early copper-using horizon'. We also know that this early horizon used a few very distinct types of copper, mostly containing arsenic and some possibly alloyed with it. Local copper production cannot be proven conclusively for this early horizon, although it may be suggested for at least one type of copper (type 1.5). Evidence for metal working and smithing activities however can be found in this horizon, namely in the Pfyn and Mondsee cultures and possibly also in the Cortaillod culture.

It does not seem likely that metal or metallurgy was introduced from one metallurgical centre alone either simultaneously or successively, since the types of copper used in the second and third copper-using horizons change considerably. In these later horizons there is a predominance of types of copper rarely, if at all, used in the early horizon. Moreover, several types of copper used in the later horizon can be assumed to have been mined locally in the copper-rich eastern Alps and were used predominantly in the western area, i.e. in modern Switzerland.

Thus we find a rather complex flow pattern of material which could not have been suspected from the typological or purely archaeological study alone.

However small the quantities of metal used may seem to someone who is accustomed to dealing with the vast quantities of the Bronze Age, they are not the results of stumbling efforts of people who did not really know what they were doing. Although the copper artifacts were in my opinion largely produced in local smithing centres and the ore was mined in local mining centres, (at least by the third copper - using horizon), and although these centres were probably independent of their more developed (eastern) neighbours as suggested by their less complex casting methods, the technological knowledge of the craftsmen was considerable. This becomes the clearer the more one tries to unravel the history of metallurgy. Is it not true that some of the processes involved are still incompletely understood? Is it not true that some of the empirical knowledge that these craftsmen had, has been lost completely to modern man? I am thinking in particular about the ability of distinguishing the different kinds of ore. Witter suggested that softer and harder coppers (presumably pure and impurity-containing copper) could be distinguished by the sound they made (Witter, 1938, 30). Similarly, Tylecote demonstrated recently the 'cry' of tin which is due to deformation of the crystal structure when bending the metal (Archaeometry Symposium, 1977), and Otto (1973) suggested recognition of arsenic - containing ores by the characteristic garlic smell given off during roasting. It is also striking that the quantity of arsenic added to copper was extremely well controlled and depended on the type of artifact for which it was going to be used.

It is difficult to ascertain whether copper, or the possession of copper, carried any social status. This kind of question is usually most easily answered from a detailed examination of grave goods. Hardly any of the cultures involved in the northern alpine region have securely associated burials, before the Corded Ware and Baden periods. Consequently, it is impossible to answer this question. It is, however, likely, although by no means proven, that there was some social stratification within the cultures where mining and smelting was carried out, as suggested by Chernych (1975). One would expect to find professional miners, smelters and perhaps smiths coming into existence a few generations after the start of local exploitation, in particular, since these occupations could not just be carried out in seasons when the fields needed no tending, because the severe winters in the Alps would have made work of any kind impossible at that time of year.

In retrospect, the choice used to delineate the period discussed in this study may seem somewhat arbitrary. It was done as a result of the observation that in northern Europe there is a considerable break in the pattern of metallurgy just before the beginning of the Corded Ware culture (Ottaway, 1973d). I expected this - rightly, as it appeared - to be true also for the northern alpine region. The break occurred in the northern alpine area during the second of the copper-using horizons, that is during the Lüscherz, Horgen and Boleráz periods, i.e. again just before the start of the Corded Ware and coeval cultures. At the same time, one must stress that there is no break - at any rate in Switzerland - at all, between the third horizon and the Early Bronze Age. This is particularly clear from the partial contemporaneity of the Swiss late Corded Ware and the earliest Bronze Age, where an exchange of ideas and patterns has been clearly demonstrated (Strahm, 1974, & 1977). From then on there is a rapid increase in technological innovation as well as in the sheer amount of copper used. Some of the Early Bronze Age cultures, e.g. Singen, do continue to use more copper than bronze, presumably because of supply problems with tin, and perhaps the terminology should be revised. This rise in technological innovation was accompanied by an increase in the variety of metal artifacts produced, and by increasing evidence of sophisticated smelting and mining methods (Neuninger et al., 1969a, 1970a, 1970b; Preuschen & Pittioni, 1956; Pittioni, 1965a, 1967). For instance, the prehistoric mining area at the Kelchalpe, near Kitzbühel in the Tyrol, was found to have running water, i.e. water was collected from a nearby spring and guided along wooden troughs; it was found to have areas which were reserved for the separation of the ore, others for the smelting and yet others for living (Preuschen & Pittioni, 1939). Later again, in Lower Austria, there is evidence for sophisticated double smelting pits (e.g. Puhr, 1972, Fig. 12). Numerous moulds (e.g. Hell, 1943, Fig. 19) give us a good insight into the casting procedure used. The social structure of Bronze Age populations became differentiated as can be witnessed by their graves, by their dress, and weapons. The whole attitude to metal changed - it was now often used for fabricating showpieces, whereas before it was mostly used for day-to-day tools. Much later again, dealings in metal became very complex indeed and trading, quite apart from mining and working of metal, was a specialized activity. Also supply and demand patterns changed seasonally, for instance, at the Magdalenensberg in Austria, clients from the south came in the summer, using sea transport, whereas the locals came in the winter, using sledge transport (cf. Egger, 1961). The appearance of numerous hoards, mostly of uniform shapes, indicates an entirely different approach and supply pattern than in preceeding periods. This also implies true trade, in the sense of balanced exchange of materials.

On examining the cultures that inhabited the northern alpine region and which were using the first copper artifacts, it was clear that most of them had a highly organised way of life (Ottaway, 1978^{+},28). They were accustomed to obtain certain raw materials from outside their immediate neighbourhood. The Cortaillod culture, for instance, obtained cattle for breeding purposes from outside their own settlements. The Pfyn culture obtained antler beakers and perhaps birch-bark decorated vessels, presumably with their contents, from their neighbours. The Altheim culture was in contact with its western and eastern neighbours, and exchange of ideas and artifacts makes it sometimes difficult to decide whether we are dealing with the Altheim or the Mondsee culture (as for example at Auhögl). The Swiss Auvernier culture is part of a larger culture - the Saône-Rhône-culture complex - with which it shares many traits. Both the Auvernier and the Lüscherz cultures imported Pressigny flint from the Loire region of France. Thus, flow patterns of goods are known from this period but they tend, on the whole, not to cover very long distances, but rather to exploit the resources of the surrounding neighbourhood. The notable exceptions are copper and Pressigny flint. It follows that different flow patterns existed for the former types of goods and the latter two.

In terms of final interpretation we must ask ourselves whether we are right in focussing attention on the spatial distribution of natural resources. A common interpretation of the spatial distribution of a material, such as has been studied in the preceding Chapters, is the existence of trade. In the following brief discussion I acknowledge a heavy debt to the Symposium on 'Ancient Civilization and Trade' (Sabloff & Lamberg-Karlovsky, 1975) and in particular to a paper by Chang, which I found most stimulating, perhaps because he expressed lucidly concepts towards which I had been struggling during my attempts to interpret the data for the northern alpine region. Chang wrote (and I quote here extensively, because I cannot express it any better):

'Archaeological ecosystemists often seem to assume that the population as a whole, or its procuring segments, act in concert, according to survival needs. The homogeneity of the population in terms of its survival interest as a whole is also implicitly assumed. ... in the short run, at the operation level, an ecosystemic interpretation must take due account of the way in which individuals are organized into populations, and it is more often than not these human organisations that determine what natural resources are to be exploited, processed and distributed, and in what way'. I also subscribe to Chang's view that '... trade can be studied only in the total context of the distribution of raw and processed natural resources within a societal framework' and that 'archaeological data pertaining to the identification and distribution of natural resources through space merely pose the problem'. This author also advances the view that the solution to the problem can only begin with a knowledge about the social units involved, about the reciprocity in the flow of resources between the units and the means by which transactions were effected, i.e. whether the flow was bilateral, redistributive, etc.

It seems to me that for only a very few of the cultures treated here do we have enough information to fulfil some of these basic requirements. This is partly because social structures within the societies are not yet visible, but it is also due to the fact that studies of natural resources and all socio-economic factors are only just beginning (cf. Sakellaridis[+] (1979) for Switzerland). Renfrew (1975) has pointed out how important is the study of internal trade, yet we can only infer this internal trade for domestic animals and possibly also for seeds of cultivated plants, and for some of the goods mentioned earlier.

If not trade, what other pattern can we offer which would fit the data collected in this book? The answer, as usual, must surely be as manifold as the data and of these the most unusual and outstandingly clear-cut one is that of the Swiss smiths who - as suggested - obtained their raw material from Austrian mining areas.

The question of flow patterns, trade and exchange mechanisms with regard to copper, has been reviewed (Ottaway,in press[+]), and Renfrew's (1975) 'Direct Access Mode' was found to be most closely suited to the unusual pattern indicated above. Interestingly, the distribution pattern of the earlier , i.e. first copper-using horizon was less simple than the Direct Access Mode belonging to the third copper-using horizon.

All flow patterns are partly determined by geographical facts, but partly they must be expressions of the different ways in which different populations reacted to them, and are thus one of the keys to the organisation and behaviour of the cultures studied here. Thus the northern alpine area can, in terms of fluctuations in the use of copper and the general types of artifacts which it used, be regarded as an ecological unit over a long period of time, but it was far from being a homogeneous set of units when studied in detail.

SUMMARY

The earliest copper-based objects ins Switzerland, south Germany and Austria, have been studied in their cultural contexts. The chronological and spatial distribution and the archaeological material of the relevant Late Neolithic cultures in this area and their relationship with one another are only briefly reviewed here; a more detailed report will be published elsewhere.

A first copper-using horizon was found to be followed by a discontinuity (second horizon) in which the use of copper was less frequent. This discontinuity was coeval with the considerable break in the pattern of copper-using cultures in the north European Plain just before the beginning of the Corded Ware culture. The second horizon was succeeded by a third copper-using horizon which again used copper intensively. This latter horizon continued, particularly in Switzerland, without a break into the Bronze Age. The period studied here encompasses the time span - expressed in uncalibrated radiocarbon years - from 3400 to ca 2000 bc.

About one hundred samples of metal objects from Swiss and Austrian museums were analysed for the first time for eleven elements, mainly by neutron activation analysis and atomic absorption spectroscopy. Some samples of objects which had been previously analysed elsewhere, and three international standards, were also analysed to establish comparability of results. In addition, 330 published analyses possibly pertaining to the Late Neolithic period were considered, chosen primarily because the artifacts concerned were of types occuring in secure Late Neolithic associations.

The impurity patterns of objects containing less than 2% tin (about 360) and those containing more than 2% tin (i.e. the bronzes) were grouped separately by cluster analysis, using a computer program. Ten main copper groups, and six bronze groups, emerged, all coherent and sharply defined. They are discussed in terms of their composition, their archaeological, chronological and geographical significance. One of the three earliest copper groups contained significant amounts of arsenic, and probably came from outside the region. By the third copper-using horizon there is strong evidence for mining and smelting in several areas within the Salzach region. This mined copper was mostly used in Switzerland, suggesting that Swiss groups or individuals procured their copper from Austria.

It is concluded that the introduction of copper into the northern alpine region is due, not to a single culture, but to a complex network of multiple contacts and that this resulted not in one single culture which was the earliest to use copper, but in an entire early copper-using horizon. The start of the metal-using horizon was soon followed by local smithing and also mining activities.

The implications in terms of social structure, independant invention, and possible trade are briefly discussed.

ZUSAMMENFASSUNG

Diese Arbeit untersucht die frühesten Kupfergegenstände und die kulturellen Zusammenhänge, in denen sie gefunden wurden. Die chronologische und räumliche Verteilung der spätneolithischen Kulturen in denen sie erscheinen, wird hier nur kurz behandelt; eine detailliertere Studie des archäologischen Materiales wird andernorts erscheinen.

Auf den ersten, kupferführenden Horizont (first copper-using horizon) folgte eine Diskontinuität (der zweite Horizont), in welcher Kupfer wesentlich seltener auftrat. Diese Diskontinuität war mit einer Verschiebung der kupferführenden Kulturen in der nordeuropäischen Tiefebene zeitgleich, die dort vor dem Anfang der schnurkeramischen Kulturen eintrat. Der dritte kupferführende Horizont, in dem Kupfer wieder intensiv gebraucht wurde, ging - besonders in der Schweiz - ohne Unterbrechung in die Bronze Zeit über. Die untersuchte Periode umfasst die Zeitspanne - in unkalibrierten Radiokarbondaten ausgedrückt - von ca 3400 bis ca 2000 v.u.Z.

Ungefähr hundert Proben, entnommen von Metallfunden in Schweizer und österreichischen Museen, wurden zum ersten Mal analysiert. Es wurden 11 Elemente hauptsächlich durch Neutronen Aktivierungsanalyse und Atom Absorptionspektroskopie bestimmt. Einige Proben von Objekten, die schon von anderen Laboratorien analysiert worden waren, sowie drei internationale Standardproben wurden ebenfalls in das Analysenprogramm eingeschlossen, um die Vergleichbarkeit der Ergebnisse festzustellen. Zusätzlich wurden 330 schon veröffentlichte Analysen von Metallfunden mit ausgewertet. Diese Objekte kamen entweder aus gesicherten, spätneolithischen

Fundverhältnissen, oder wurden aufgrund ihrer typologischen Ähnlichkeit zu spätneolithischen Kupferobjekten mit eingeschlossen.

Die Analysen wurden in zwei Gruppen unterteilt; eine mit Zinngehalten unter 2% (ungefähr 360), und eine andere mit über 2% liegenden Zinngehalten (d.h. die Bronzen). Diese Gruppen wurden mittels eines Computers getrennt der Clusteranalyse unterworfen. Es schälten sich zehn gut definierte Hauptkupfergruppen und sechs scharf getrennte Bronzegruppen heraus. Sowohl die chemische Zusammensetzung dieser Gruppen, wie auch ihre archäologische , chronologische und geographische Aussagekraft werden diskutiert. Eine der drei frühesten Kupfergruppen enthielt bedeutende Mengen Arsen und kam wahrscheinlich von ausserhalb der hier behandelten Region herein. Zur Zeit des dritten kupferführenden Horizontes gibt es gute Beweise des Kupferabbaues und Schmelzens entlang des Salzachtales in Österreich. Dieses Kupfer wurde den Funden nach hauptsächlich im westalpinen Gebiet, d.h. der Schweiz benutzt; was darauf schliessen lässt, dass sich Schweizer Gruppen oder Einzelpersonen ihr Kupfer von Österreich beschafften.

Zusammenfassend wird aus dem untersuchten Material geschlossen, dass die Einführung des Kupfers in den nordalpinen Raum nicht auf eine einzige Kultur zurückzuführen ist, sondern auf ein kompliziertes, aus mehrseitigen Kontakten bestehendes Netz. Kontakte dieser Art führten nicht zu einer einzelnen, ersten kupferführenden Kultur, sondern zu einem ganzen frühesten kupferführenden Horizont. Auf diese Anfänge folgten bald lokale Bergbau- und Schmelzaktivitäten.

Die Bedeutung dieser Erscheinungen in Bezug auf gesellschaftliche Struktur. eventuelle unabhängige Entwicklung der Kupfermetallurgie und Handel werden diskutiert.

RESUME

Les objets de cuivre les plus précoces et les contextes culturels dans lesquelles ils apparaissent n'est que brièvement traitée ici; une analyse plus détaillé du mobilier archéologique sera publiée ailleurs.

A la suite du premier horizon utilisant le cuivre (first copper-using horizon) on observe une discontinuité, le second horizon, dans lequel le cuivre apparaît beaucoup plus rarement. Cette discontinuité est contemporaine d'un déplacement des cultures utilisantes le cuivre à l'intérieur de la basse plaine du nord de l'Europe, qui intervient là-bas avant le début de la civilisation de la Céramique cordée. Le troisième horizon utilisant le cuivre, dans lequel ce métal est à nouveau utilisé intensément, s'étend - en particulier en Suisse - sans interruption jusqu'à l'âge du Bronze. La période étudiée couvre une durée - en datation radiocarbone non calibrée - comprise entre 3400 et 2000 av. J.-C. environ.

Une centaine d'échantillons, prélevés sur des trouvailles métalliques conservées dans des musées suisses et autrichiens, sont analysés pour la première fois. Onze éléments ont été déterminés, principalement par les méthodes d'activation neutronique et de spectroscopie d'absorption atomique. Quelques échantillons d'objets déjà analysés dans d'autres laboratoires, ainsi que trois échantillons standard sur le plan international, furent également inclus dans le programme d'analyse, pour établir avec certitude que les résultats sont comparables. Trois cents trente analyses d'objets métalliques déjà publiées sont étudiées en parallèle. Tous ces objets proviennent soit de contextes assurés du Néolithique final, ou alors ont été assimilés, sur la base de similitudes typologiques, aux objets de cuivre du Néolithique final.

Les analyses ont été séparées en deux groupes; le premier dont la composante d'étain est inférieure à 2% (environ 360) et le second avec un pourcentage d'étain supérieur à 2% (soit les bronzes). Ces groupes ont été individualisés à l'aide d'un ordinateur et soumis à la méthode de "cluster analysis". Dix groupes principaux bien définis dans les cuivres et six groupes fortement distincts dans les bronzes ont été isolés. Les composantes chimiques de ces groupes, comme leur signification archéologique, chronologique et géographique, sont discutées. L'un des trois plus anciens groupes du cuivre comporte des quantités significatives de manganèse et d'arsenic; il provient

vraisemblablement d'ailleurs que la région considérée ici. En ce qui concerne l'époque du troisième horizon utilisant le cuivre, on possède de bonnes preuves d'exploitation et de fonte de ce métal le long de la vallée du Salzach en Autriche. Ce cuivre fut utilisé principalement, d'après les trouvailles archéologiques dans le territoire situé à l'ouest des Alpes, soit en Suisse; il en découle que des communautés suisses, ou des individus, se procuraient leur cuivre en Autriche.

En résumé, on conclut, sur la base du matériel étudié, que l'introduction du cuivre au nord des Alpes n'est pas rattachée à une seule civilisation, mais dépend d'un réseau complexe de contacts multilatéraux. De tels contacts ne conduisirent pas à une première et unique civilisation porteuse de cuivre, mais à un horizon le plus précoce tout entier, connaissant et utilisant le cuivre. Des extractions locales et des activités de fonderie succédèrent bientôt à ces débuts.

La signification de cette apparition compte tenu des structures sociales, un éventuel développement indépendant de la métallurgie du cuivre et de son commerce sont discutés.

Trad. G. Kaenel

List of Abbreviations used in Bibliography

AAC = Acta Archaeologica Carpathica

ABB = Archives of Biochemistry and Biophysics

Acta Arch. = Acta Archaeologica

Acta Bern. = Acta Bernensia

ADJ = Arheolosko Drustvo Jugoslavije

AIPF = Atti della XV Riunione Scientifica dell'Istituto Italiano di Preistoria et Protostria Firenze

AJ = Antiquaries (The) Journal

AJA = American Journal of Antiquities

AMN = Acta Musei Napocensis

Am. Ant. = American Antiquity

Anal. Chem. = Analytical Chemistry

Arb.& Forschgem.SB = Arbeits- & und Forschungsgemeinschaft zur sächsischen Bodendenkmalspflege

Arch.Austr. = Archaeologica Austriaca

Arch.Ert. = Archeologica Értesitö

Arch. Geo. = Archaeologia Geographica

Arch. Hung. = Archaeologica Hungarica

Arch. Korrbl. = Archäologisches Korrespondenzblatt

Arch. Pol. = Archaeologia Polona.

Arch. Roz. = Archeologiché Rozhledy

ASA = Anzeiger für schweizerische Altertumskunde

ASAG = Archives Suisse d'Anthropologie Générale,Genève.

ASpectr. = Applied Spectroscopy

Bad.Fund.= Badische Fundberichte.

Bay.Vorg. = Bayerische Vorgeschichtsblätter

B.A.R. = British Archaeological Report.

BPI = Bulletino di Paletnologia Italiana

BRGK= Berichte der Römisch-Germanischen Kommission.

Bull.SPF = Bulletin de la Société Préhistorique Française

Congres de l'UISSP = Actes du Congrês International des Sciences Préhistorique et Protohistorique

FAP = Fontes Archaeologici Pragenses.

FB = Fundberichte Schwaben.

FBW = Fundberichte aus Baden-Württemberg

Fundber.O. = Fundberichte Österreich

GP = Gallia Préhistoire

Helv.Arch. = Helvetia Archaeologica

ISAAP = International Symposium on Archaeometry and Archaeological Prospection

JAWL = Jahrbuch der akademischen Wissenschaft und Literatur

JBB = Jahresberichte der Bayerischen Bodendenkmalspflege

JBHM= Jahrbuch des Bernischen Historischen Museum

JFA = Journal of Field Archaeology

JGK = Journal of Geophysical Research

JHMS = Journal of the Historical Metallurgy Society

JIF = Jahresbericht des Instituts für Vorgeschichte der Universität Frankfurt/Main

JKKZW = Jahrbuch der Kaiserlich-Königlichen Zentralkommission,Wien.

JMV = Jahresschrift für Mitteldeutsche Vorgeschichte

JOOM= Jahrbuch des Oberösterreichischen Musealvereines.

JSGU = Jahrbuch der Schweizerischen Gesellschaft für Urgeschichte.

JVSTL = Jahresschrift der Vorgeschichte Sächsisch Thüringischer Länder.

MAGW = Mitteilungen der anthropologischen Gesellschaft Wien.

MAGZ = Mitteilungen der Antiquarischen Gesellschaft,Zürich

Mem. et Doc. = Mémoires et Documents publiés par la Société

D'Histoire de la Suisse Romande

MIA = Materialy i Issledovaniya po Aekheologii SSSR

MMKV = Mitteilungen der Museen des Komitates Veszprém

MNZ = Mitteilungen der Naturforschenden Gesellschaft,Zürich

MOAG = Mitteilungen der Österreichischen Arbeitsgemeinschaft für Ur- und Frühgeschichte, Wien.

MPK = Mitteilungen der prähistorischen Kommission der Akademie der Wissenschaften,Wien

MZBV = Materialhefte zur bayerischen Vorgeschichte

OKT= Österreichische Kunsttopographie.

PA= Problemy Archeologii,Leningrad.

PAO = Prähistorische Archaologie in Oberösterreich

Pam.Arch. = Památky Archaeologické.

Phil.Trans.Roy.Soc. = Philosophical Transactions of the Royal Society,London

PM= Prace i Materiały.

PPS = Proceedings of the Prehistoric Society,London

Przeglad A.= Przegląd Archeologiczny.

PZ = Prähistorische Zeitschrift.

RAPC = Rivista Archeologica,Provinciae Diocesi di Como

RGZ = Römisch-Germanisches Zentralmuseum

SAM I = Junghans,S, Sangmeister,E. & Schröder, 1968

SAM II = Junghans,S.,Sangmeister,E. & Schröder, 1968 & 1974

Slov. Arch. = Slovenská Archéologia

SMbl = Salzburger Museumsblätter

SNMP = Sborník Národního Muzea v Praze

Sov. Ark. = Sovetskaya Arkheoloiya

Symp. Baden = Symposium über die Entstehung und Chronologie der Badener Kultur. Chropovsky,B. (ed),Verlag der Slowakischen Akademie der Wissenschaften,Bratislava 1973.

SZ =Študijné Zvesti

UFAS = Ur- und frühgeschichtliche Archäologie der Schweiz, Drack,W.(ed)

UISPP = Union International des Sciences Prehistoriques et Protohistoriques

VLMH = Veröffentlichungen des Landesmuseums für Vorgeschichte, Halle

VNGZ = Vierteljahrschrift der naturforschenden Gesellschaft,Zürich

World Arch. = World Archaeology.

WPZ= Wiener Prähistorische Zeitschrift.

ZA = Zeitschrift für Archäologie

ZD = Züricher Denkmalspflege

ZSAK = Zeitschrift für Schweizer Archäologie und Kunstgeschichte.

* References marked with an asterisk (*) can be found in the Addendum to the Bibliography.

Bibliography

Adler,H. 1965 ,Linzer Archäologische Forschung.Stadtmuseum Linz

Agett,J.& Sprolt,A.J. 1974 Analitica Chimica Acta ,72,49-65

Agricola. 1556. De Re Metallica. Dibner,B.(ed)1958. (Agricola on Metals) Burndy Library,Norwalk,Connectitut.

Allen,I.,Britton,D.,Coghlan,H.H. 1970 Occasional Papers on Technology, Penniman,T.K.& Blackwood,B.M. (eds) Oxford

Allison,A.C. 1961 Annals of the New York Academy of Sciences 91, 710-729.

Amrein,W. 1939.Urgeschichte des Vierwaldstätter Sees und der Innenschweiz. Aarau: Sauerländer.

Amschler,J.W. 1949. Arch. Austr., 3,1-100.

Angel,J.L. 1966. Science, 153, 760 -763.

Angel,J.L.1972. World Arch.,4,88-105.

Angeli,W. 1953. JBSGU, 134-141.

Angeli,W. 1967. Ann. Naturhist. Mus. Wien. 70,

Angerer,F. 1931.WPZ,18,156 ff.

Angino,E.A. & Billig,G.K. 1972 Atomic absorption spectrometry in geology. 2.ed. Methods in Geochemistry and Geophysics Series No 7. London: Elsevier.

Asmus,G. 1974 in Bevölkerungsbiologie. Bernhard W. & Kandler,A.(eds) Stuttgart.430 - 440.

Baer,A. 1959 Die Michelsberger Kultur in der Schweiz. Monographien zur Ur- und Frühgeschichte der Schweiz.Basel.

Bailloud,G. 1973. Arch. Korrbl.,3, 187-190.

Bailloud,G. 1974 in France before the Romans. Piggott,S.,Daniel,G. & McBurney,C.(eds) London:Thames and Hudson.102-130.

Ball,H. 1971. Classification Analysis. Stanford Research Institute Project 5533.

Bandi,H.G. & Müller-Beck,H. 1963 - 1974. Seeberg Burgäschisee-Süd. Acta Bernensia II.

Bandi,H.G. 1966 Palaeohistoria,12, 17-32.

Banner,J. 1956 Die Péceler Kultur. Arch.Hung.S.N. 35.

Barfield,L.H. 1969. The Neolithic and Copper Age Settlements of Northern Italy. PhD Thesis, University of Cambridge

Barfield,L. 1971. Northern Italy before Rome.London:Thames and Hudson.

Barfield,L.H. & Fasani,L. 1972. Musaica,23,45-63.

Barfield,L.H. & Fasani,l. 1973.AIPF, 181-189.

Barker,G. 1972. PPS,38,170-208.

Barker,G. 1974 Prehistoric economies and cultures in central Italy. PhD Thesis,Iniversity of Cambridge.

Bath-Bilkova,B. 1973. Pam.Arch.64, 1,24-41.

Bayer,J. 1928.Eiszeit und Urgeschichte,5,60-91.

Bayer,J. 1930. Forschung und Fortschritte,6,273 ff.

Bayer,J. 1930. Mannus,22,374.

Becker,B. 1971. JAWL,140-146.

Behrens,H. 1968. JMV,52,67-80.

Behrens,H. 1973. Arch. Roz.,25,647-654

Behrens,H. 1975. in Archaeozoological studies. Clason,A.(ed). 395-396

Behrens,H. & Schlette,F. 1969. (eds) Die neolithischen Becherkulturen im Gebiet der DDR und ihre europäischen Beziehungen.VLMH ,Vol 24.Berlin:Deutscher Verlag der Wissenschaften.

Benac,A. 1961. BRGK.,42,1-170.

Bender,B. 1975. Farming in prehistory.London: John Baker.

Benesova,A. 1957. MAGW, 87,70-75.

Benesova,A. 1956. Pam.Arch.,47,236-244.

Beninger,E. 1960.in Festschrift für Lothar Zotz.Bonn.39-59.

Beninger,E. 1961. Die Paura an der Traun. Schriftenreihe der Oberosterreichischen Landesbaudirektion,Nr.17.

Beninger,E.,Mühlhofer,F.,Geyer,E. 1930. MAGW,60,65-140

Berg,F. 1967. (1951 - 1955). Fundber.O.,6,16 ff.

Bergmann,J. 1974. PZ 49, 129-138.

Bernhart,R. 1968. Die Pfahlbausammlung des Heimathauses Vöcklabruck. MPK,11-12,1963-1968.

Bernhard,W. & Kandler,A. (eds) 1974. Bevölkerungsbiologie. Beiträge zur Struktur und Dynamik menschlicher Populationen in anthropologischer Sicht.Festschrift I.Schwidetzky.Stuttgart:Gustav Fischer.

Bersu,G. 1937. Germania,21,149-158.

Bieber,A.M., Brooks,D.W., Harbottle,G. & Sayre,E.V. 1976. Archaeometry, 18,59-74.

Biek,L. 1957. MAN, 57,72 ff.

Blance,B.M. 1971. Die Anfänge der Metallurgie auf der Iberischen Halbinsel. Römisch-Germanisches Zentralmuseum,Studien zu den Anfängen der Metallurgie, B.4.Berlin:Mann.

Bloesch,H. 1948. JBHM, 28,24 ff.

Bocksberger,O.-J.,1962-1964. Valleria,21,1-28.

Bocksberger,O.-J., 1971. JSGU,56,77-100.

Boessneck,J. 1956. Studien an vor- und frühgeschichtlichen Tierresten Bayerns. 1.Tierknochen aus spätneolithischen Siedlungen Bayerns. München.

Boessneck,J. 1958. Studien an vor- und frühgeschichtlichen Tierresten Bayerns II. Zur Entwicklung vor- und frühgeschichtlicher Haus- und Wildtiere Bayerns im Rahmen der gleichzeitigen Tierwelt Mitteleuropas.München.

Boessneck,J. ,Jequier,J-P, & Stampfli,H.R. 1963.Seeberg Burgäschisee-Süd. Teil 3,Die Tierreste.Acta Bernensia II.

Bognár-Kutzian,I. 1963. The copper age cemetery of Tiszapolgár Basatanya. Budapest.

Bognár-Kutzian,I. 1972. The early copper age Tiszapolgár culture in the Carpathian basin. Arch. Hung. S.N. 48. Budapest.

Bognár-Kutzian,I. 1973. in Symp. Baden,13-21.

Bognár-Kutzian,I. 1973. in Symp.Baden,31-50.

Böhm,J. & De Laet,S.J. 1961. L'Europe à la fin de l'âge de la pièrre. Academie Tchecoslovaque des Sciences,Praha.

Böhne,C. 1965. in Technische Beiträge zur Archäologie II,Mainz: Habelt. 126-130.

Böhne,C. 1968. Arch.Austr.44,49-60.

Bökónyi,S. 1975. in Achaeozoological studies. Clason,A.(ed),167-178.

Boomert,A. 1975. Helinium, 15, 134-161.

Bosch,R.1938. in Festschrift Tatarinoff. Solothurn. 11-21.

Bowman,R.,Friedman,A.M.,Lerner,J.& Misted,J. 1975. Archaeometry,17,157-164.

Brea,L.B. 1962. Atti I. Convegno Magna Grecia.61-97.

Briard,J. & Maréchal,J.R. 1958. Bull.SPF,55,422 ff.

Brill,R.H.(ed), 1971. Science and Archaeology.MIT Press,Cambridge,Mass.

Britton,D. 1961. Archaeometry,4, 39-52.

Britton,D. 1963. PPS,29, 258-325.

Britton,D. & Richards,E.E.1969. in Science in Archaeology. Brothwell ,D.& Higgs,E. (eds). London:Thames and Hudson. 603-613.

Brothwell,D.R. & Sandison,A.T. 1967.Disease in antiquity. Springfield III, Charles C.Thomas.

Brukner,B. 1964. ADJ,57-62.

Brukner,B.,Jovanovič,B.& Tasic,N. 1974. Praistorija Vojvodine.Novi Sad.

Buchvaldek,V. 1966. Pam.Arch.,57,126-171.

Buchvaldek,M. 1975.AAC,15,191-203.

Butler,J.J. & Van der Waals,J.D. 1964.Helinium, 4,3-39.

Butler,J.J. & Van der Waals,J.D. 1966. Palaeohistoria,12, 41-139..

Buttler,W. 1938. Der Donauländische und westische Kulturkreis. Berlin.

Butzer,K.W. 1974. Environment and Archaeology:an ecological approach to prehistory.2nd ed. 3rd pr. Chicago.

Caldwell,J.R. 1968.Archaeologia Viva,I

Cann,J.R. & Renfrew,C. 1964. PPS,30,111-133.

Carroll,D.L. 1972. AJA,76,321.ff.

Case,H. 1967. (1966) Palaeohistoria,12, 141-177.

Casteel,R.W. 1975. in Archaeozoological studies. Clason,A.

(ed),70-86..

Cavalli-Sforza,L.L. & Bodmer,W.I. 1971.The genetics of human populations. San Francisco:Freeman.

Cavalli-Sforza,L.L. 1974. Scientific American, 231,3,81-89.

Chaix,L. 1976. JSGU,59,61-65.

Chaix,L. 1976. JSGU, 59,34-42.

Chang,K.C. 1975.in Ancient Civilizations and Trade. Sabloff, J.A.& Lamberg-Karlovsky,C.C.(eds), 211-224.

Charles,J.A. 1967. AJA,71,21-26.

Charles,J.A. 1973. Archaeometry 15,104-114.

Chase,W.T. 1975. Advances in Chemistry Series,138,9,148-185.

Chernych,E.N.1966. MIA,132,1ff.

Chernych,E.N. 1975. Sov Ark.,4,132-153.

Childe,V.G. 1930. The Bronze Age. Cambridge:University Press.

Christaller,W. 1966.Central places in southern Germany.Englewood Cliffs N.J. Prentice-Hall.

Chropovský,B.(ed) 1973. Symposium über die Entstehung und Chronologie der Badener Kultur. Verlag der Slowakischen Akademie der Wissenschafter.Bratislava.

Clarke,D.L. 1968. Analytical Archaeology. London:Methuen.

Clarke,J.G.D., 1952. Prehistoric Europe - the economic basis.London:Methuen.

Clarke-Forbes,M.H. 1976. Annals of the New York Academy of Sciences, 268,127-142.

Clason,A.T. 1966. Palaeohistoria, 12,581-585.

Clason,A. 1969. in Die neolithischen Becherkulturen im Gebiet der DDR. Behrens,H. & Schlette,F.(eds),173-195.

Clason,A. 1972. Helinium,12, 139-153.

Clason,A.(ed) 1975.Archaeozoological studies. Amsterdam:North-Holland.

CLIMAP Project members 1976. Science,19,191,No.4232,1131-1137.

Clutton-Brock,J. 1975. in Archaeozoological studies. Clason,A. (ed),21-34.

Cockburn,T.A. 1971. Current Anthropology, 12,45-62.

Coghlan,H.H. 1942. AJ, 22,22-38.

Coghlan,H.H.1951. MAN,51,90-93.

Coghlan,H.H.1958. Arch.Austr. Beiheft 3,57 ff.

Coghlan,H.H.1962. PPS, 28,58-67.

Coghlan,H.H. 1968. Arch.Austr.,44,61-82.

Coghlan,H.H. 1972. Arch. Austr.,52. 92-104.

Coghlan H.H. & Case, H. 1957. PPS, 23,91-123.

Colquhoun,D. 1971.Lectures on Biostatistics.Oxford:Clarendon Press.

Cook,S.F. 1972. Prehistoric demography. Addison-Wesley Modular Publications,McCaleb Module in Anthropology 16,Reading,Mass.

Corbin,H.B. 1973. Anal.Chem.,45,534-537.

Čović,B. 1961. Glasnik Zemaljskog Muzeja, 15-16,79-139.

Dalton,G. 1975. in Ancient Civilisation and Trade. Sabloff,J.A. & Lamberg-Karlovsky,C.C.(eds),63-132.

Damon,P.E., Long,A.,Watlick,E.T. 1972. in Proc.of 8th International Conference on Radiocarbon Dating, 44-59.

David,N. & David-Hennig,H. 1971. Bay.Vorg.,36,289-317.

DeJesus,P. 1974. Anatolia,25,129-140.

Derkosch,J. & Neuninger,H. 1957. Microchimica Acta,12,174-182.

Derkosch,J. Mayer,F.X.,Neuninger,H. 1956. Microchimica Acta,11,164.

Dolenz,H. 1938. WPZ,25,59-76.

Doran,J.E.& Hodson, F.R. 1975. Mathematics & Computers in Archaeology. Edinburgh:University Press.

Drack,W. 1955. Die jüngere Steinzeit der Schweiz.Zürich.

Drack,W. 1961. ZD,1,(1958-1959),46.

Drack,W.1961. ZD 2.Bericht.125-130.

Drack,W. 1963. JSGU,50,62ff

Drack,W. 1969. in UFAS,2, 67-82.

Driehaus,J. 1952. Arch.Geo.,3,1-8

Driehaus,J. 1957.Arch.Geog.6,44.

Driehaus,J. 1960. Die Altheimer Gruppe und das Jungneolithikum in Mitteleuropa.Mainz:Habelt.

Eaton,E.R. & McKerrell,H. 1976. World Arch.,8,169-191.

Ebert,M.1927 Reallexikon der Vorgeschichte,Band I.Taf.32.& Band 8,498.

Egger,R. 1961. Die Stadt auf dem Magdalenensberg ein Grosshandelsplatz -Die ältesten Aufzeichnungen des Metallwarenhandels auf dem Boden Österreichs. Denkschriften der Österreichischen Akademie d.Wissenschaftlich-philosophisch-historischen Klasse 79.

Egloff,M. 1972.Helv. Arch.,3,3-29.

Egloff,M. 1973. Helv.Arch.,3,3-12.

Eibner,C. 1972. MOAG,23,52-53.

Evens,E.D.,Grinsell,L.V.,Piggott,S.,Wallis,F.S. 1962. PPS,28,209-266.

Everitt,B. 1974. Cluster Analysis. Social Science Research Council Publication,Heinemann.

Felsenfeld,G. 1960. ABB,87,247-251.

Ferguson,C.W.,Gimbutas,M. 1976. Science,191,1170-1172.

Fields,P.R.,Milsted,J.,Henrickson,E.& Ram,R. 1971. in Science and Archaeology. Brill,R.H. (ed),131 ff.

Filip,J. 1969.Handbuch der Archäologie. Praha:Academia.

Fischer,L.H. 1898. MAGW,28,107 ff.

Fischer,U. 1956. Gräber der Steinzeit im Saalegebiet. Berlin: de Gruyter.

Fleming,A. 1972. World Arch.,4,179-191.

Forbes,R.J. 1972. Studies in Ancient Technology.Vol.9.2nd revised edition.Leiden:Brill.

Forrer,R. 1885. Antiqua,81-176.

Franz,G.(ed), 1969. Deutsche Agrargeschichte.Band 1.Stuttgart.

Franz,L.&Weninger,J. 1927. Die Funde aus den prähistorischen Pfahlbauten im Mondsee.Wien.

Franz,L.& Weninger,J. 1927. Materialien zur Urgeschichte Österreichs,3,55.

Freund,G. 1963. JBB,4,9-167.

Friedman,A.M., Conway,M.,Kastner,M.,Milsted,J.,Metta,D., Fields,P.R. & Olsen,E. 1966. Science,152,1504-1506.

Friesinger,H. 1972. Arch.Austr.51.113-189.

Gabel,G.1967. Analysis of prehistoric economic patterns.New York:Holt,Rinehart & Winston.

Gallay,A. 1963. ASA,28,1-29.

Gallay,A. 1965. ASA,30,57-82.

Gallay,A. 1966. Ur Schweiz,30,1,3-9.

Gallay,A. 1971a. Archäologischer Anzeiger,1,155

Gallay,A. 1971b. Germania,49,221-231.

Gallay,A. 1971c. Germania,49,1-2.

Gallay,A. 1972a. Homo,72,1-2.

Gallay,A. 1972b.Sion,Petit-Chasseur(Valais).Programme d'Elaboration.Université de Genève.

Gallay,A. 1972c.Helv. Arch. 3,35-61.

Gallay,A. 1976. 9. Congrès UISPP,Nice.

Gallay,A. & Gallay,G. 1966. ASA,31,28-41.

Gallay,A. & Gallay,G. 1968. ASA, 33,1 ff.

Gallay,G. 1971. JSGU, 56,115-139.

Gallay,G.,& Spindler,K. 1972. Helv. Arch.,3,62-89.

Gallay,M. 1970.Besiedlung der südlichen Oberrheinebene in Neolithikum und Frühbronzezeit. Bad. Fund.,Sonderheft 12.

Garasanin,M. 1954. BRGK, 34, 61-76.

Gersbach,E. 1967.JSGU,53,15-28.

Gessner,V. 1946. Die geometrische Ornamentik des spätbronzezeitlichen Pfahlbaukreises der Schweiz.Phil. Diss. Zürich.

Gilmore,G.R. 1976. Modern Trends in Activation Analysis.2,1187-1192.

Gilmore,G.R. & Ottaway,B.S. 1977. 'Optimal Methods for Analysing Copper-Based Artifacts.' Paper given at the ISAAP, Philadelphia.

Gimbutas,M. 1974. JFA,1,26-66.

Giot,R.R. 1960. Brittany.London:Thames and Hudson.

Godelier,M. 1971. in Studies in Economic Anthropology.Dalton,G.(ed),52-73.

Godwin,H.1956. The history of the British flora.Cambridge :University Press.

Godwin,H. 1966. Introductary address in World Climate from 8000-0 BC. Royal Meteorological Society,London,3-14.

Gonzenbach,V.1949. Die Cortaillodkultur in der Schweiz.Monographien zur Ur- und Frühgeschichte der Schweiz.12. Basel.

Gowland,W. 1899. The Early Metallurgy of Copper,Tin and Iron in Europe and the Primitive Processes Surviving in Japan. London.

Grbić,M. 1929. Pločnik.Eine prähistorische Ansiedlung aus der Kupferzeit.Belgrade.

Greeves,T.A.P.1973. The use of copper in the Cucuteni-Tripolye culture of south-east Europe.M.A.Thesis,Edinburgh.

Gregory,E. & Simons,E.N. 1948. Non -Ferrous Metals and Alloys. London:Paul Eck.

Gripp,K. 1971.Offa,28,47-54.

Gross,V. 1883. Les Protohelvètes. Berlin.

Gross,V. 1882.ASA,4,259.

Grothe,H. 1970. Arch. Austr., 47,78-86.

Guerreschi,G. 1967. RAPC,148-149,5.

Guyan,W.U. 1955 Das Jungsteinzeitliche Moordorf von Thayngen-Weier.Das Pfahlbauproblem.Monographie zur Ur- und Frühgeschichte der Schweiz.11.

Guyan,W.U. 1967. ZSAK,25,1 -39..

Guyan,W.U. 1971. Erforschte Vergangenheit:Schaffhausener Urgeschichte. Schaffhausen.

Guyan,W.U. 1972. JSGU, 57,206 ff.

Guyan,W.U. 1976. JSGU 59,93-117.

Haarnagel,W. 1951.in Festschrift für G.S.Schwantes, Kersten,K.(ed) Neumünster: Wachholtz.78-84.

Habermeier,K. 1974. Fundber.O.,12(1973),23-24.

Hachmann,R. 1973. in Symp. Baden,.79-109.

Hallpike,C.R. 1976. MAN,11,2,251-270.

Hammond,N.,Harbottle,G. & Gazzard,T. 1975.'Neutron Activation and numerical taxonomy of a group of sherds from Lubaanum, Belize.' Paper given at the ISAAP, Oxford.

Harbison,P. 1969. The axes of the early Bronze Age in Ireland. Prähistorische Bronzefunde Abt.9,1.München.

Härke,H.1975. Probleme der optischen Emissionsspektralanalyse in der Urgeschichte .Magisterarbeit,Göttingen.

Harris,H. 1970.The principles of human biochemical genetics.Amsterdam:North-Holland.

Harriss,J.C. 1971.PPS,37,38-55.

Harsema,O.H. 1964. Thurgauer Jahrbuch,7 ff.

Harsema,O.H. 1973. JSGU,57, 219-225.

Harter,G. 1961. Biometrika, 48, 151 - 165.

Hartmann-Frick,H. 1969.in UFAS, 2,17-32.

Häusler,A. 1966. Arb.& Forschgem.SB.,14-15,25-73.

Häusler,A. 1968.Ethnographisch-Archäologische Zeitschrift 9,1 -30..

Hawkes,C. 1973. Antiquity,47,176-178.

Heierli,J. & Oechsli,W. 1896. MAGZ, 24

Heierli,J. 1901.Urgeschichte der Schweiz. Zürich.

Heierli-Scherer,1924. MNZ,9,62 ff.

Heierli,J. 1886. MAGZ,22,1

Hell,M. 1919.MAGW,48-49,(1918-1919),208-220.

Hell,M.1921.MAGW,51,31-39.

Hell,M.1926.WPZ,13,82-86.

Hell,M. 1944-1950. Germania,28-29,173-175.

Hell,M. 1943.WPZ,30,55-66.

Hell,M. 1952a. Arch. Austr.,9,38-48.

Hell,M. 1952.(1940-1945). Fundber.O.,4,12 ff.

Hell,M. 1952c.Arch.Austr.,10,38

Hell,M. 1953a.Arch.Austr.,12,95-96.

Hell,M. 1953b. Arch.Austr.,12,33-37.

Hell,M. 1954. Arch.Austr.,14,11-34.

Hell,M. 1955a. Arch.Austr.,17,1-22.

Hell,M. 1955b. Arch.Austr.,17,23-30.

Hell,M. 1961. Arch.Austr.,30,1-38.

Hell,M. 1969. Arch.Austr.,46,1-4.

Hell,M. 1971.MOAG, 12,69-70.

Hell,M. 1975. Arch.Austr.,57,9-20.

Hell,M. & Koblitz,H. 1918. OKT,17, 1-37.

Hennig,E. 19 Arch.Roz.,682 ff

Hescheler,K. & Rueger,G. 1942. VNGZ,87,383-486.

Higham,C.F.W. 1967. PPS,33,84-106.

Higham,C.F.W. 1967. VNGZ,112,123

Higham,C.F.W. 1968.MAN,3,64-75.

Higham,C.F.W. 1969.ZSAK,26,1-7.

Higham,C.F.W. 1969.Acta Arch.,40,200-209.

Hillebrand,J. 1929. Arch.Hung.,4,

Hillebrand,J. 1935. Arch.Hung.,17

Hodder ,I. & Orton,C. 1976. Spatial Analysis in Archaeology.New Studies in Archaeology. I. Cambridge:University Press.

Hodge,S.E. & Seed,M.L.1972. Statistics and Probability.London:Blackie.

Hoel,P.G. 1966. Introduction to Mathematical Statistics.London:John Wiley & Sons.

Hoernes,M. 1903.JKKZW,1,2-51.

Hofer,P. 1906. JVSTL,5,1

Hoof,D. 1970. Die Steinbeile und Steinäxte im Gebiet des Niederrheines und der Maas.Antiquas Reihe 2,9.Bonn.

Horedt,K. 1968. Apulum,7,1. 103-116

Houstova,A. 1960. FAP,3,11

Hubbard,R.N.L-B.1976. World Arch.,8,159-168.

Huber,B. & Merz,W. 1963. Germania,41,1-9.

Hübscher,J.C. 1959. JSGU,47,140ff.

Hughes,M.J.,Cowell,M.R. & Craddock,P.T. 1976. Archaeometry,18,19-37.

Hundt,H.J. 1951.Germania,29,5-17.

Hundt,H.J. 1952. Germania,30,252

Hundt,H.J. 1957. FB,14,34 ff.

Hundt,H.J.1958. Katalog StraubingI. Kallmünz.

Hundt,H.J.1961. In Kommission für das Anäolithikum und die ältere Bronze Zeit.Bratislava. 145-176.

Hundt,H.J. 1958. Germania, 36,344-361.

Hwang,J.Y. & Sandonato,L.M. 1970. Anal.Chem.,42,744-747.

Ischer,T. 1919. ASA,21,129-154.

Ischer,T. 1928. Pfahlbautern des Bielersees.Biel.

Itten,M. 1969. in UFAS,II, 83-96.

Itten,M. 1970.Die Horgener Kultur. Monographien zur Ur-und Frühgeschichte der Schweiz,Band 17.

Jarman,M. 1971. World Arch.,2,255-265.

Jarman,M. 1976. in Problems in Economic and Social Archaeology. Sieveking,G, Longworth,I.H. & Wilson,K.E.(eds),London:Duckworth.523-548.

Janik,V.C.1969. JOOM,114,181-200.

Jaździewski,K. 1973. PM,20,5-7.

Jenkins,E.N. & Smales,A.A. 1956.Quarterly Review,10(1),83-107.

Joos,M. 1976. JSGU,59, 31-34.

Jovanović,B. 1971.Metallurgy of the Eneolithic Period in Jugoslavia.Archaeological Institute,Beograd.

Jovanović,B. 1976. Der Anschnitt,5,149-157.

Jovanović,B. & Ottaway,B.S. 1976. Antiquity,50,104-113.

Junghans,S. 1968. Germania,46,1ff.

Junghans,S., Klein,H. & Scheufele,E. 1954.BRGK,34,77-114.

Junghans,S., Sangmeister,E. & Schröder,M. 1960.Metallanalysen.

kupferzeitlicher und frühbronzezeitlicher Bodenfu^nde aus Europa. Berlin: Mann.

Junghans,S., Sangmeister,E.& Schröder,1968. Kupfer und Bronze in der frühen Metallzeit Europas. Berlin: Mann.

Junghans,S.,Sangmeister,E. &Schröder, 1974. Kupfer und Bronze in der frühen Metallzeit Europas. Berlin:Mann.

Jürgens,H.W. 1974.in Bevölkerungsbiologie.Bernhard,W.,Kandler,A.(eds),270-279.

Kaenel,G.1976. JSGU,59,7-29.

Kalicz,N. 1963.Die Péceler Kultur und Anatolien.Budapest.

Kalicz,N. 1969. MMKV, 8, 83-89.

Kalicz,N. 1970. Götter aus Ton.Das Neolithikum und die Kupferzeit in Ungarn. Budapest.

Kalicz,N. 1973. in Symp. Baden ,131-165.

Keller,F. 1878.The lake Dwellings of Switzerland and other parts of Europe.London:Longmans,Green & Co.

Keller-Tarnuzzer,K. 1936. JSGU,28,16-18.

Keller-Tarnuzzer,K.1945. JSGU,36.23

Keller-Tarnuzzer,K. 1928. JSGU, 26

Kimmig,W. 1950. Bad.Fund.,18,(1948-1950) 69-77.

Kimmig,W. 1958. Vorzeit an Rhein und Donau,Südwestdeutschland,Nordschweiz,Ostfrankreich. Lindau.

Kimmig,W. 1966. SNMP.,Ser.A.20,101-106.

Klein,L.S. 1968. PA,I,5-74.

Kloiber,A. & Reitinger,J. 1970. JOOM,115,21-36.

Kneidinger,J. 1942.MAGW,72,278-290.

Koster,C. 1966. PZ,43-44,(1965-1966),2-95.

Kostrzewski,B. 1949. Przegląd A.,8,248-299.

Košťuřik,P. 1972.Die Lengyel Kultur in Mähren.Studie Arch.Ustáv Československ.Akademie Brno.

Kowalczyk,J. 1962. Arch.Pol.,4,111-120.

Kunze,W. 1973. PAO.,(1972-1973),1-8.

Kunze,W. 1974. Fundber.O.,8,(1961-1965),31

Kyrle,G. 1918. WPZ,5,19-47.

Kyrle,G. 1924. OKT,18,24-26.

Kyrle,G. & Klose,O. 1918. OKT,17,11-158.

Ladenbauer,-Orel, H. 1954. Arch. Austr. 16, 67ff.

LaMarche, V.C., & Harlan,T.P. 1973. JGK. 78, 8849 ff.

Lamberg-Karlovsky, C.C. 1975. in Ancient Civilizations and Trade. Sabloff J.A.& Lamberg-Karlovsky,C.C.(eds), 341-348.

Laviosa-Zambotti,P. 1939. BPI.,3,1 ff.

Leben, F. 1973. in Symp. Baden,187-197.

Lehmann,H. & Huntsman,R.G. 1966. Man's Haemoglobins. Amsterdam.

Lehmann,H.,Huntsman,R.G. & Ager,J.A.M.1966. in The Metabolic Basis of Inherited Disease.Stanbury,J.B.,Wyngaarden,J.B. & Fredrickson,D.S.(eds).2nd ed. New York:Mc Graw-Hill.

Leroi-Gourhan, A. & Girard, M. 1971. JSGU 56, 7-15.

Ladurie, E.L. 1971. Times of Feast, Times of Famine. New York.

Lichardus, J. & Šiška, S. 1970. Slov. Arch. 18(2), 342-352.

Lichardus, J. & Vladár, V. 1964. Slov. Arch. 12(1), 69-162.

Lindblom, K.G. 1939. Smarre Meddelanden 15, 5-38.

Lorenzen, W. 1967. Offa 24, 106-107.

Louis, M. & Audibert, J. 1953. JSGU 166-177.

Lucas,M. 1965. Kataloge zur mitteldeutschen Schnurkeramik 2:Saalemündungsgebiet.VLMH,20.

Lüning, J. 1967. BRGK 48, 1-350.

Lüning,J. 1971. Arch.Korrbl.,1,31 ff.

Lüning,J. 1972. PZ,47,145 ff.

Lüning,J. 1973. Arch.Korrbl.,3,15-22.

Lüning, J.1969.Die jungsteinzeitliche Schwieberdinger Gruppe. Veröffentl. der Staatl. Amtes f. Denkmal- pflege, Stuttgart. Reihe A, Vol. 13.

Lüning, J. 1975. in Ausgrabungen in Deutschland. Teil I. Monographien RGZ,1(1).Bonn.77-84.

Lunz, R. 1973. Ur- und Frühgeschichte Südtirols. Bozen.

Maczck, M., Preuschen, E. & Pittioni, R. 1953 Arch. Austr. 12, 67ff.

Maddin,R.,Muhly,J.D. & Wheeler,T.S. 1978.'Can ancient objects made of native copper be distinguished from objects made of smelted copper?'. Paper given at the ISAAP,Bonn.

Maier, R.A. 1955. Germania 33, 155-173.

Maier, R.A. 1957. Germania 35, 6-10.

Maier, R.A. 1959. Germania 37, 35-52.

Maier, R.A. 1962a. Germania 40, 33-43.

Maier, R.A. 1962b. Germania 40, 119-125.

Maier, R.A. 1962c. JBB 21, 16ff.

Maier,R.A. 1963. Germania 41, 70-74.

Maier,R.A.. 1964. Germania 42, 19-27.

Maier, R.A. 1965a. JBB 5, 9-197.

Maier, R.A. 1965b. Germania 43, 8-16.

Maier,R.A. 1965c. Germania 43, 148-152.

Maier, R.A. 1967b. Germania 45, 143-148.

Maier, R.A. 1967a. Germania 45, 148.

Maier, R.A. 1972. Germania 50, 221-226.

Maier, R.A. 1973. in Symp. Baden, 199-206

Maier, R.A. 1975. Germania 53, 144-148.

Maréchal, J.R. 1962 Considerations sur la metallurgie préhistorique. Lammersdorf:Junker.

Marriott,F.H.C.1974. The Interpretation of Multiple Observations. London:Academic Press.

Matthias, W. 1968. Katalog zur mitteldeutschen Schnurkeramik.Teil III:Nordharzgebiet.VLMH, 23.

Matzner, K. 1970. Fundber.O. 9, 252 ff.

Mauser-Goller, K. 1969. Die relative Chronologie des Neolithikums in Süd West Deutschland und der Schweiz.. Schriften zur Ur- und Frühgesch. der Schweiz,15. 87ff.

Mauss, M. 1970.The Gift.Forms and Functions of Exchange in Archaic Societies. (Eng. trans. I. Cunnison). London:Cohen & West.

Mayrhofer, R.J. 1953. Arch. Austr. 13, 73-104.

McPherron, A. & Srejević, D. 1971. Early Farming Cultures in Central Serbia,Jugoslavia.Kragujevac.

Medunová-Benešová, A. 1964. Pam. Arch. 55(1), 91-153.

Medunová-Benešová, A. 1972. Jevišovice-Starý Zámek, Schicht B: Katalog der Funde. Brno.

Mellaart, J. 1960. Antiquity 34, 270-278.

Mellaart, J. 1970. Anatolian Studies 14,39-119.

Mellaart, J.1976. The Neolithic of the Near East. London.Thames & Hudson.

Melzer, G. 1975. Fundber.O., 13, 20-21.

Menke, H. 1973. Arch.Korrbl. 3, 413-416.

Michael, H.N. & Ralph, E.K. Radiocarbon 16, 198-218.

Michna, H.K. 1929. WPZ 16, 13-33.

Michna, H.K. 1929. WPZ 16, 109-112.

Milojčić, . 1953. Germania 31, 7-11..

Mitscha-Märheim, H. 1929. MAGW 59, 181-194.

Mitterkalkgruber,D. 1954. JOOM,99,123 ff.

Mitterkalkgruber, D. 1967. Fundber.O. 6, 20ff.

Mitterkalkgruber, D. 1971. Fundber.O. 7, 23 ff.

Moddermann, P.J.R. 1971. JBB 10, 7-26.

Modrijan, W. Die Steiermark, Land, Leute, Leistung. 2nd ed. Graz.287-312.

Moeschler, P. 1969. ASA 34, 76-78.

Moorey, P.R.S. & Schweizer, F. 1972. Archaeometry 14, 177-198.

Morton, F. 1967. Arch. Austr. 42, 145 ff.

Morton, F. 1968. Arch. Austr. 44, 83 ff.

Mossler, G. 1948. Arch. Austr. 1, 96 ff.

Moucha, V. 1958. Arch. Roz. 10, 62ff.

Much, M. 1872. MAGW 2, 324 ff.

Much, M. 1879. MAGW 9, 18-59.

Much, M. 1893. Die Kupferzeit in Europa. Jena.

Muhlhofer, F. 1952. Arch. Austr. 9, 77-88.

Muhly, J.D. 1973. Copper and Tin. The Distribution of Mineral Resources and the Nature of the Metals Trade in the Bronze Age. Transactions of the Connecticut Academy of Arts and Sciences. 43, 155-435.

Müller-Beck, H.J. 1961. Germania 39, 420-434.

Müller-Beck, H.J. 1965. Seeberg, Burgäschisee-Süd. Holzgeräte and Holzverarbeitung. Acta Bern. 2, Part 5.

Müller-Beck, H.J. & Oeschger, I., 1967. in Acta Bern., 2, 4, 157-174.

Müller-Karpe, H. 1952. Arch. Austr. 9, 48-51.

Müller-Karpe, H. 1961. Die spätneolithische Siedlung von Polling. MZBV, 17.

Müller-Karpe, H. 1968. Handbuch der Vorgeschichte. Vol. 2. Neolithikum. München: Beck.

Müller-Karpe, H. 1974. Handbuch der Vorgeschichte. Vol. 3. Kupferzeit. München: Beck.

Müller-Karpe, H. 1974. JIF, 7-18.

Munro, R. 1890. The Lake Dwellings of Europe. London: Caselle.

Murray, J. 1970. Murray's Handbook for Travellers in Switzerland 1838. Reprinted Leicester University Press.

Nemeskéri, J. 1974. in Bevölkerungsbiologie. Bernhard, W. & Kandler A. (eds) 31-49.

Němejková-Pavúková, V. 1964. Slov. Arch. 12, (1), 163-268.

Němejcová-Pavúková, V. 1966. Germania 44, 234-264.

Němejcová-Pavúková, V. 1968. Slov. Arch. 16 (2), 353-433.

Němejcová-Pavúková, V. 1973. in Symp. Baden, 297-316

Nestor, J. 1932. BRGK 22, 76-79

Neuffer, E.M. 1962. Das Aeneolithikum in Südfrankreich und seine Beziehungen zu Mitteleuropa. Diss. Univ. Freiburg/Breisgau.

Neuninger, H. 1962. Arch. Austr. 31, 103-107.

Neuninger, H. & Pittioni, R. 1960. Arch. Austr. 28, 58-60.

Neuninger, H. & Pittioni, R. 1962a. Arch. Austr. 31, 96-102.

Neuninger, H. & Pittioni, R. 1962b. Arch. Austr. 32, 105-120.

Neuninger, H. & Pittioni, R. 1964. Arch. Austr. 35, 96-97.

Neuninger, H. Pittioni, R. & Preuschen, E. 1969a. Arch. Austr.Beiheft 9.

Neuninger, H., Preuschen, R. & Pittioni, R. 1969b. Arch. Austr. 46, 99-109.

Neuninger, H., Preuschen, E. & Pittioni, R. 1970a. Arch. Austr. 47, 72-77.

Neuninger, H., Preuschen, E. & Pittioni, R. 1970b. Arch. Austr. 48, 19-25.

Neustupný, E. 1959. Slov. Arch. 7, 260-282.

Neustupný, E. 1968. Slov. Arch. 16(1), 19-60

Neustupný, E. 1969. Arch. Roz. 21, 43-68.

Neustupný, E. 1973a. in Symp. Baden,317-352.

Neustupný, E. 1973b. Zbornik filosoficky fakulty Univ.Komitat. Musaica Ročnik.Bratislava 24, 63-67.

Neustupný,J. 1956. Studie o eneolitické plastice.Praha.

Novotná, M. 1955a. Arch. Roz. 7, 510-516.

Novotná, M. 1955b. Slov. Arch. 3, 70-100..

Novotná, M. 1957. Slov. Arch. 5(2)309-316.

Novotná, M. 1970. Prähist. Bronzefunde. Abt. 9,Vol. 3.München:Beck.

Offenberger,J.1970. Fundber.O.,(1969),9,171-172.

Offenberger,J. 1973. Fundber.O. (1972),11,33-34.

Offenberger,J. 1974. Fundber. O. (1973),12,22-23.

Ohrenberger,A.1969. Študijné Zvesti,17,301 ff.

Olivier,D.C. 1973. Aggregative Hierarchical Clustering Program Writup.Harvard University,Cambridge,Mass.

Osborne, 1884. Antiqua.

Ottaway,B. 1971.The Earliest Copper Ornaments in Neolithic Europe, north of the Alps. M.A.Thesis,Edinburgh.

Ottaway,B.S. 1973a. Archaeometry,15, 5-12.

Ottaway,B.S. 1973b. Antiquity,47,187, 231-233.

Ottaway,B.S. 1973c. in The explanation of culture change.

Renfrew,C. (ed),London:Duckworth,606-616.

Ottaway,B.S. 1973d. PPS,39, 294-331.

Ottaway,B.S. 1974. Archaeometry, 16,2, 221-231.

Ottaway,B.S. 1975. JHMS,9,1,30-31.

Ottaway,B.S. 1975a. 'Cluster analysis reviewed'.Paper given at the ISAAP,Oxford.

Ottaway,B.S. & Jovanović,B. 1976. Antiquity,50,104-113.

Ottaway,B.S. & Ottaway,J.H. 1972. Nature,239,512-513.

Ottaway,B.S. & Ottaway,J.H. 1974. Nature,250,407-408.

Ottaway,B.S. & Ottaway,J.H. 1975. in Radiocarbon: Calibration and prehistory. Watkins,T. (ed),Edinburgh,28-38.

Ottaway,B.S. & Strahm,C. 1975. World Arch. 6,307-332.

Otto,H. 1950. JMV,34,90-100.

Otto,H. 1953. Arb.& Forschgem.S.B.,3,40 ff.

Otto,H. 1958.JMV,41-42,315-329.

Otto,H. 1961. Die Naturwissenschaften,21,661-664.

Otto,H. 1973. Acta Praehistorica et Archaeologia,4,1-9.

Otto,H. & Witter,W. 1952. Handbuch der ältesten vorgeschichtlichen Metallurgie in Mitteleuropa. Leipzig:Barth.

Paschinger,H. 1957.Zeitschrift für Geomorphologie,N.F. Vol.1,237-270

Patay,P. 1958. Slov.Arch.6(2),309-313.

Patay,P. 1958. Arch.Ert.85,3 ff

Patay,P. 1959. Acta Arch.Hung.,9,141 ff.

Patay,P. 1968. Folia Archaeologica 19,9-24.

Patay,P. 1973. in Symp. Baden,353-366.

Patay,P. 1974. BRGK.,55,1-71.

Pavelčik,J.1970. Přehled Výzhumu (1971),16-18.

Pavuk,J. & Šiška, S. 1971. Slov. Arch.19(2),359-364.

Pawlik,B. & Schweingruber, F.H. 1976.JSGU,59,77-92.

Payne,S. 1975. in Archaeozoological studies. Clason,A. (ed),7-17.

Pelissonnier,H. & Michel,H. 1972. Les dimensions des gisements de cuivre du monde.Mémoires du Bureau de Recherches Geologiques et Minières. No. 57.

Perkins,D. 1972. Science,176(4038),1008-1009.

Pesta,H. 1937. WPZ. 24,80-81.

Peyrolles,J.& Arnal,J. 1954. Zephyrus,5,169 ff.

Phillips,P. 1971.An analysis of the Southern French Chassey Culture and its Relationship to the Cortaillod and Lagozza Cultures. PhD.Thesis,London.

Phillips,P. 1971a. MAN, 6,341-352.

Phillips,P. 1972. World Arch.,4,41-56.

Phillips,P. 1975. Early Farmers of West Mediterranean Europe.London:Hutchinson.

Piggott,S.1938. PPS, 4,52-106.

Piggott,S. 1965, Ancient Europe. Edinburgh:University Press.

Pike,A.W. 1967. Diseases in Antiquity. Brothwell,D.R. & Sandison,A.T.(eds) Illinois.

Pinösch,S. 1947. Jahrbuch der Solothurnischen Geschichte,20. 1ff

Pirchl,J. 1968. Arch.Austr.,43,18-91.

Pittioni,R. 1938. Österreichs Urzeit im Bilde.Wien.

Pittioni,R. 1947.MAGW, 73-77,225-234.

Pittioni,R. 1953. Schild von der Steier,2,9 ff.

Pittioni,R. 1954. Urgeschichte des Österreichischen Raumes. Wien:Deuticke.

Pittioni,R. 1957. Arch.Austr.,Beiheft 1,53-57.

Pittioni,R. 1959. Arch. Austr.,26,67-95.

Pittioni,R. 1964. Österreichische Akademy der Wissenschaften.Philosophischer-historischer Sitzungsbericht,244,13 ff.

Pittioni,R. 1965. Arch.Austr. 37,18-24.

Pittioni,R. 1965a. Arch. Austr. 37,117-118.

Pittioni,R. 1966. Arch. Austr. 39,93 ff

Pittioni,R. 1967. Arch. Austr. 41,44-47.

Pittioni,R. 1971. Arch. Austr. 49,48-62.

Plesl,E. 1972. Pam.Arch.,63(2),375-420.

Pleslová,E. & Knor,A. 1964. Arch. Roz. 16 ff.

Pleslová-Štiková,E. 1969. Bay.Vorg.,34,1-2,1-29.

Podborský,V. 1970. Slov. Arch.18(2),235-287.

Podkowińska, & Rauhut,D. 1960. Arch. Pol. 3, 194 ff

Polany,K. 1975. in Ancient civilizations and trade. Sabloff,J.A. & Lamberg-Karlovsky,C.C.(eds)133-154.

Preuschen,E. & Pittioni,R. 1939. MPK,III,1ff.

Preuschen,E. & Pittioni,P. 1954. Arch. Austr.,15,1-97.

Preuschen,E. & Pittioni,R. 1955. Arch.Austr.,18,45-79.

Preuschen,E. & Pittioni,R. 1956. Arch. Austr.,19-20,264-278.

Prokic,M. 1975. Palaeohistoria, 17,9-16.

Puhr,M. 1972. Arch. Austr., 51,190-206.

Quitta,H. Antiquity,41,263-270.(1967)

Quitta,H. & Kohl,G. 1969. ZA.,3,223-255.

Raczky,P. 1974. Arch.Ert.,2,185-210.

Ralph,E.K.,Michael,H.N. & Han,M.C. 1973. MASCA Newsletter,9,1-20.

Randsborg,K. 1979. in Proceedings of the Fifth Atlantic Colloquium. Ryan,M.(ed). Dublin. 1979. 303-318.

Rapp,G. 1977. 'Trace elements as a guide to the geographical source of tin'. Paper given at the Symposium 'Search for Tin',Washington,Smithsonian Institution.

Reber,B. 1917. ASA,NS,19,73-77.

Reece,R. 1976. Current Archaeology,52,141-142.

Reinecke,P. 1924. Der bayerische Vorgeschichtsfreund.4,15 ff.

Reinecke,P. 1924. Germania,8,43 ff.

Reinerth,H. 1924. WPZ, 11,97 -104.

Reinerth,H. 1936. Das Federseemoor als Siedlungsland der Vorzeitmenschen.Leipzig:Rabitzsch.

Reinerth,H. 1940. Pfahlbauten am Bodensee.Leipzig.

Reitinger,J. 1965. Bibliographie zur Ur- und Frühgeschichte Österreichs,Band 3,(1939-1960). Wien.

Reitinger,J. 1968. Die ur- und frühgeschichtlichen Funde in Oberösterreich,Band 3, Schriftenreihe des Oberösterreichischen Landesmuseums,Linz.

Reitinger,J. 1969. Oberösterreich in ur- und frühgeschichtlicher Zeit. Linz.

Reitinger,J. & Kloiber,A. 1960. JOOM,105,139-147.

Renfrew,C. 1969. PPS,35,12-47.

Renfrew,C. 1972. The Emergence of Civilization, the Cyclades and the Aegean in the Third Millennium B.C.. London: Methuen.

Renfrew,C. 1973. in Symp. Baden,427-439.

Renfrew,C. 1973a. The Explanation of Culture Change:Models in Prehistory. London:Duckworth.

Renfrew,C. 1973b. Before Civilisation:The Radiocarbon Revolution and Prehistoric Europe.London:Jonathan Cape.

Renfrew,C. 1975. in Ancient civilizations and trade. Sabloff,J.A. & Lamberg-Karlovsky,C.C. (eds),3-59.

Richards,E.E. & Blin-Stoyle,A.E. 1961. Archaeometry,4,53-55.

Richardson,J.B. 1974. Metal Mining. London.

Rickard,T.A. 1929. The early use of metals. Institute of metals, Advance copy 525.

Rickard,T.A. 1934. Journal of the Royal Anthropological Institute,64,265-287.

Ritter,H. 1963. Jahresheft für Karst- und Höhlenkunde.3,275 ff.

Rowlands,M.J. World Arch.,2,210-224.

Ruttkay,E. 1970. MAGW,100,70-83.

Ruttkay,E. 1971. Arch.Austr.,50,21-63.

Ruttkay,E. 1971. Arch.Korrbl.,1,141-147.

Ruttkay,E. 1973. in Symp.Baden,441-452.

Ruttkay,E. 1973. MAGW,102,33-39.

Ruttkay,E. 1975. MOAG,25,41-64.

Ruttkay,E. 1976. in Festschrift für R. Pittioni zum 70. Geburtstag. Wien; Deuticken. 285-319.

Ruttkay,E. (in press) Der Epi-Lengyel Komplex.

Ruoff,U. 1963 (1962). ZD,3,161 ff.

Ruoff,U. 1976. JSGU,59,67-75.

Ryndina,N.V.1962. Materialy i Issledovoniya po Arkheologii SSR.102,86-88.

Ryndina,N.V. 1971. Drevneyshee Metalloobrabat yvaynshchee Proizvodstvo Vostochnoy Evropy.Moscow.

Sabloff,J.A. & Lamberg-Karlovsky,C.C.(eds) 1975. Ancient Civilisation and Trade. University of Mexico Press.

Sacken,E.V. 1865. Sitzungsbericht der Akademie der wissenschaftlich philosophisch-historische Klasse,49,1 ff.

Sacken,E.v. 1887. Abhandlungen der kaiserlich-königlich geologischen Reichsanstalt. 9, 393 ff.

Sahlins,M. 1974. Stone Age Economies.London:Tavistock.

Sangmeister,E. 1951.Die Jungsteinzeit im Nordmainischen Hessen. 3. Die Glockenbecherkultur und die Becherkulturen. Melsungen.

Sangmeister,E. 1966.in Festschrift Vogt.Helvetia Antiqua.65-74.

Sangmeister,E. 1968. Germania,46,4 -10.

Sangmeister,E. 1971. Mélanges de Prehistoire,d'Archeo-Civilization et d'Ethnologie offerts a Andree Varagnac, 6 41-680.

Sangmeister,E. & Gerhardt,K. 1965. Bad.Fund.Sonderheft 8.

Sangmeister,E. & Schneider,J. 1958. Bad.Fund.,21,77 -92.

Sangmeister,E. & Strahm,C. 1974.Die Funde aus Kupfer in Seeberg,Burgäschisee-Süd. Acta Bern.,II-6.

Sauter,M.R. 1950. Vallasia,5,1-160.

Sauter,M.R. 1963. Ur-Schweiz,27,1-10.

Sauter,M.R. 1975. Switzerland. London:Thames and Hudson.

Sauter,M.R. & Gallay,A. 1966. ASAG,31,10-27.

Sauter,M.R. & Gallay,A. 1969. in UFAS,2,47-66.

Sauter,M.R. Gallay,A. & Chaix,L. 1971.JSGU,56,17-56.

Sauter,M.R. & Rossmanith,K. 1967. Arch.Austr. 41,1-5.

Scheffrahn,W. 1967. Germania,45,34-42.

Scherer,E. 1920.ASA,22,236-246.

Scherer,E. 1922.ASA,24,1 -7.

Schickler,H. 1968.Germania,46,11-19.

Schlette,F. 1969. in Die neolithischen Becherkulturen im Gebiet der DDR. Behrens,H. & Schlette,F. (eds) 153-168.

Schmid,W. 1933. PZ,34,219 ff.

Schmidt,R.R. 1945. Die Burg Vučedol.Zagreb.

Schneider,O. 1968.Bay.Vorg.,33,2-18.

Schönweiss,W. & Werner,H.J., 1974. Bay.Vorg.,39,1-29.

Schroller,H. 1933. Die Stein- und Kupferzeit Siebenbürgens. Berlin: de Gruyter.

Schröter,P. 1975. in Ausgrabungen in Deutschland. Monographien RGZ 1(1),Bonn. 98-114.

Schubert,F. 1965. Germania,43,274-295

Schubert,E. 1973. BRGK,1-106.

Schultze-Motel,J. 1969. in Die neolithischen Becherkulturen im Gebiet der DDR. Behrens H.& Schlette,F.(eds).169-172.

Schwab,H.1963. Ur-Schweiz,23,55-59.

Schwab,H. 1970. JSGU,55,13-21.

Schwab,H. 1971a. Jungsteinzeitliche Fundstellen im Kanton Freiburg. Schriften zur Ur- und Frühgeschichte der Schweiz.Basel.

Schwab,H. 1971 b. Arch. Korrbl.,1,91-93.

Schwab,H. & Müller,R. 1973. Die Vergangenheit des Seelandes in neuem Licht.& Über die Wasserspiegel der Juraseen. Freiburg(Schweiz):University Press.

Schwabedissen,H. (ed) 1971. Die Anfänge des Neolithikums vom Orient bis Nordeuropa. Fundamenta, Rhe A,Teil 6.Frankreich. Lüning,J.(ed). Koln.

Seewald,O. 1940. Praehistoria,7,1-15.

Seewald,O. 1966. Arch.Austr.,40,25-33.

Selimchanov,I.R. 1962. PPS,28,68-79.

Selimchanov,I.R. 1968. Slov.Arch.,16(2),461-472.

Selimchanov,I.R. 1968a. *Janus,55,62.*

Selimchanov,I.R. & Maréchal,J.R. 1965. Bull.SPF,62,432-449.

Selimchanov,I.R. & Maréchal,J.C. 1966. Arch.Austr.,39,87 ff.

Semenov,S.A. 1964. Prehistoric Technology; an experimental study of the oldest tools and artefacts from traces of manufacture and wear. London.

Shaw,F. & Ottaway,J.M. 1974. Analyst,99,184-189.

Sherratt,A. 1976. in Problems in Economic and Social Archaeology. Sieveking,G.G.,Longworth,I.H.& Wilson,K.E. London:Duckworth.557-581.

Siegel,S. 1956. Nonparametric Statistics for the Behavioural Sciences. New York: McGraw-Hill.

Siegroth,H. *1972.* Bay.Vorg.,*37,117-118.*

Silber,M. 1932. SMbl,11,fig.1-3.

Simpson,D.D.A. 1971. in Neolithic and Early Bronze Age Britain and Europe.Leicester:University Press.

Šiška,S. 1964. Slov. Arch. 12(2)293-356..

Šiška,S. 1966. Slov. Arch.,14(1),73-76.

Šiška,S. 1972. Slov. Arch., 20(1),107-176.

Šiška,S. 1973. in Symp. Baden,453-464.

Sitterding,M. 1972. Le Vallon des Vaux.Rapport culturels et chronologiques.Basel.

Slater,E.A. 1972. Metallurgical Aspects of BA Technology.Ph.D.Thesis,Cambridge.

Slater,E.A. & Charles,J.A. 1970. Antiquity,44,207-213.

Slavin,W. & Slavin,S. 1969. ASpectr.,23,5,421-433.

Smith,B.D.1973. in Archaeozoological studies. Clason,A.(ed),99-106.

Smolla,G. 1974. in Bevölkerungsbiologie. Bernhard,W et al (eds),333-343.

Snedecor,G.W. & Cochran,W.G. 1967.Statistical Methods.6.Ed.,Iowa:University Press.

Speck,J. 1953. JSGU,44,41ff

Spindler,K. 1971. JSGU,56,101-114.

Stloukal,M. 1974. in Bevölkerungsbiologie. Bernhard,W.et al (eds),414-429.

Strahm,C.1962.(1961-1962) JBHM,41-42,447-477.

Strahm,C. 1965. Ur-Schweiz,29,4,63-66.

Strahm,C. 1966a.(1965-1966)JBHM,45-46,283-318.

Strahm,C. 1966b.(1965-1966) JBHM, 45-46,360 ff.

Strahm,C. 1969. UFAS,2,97-116.

Strahm,C. 1971a. Die Gliederung der Schnurkeramischen Kultur der Schweiz. Acta Bernensia,VI.

Strahm,C. 1971b. UFAS,III,5-26.

Strahm,C. 1971c.(1970-1971) Helv.Arch.,1 ,3-7.

Strahm,C. 1972a. Archäologische Informationen,1,55-62.

Strahm,C. 1972b. Helv.Arch.,3,99-112.

Strahm,C. 1973. JSGU,57,7-16.

Strahm,C. 1974. Preistoria Alpina,10,21-42.

Strahm,C. 1975. Arch.Korrbl.,5,273-282.

Strahm,C. 1975a. Helv.Arch.,6,16-21.

Strahm,C. 1977. FBW, 3, 115-143.

Stroh,F. 1940.Germania,24,82-85.

Stroh,F. & Kloiber,A. 1954. Arch.Austr.,14,35-42.

Struempler,A.W.,1973. Anal.Chem.,45,13,2251-2254.

Suess,H. & Strahm,C. 1970. Antiquity,44,91-99.

Sulimirski,T.,1961. MAGW,91,91-97.

Süss,L.,1967. Bay.Vorg.,32,14-22.

Sylvest,B.& Sylvest,J.,1960.Kuml, 23 ff

Telegin,D. 1971. Sov.Ark.,2,3-31.

Theuer,E. 1925. Urgeschichte Oberösterreichs. Linz.

Thomas,E. 1956. in Archäologische Funde in Ungarn. Vertes,L. & Patay,P. (eds),84ff

Tite,M.S.,1971. Methods in physical examination in archaeology. London.

Točik,A. 1961. Pam.Arch.,52(2),321-343.

Todorova-Simenova,H. 1973a. in Symp.Baden,465-470.

Todorova-Simenova,H.,1973b. Sov.Arch.,IV,16-31.

Torma.I.1973. in Symp.Baden,483-512.

Trnackova,Z. 1971. Arch.Roz.,23,129-139.

Troyen,F. 1860. Mem.et Doc.,17.

Tringham,R. 1971. Hunters,Fischers and Farmers of Eastern Europe 6000-3000 BC.London: Hutchinson.

Tschumi,O. 1921. JBHM,1,91-92.

Tschumi,O. 1930.MAGZ,30,20

Tschumi,O. 1940. Die Ur-und frühgeschichtlichen Fundstelle von Port im Amt Nidau.Biel.

Tschumi,O. 1950. Urgeschichte des Kantons Bern.Bern.

Tylecote,R.F. 1962. Metallurgy in Archaeology.London: Arnold.

Tylecote,R.F. 1968. The Solid Phase Welding of Metals.London:Arnold.

Tylecote,R.F. 1968. in Burgess,C. Metalwork in Northern England. Newcastle: Oriel.

Tylecote,R.F. 1970. Antiquity, 44,19-25.

Tylecote,R.F. 1973. JHMS,7,1-5.

Tylecote,R.F. 1974. JHMS,8,54.

Tylecote,R.F. 1976. A History of Metallurgy.London: Mid-County Press.

Tylecote,R.F. 1977.' Results of Experimental Work on Early Copper Smelting'. Paper given at the ISAAP,Philadelphia.

Tylecote,R.F. & Boydell,P.J. 1978. Archaeo-Metallurgy. Institute for Archaeo-Metallurgy Studies,London.Monograph No 1.

Uenze,H.P. 1964. Bay.Vorg.,29,2-25.

Uenze,H.P. 1965. Bay.Vorg.,30,56-70.

Uerpmann,H.P..1973. World Archaeology,4,307-322.

Uerpmann,M.1975. Untersuchungen zur Technology neolithischer Feuersteingeräte. Dissertation Freiburg,Germany.

Uerpmann,M. 1976. Zur Technologie und Typologie neolithischer

Feuersteingeräte.Tübinger Monographien zur Urgesc hichte,2.Tübingen.

Viollier,D. 1931.MAGZ,30 (1925-1931).

Vizdal,J. 1973. Zemplin V Mladsej Bobe Kamennej.Kosice.

Vladár,J.& Krupica,O. 1970. Slov.Arch.,18-2,353-371.

Vlassa,N. 1967. AMN,IV,403-423.

Vlassa,N. 1969. SZ,17,513-535.

Vlassa,N. 1970. Materiale si Cercetari Arheologice,9,167ff.

Vlassa,N. 1974.PZ,49,181-192.

Vogt,E. 1932. ASA,34,(1932-1933),161 -175.

Vogt,E. 1938.ASA,40,1-14.

Vogt,E. 1948. in Festschrift O. Tschumi,53-69..

Vogt,E. 1952. Acta Arch.,24,174-185..

Vogt,E. 1954. Pfahlbaustudien. Schaffhausen

Vogt,E. 1966. Helvetia Antiqua. Festschrift E. Vogt.Degen,R.,Drack,W. & Wyss,R. (eds). Zurich.

Vogt,E. 1967. Germania,45,1-20.

Vonbank,E. 1948. JSGU,39,105-112.

Vouga,P. 1883.ASA,456-462.

Vouga,P. 1929. ASA,31,81-91.

Vouga,P. 1934.Le Néolithique Lacustre ancien.Neuchâtel.

Walter,H. 1974. in Bevölkerungsbiologie. Bernhard,W. et al (eds),60-94.

Waterbolk,H.T.,1975. in Archaeozoological studies. Clason,A. (ed),383-394.

Waterbolk,H.T. & Butler,J.J. 1965. Helinium,5,227-251.

Waterbolk,H.T.& Zeist,van W., 1966. Palaeohistoria,12,559-580.

Weisgerber,G. 1976. Der Ausschnitt,28,38-49.

Werner,A.E.A. 1970. Phil.Trans.Roy.Soc.,269,179-185.

Wertime,T.A.1964.Science,146,1257ff

Wertime,T.A. 1973a.American Scientist,61,670-682.

Wertime,A.T. 1973b.Science,182,875-887.

Wertime,T.A. 1976. National Geographic Society Research Reports,1968 Projects,483-492.

Wheeler,T.S. & Maddin,R. 1976. Expedition,18,38-47.

Wheeler,T.S. & Maddin,R. 1977.′ Late Bronze Age Smelting Procedures in Cyprus.′ Paper given at the ISAAP,Philadelp hia.

Willvonseder,K. 1933. Oberösterreich in der Urzeit.Wien.

Willvonseder,K. 1933.MAG,63,17-27.

Willvonseder,K.,1937a.WPZ,24,15-28.

Willvonseder,K.,1937b. WPZ,24,77-81.

Willvonseder,K. 1968.(1963-1968) Die jungsteinzeitlichen und bronzezeitlichen Pfahlbauten des Attersees in Oberösterreich.MPK.11&12.

Winefordner,J.D.& Vickers,T.J. 1974. Anal. Chem. 46,5,192-227.

Winiger,J. 1971.Das Fundmaterial von Thayngen-Weier im Rahmen der Pfyner Kultur. Monographien zur Ur- und Frühgeschichte der Schweiz. 18. Basel: Birkhäuser.

Witter,W. 1938.Die älteste Erzgewinnung im nordisch-germanischen Lebenskreis. Band I.Leipzig.

Wobst,H.M. 1974. Am.Ant.,39(2),147-175.

Wurmbrand, 1875.MAG, 5, 117-138.

Wyss,R. 1955.Germania,33,349ff

Wyss,R.1967.Germania,45,20-34.

Wyss,R. 1969. UFAS,II,117-138.

Wyss,R. 1970.Die Pfyner Kultur. Aus dem Schweizer Landesmuseum,Heft 26.

Wyss,R. 1971.UFAS,3,103-122.

Wyss,R. 1974. Helv.Arch.,17,2-9.

Zotz,L.1963.Bay.Vorg.,28,3-17.

Zschocke,K. 1968. Arch.Austr.,43,2-17.

Zürn,H. 1968. Das Jungsteinzeitliche Dorf Ehrenstein. Veröffentlichungen des Staatlichen Amtes für Denkmalpflege,Stuttgart,Reihe A,10-I & 10-II.

Zürn, H. 1975. in Ausgrabungen in Deutschland. Teil I. Monographien RGZ. 1(1). Bonn 115-118.

ADDENDUM TO BIBLIOGRAPHY

Boisaubert,J.L.,Schifferdecker,F.& Petrequin,P. 1974. Bull.SPF; 71,355-382.

Burger,I. 1978. Beilage: Amtliche Schulanzeiger für den Regierungsbezirk Niederbayern. No.1, 28-44.

Chernych,E.N. 1978. PPS, 44, 203 - 217.

Christlein,R. 1964. Bay.Vorg.29, 25 - 63.

Gilmore,R.G. & Ottaway,B.S. (in press). Journal of Archaeological Science.

Greeves,T.A.P. 1975. PPS, 41, 153 - 166.

Ivanov,I. 1978. Treasures of the Varna Chalcolithic Necropolis. Sofia.

Jaguttis-Emden,M. 1977. Zur Präzision archäologischer Datierung. Archaeologica Venatoria. Institut für Urgeschichte, Tübingen.

Lanting,J.N. & Mook,W.G. 1977. The Pre- and Protohistory of the Netherlands in Terms of Radiocarbon Dates. Groningen.

Liese-Kleiber,H. 1977. JSGU, 60, 7 - 41.

Modderman, P.J.R. 1977. MZBV, 33, 122.

Modderman,P.J.R. (in preparation) Die Neolithische Besiedlung bei Hienheim , Landkreis Kelheim. II.

Ottaway,B.S. 1978. Aspects of the Earliest Copper Metallurgy in the Northern Sub-Alpine Area in its Cultural Setting. Unpubl. PhD.Thesis, Edinburgh University.

Ottaway, B.S. (in press) Slov.Arch.

Pape,W. 1978. Germania, 56, 53 - 65.

Pape,W. 1979. Germania, 57, 1 - 51.

Ruoff,U. 1978. Arch. Korrbl. 8, 275 - 283.

Sakellaridis,M. 1979. The Economic Exploitation of the Swiss Area in the Mesolithic and Neolithic Periods. B.A.R. S.67. Oxford.

Stickel,E.G. 1974. A Temporal and Spatial Analysis of Underwater Neolithic Settlements in the Alpine Foreland of Switzerland. PhD Thesis, University of Californai, Los Angeles.

Stickel,E.G.& Berger,R. 1979. in Radiocarbon Dating.Proc. of the 9.International Conf. Los Angeles, La Jolla 1976. Berger,R & Suess,H.E.(eds),102.

Thevenot,J.P.,Strahm,Ch.,Beeching,A.,Bill,J.,Bocquet,A.,Gallay,A.,Petrequin,P., Schifferdecker,F. 1976. Revue Archéologique de l'Est etCentre,27,331-420.

Todorova,H. 1978. The Eneolithic in Bulgaria . B.A.R. S.49, Oxford.

Vizdal,J. 1977. Tiszapolgâr Pohrebisko vo Vèl'ke Raškovciach. Košice

Zimmermann,H.W. 1966. VNGZ, 1 - 22.

FIGURES

MAPS

PLATE

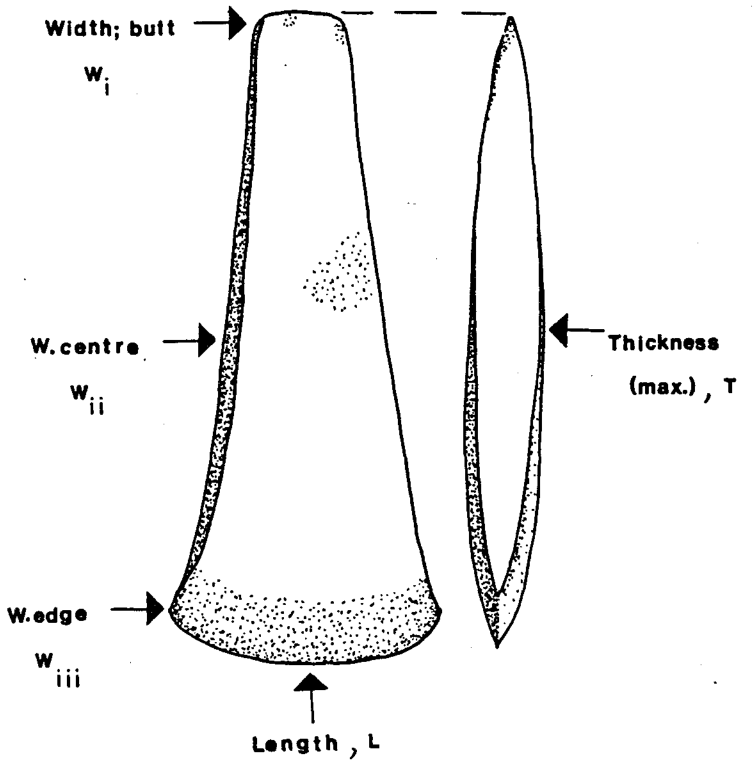
APPENDICES

PRINT-OUTS

THE BASIC MAP USED IN THIS WORK (EXCEPT FOR MAP 1) IS THE 'STUMME KARTE VON MITTELEUROPA' DESIGNED BY THE INSTITUTE FÜR VOR-& FRÜHGESCHICHTE DER UNIVERSITÄT TÜBINGEN, 1966.

THE SCALE ON ALL THESE MAPS IS 1 : 3,000,000.

ENCIRCLED SYMBOLS ON MAPS 2 - 18 DENOTE MORE THAN TWO FINDS OF THE SAME TYPE FOUND ON A SINGLE SITE.




```
               02.-.
     -0.020    04.-I
     -0.063    05.-I
     -0.050    56.-I
  R  -0.119    03.-I
     -0.149    12.-'---.
     -0.936       58.-'-.
     -1.649    59.-.     I--------------------------------.
     -0.162    62.-'-.   I                                I
     -0.476      46.-'---'                                I
     -9.778    50.-.                                      I-
     -0.028    51.-I                                      I
     -0.225    49.-'-.                                    I
     -0.688    09.-. I-------.                            I
     -0.040    11.-I I       I                            I
  T  -0.137    01.-I I       I                            I
     -0.188    15.-'-'       I                            I
     -2.508    13.-.         I--------------------.       I
     -0.137    52.-'-.       I                    I       I
     -0.380      47.-'-.     I                    I       I
     -1.086      19.-. I-----'                    I       I
     -0.364      48.-'-'                          I       I
     -7.654    24.-.                              I-------'
     -0.053    54.-'-.                            I
  B  -0.315    14.-. I                            I
     -0.065    55.-'-I                            I
     -0.494    53.-. I----------------------------'
     -0.082    57.-'-'
```

Fig.1 (top) Drawing indicating where measurements for discriminant analysis were taken.

Fig.2 (bottom) Clustering on 'hard core' of 28 Swiss flat axes. Three types were formed: R = Robenhausen, T = Thayngen and B = Bevaix.

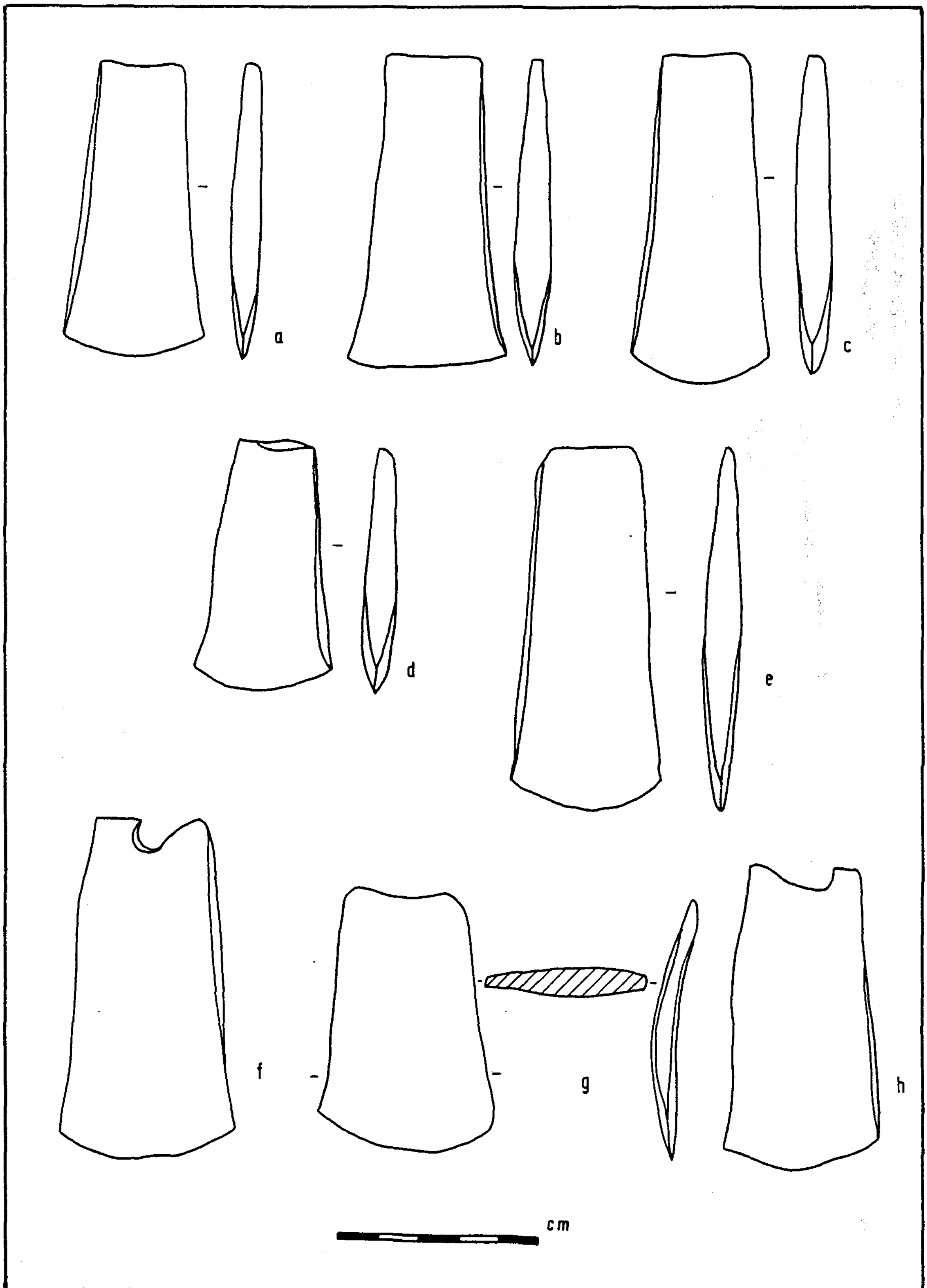
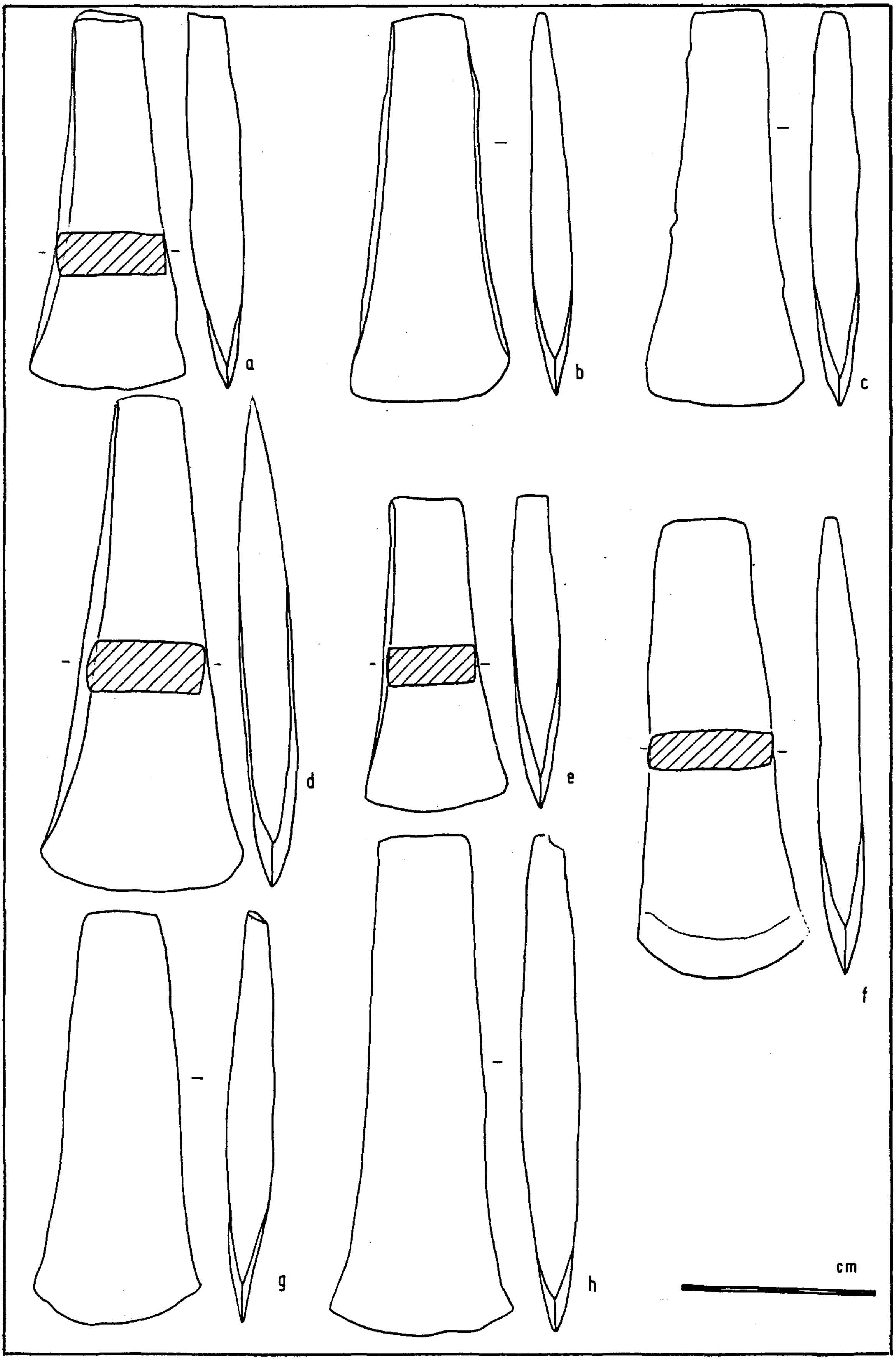


Fig. 3 Flat axes of type Robenhausen . a; Wetzikon-Robenhausen,
b & c : Zürich-Wollishofen, d : Zürich Bauschanze, e : Risch-Schwarzbach.
and of subgroup Robenhausen/Bevaix f : St.Blaise, g : Estavayer,
h : Préfargier.



<u>Fig. 4</u> Flat axes of type Thayngen. a : Cham-St.Andreas, b : Dietikon, c : Limmat, d : Mönchaltdorf, e : Hitzkirch, f : Vinelz, g : Auvernier, h : Egolzwil.

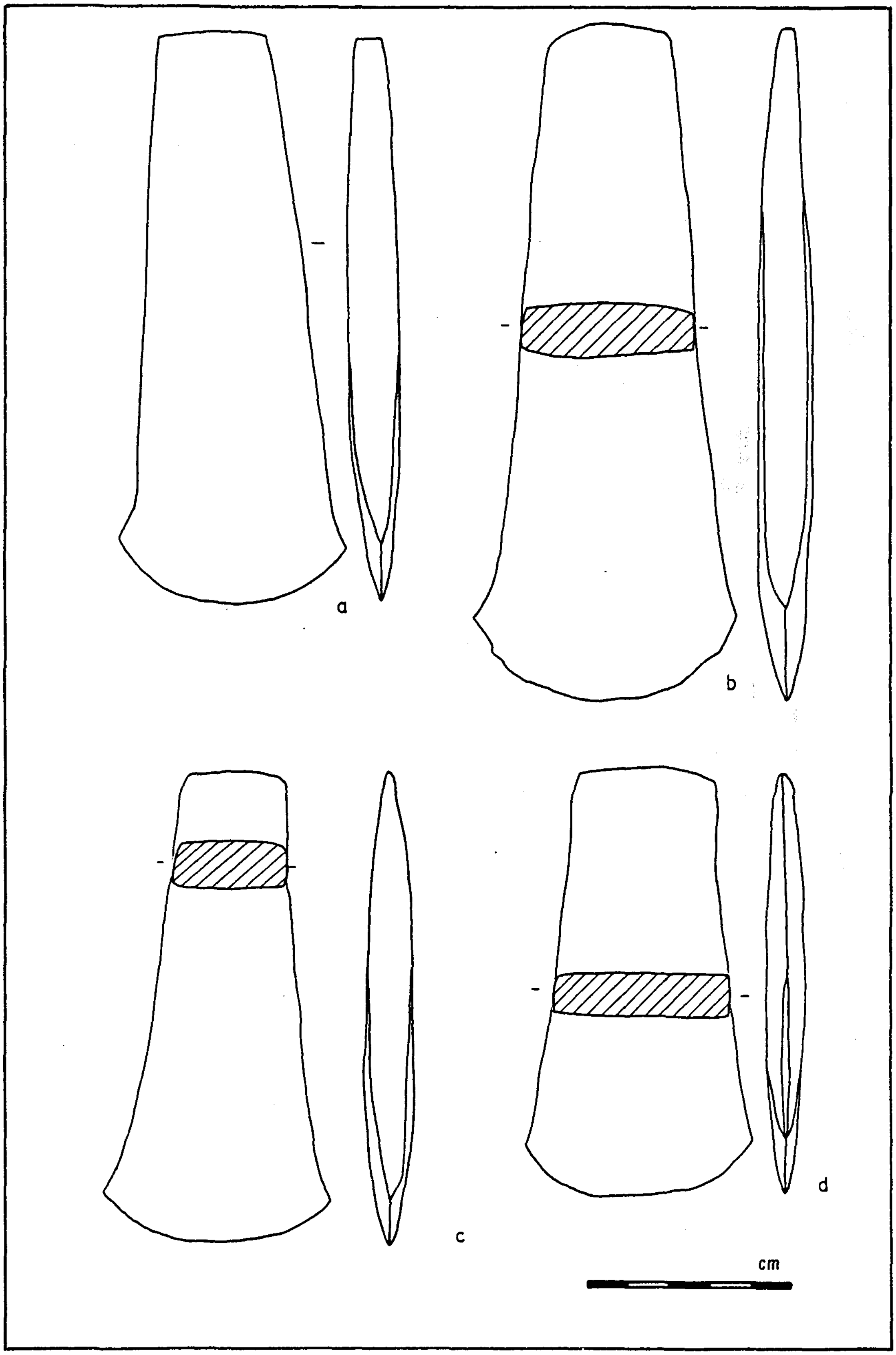


Fig.5 Flat axes of type Bevaix. a : Treytel, b : Vallamand, c : F.U., Lake Neuchâtel, d : Eschenz.

```
             50.-.
    -0.000   65.-I
    -0.025   51.-I
    -0.123   49.-'-.
    -0.612   21.-. I
    -0.266   23.-'-I
    -1.113   09.-. I-.
    -0.034   11.-I I I
    -0.126   15.-I I I
T   -0.046   38.-I I I
    -0.226   01.-I-' I
    -0.068   47.-'   I
    -1.617   19.-.   I-.
    -0.056   42.-I   I I
    -0.200   48.-'---' I
    -3.246   13.-.     I---------.
    -0.066   52.-'-.   I         I
    -0.736   07.-. I---'         I
    -0.096   37.-'-'             I
    -8.294   02.-.               I-----------------------.
    -0.009   04.-I               I                       I
    -0.036   03.-I               I                       I
    -0.041   05.-I               I                       I
    -0.027   56.-I               I                       I
    -0.068   12.-I               I                       I
R   -0.477   41.-I-.             I                       I
    -0.063   58.-' I             I                       I
    -1.565   40.-. I-------------'                       I
    -0.011   63.-I I                                     I
    -0.051   34.-I I                                     I
    -0.239   18.-I I                                     I
    -0.094   64.-I I                                     I
    -0.427   10.-'-'                                     I
   -21.167   32.-.                                       I-
    -0.001   43.-I                                       I
    -0.023   31.-I                                       I
    -0.132   08.-I                                       I
    -0.279   45.-'-.                                     I
    -0.772   25.-. I                                     I
    -0.069   27.-I I                                     I
    -0.303   20.-I-I                                     I
    -0.127   60.-' I                                     I
    -1.115   14.-. I-.                                   I
    -0.062   55.-I I I                                   I
    -0.455   24.-I-' I                                   I
B   -0.070   54.-'   I                                   I
    -2.066   44.-.   I-------.                           I
    -0.100   66.-'---'       I                           I
    -5.844   17.-.           I---------------------------'
    -0.020   53.-I           I
    -0.446   29.-I---.       I
    -0.063   57.-I   I       I
    -0.161   16.-'   I       I
    -1.830   22.-.   I-------'
    -0.153   59.-'-. I
    -0.571   46.-. I-'
    -0.250   62.-'-'
```

Fig. 6 Clustering on all Swiss flat axes with five attributes.

```
                  A15-.
     -0.008       A37-I
     -0.055       A10-I
     -0.014       A52-I
     -0.031       A23-I
     -0.233       A22-I
     -0.039       A46-I
D    -0.406       A06-I-.
     -0.011       A17-I I
     -0.056       A33-I I
     -0.149       A28-I I
     -0.123       A54-' I
     -0.726       A36-. I-.
     -0.035       A57-'-' I
     -2.048       A01-.   I-----.
     -0.312       A18-'---'     I
     -5.079       A16-.         I-----------------------------.
     -0.021       A47-I         I                             I
     -0.460       A02-I-.       I                             I
     -0.112       A14-I I       I                             I
     -0.133       A25-' I       I                             I
     -1.009       A19-. I-------I                             I
E    -0.046       A29-I I       I                             I
     -0.194       A04-'-'       I                             I
     -4.617       A03-.         I                             I
     -0.103       A21-I         I                             I
     -0.118       A44-'-.       I                             I
     -1.202       A24-. I-------'                             I
     -0.152       A56-I I                                     I
     -0.467       A05-'-'                                     I
    -19.483       A49-.                                       I-
     -0.013       A51-I                                       I
     -0.268       A40-I-.                                     I
     -0.050       A55-I I                                     I
F    -0.199       A50-' I                                     I
     -0.885       A07-. I---------.                           I
     -0.166       A41-I I         I                           I
     -0.236       A48-'-'         I                           I
     -5.754       A09-.           I---------------------------'
     -0.015       A27-I           I
     -0.033       A26-'-.         I
     -0.507       A35-. I         I
     -0.027       A45-'-I         I
G    -1.091       A08-. I---------'
     -0.018       A42-I I
     -0.078       A43-I I
     -0.155       A34-I-'
     -0.030       A53-'
```

Fig. 7 Clustering on all Austrian flat axes with 5 attributes.

```
             40.-.
    -0.012   63.-I
    -0.035   A46-I
    -0.407   38.-I---.
    -0.043   64.-I   I
    -0.150   18.-'   I
    -2.221   A52-.   I------------------------------.
    -0.023   05.-I   I                              I
    -0.062   02.-I   I                              I
    -0.270   A10-I   I                              I
H   -0.041   56.-I   I                              I
    -0.092   A15-I   I                              I
    -0.118   A23-I   I                              I
    -0.321   03.-'-. I                              I
    -1.145   A17-. I-'                              I
    -0.032   04.-I I                                I
    -0.211   A22-I I                                I
    -0.346   41.-'-I                                I
    -0.478     12.-'                                I
   -16.156   09.-.                                  I-----.
    -0.013   11.-I                                  I     I
    -0.064   01.-I                                  I     I
    -0.200   15.-'-.                                I     I
    -0.793   50.-. I---.                            I     I
    -0.038   51.-I I   I                            I     I
    -0.322   49.-I-'   I                            I     I
    -0.085   65.-'     I                            I     I
    -2.545   42.-.     I                            I     I
    -0.040   48.-I     I                            I     I
K   -0.366   A44-'-.   I                            I     I
    -1.108   13.-. I---I                            I     I
    -0.048   47.-I I   I                            I     I
    -0.097   52.-I I   I                            I     I
    -0.175   19.-I I   I                            I     I
    -0.426   10.-'-'   I                            I     I
    -3.152   A36-.     I----------------------------'     I
    -0.133   A57-I     I                                  I
    -0.177   34.-'-.   I                                  I
    -0.905   21.-. I---'                                  I
    -0.272   23.-'-'                                      I
   -18.616   A16-.                                        I-
    -0.015   A47-I                                        I
    -0.033   A06-I                                        I
    -0.278   A33-'-.                                      I
    -0.750     A28-I                                      I
    -1.062   A02-. I---.                                  I
    -0.017   A25-I I   I                                  I
    -0.035   A14-I I   I                                  I
    -0.076   A37-I I   I                                  I
    -0.093   A04-I I   I                                  I
L   -0.473   A19-I-'   I                                  I
    -0.069   A29-'     I                                  I
    -2.403   07.-.     I                                  I
    -0.102   37.-'-.   I                                  I
    -0.498     A18-'---I                                  I
    -2.892   A03-.     I----------------------------------'
    -0.032   A05-I     I
    -0.247   A01-I     I
    -0.360   A21-I-.   I
    -0.081   58.-' I   I
    -0.566   A24-. I---'
    -0.148   A56-'-'.
```

Fig. 8 Clustering on the upper half of the Austrian dendrogram (cf.Fig.7) and flat axes of type Robenhausen and Thayngen from Switzerland.

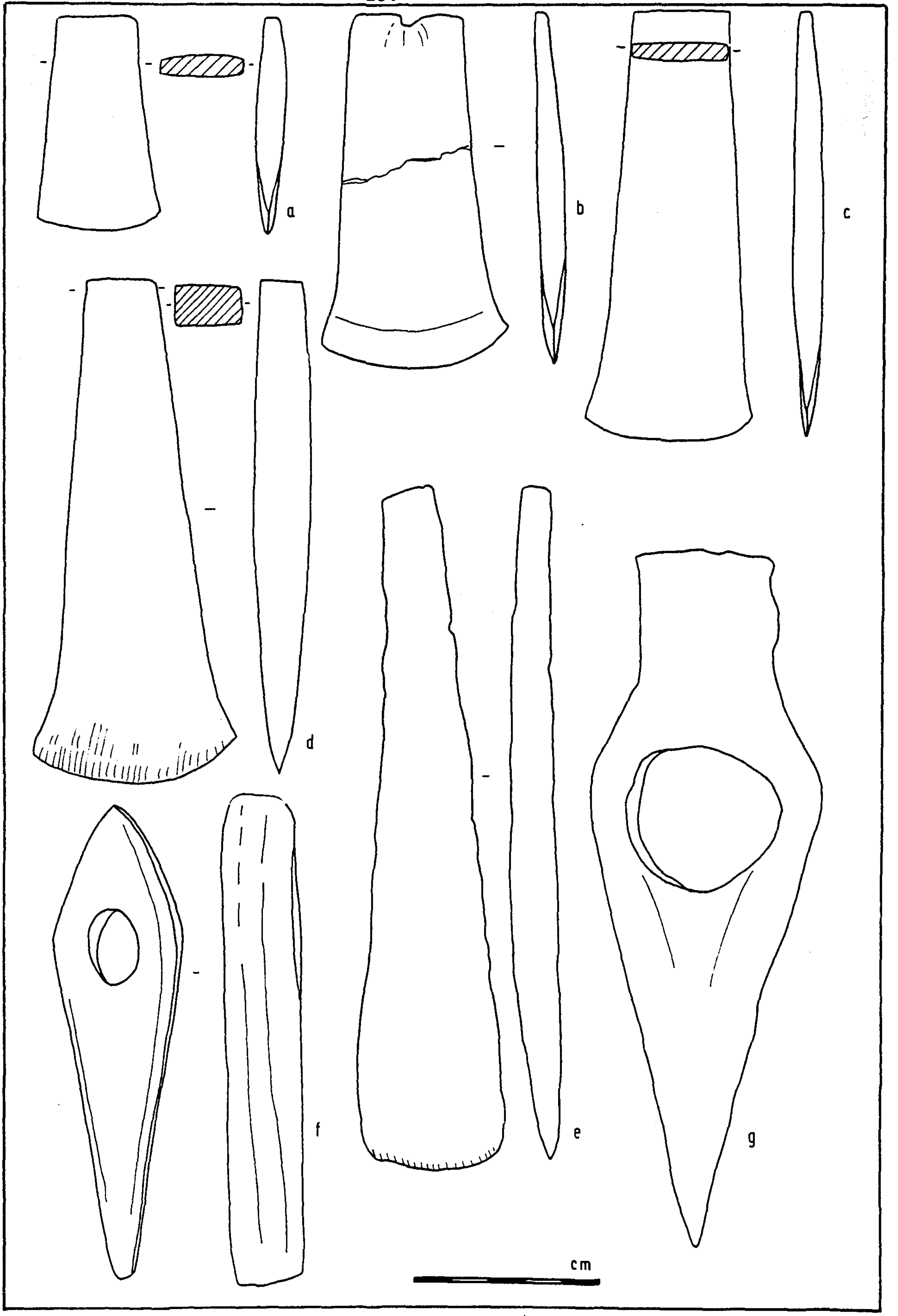


Fig. 9 Austrian flat axes, a ; Pölshals, b & c : Attersee, d : Hartberg, e : Linz St. Peter and Austrian hammer axes, f : Zwerndorf, g : Linz St. Peter.

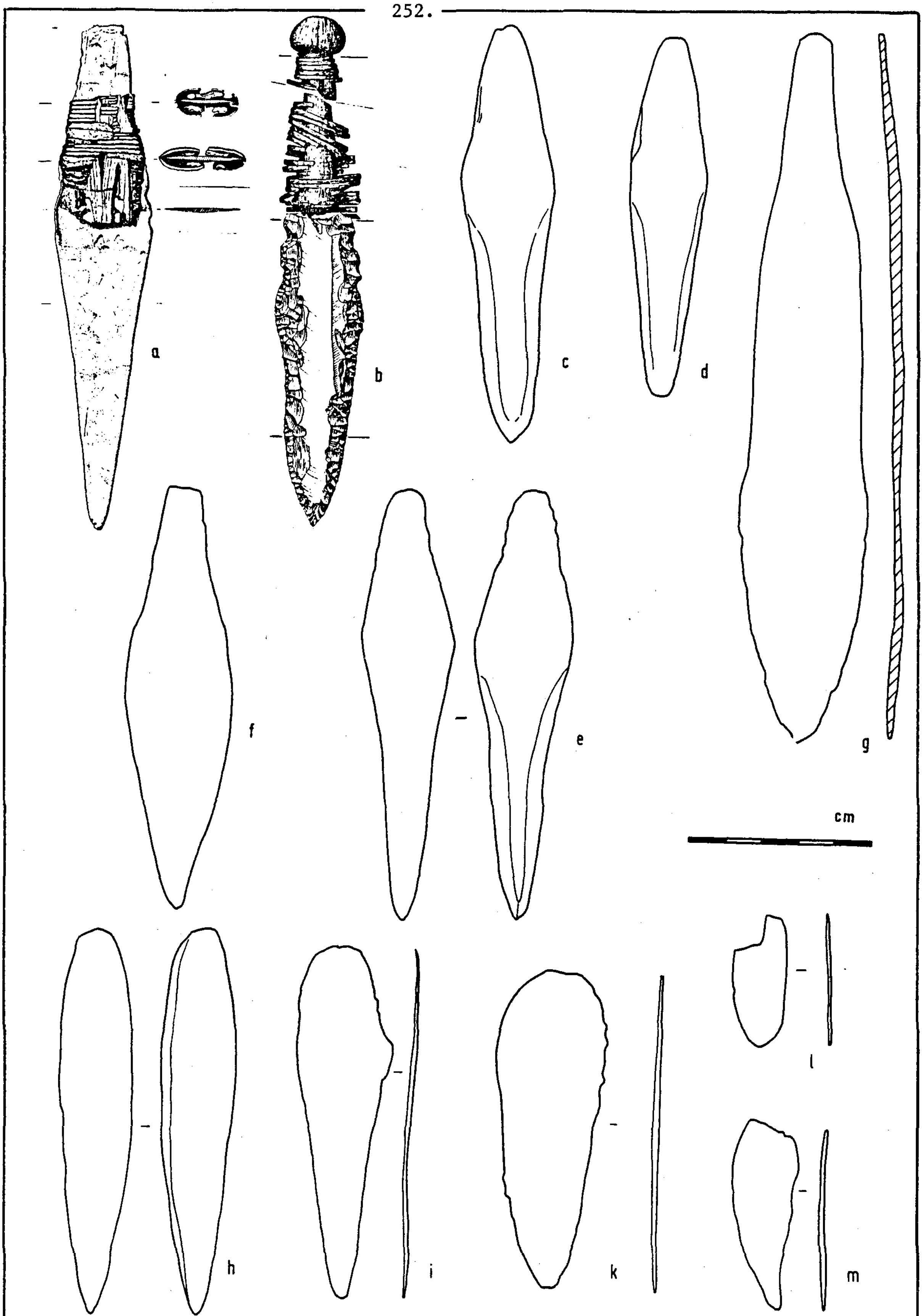


Fig. 10 Tanged daggers, a, e & f ; St. Blaise, b : Vinelz (flint), c : Lüscherz, d : Colombier, g : Wien-Aspern (Essling).
Knives; h : St. Blaise, i : Monruz, k : Erlenhölzli, l & m : Seewalchen.
Scale as on drawing, except for a & b : ½.

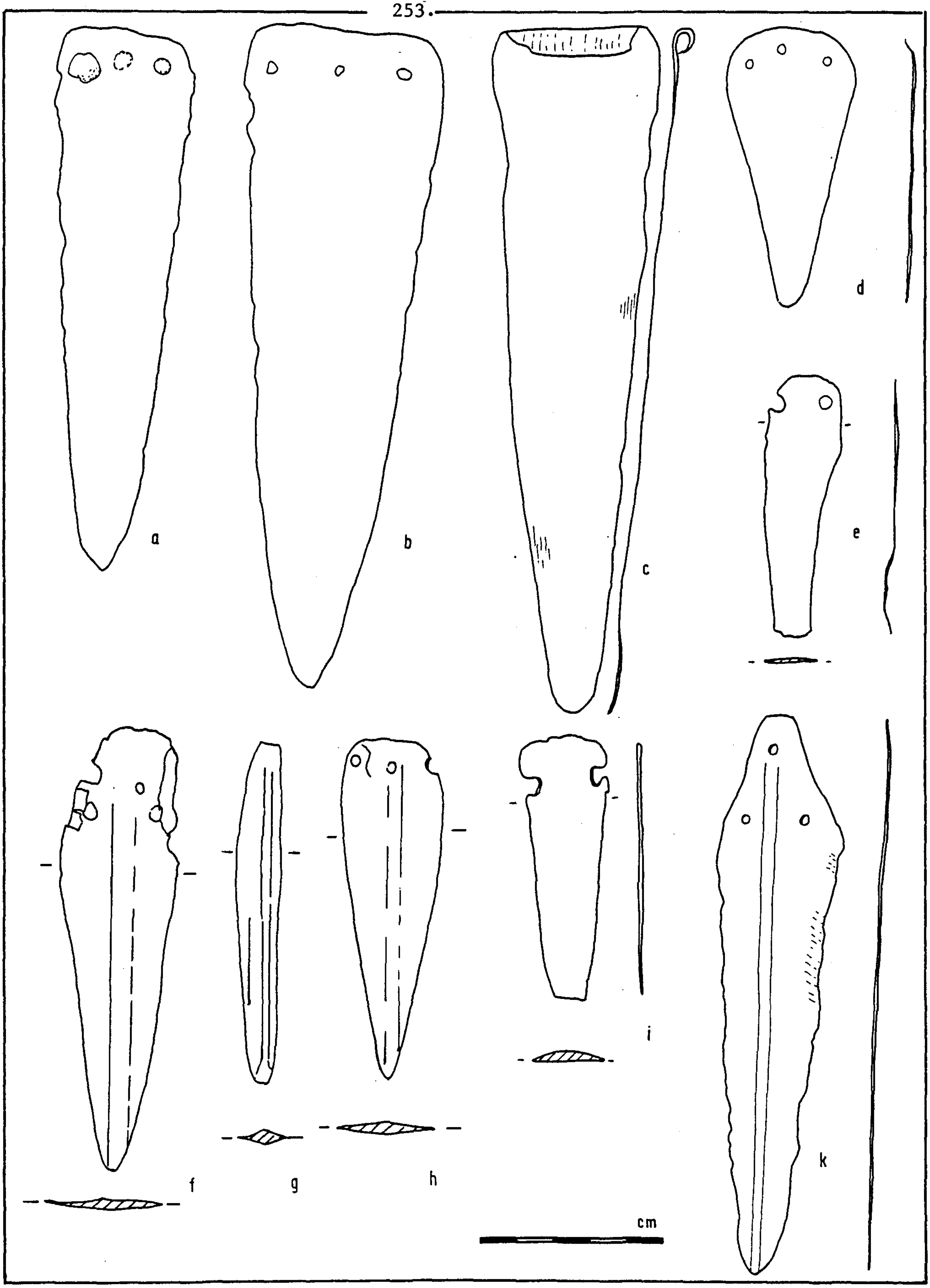


Fig. 11 Flat daggers; a : Yvonand, La Peuplerie, b : Vinelz, c : Sutz Lattrigen, d : Attersee, e : Seewalchen. Daggers with midrib or thickened middle; f - h : Vinelz, i,k : Weyeregg.

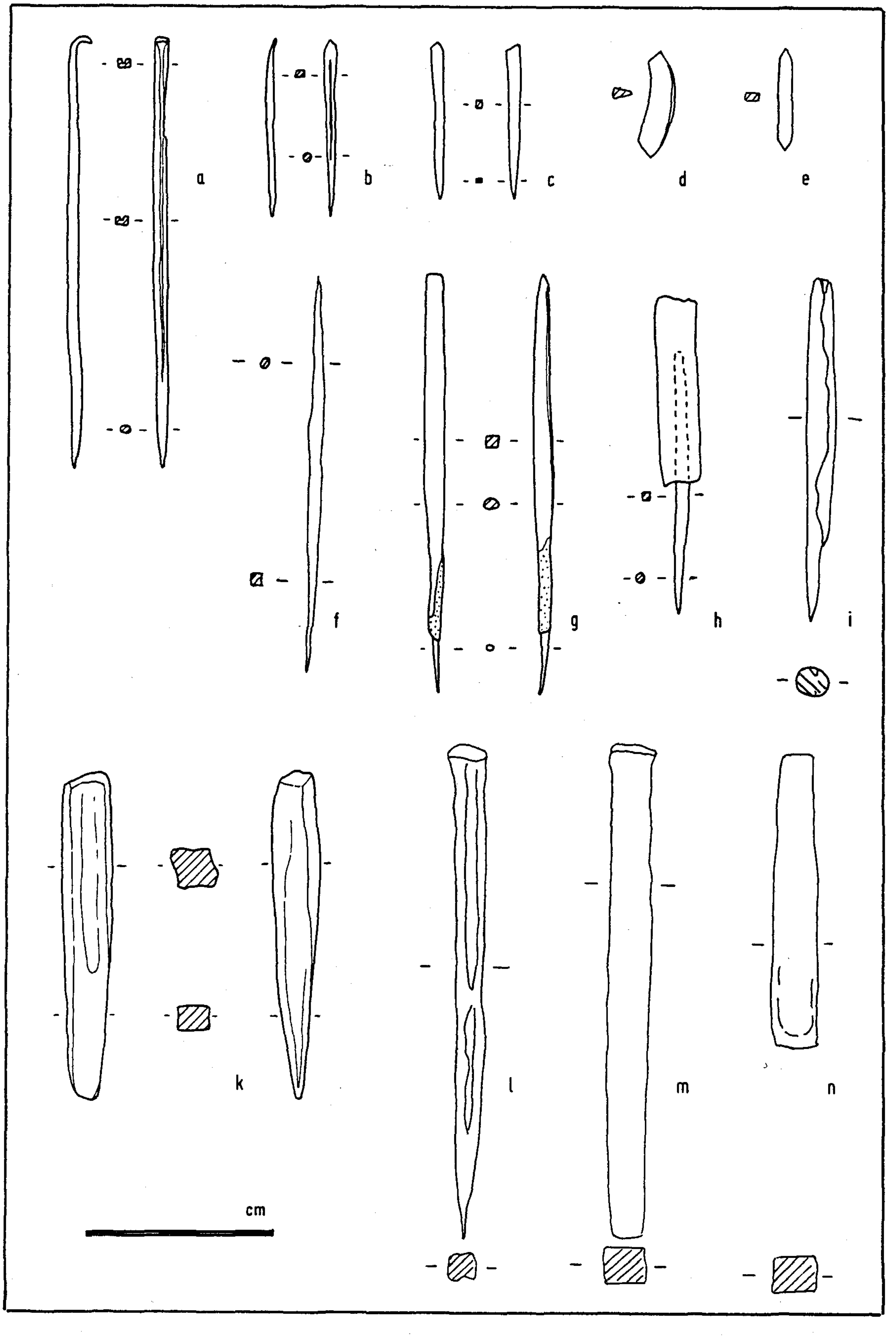


Fig. 12 Pins and awls; a & b : Yvonand-Geilinger, c & g : Seewalchen, f,h,i : Vinelz, d & e Munich.
Chisels; k : Burgäschisee-Süd, l - n : Vinelz.

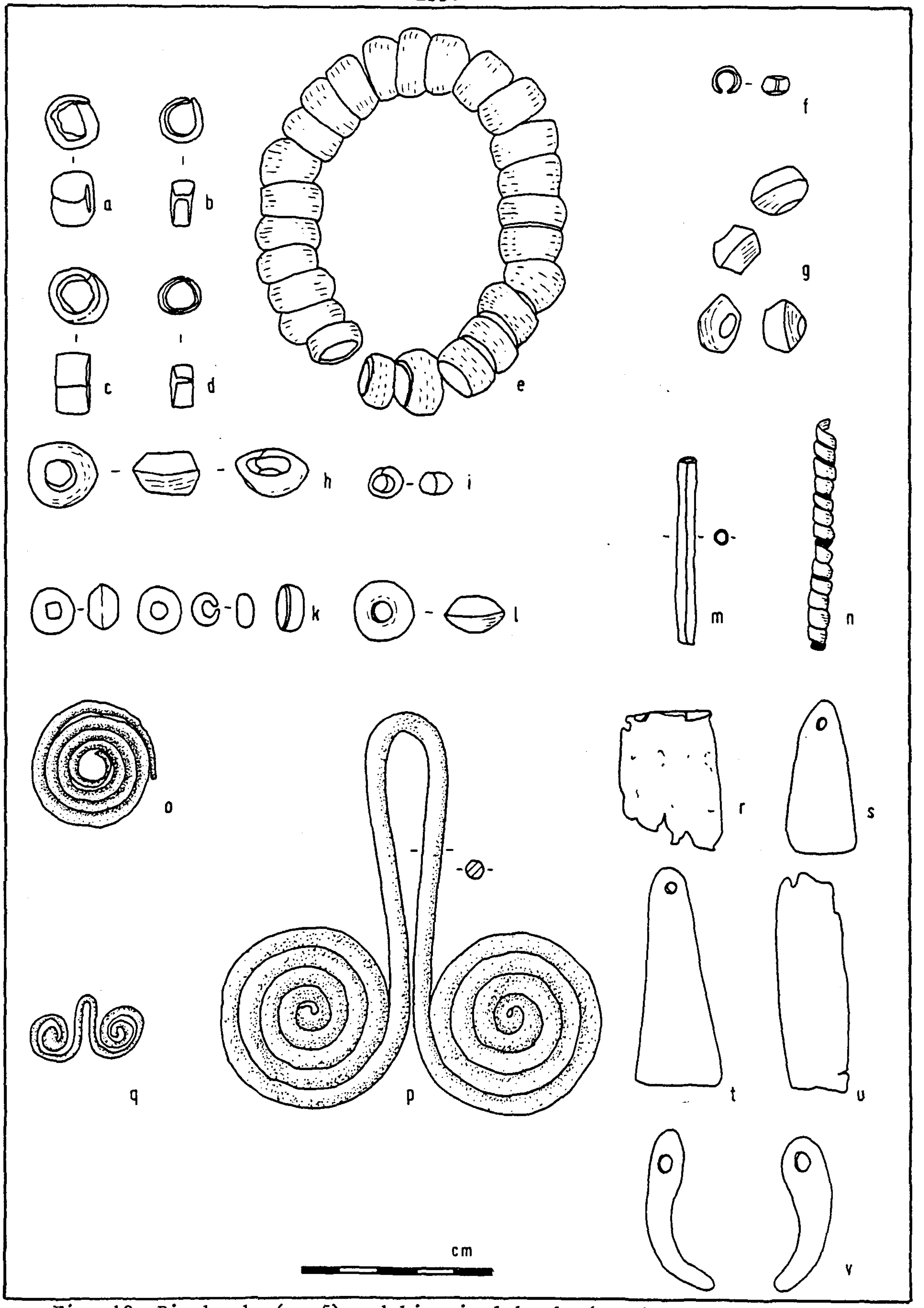


Fig. 13 Ringbeads (a-f) and biconical beads (g-l); a-d : Gerolfingen-Täuffelen, e : Préfargier, f,h,i : Estavayer, g : Vinelz, k : Font, l : St. Blaise. Tubes of sheet copper; m&n : Vinelz. Pendants; r : Altheim, s-u : Vinelz, v : St. Blaise. Single spirals, o : Lüscherz. Spectacle spirals; p : Font, q : Estavayer.

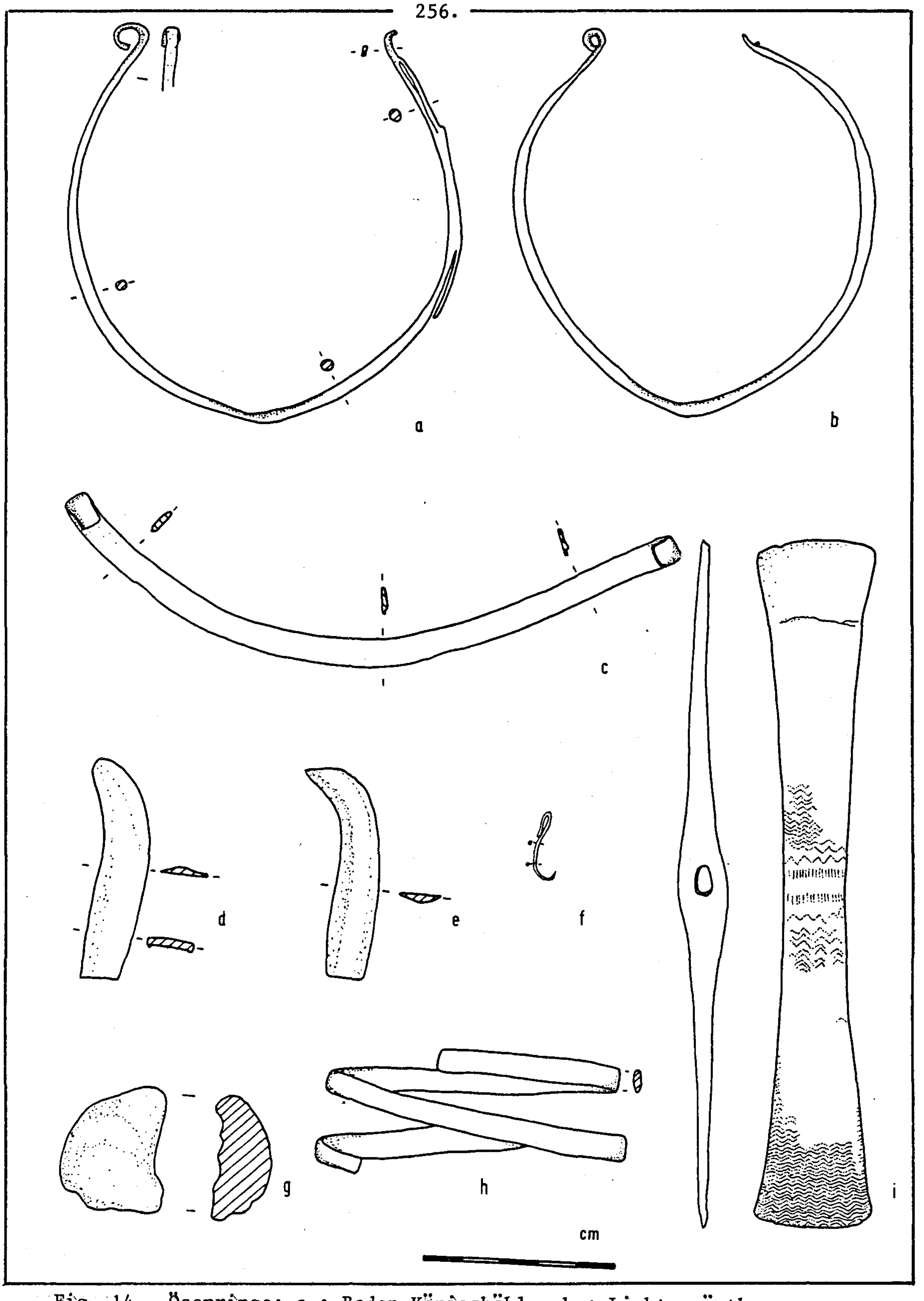
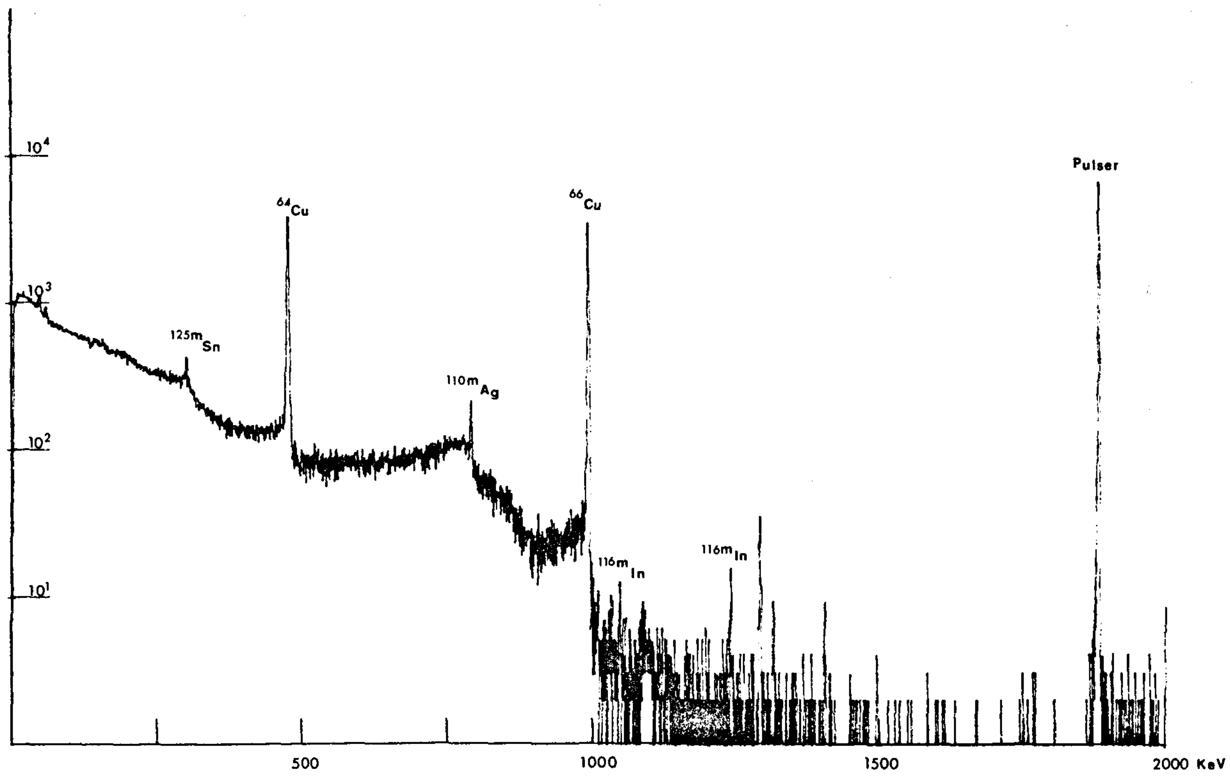


Fig. 14 Ösenringe; a : Baden-Königshöhle, b : Lichtenwörth.
Ösenband ; c : unknown findsite, Museum Neuchâtel.
Sickle ; d & e : Paura.
Fish hook ; f : Michelsdorf.
Bun ingot ; g : Freinberg,Linz.
Spiral armring ; h : Lichtenwörth.
Double axe ; i : Küssnacht.



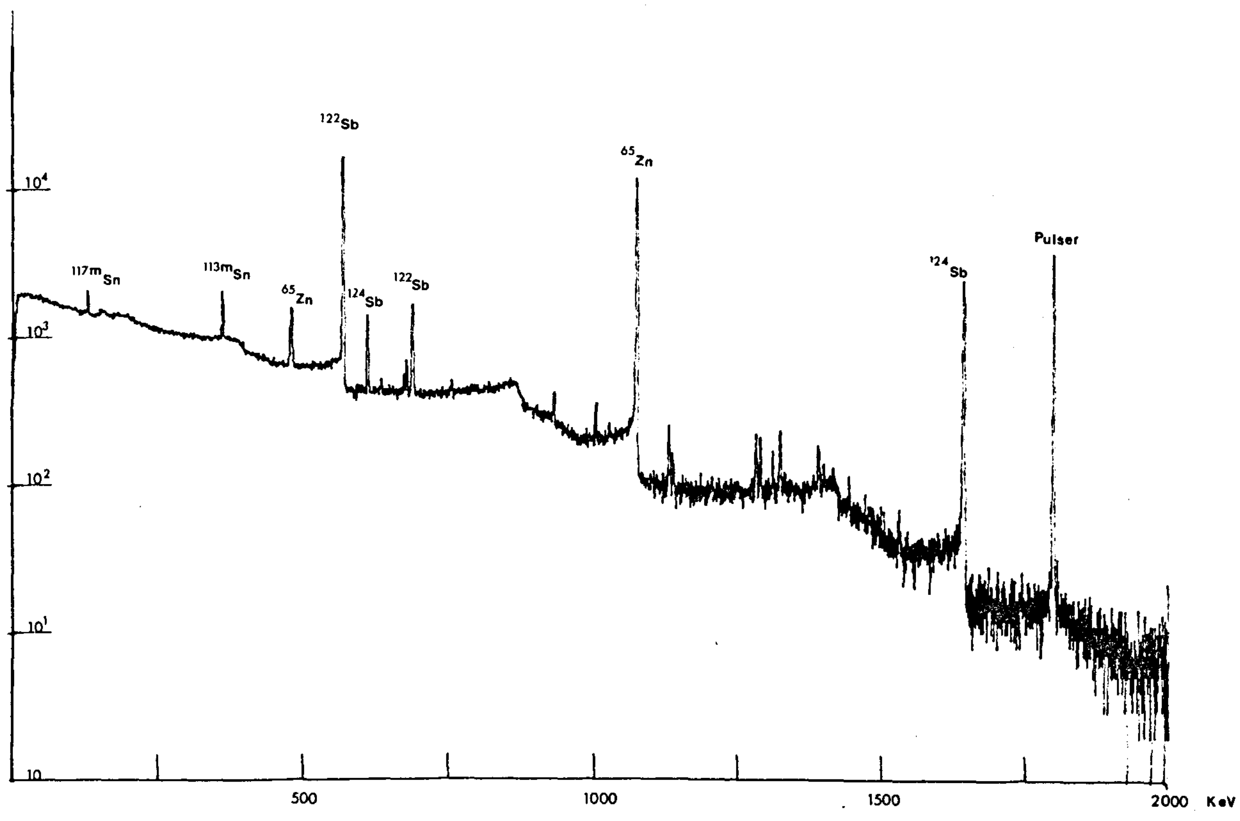
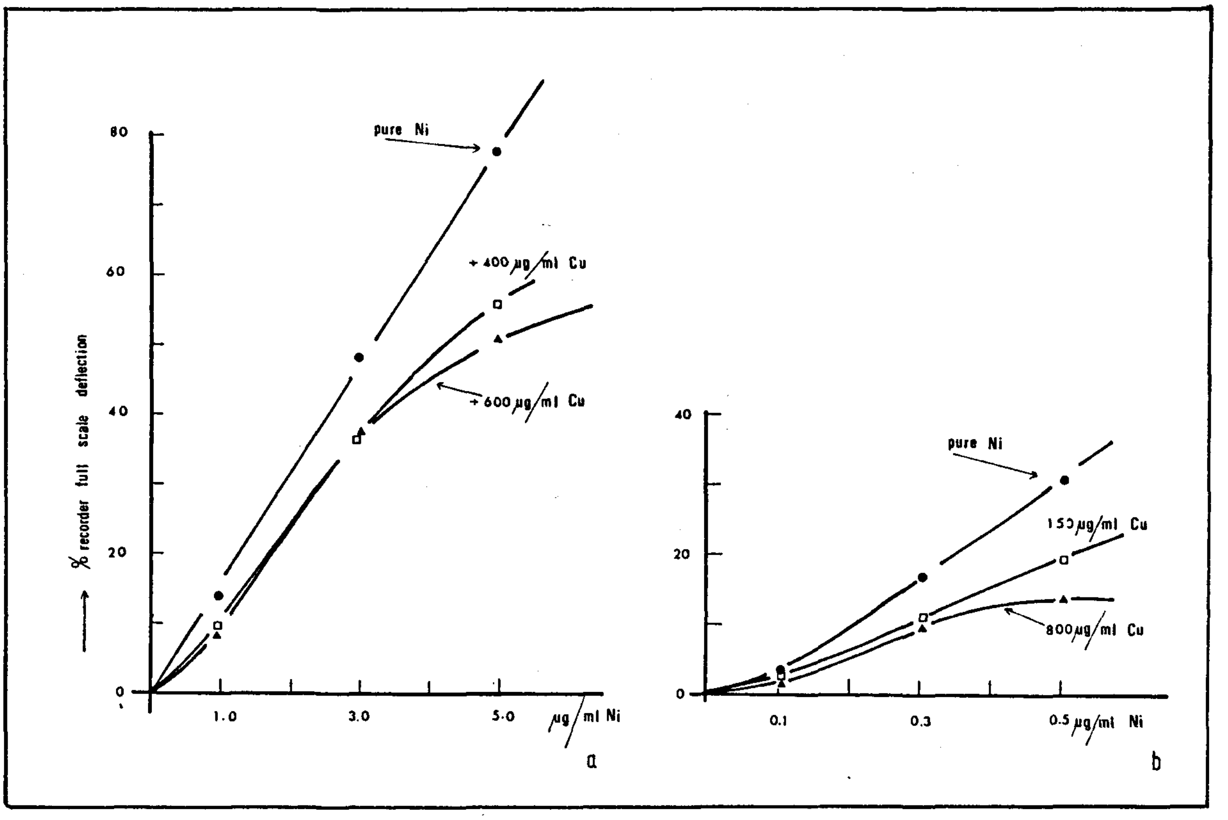


Fig. 15 a (top) γ -Spectrum of a copper-based sample after short decay.

15 b (bottom) γ - Spectrum of a copper-based sample after long decay.



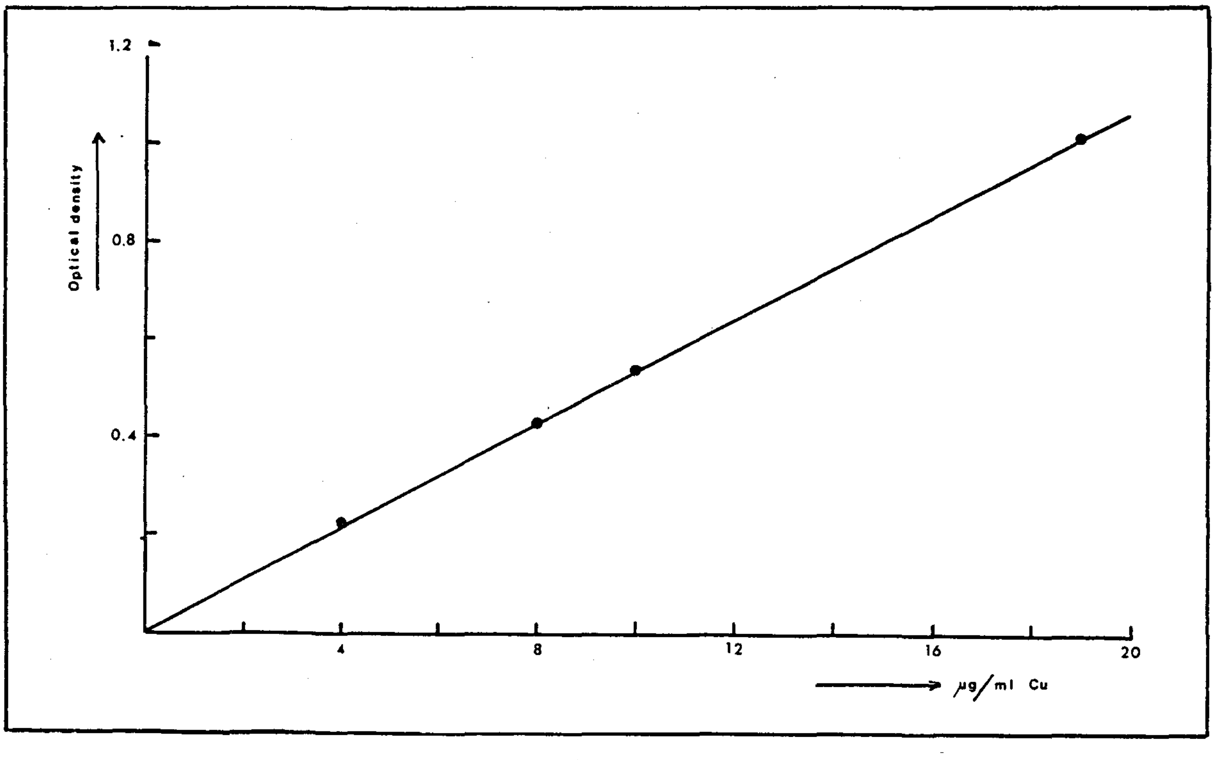
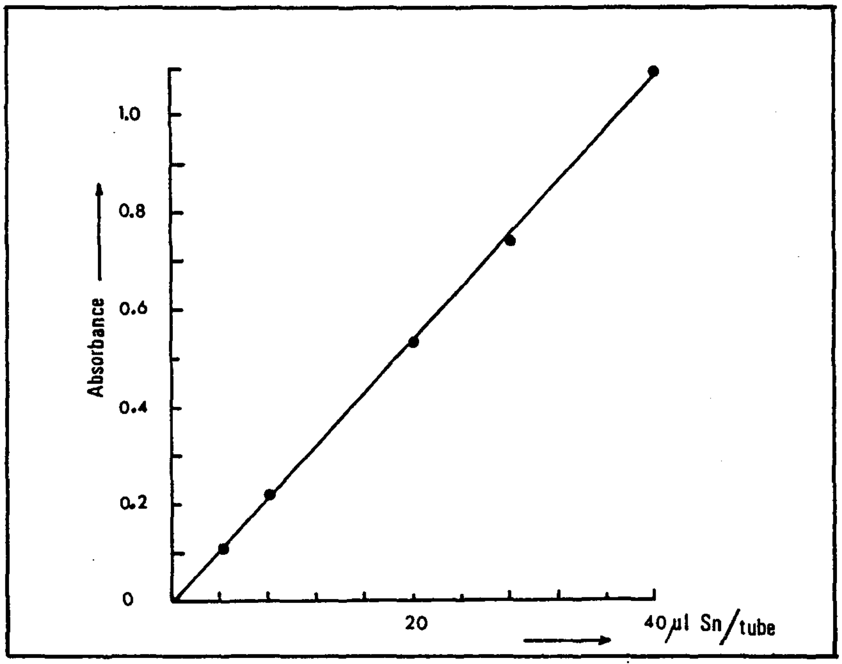


Fig 16 (top) Matrix effect on nickel during atomic absorption spectroscopy .

Fig.17 (bottom) Calibration curve for the determination of copper (after Felsenfeld,1960). Standards were read at 545 nm against reagent blank set at zero absorbance, using hydroxylammoniumchloride and biquinoline/glacial acid.



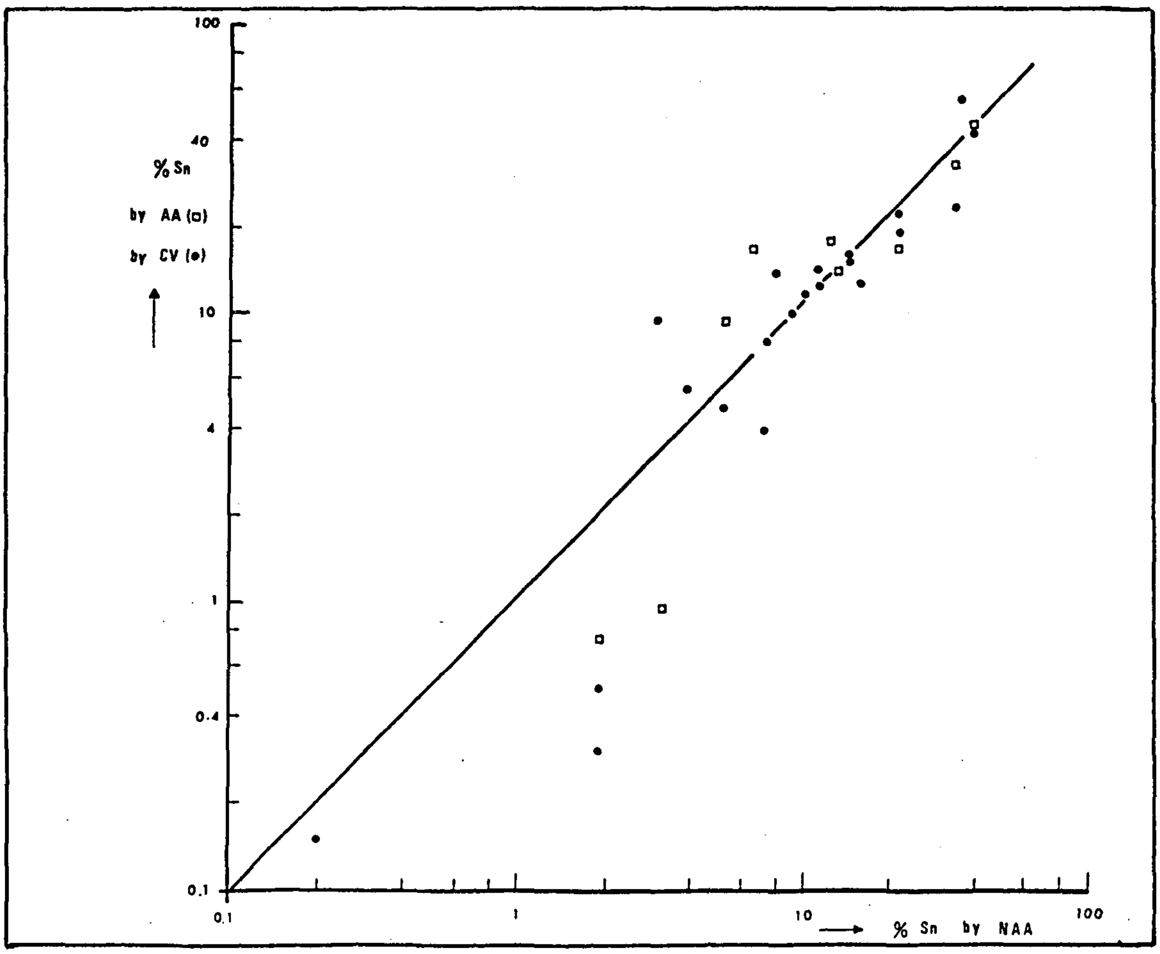
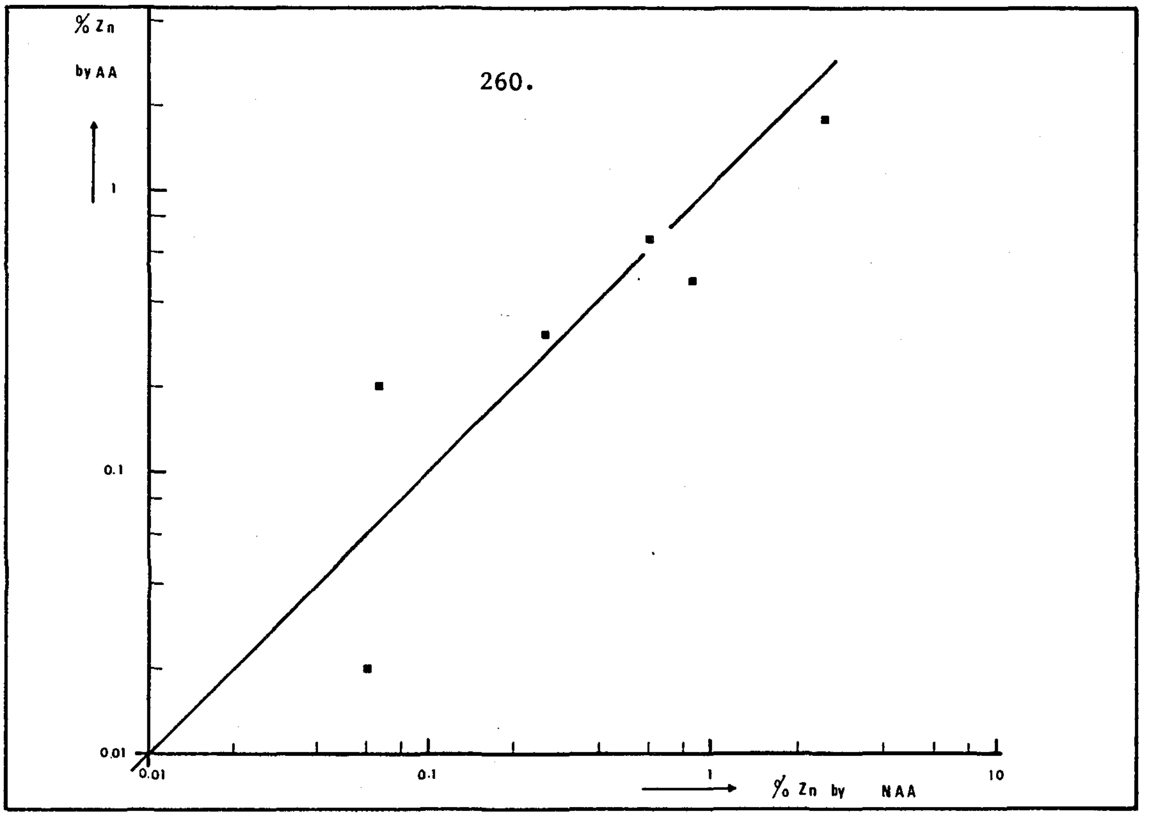


Fig. 18 (top) Calibration curve for the determination of tin (after Corbin, 1973). The standards were read at 660nm against reagent blank set at zero absorbance, using pyrocatechol violet/acid reagent.

Fig. 19 (bottom) Comparison of results of tin measurements obtained by atomic absorption spectroscopy and neutron activation analysis (□) and by pyrocatechol violet method and neutron activation analysis (●), on a double logarithmic scale.



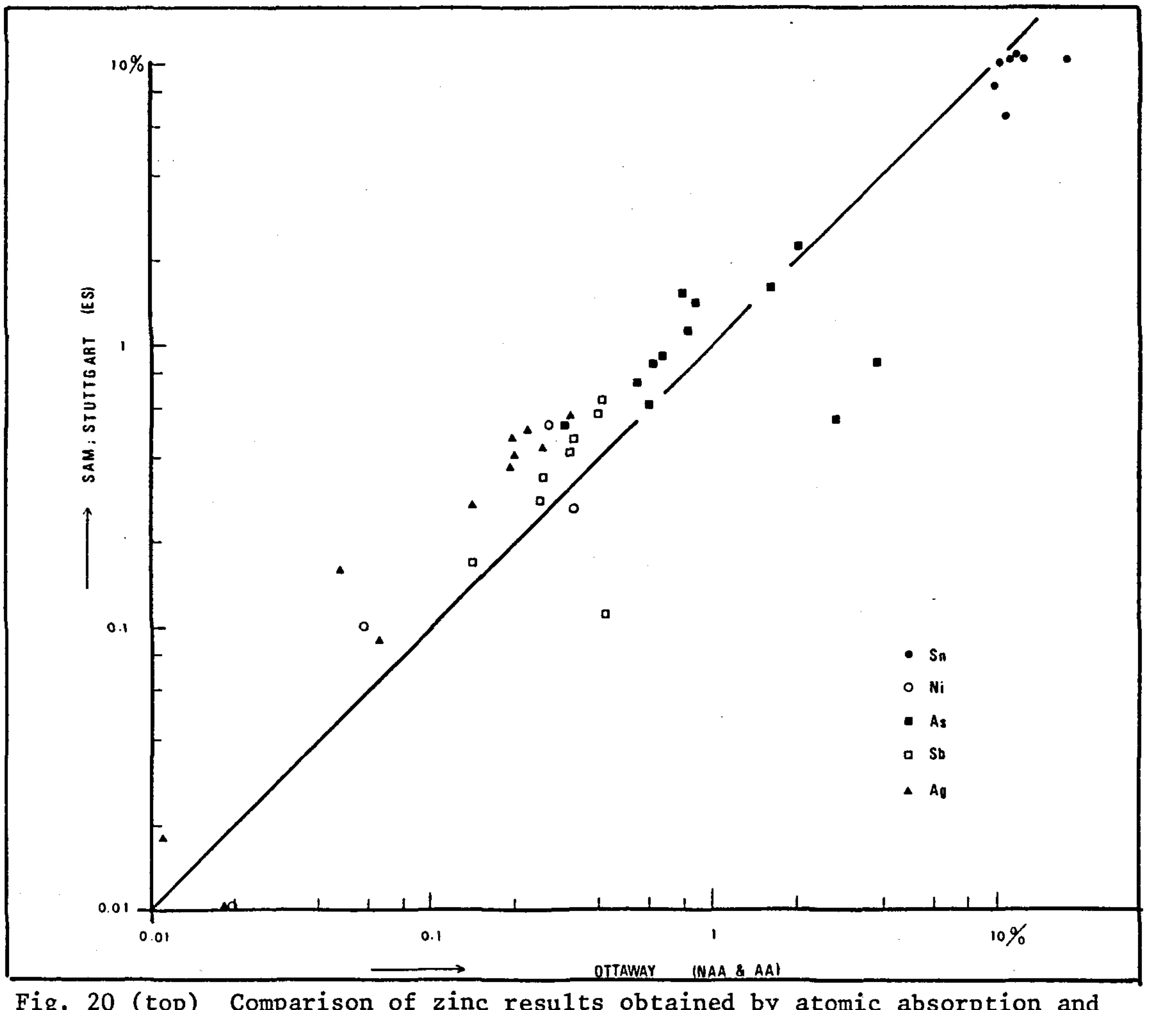


Fig. 20 (top) Comparison of zinc results obtained by atomic absorption and neutron activation analysis.

Fig. 21 (bottom) Comparison of Stuttgart's analyses (obtained by emission spectroscopy (ES))and Ottaway's analyses (obtained by neutron activation analysis (NAA) and atomic absorption spectroscopy (AA)), on a double logarithmic scale.

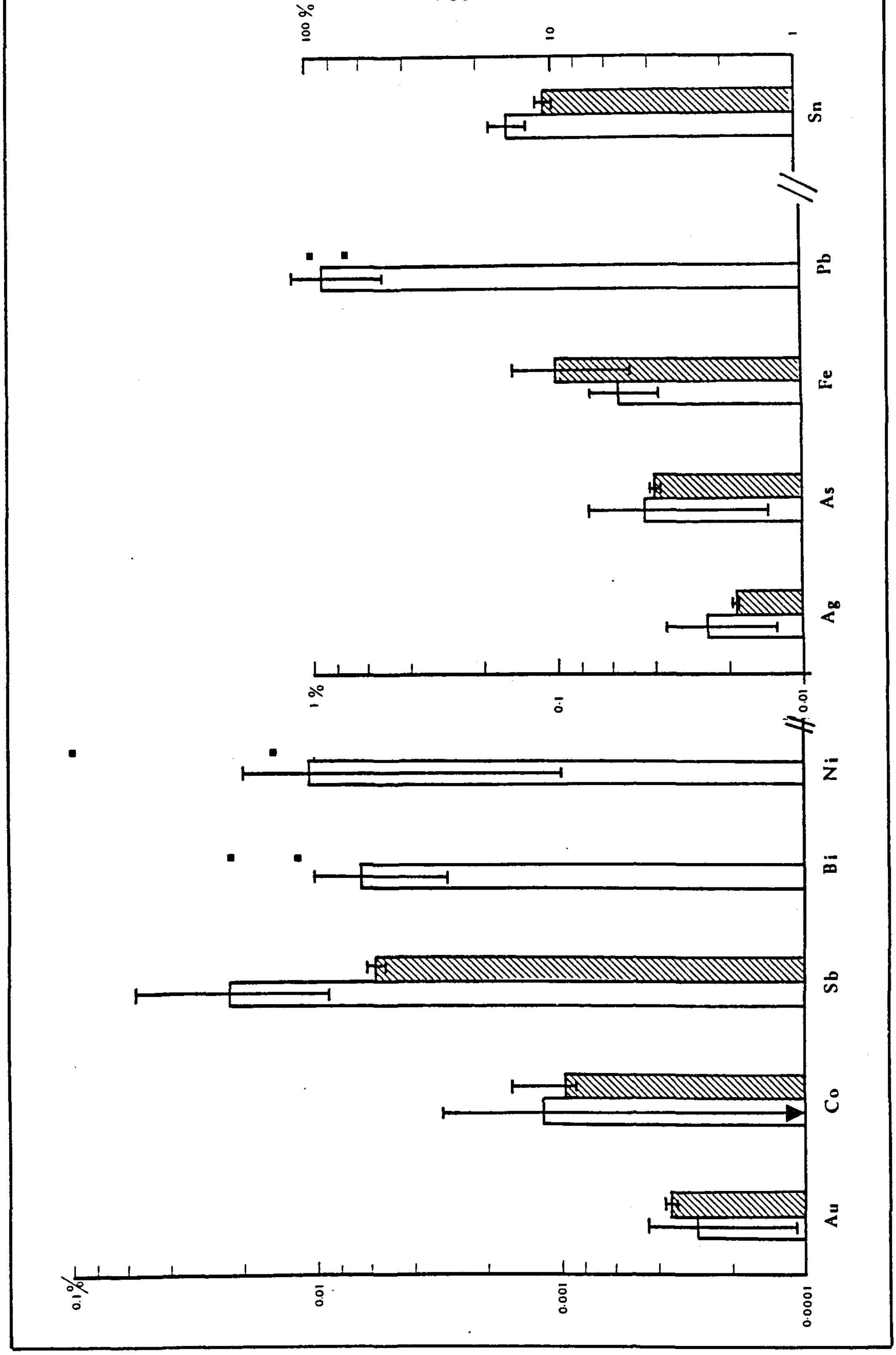


Fig. 22 Comparison of Ottaway's results (obtained by neutron activation analysis (▨) for elements Au, Co, Sb, Ag, As, Fe and Sn ; by atomic absorption spectroscopy (■) for the elements Bi, Ni and Pb) with average results collated by Chase (1975) (blank) from interlaboratory comparison on 'Washington Standard H_1 ' .

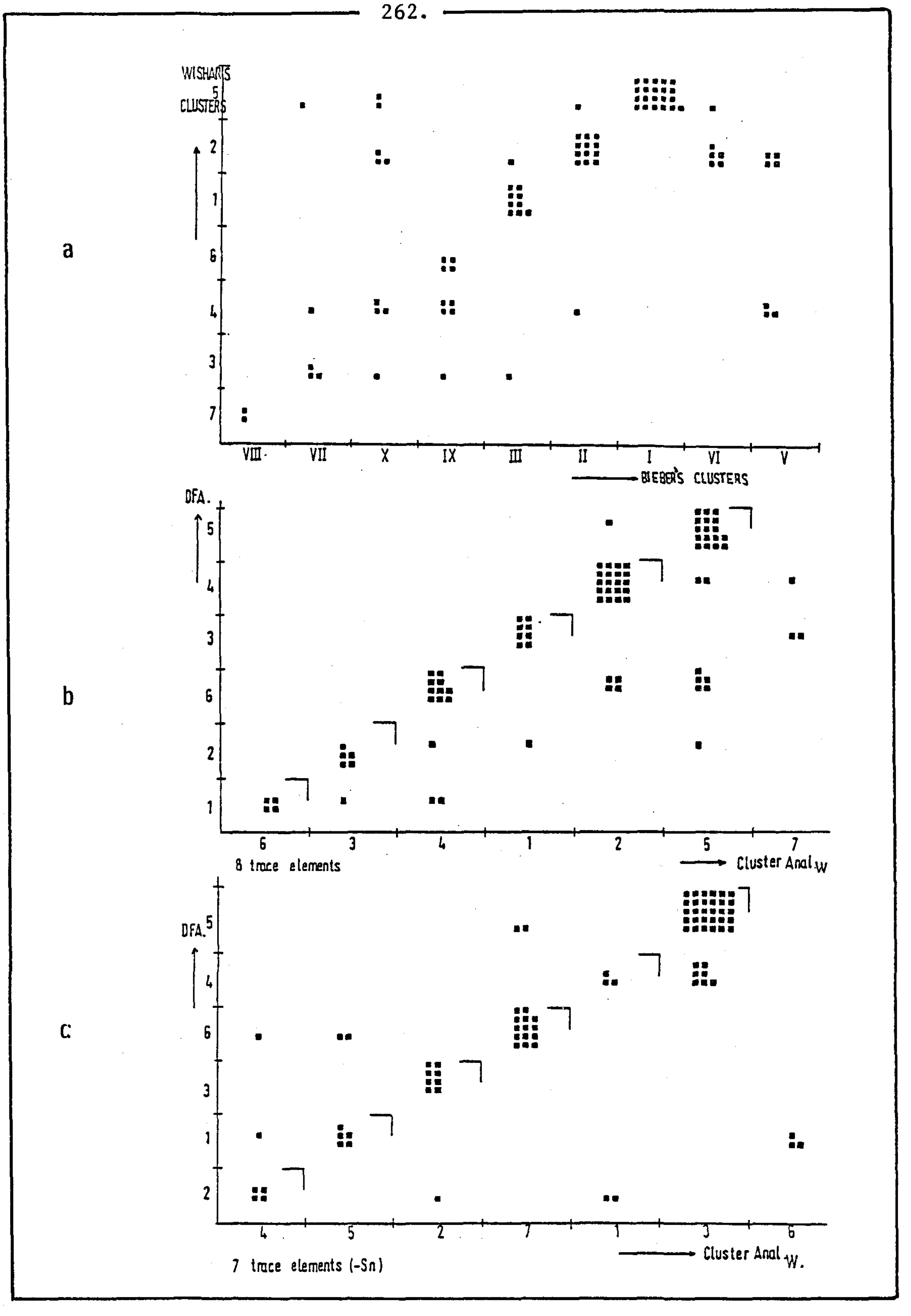


Fig. 23 Comparison of groups obtained on test data using (a) Wishart's and Bieber/Olivier's cluster analysis; (b) discriminant analysis and Wishart's cluster analysis on 8 trace elements and (c) discriminant analysis and Wishart's cluster analysis on the same test data, but with masked tin to check that its presence did not overweigh the result.

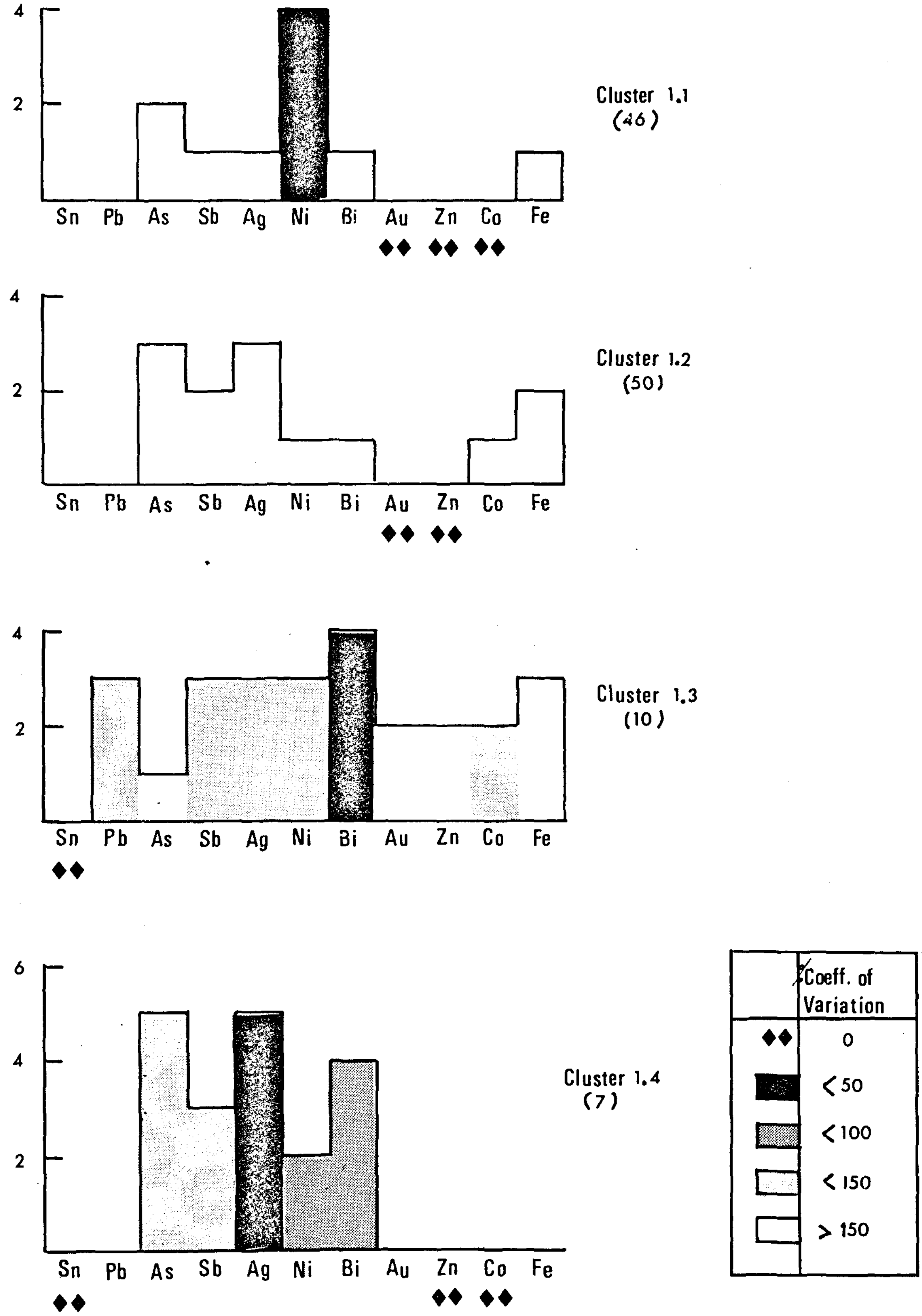


Fig. 24 Impurity patterns of sub-clusters of cluster 1. The ordinates represent log. concentrations starting from an arbitrary base for each element.

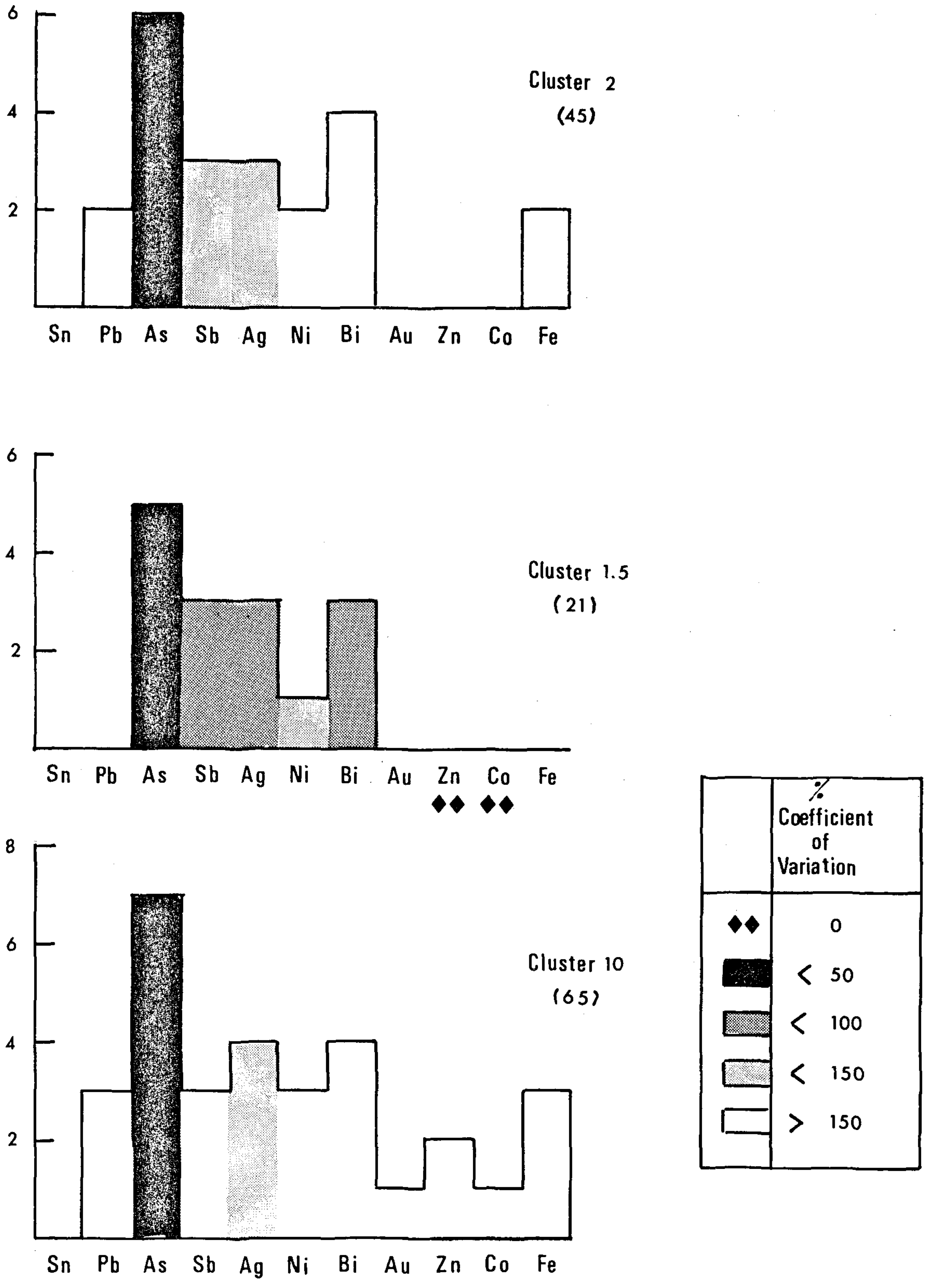


Fig. 25 Impurity patterns of clusters 2 , 1.5 and 10. The ordinates represent log. concentrations starting from an arbitrary base for each element.

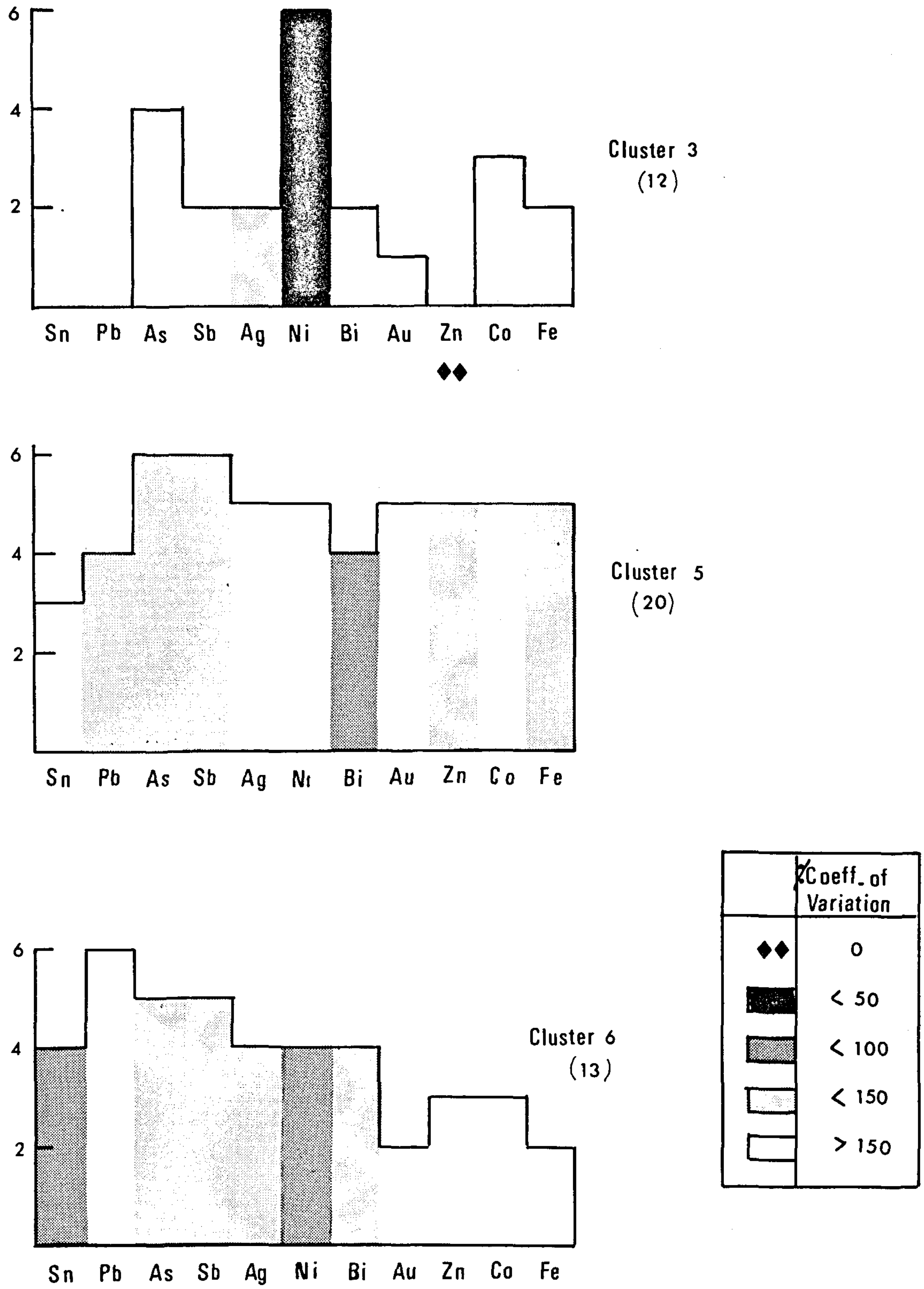


Fig. 26 Impurity patterns of clusters 3 , 5 and 6. The ordinates represent log. concentrations starting from an arbitrary base for each element.

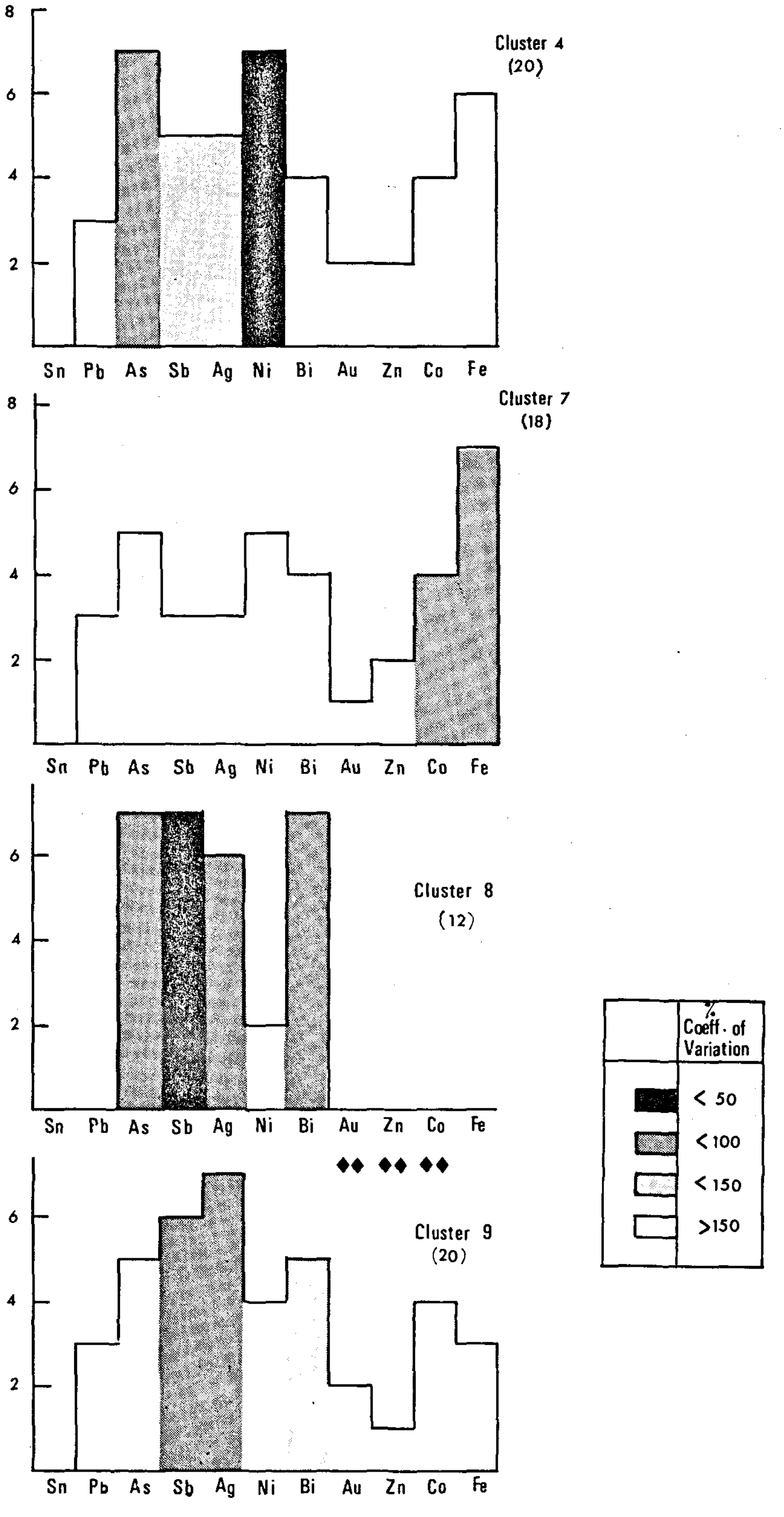


Fig. 27 Impurity patterns of clusters 4, 7, 8 and 9. The ordinates represent log. concentrations starting from an arbitrary base for each element.

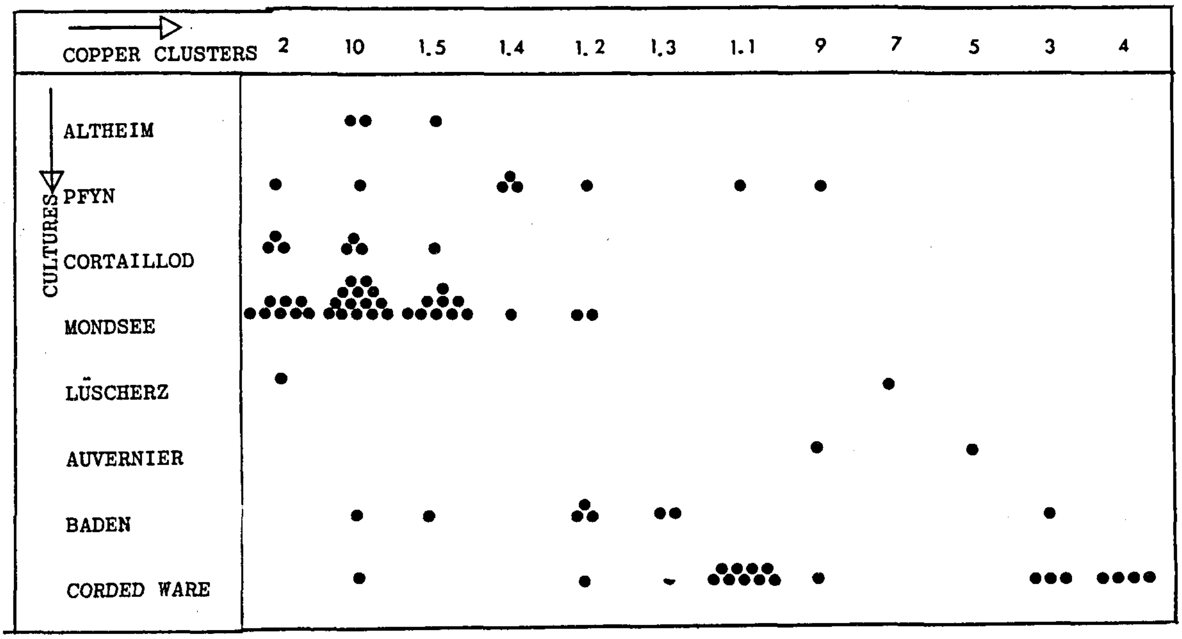
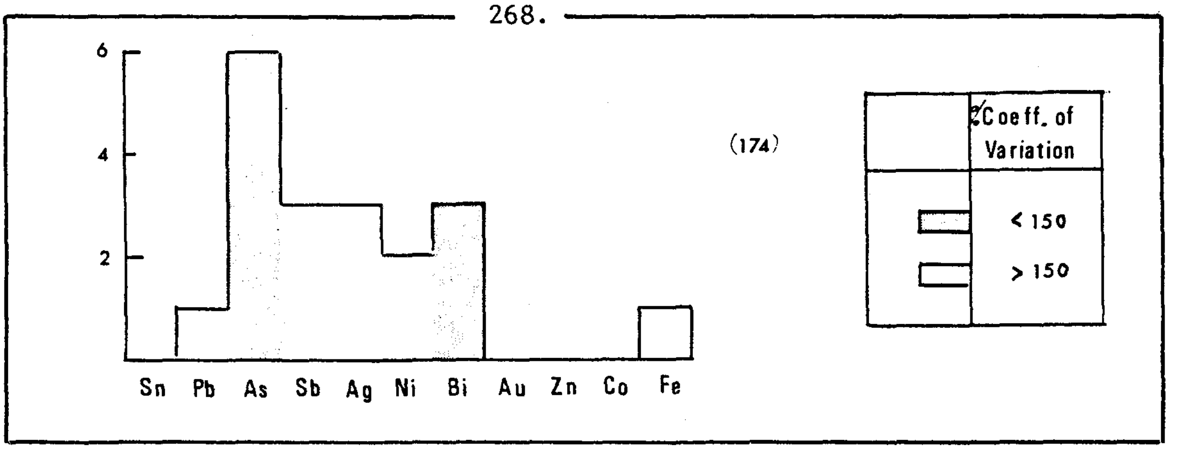


TABLE 9: COPPER CLUSTERS 1-10 PLOTTED AGAINST THE CULTURES. Row Σ_{col} indicates the number of associated artifacts in each cluster; the row below that gives the total number (associated and unassociated) and the last row the % of associated objects in each cluster.

		NUMBERS OF COPPER CLUSTERS														
		1.1	1.2	1.3	1.4	1.5	2	3	4	5	6	7	8	9	10	TOTAL
CULTURES	Altheim					1									2	3
	Pfyn	1	1		3		1							1	1	8
	Cortaillod					1	3								2.7	6.7
	Mondsee		2		1	9	8								14	34
	Lüscherz						1					1				2
	Auvernier									1				1		2
	Baden		3	2		1		1							1	8
	Corded Ware	9.4	1	0.1				3	4					1	1	19.5
Σcol.		10.4	7	2.1	4	12	13	4	4	1	0	1	0	3	21.7	83.2
No. of objects in each cluster (beads 1/10)		15.4	41	9.1	7	12	27	12	20	20	13	18	12	20	49.7	276.2
% of associated objects in each cluster.		68	17	23	57	100	48	33	20	5	0	6	0	15	44	31.14

Fig. 28 (top) Number of associated artifacts in each copper cluster, plotted against cultures in approximately chronological sequence. (bottom) Table 9, from which the top figure has been constructed, is repeated here for easier reference.



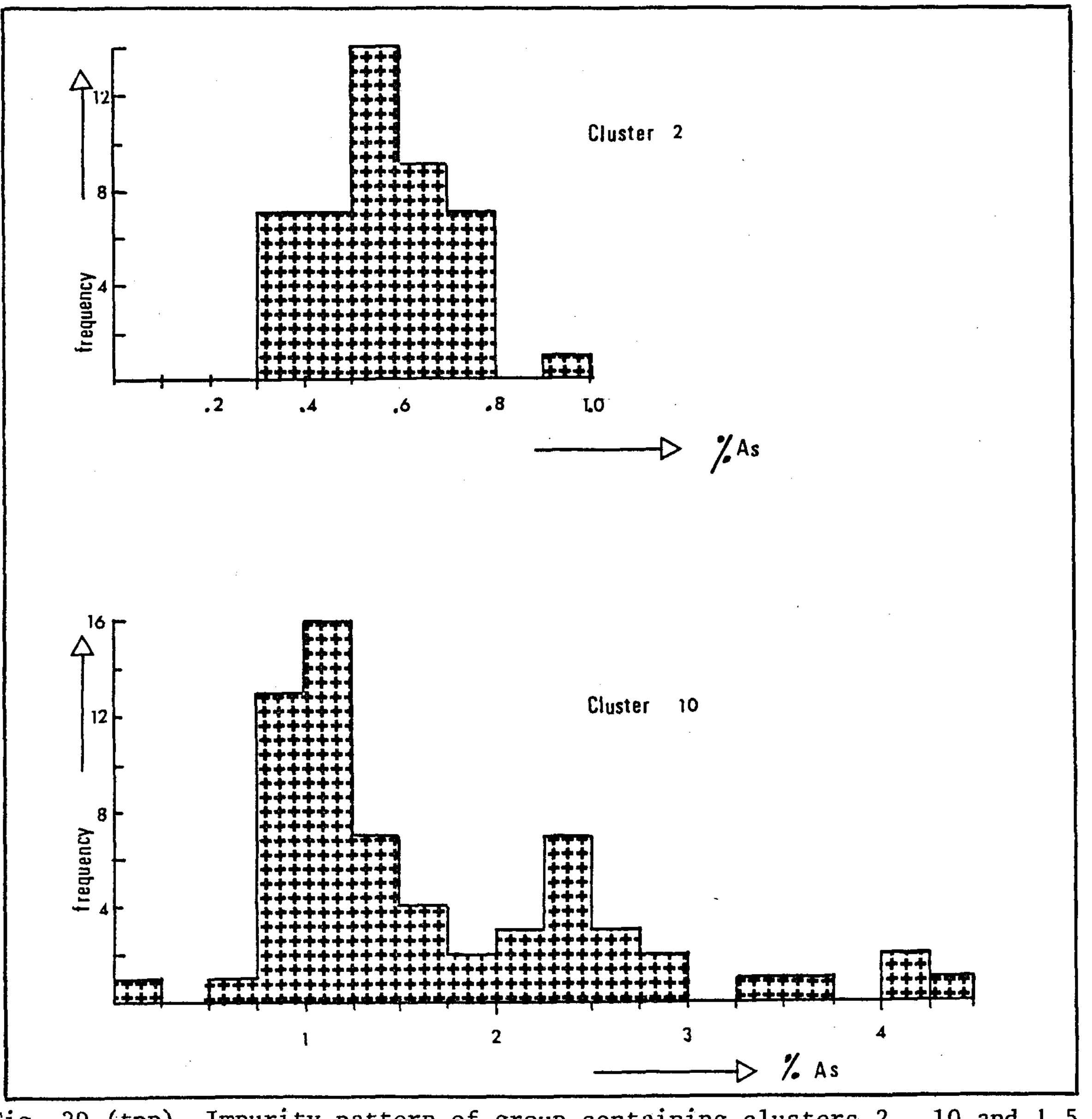
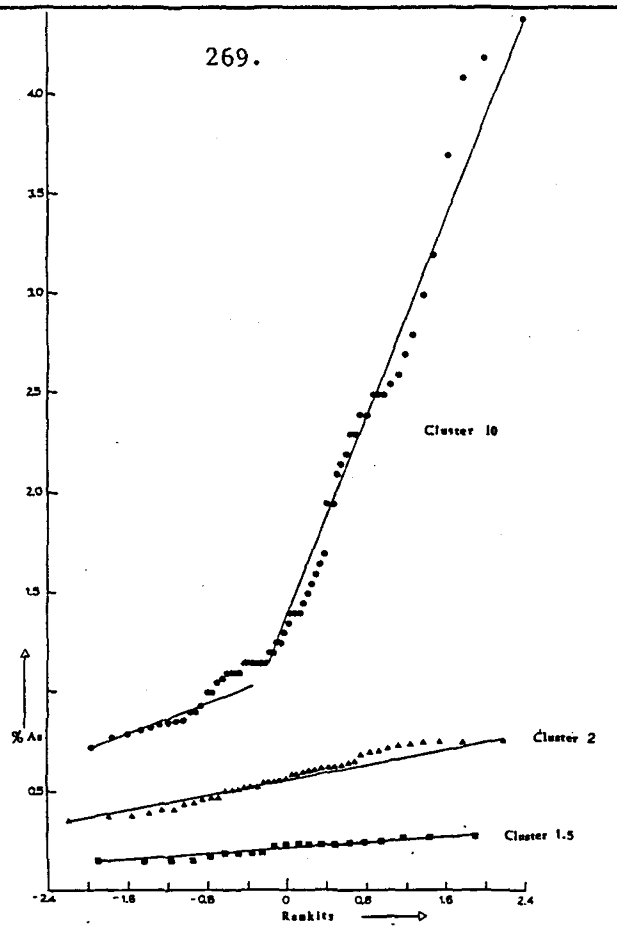


Fig. 29 (top) Impurity pattern of group containing clusters 2 , 10 and 1.5 when arsenic is masked. The ordinates represent log. concentrations starting from an arbitrary base for each element.

Fig. 30 (middle & bottom) Arsenic contents (as histograms of amount against frequency) of copper clusters 2 and 10.



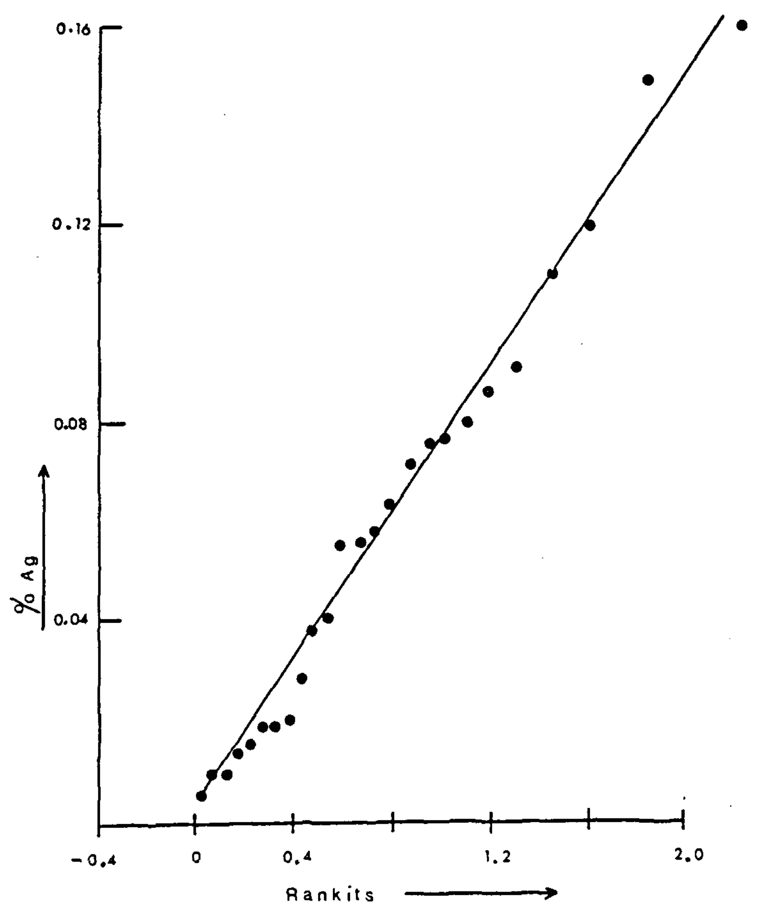


Fig. 31 (top) and 32 (bottom) Rankit tests: plotting arsenic (top) and silver (bottom) against expected normal order statistics, for clusters 1.5 , 2 and 10.(top) and cluster 10 (bottom).

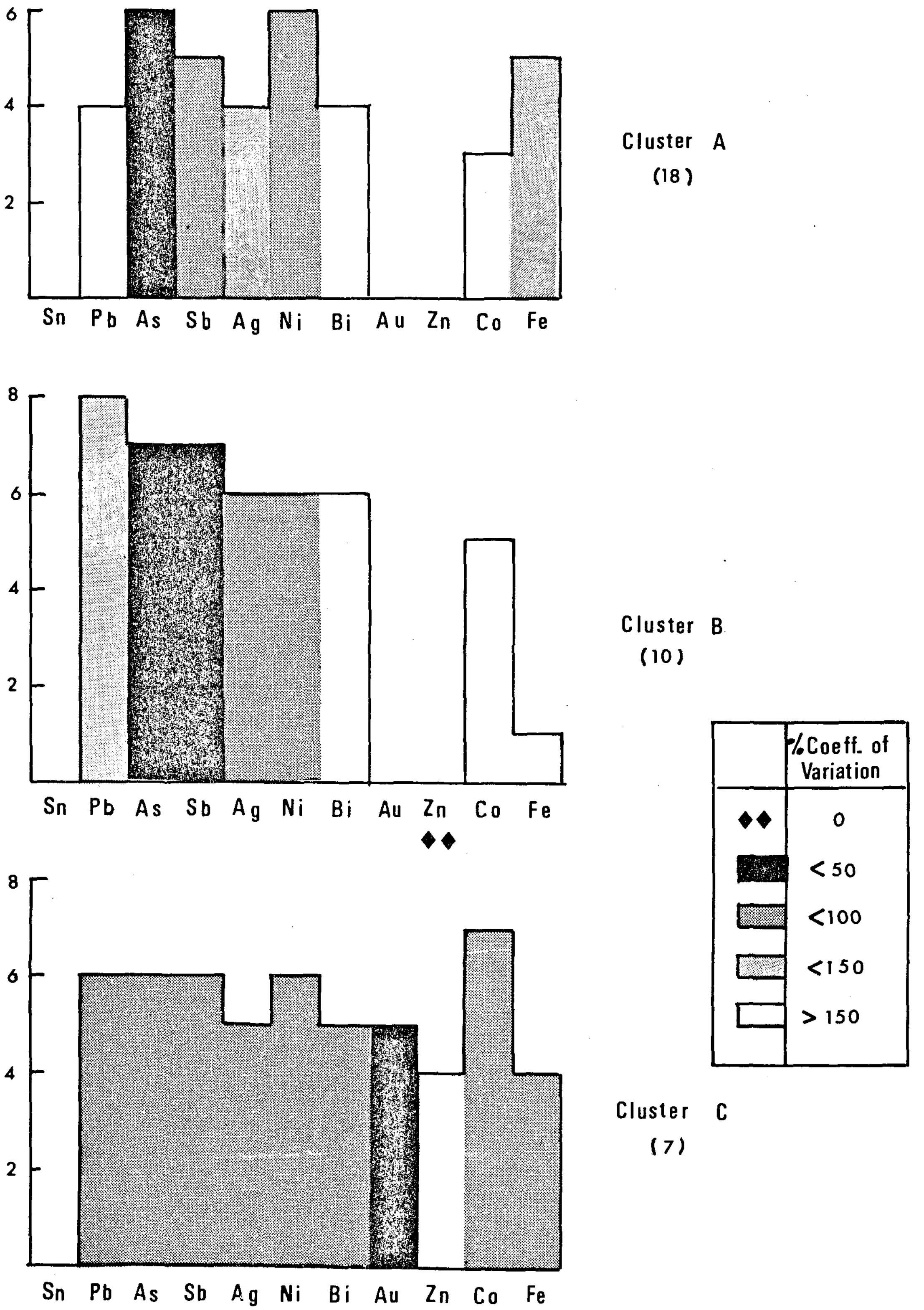


Fig. 33 Impurity patterns of bronze clusters A , B and C, where tin was masked before clustering. The ordinates represent log. concentrations starting from an arbitrary base for each element.

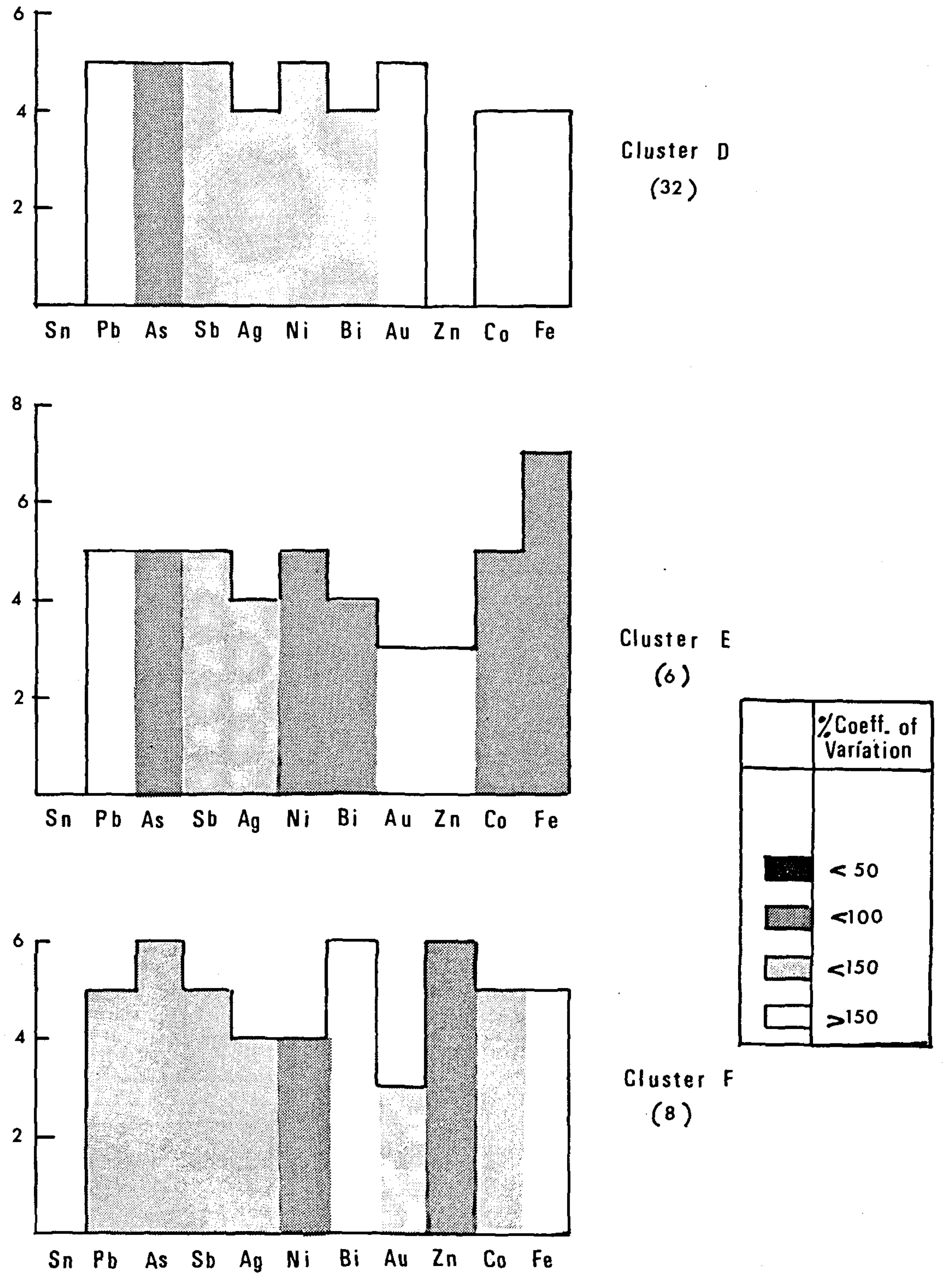


Fig. 34 Impurity patterns of bronze clusters D, E and F. where tin was masked before clustering. The ordinates represent log. concentrations starting from an arbitrary base for each element.

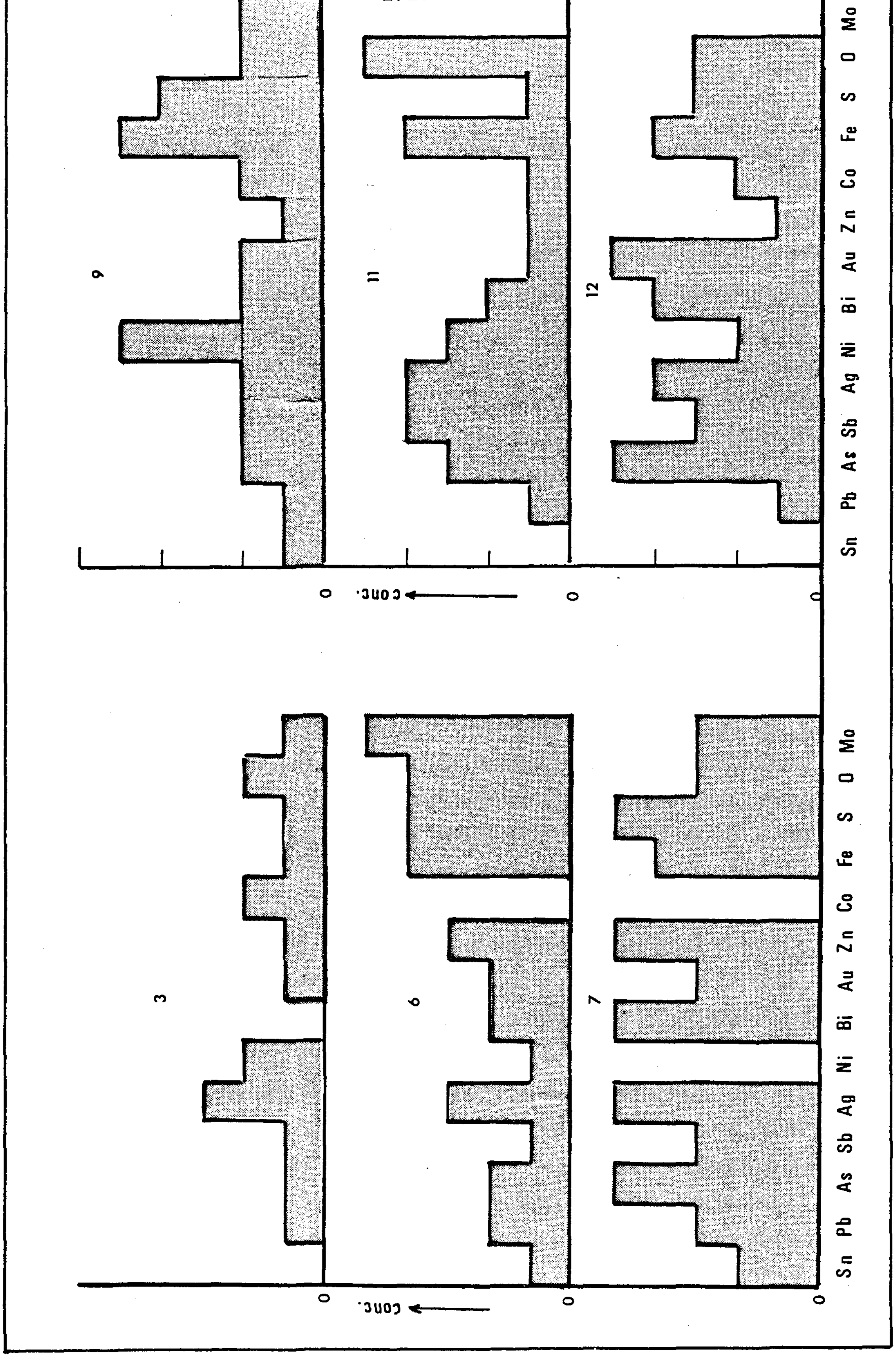


Fig. 35 Impurity patterns of copper ore types suggested by Pelissonnier & Michel (1972, p.226). The coding is theirs.

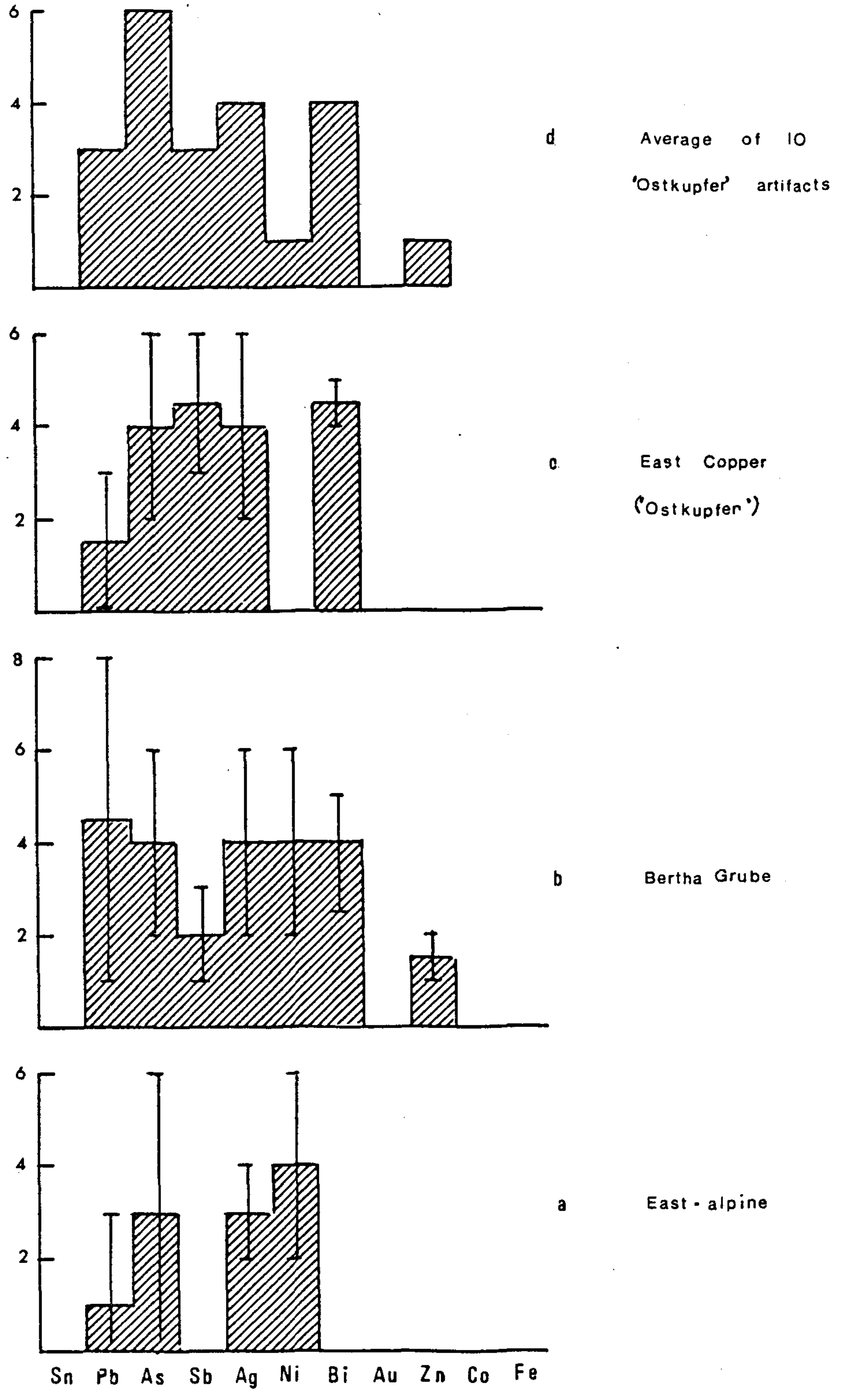
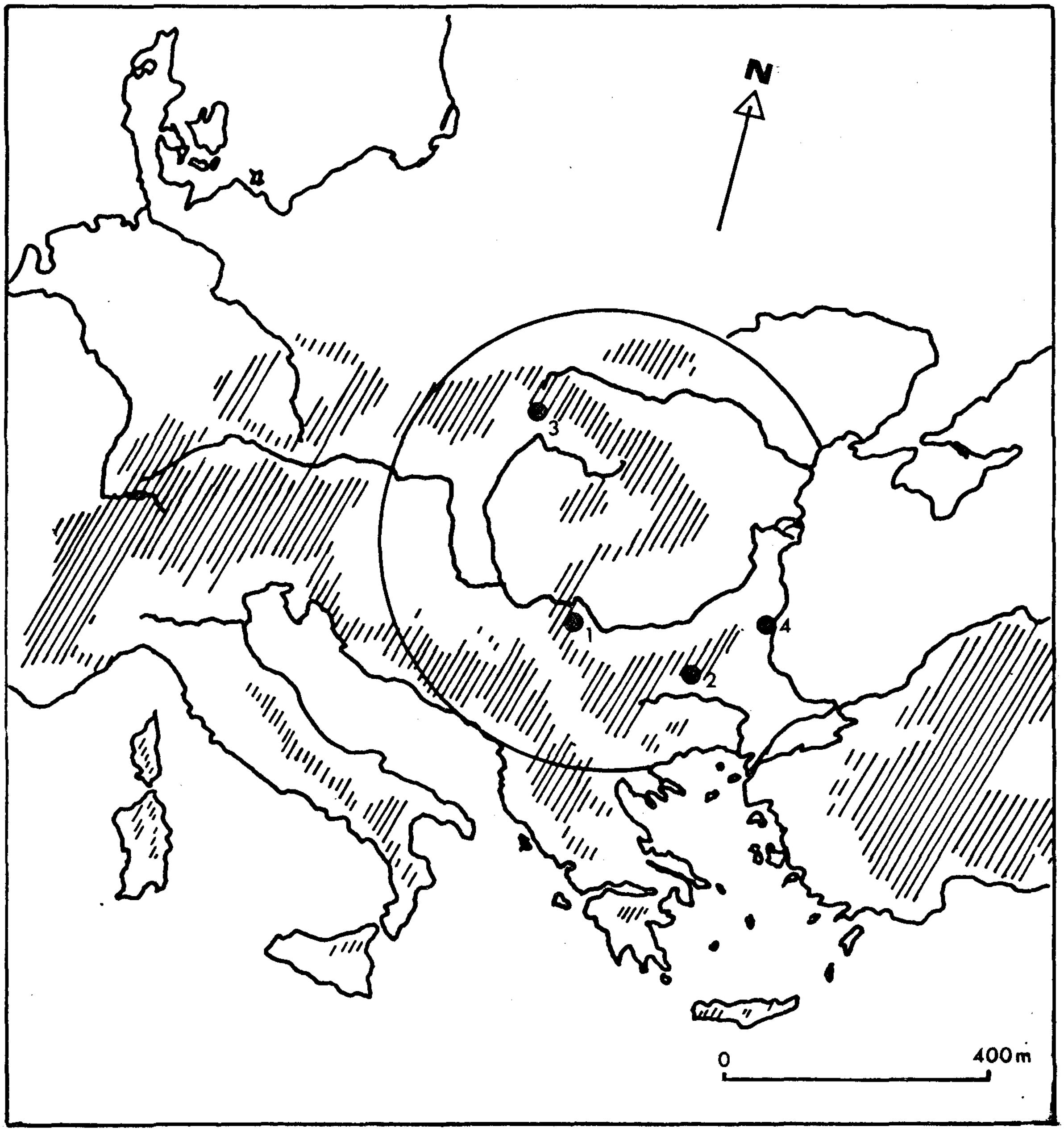
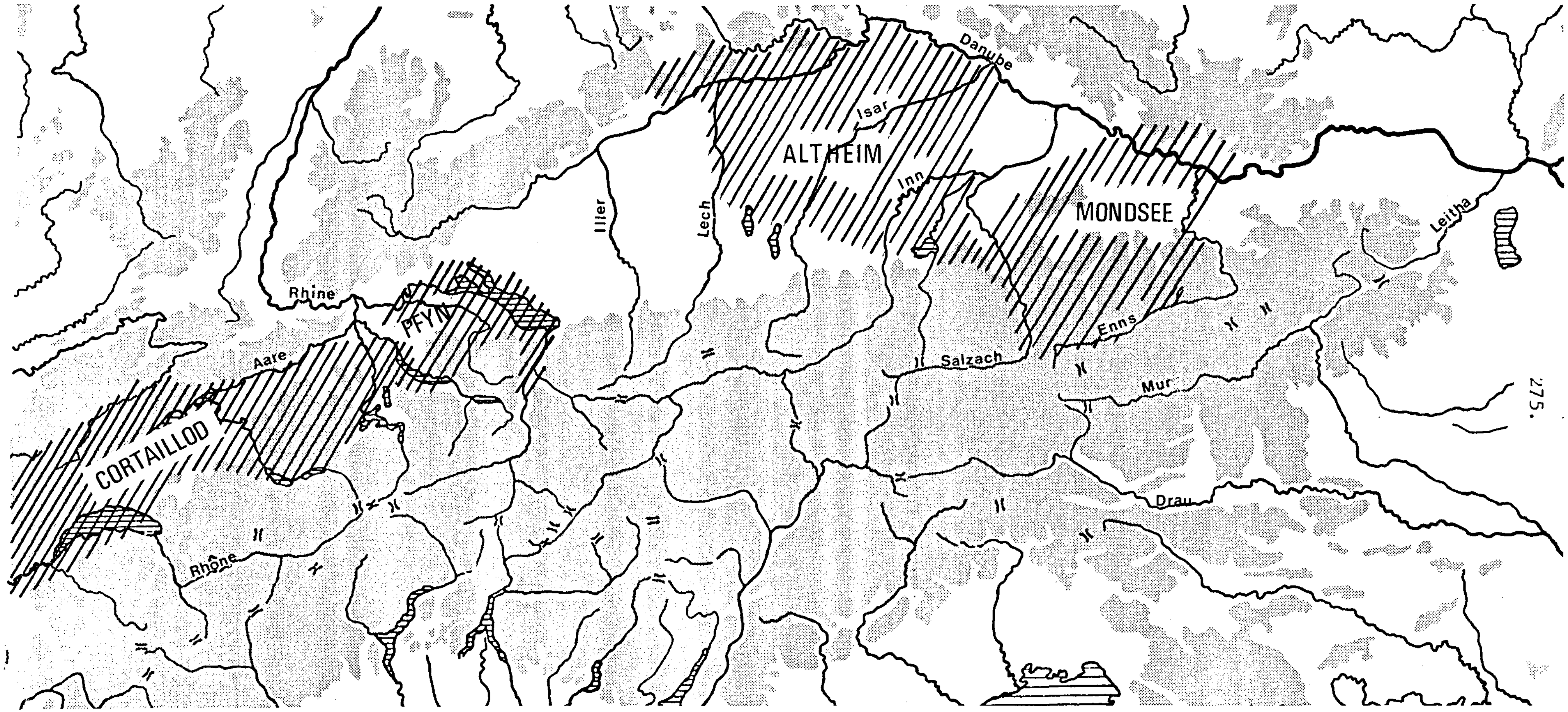


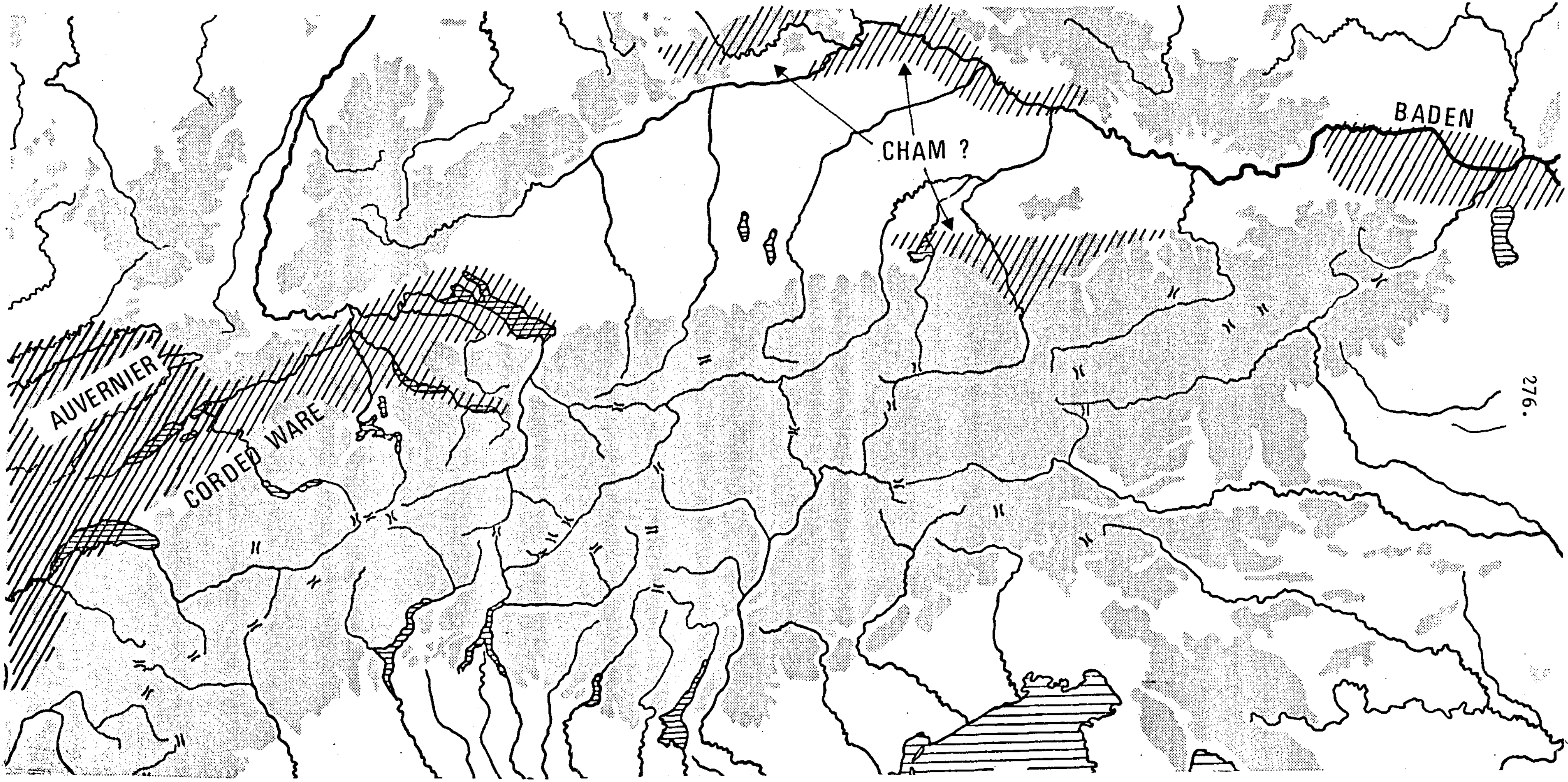
Fig. 36 Impurity patterns of Pittioni's 'East-alpine' (a) and 'Bertha-Grube' type of copper (b) and his 'East Copper' (Ostkupfer) (c); (d) = the average of ten artifacts of 'East Copper' composition (after Pittioni) analysed by Stuttgart. The ordinates represent log. concentrations starting from an arbitrary base for each element. The vertical lines indicate the range within which the element can fall.



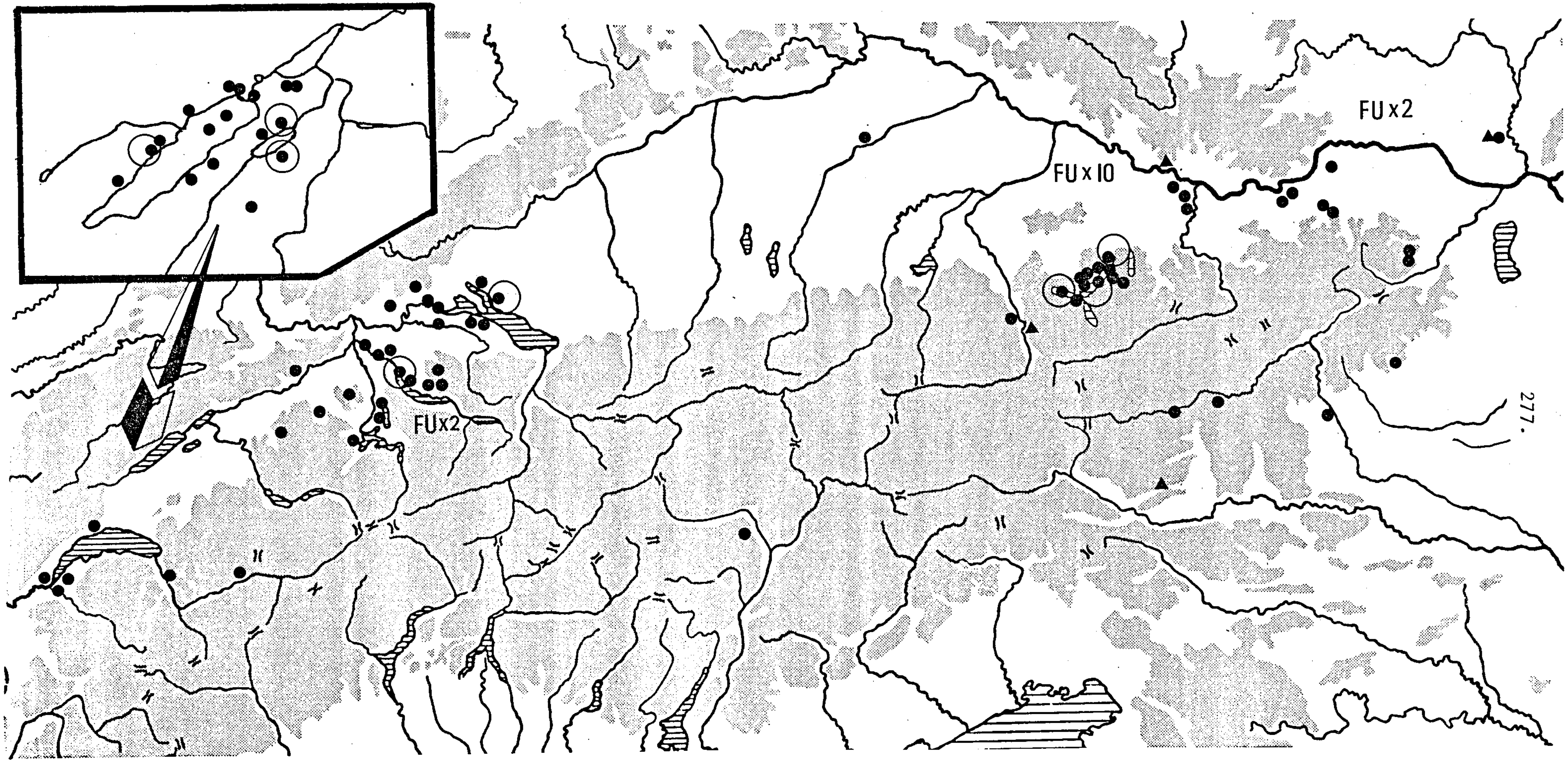
MAP 1. The earliest south east European copper-using horizon with some of the important sites: 1 = Rudna Glava, 2 = Aibunar, 3 = Vel'ke Raškovce, 4 = Varna. The isochron is covering roughly the area in which the earliest European copper artifacts have been found.



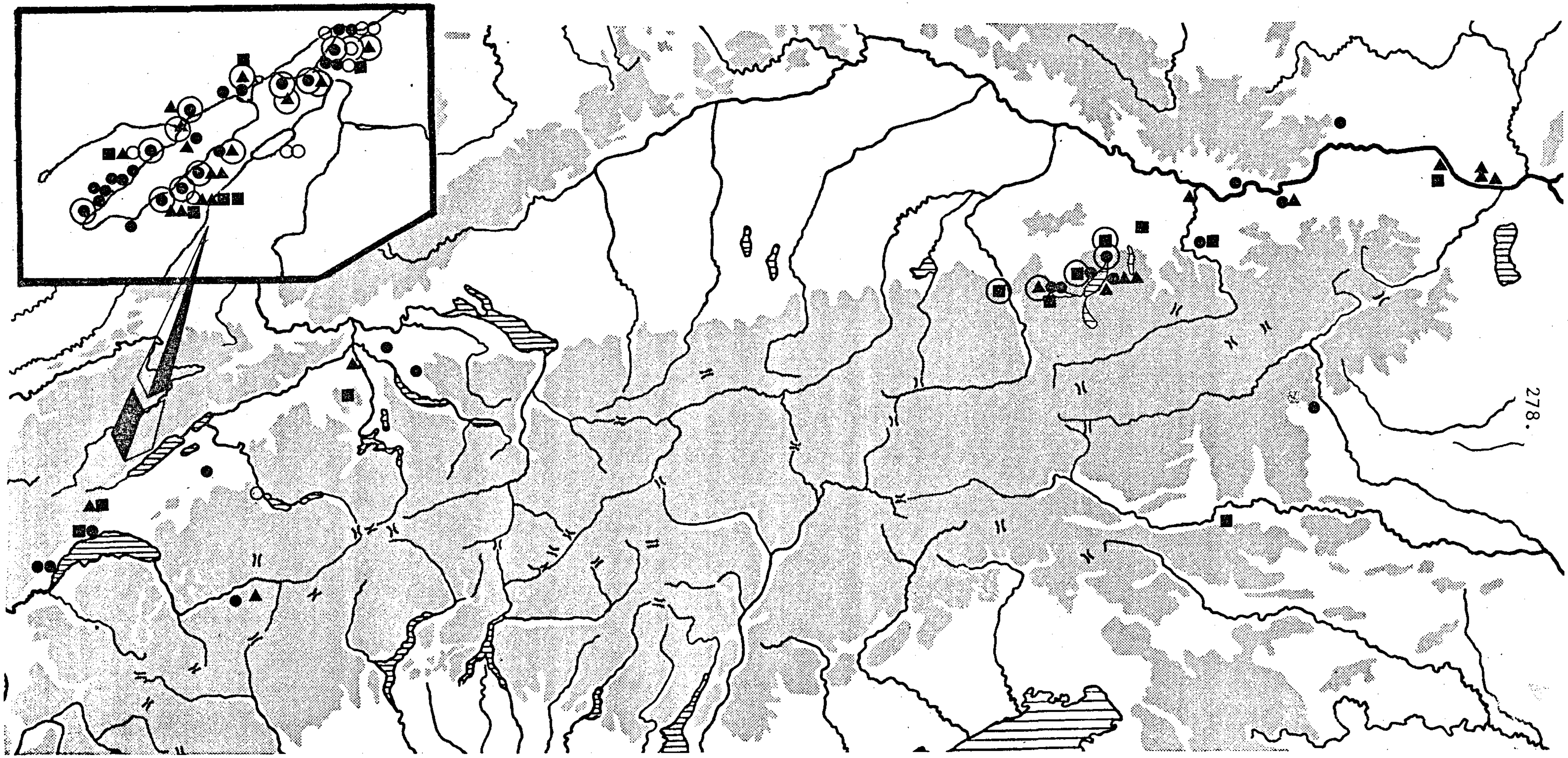
MAP 2. Distribution of the first copper-using horizon in the northern alpine area.



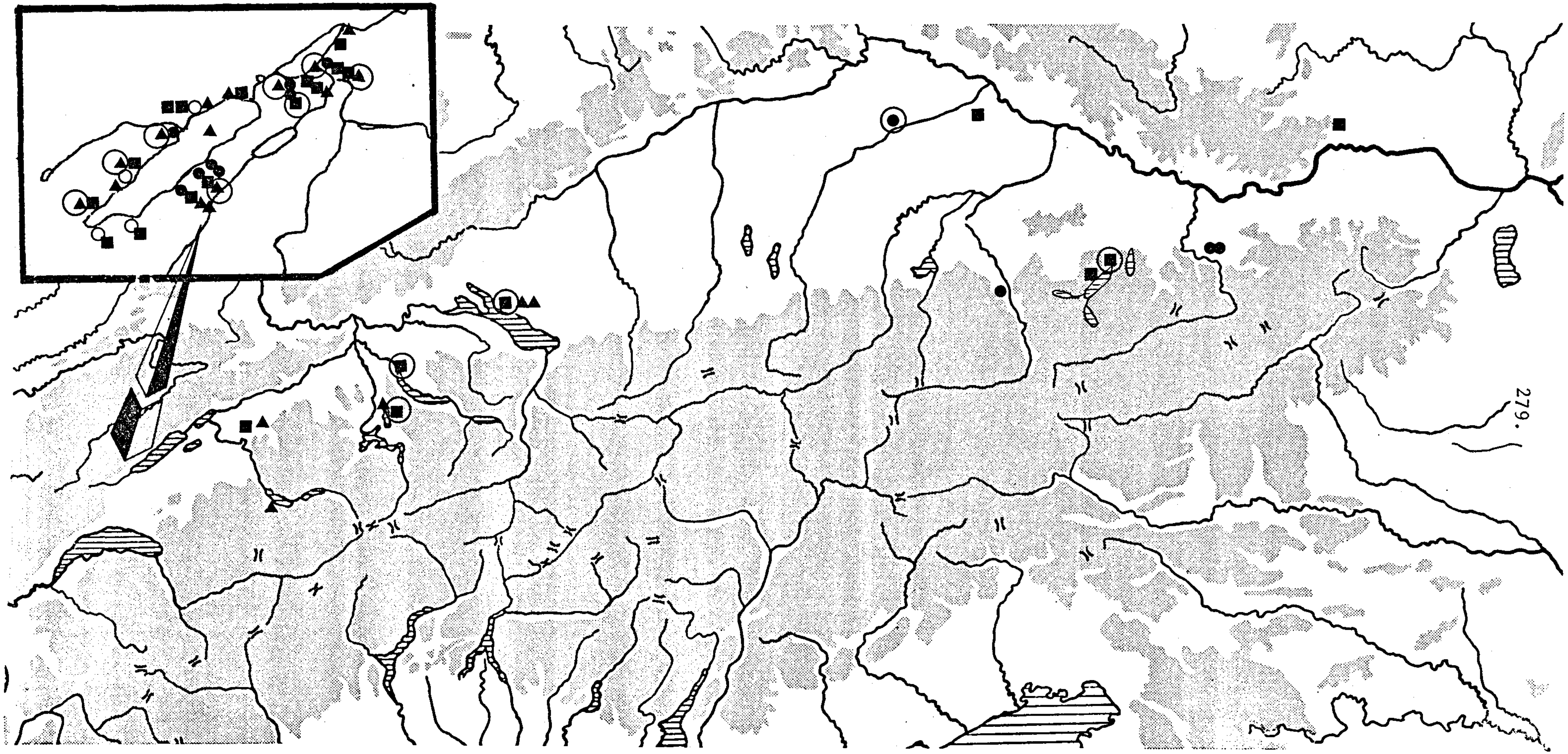
MAP 3. Distribution of the third copper-using horizon in the northern alpine area.



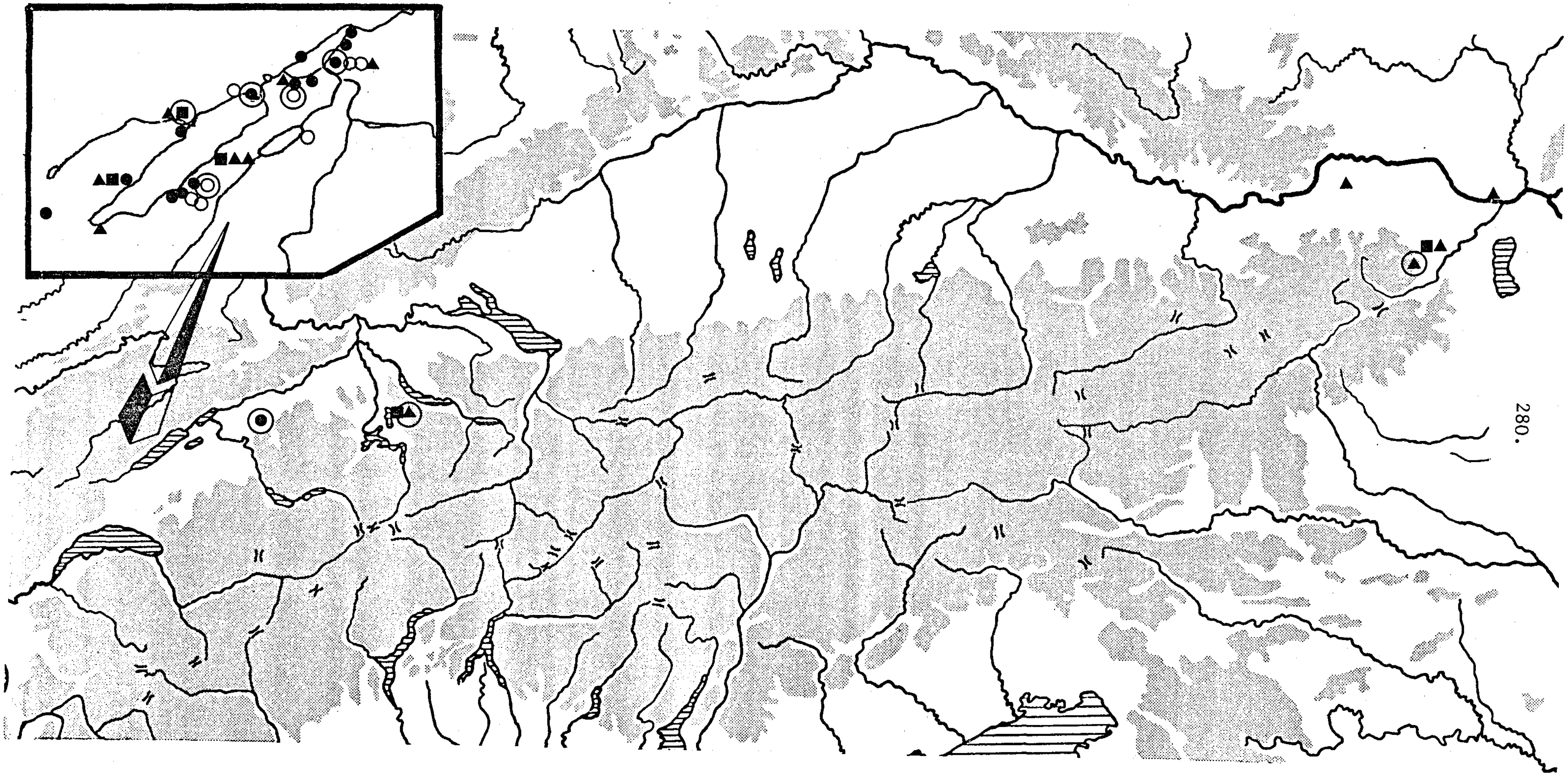
MAP 4. Distribution of flat axes (● ; cf. App. II,IVa) and axe hammers (▲ ; cf. App. IVb).
FU = exact site unknown.



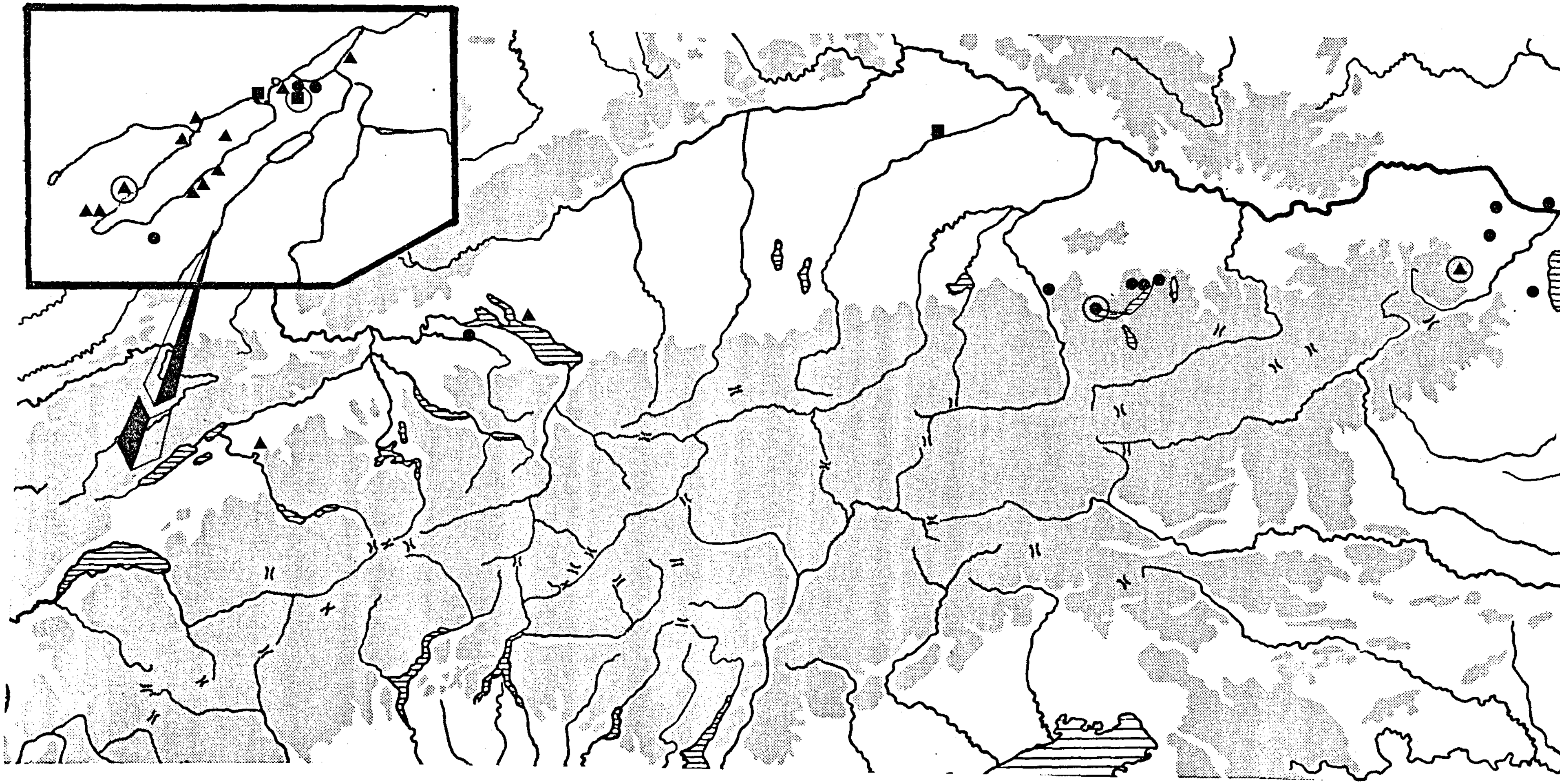
MAP 5 . Distribution of flat daggers (● ; cf App. VI a-g), midribbed and tanged daggers (▲ ; cf. App. VII a-d), knives (■ ; cf. App. VIII a - b) and daggers of uncertain type (○ ; cf. App. VI h).



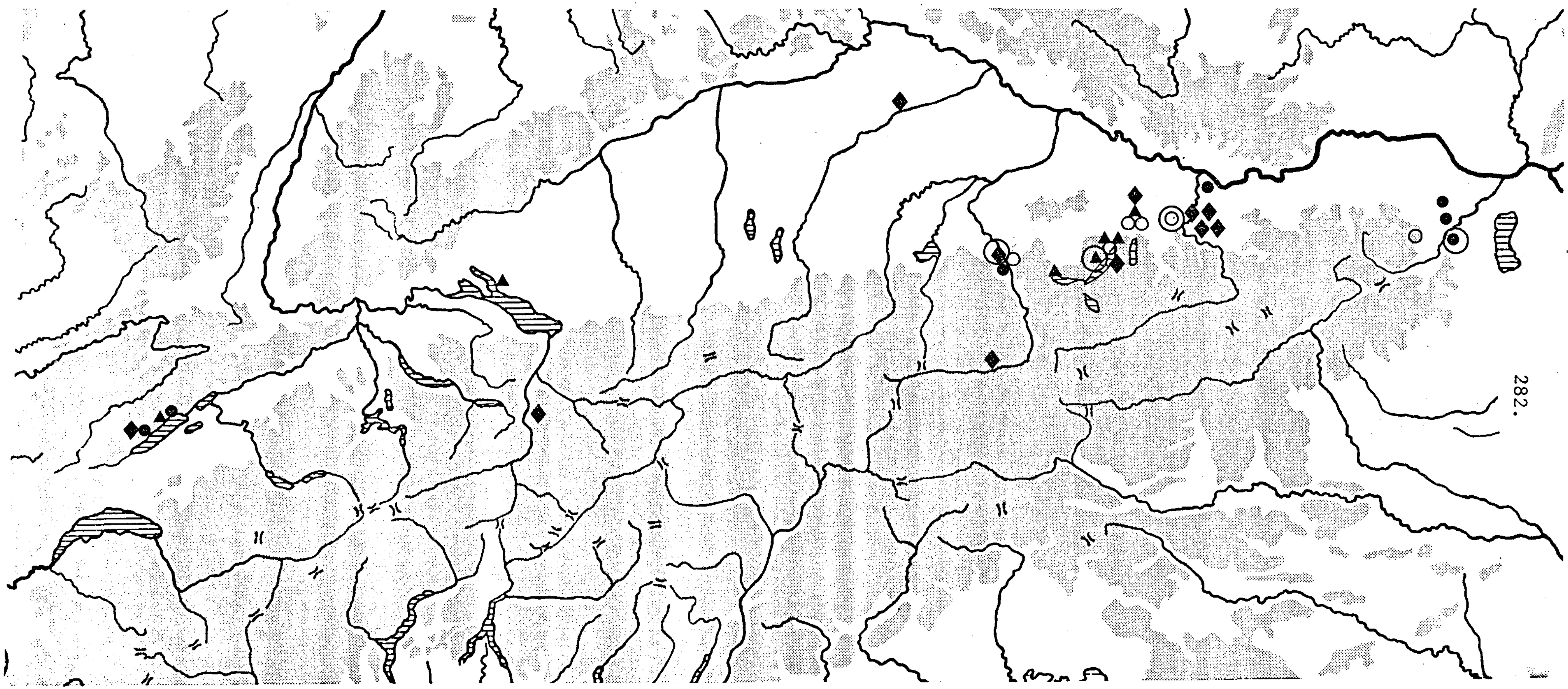
MAP 6. Distribution of Rollennadeln (○ ; cf. App. IXa), awls with round shafts (● ;cf. App. IXb), awls with square shafts and pointed ends (■ ; cf. App. IXc) and chisels (▲ ; cf.App. X).



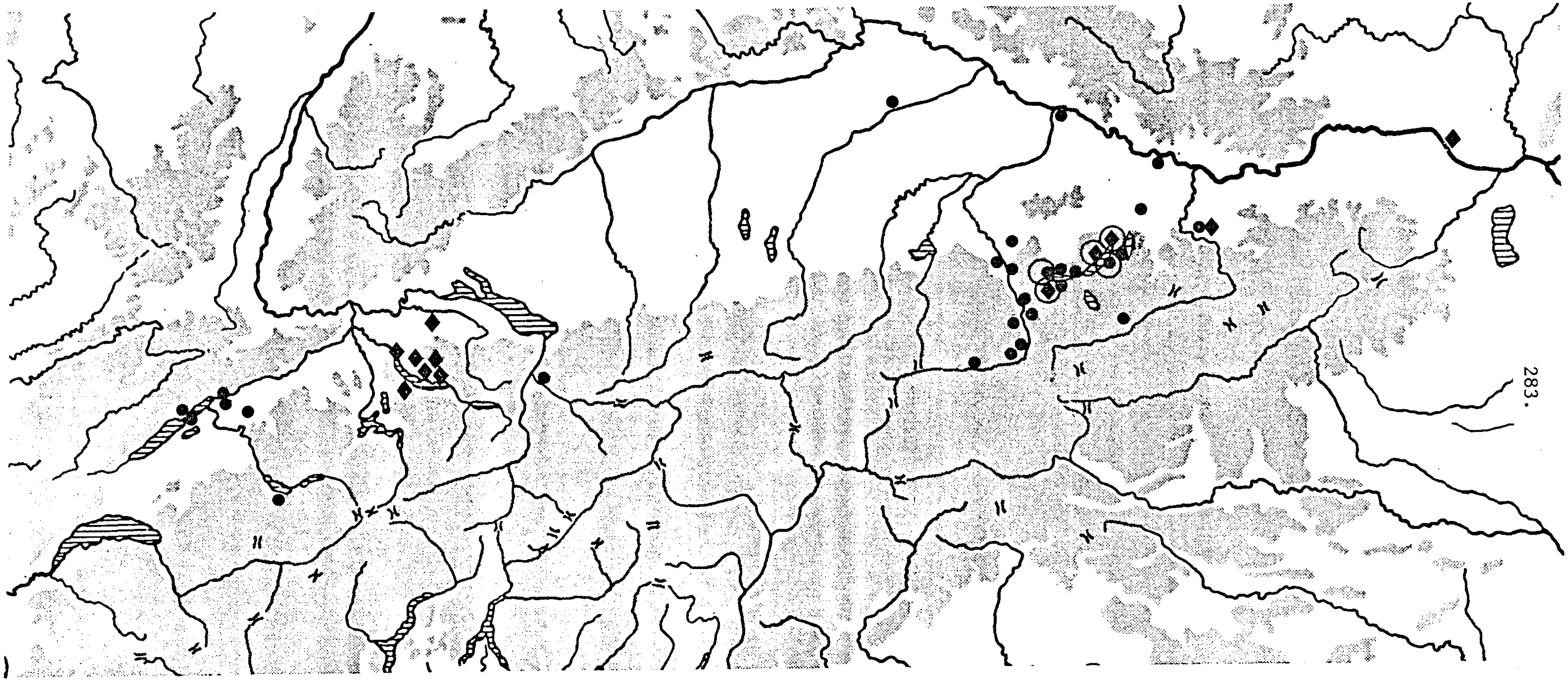
MAP 7. Distribution of ringbeads (●) and biconical beads (○ ; cf. App. XI), of tubes of sheet copper (■ ; cf. App. XII) and spiral cylinders (▲ ; cf. App. XIII).



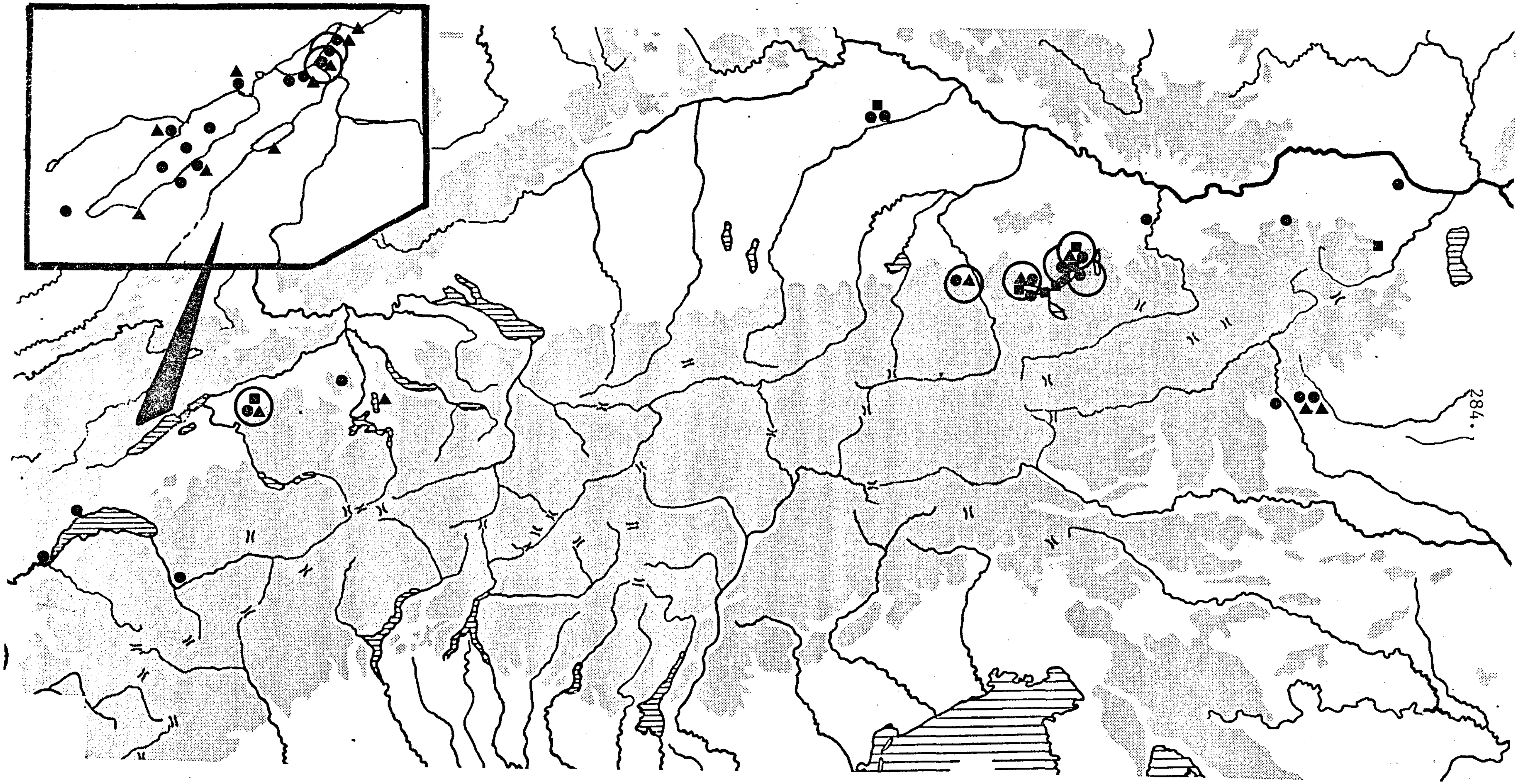
MAP 8. Distribution of single spirals (● ; cf. App. XIV), spectacle spirals (▲ ; cf. App. XV) and pendants (■ ; cf. App. XVI).



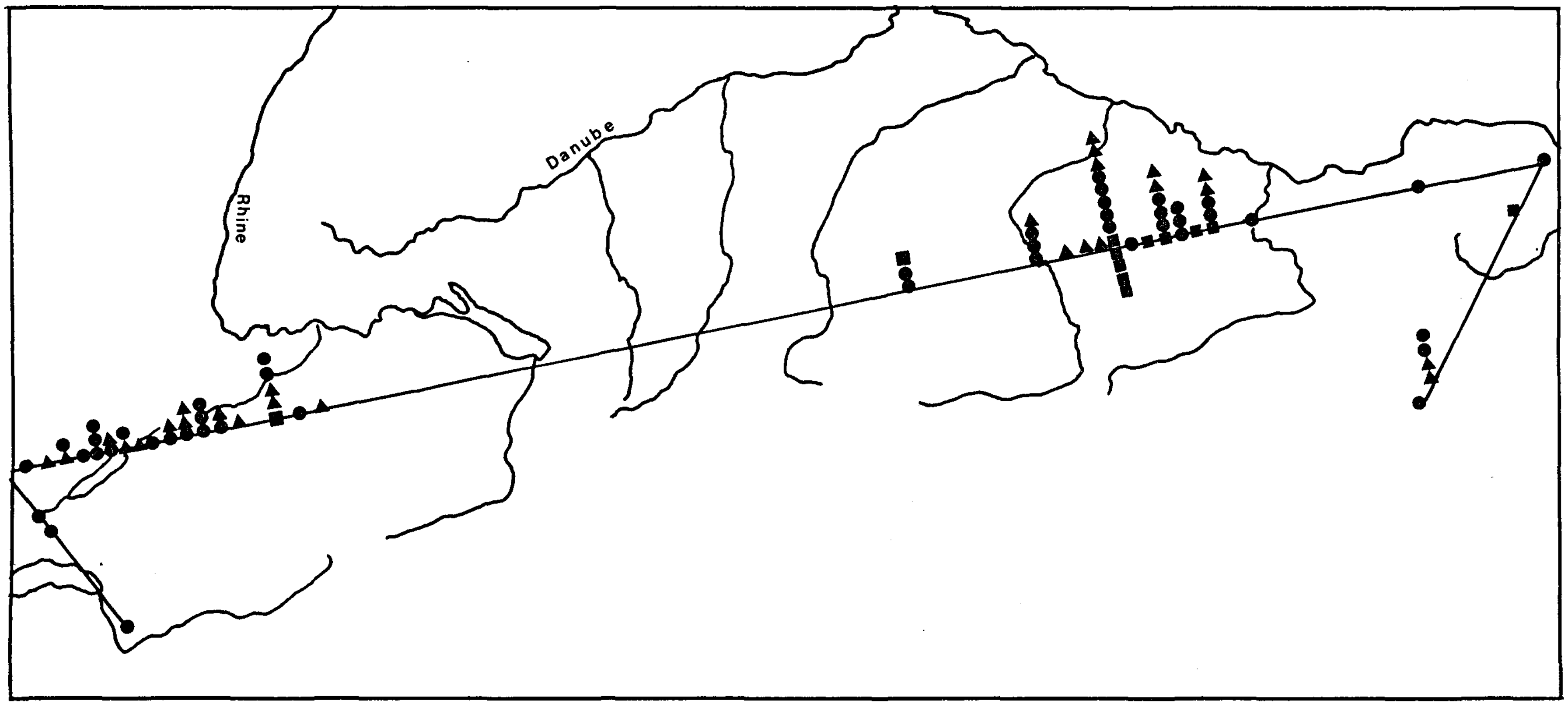
MAP 9. Distribution of Ösenhalsringe (● ; cf. App. XVII), sickles (○ ; cf. App. XVIII), fish hooks (▲ ; cf. App. XIXa) and unidentified copper pieces (◆ ; cf. App. XIXb).



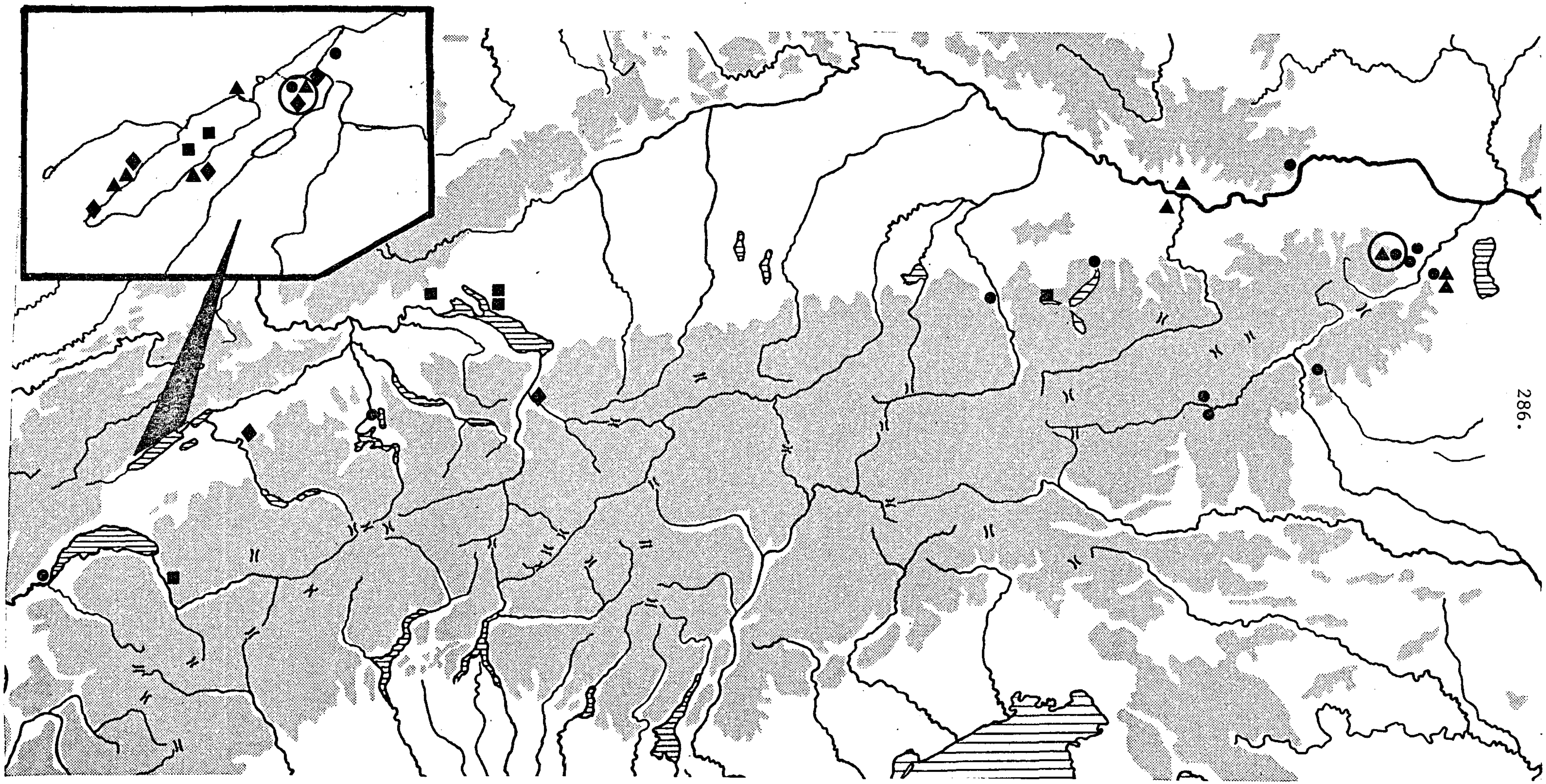
MAP 10. Distribution of pieces and droplets of metal and bun ingots (● ; cf. App. XXa), and crucibles (◆ ; cf. App. XXb).



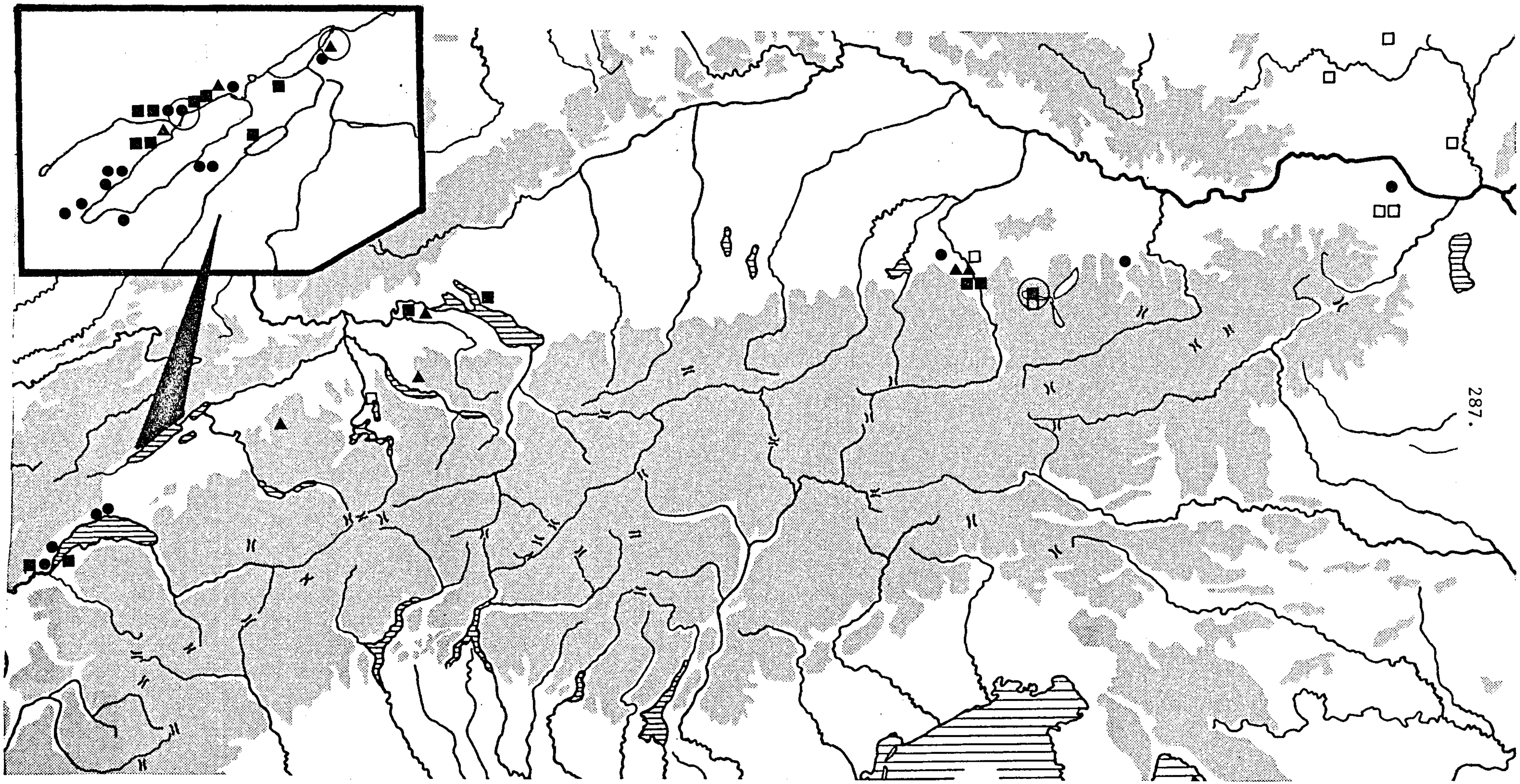
MAP 11. Distribution of copper clusters 1.5 (■), 2 (▲) and 10 (●).



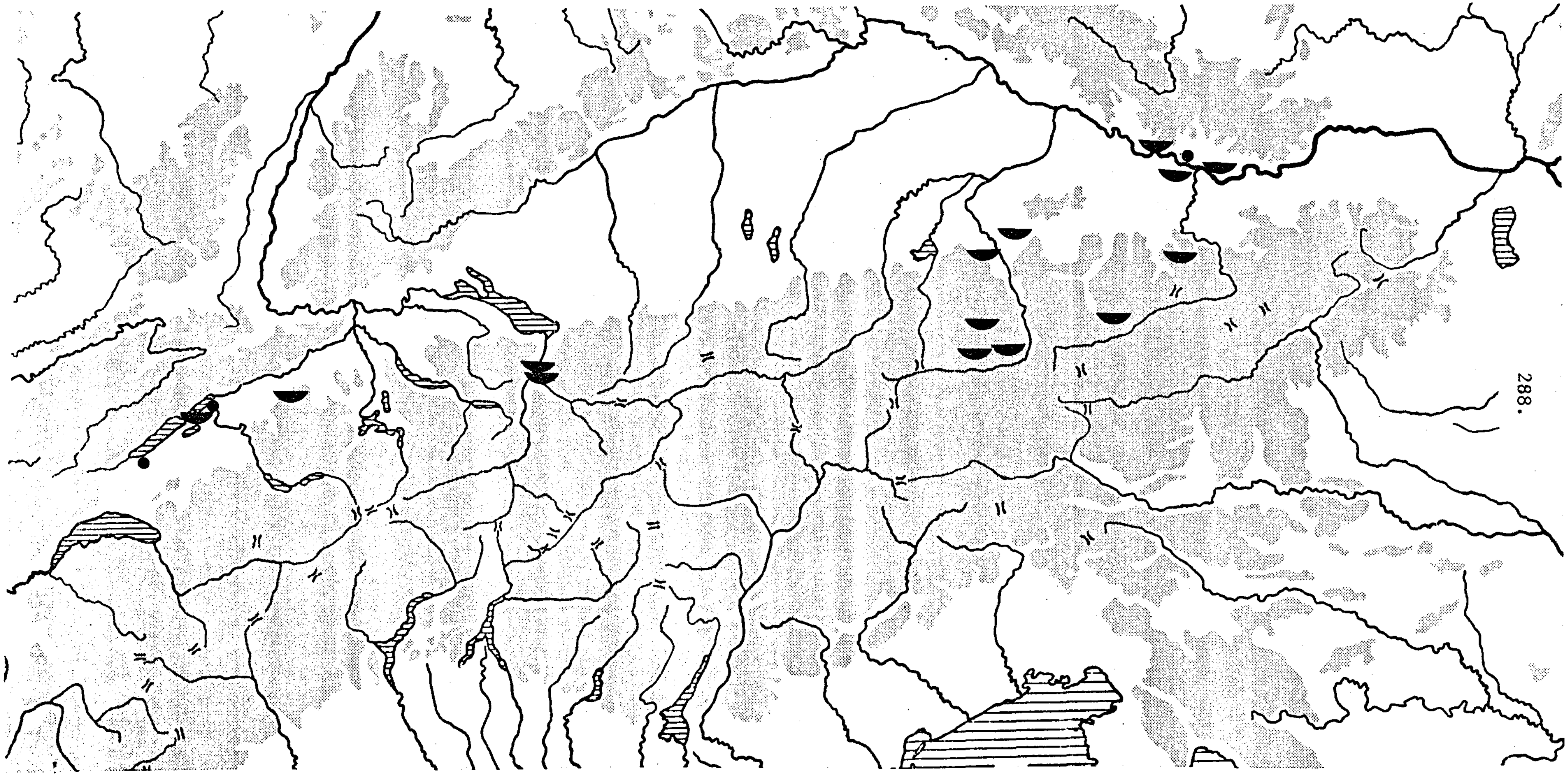
Map 12. Linear distribution of clusters 2 (▲), 1.5 (■) and 10 (●) for the Extension of the Median Test.(cf. Ch.III, p. 111).



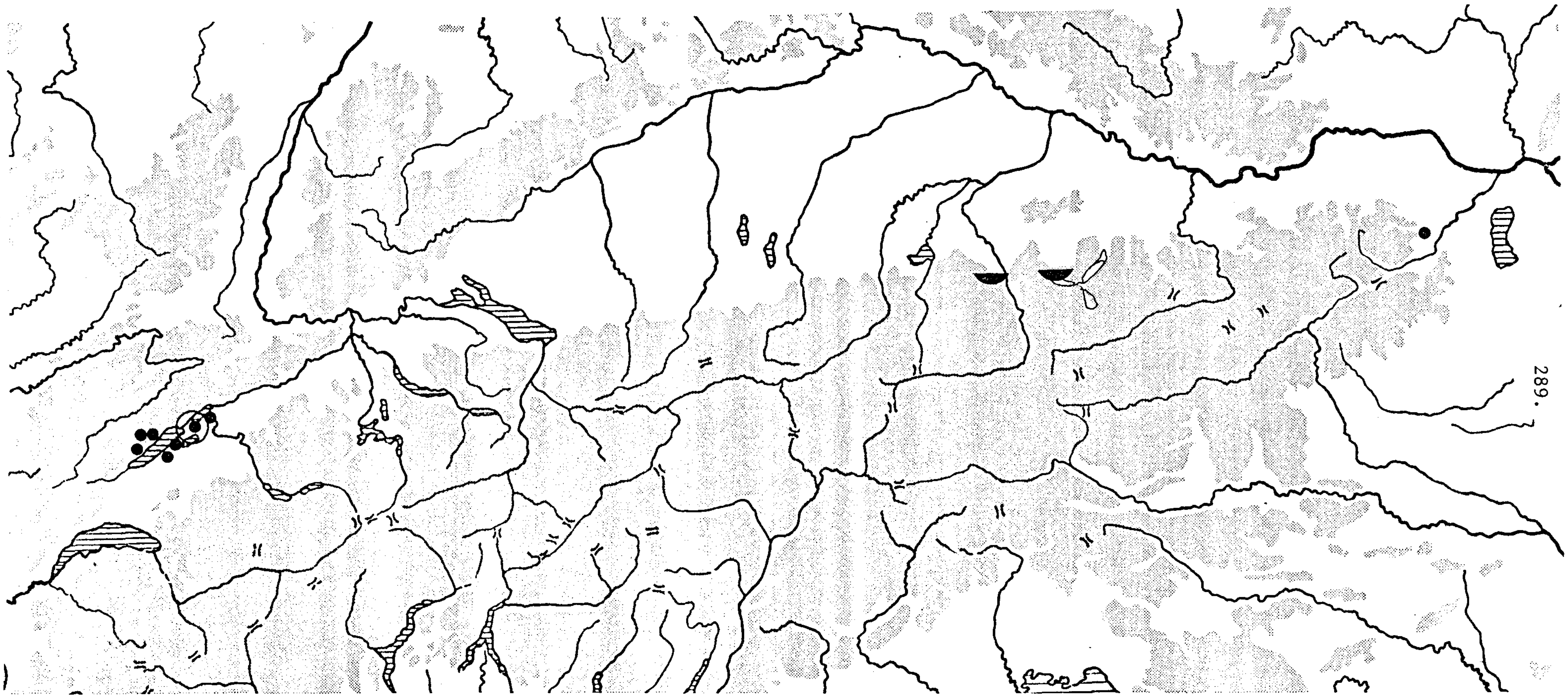
MAP 13. Distribution of copper clusters 1.1 (◆), 1.2 (●), 1.3 (▲) and 1.4 (■)



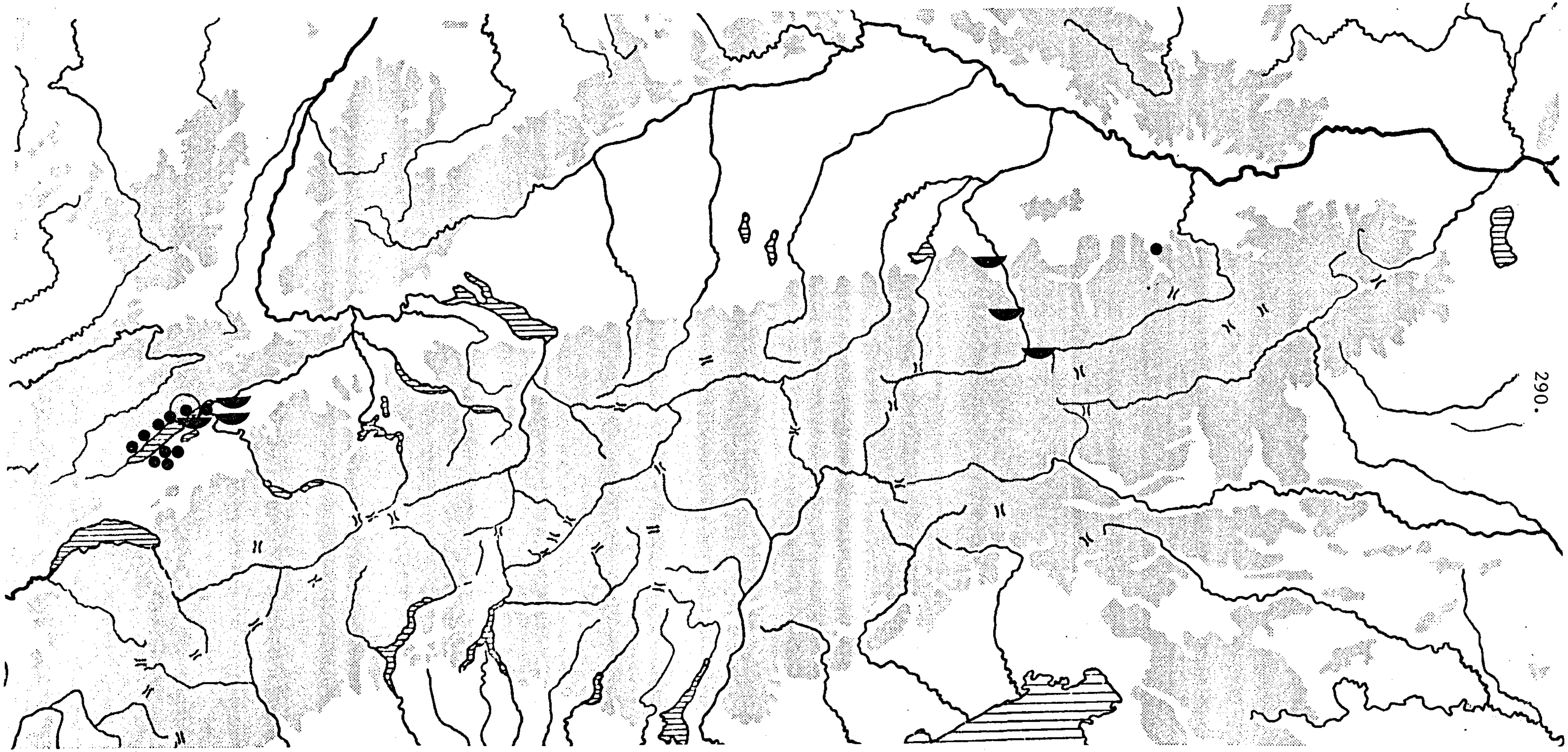
MAP 14. Distribution of copper clusters 5(●), 6 (▲), 8 (□) and 9 (■).



MAP 15. Distribution of copper clusters 7 ; ● = artifacts, ◗ = bun ingots.

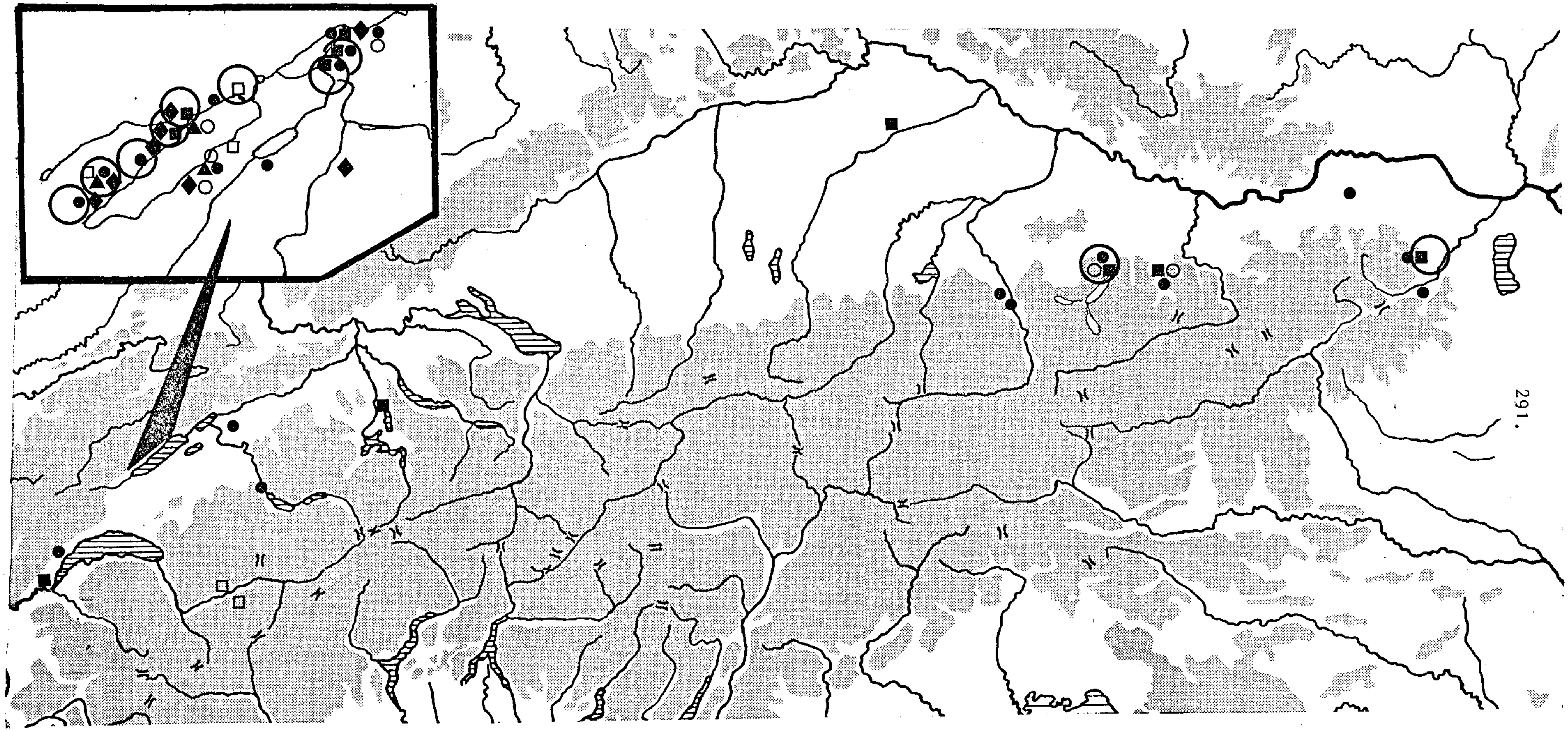


MAP 16. Distribution of copper cluster 3 ; ● = artifacts, ◓ = bun ingots.



290.

MAP 17. Distribution of copper clusters 4 ; ● = artifacts, ◡ = bun ingots.



MAP 18. Distribution of bronze cluster A (■), B (◆), C (▲), D (●), E (○) and F (□).

CAPTIONS TO PLATES

Plate 1 a Tanged dagger, Wien Aspern a.d. Zaya Inv.No.14853
Photograph by courtesy of Museum Asparn a.d.Zaya.

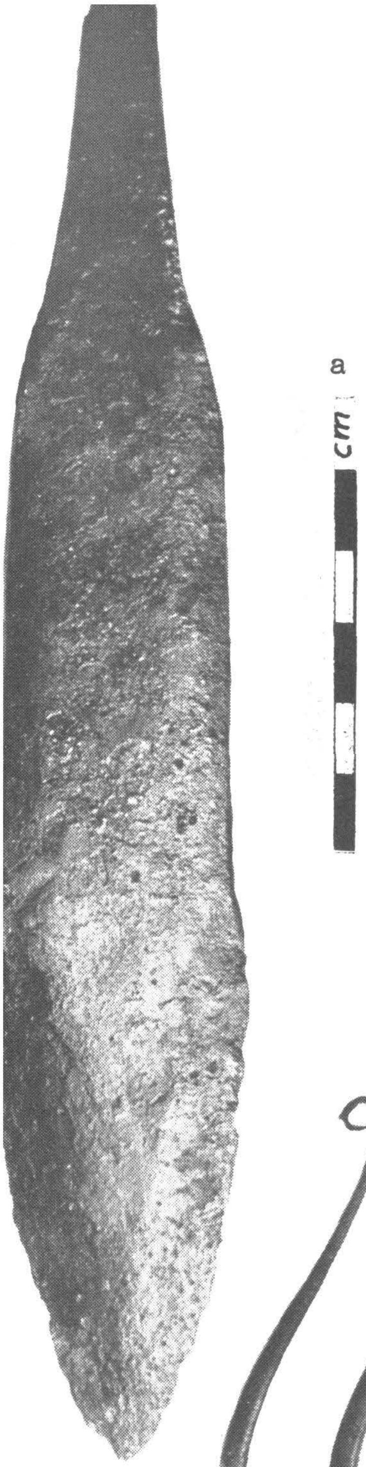
Plate 1 b Earring, Jirawetz. Museum Vienna. Inv. No. 78.950-68

Plate 1 c Spiral, Niederwil, Gachnang. (by permission Dr.Wyss,Zürich)

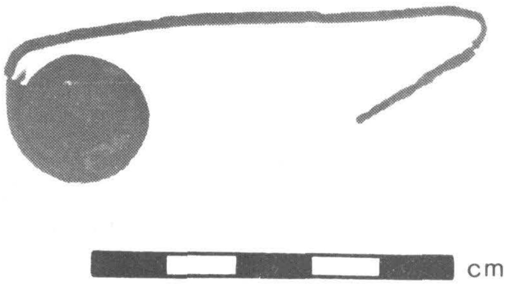
Plate 1 d Enlargement of Pl. 1 c. Photograph by courtesy of Dr.Butler and Prof. Waterbolk, Groningen.

Plate 1 e Ösenring, Lichtenwörth, Museum Asparn a.d. Zaya. Inv. No. 6173.

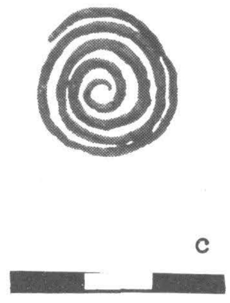
Plate 1 f Droplet of copper, Mondsee, University of Vienna.



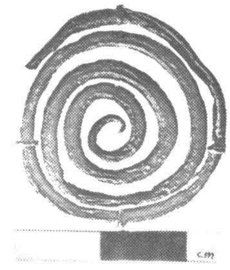
a



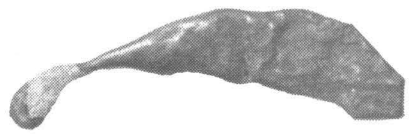
b



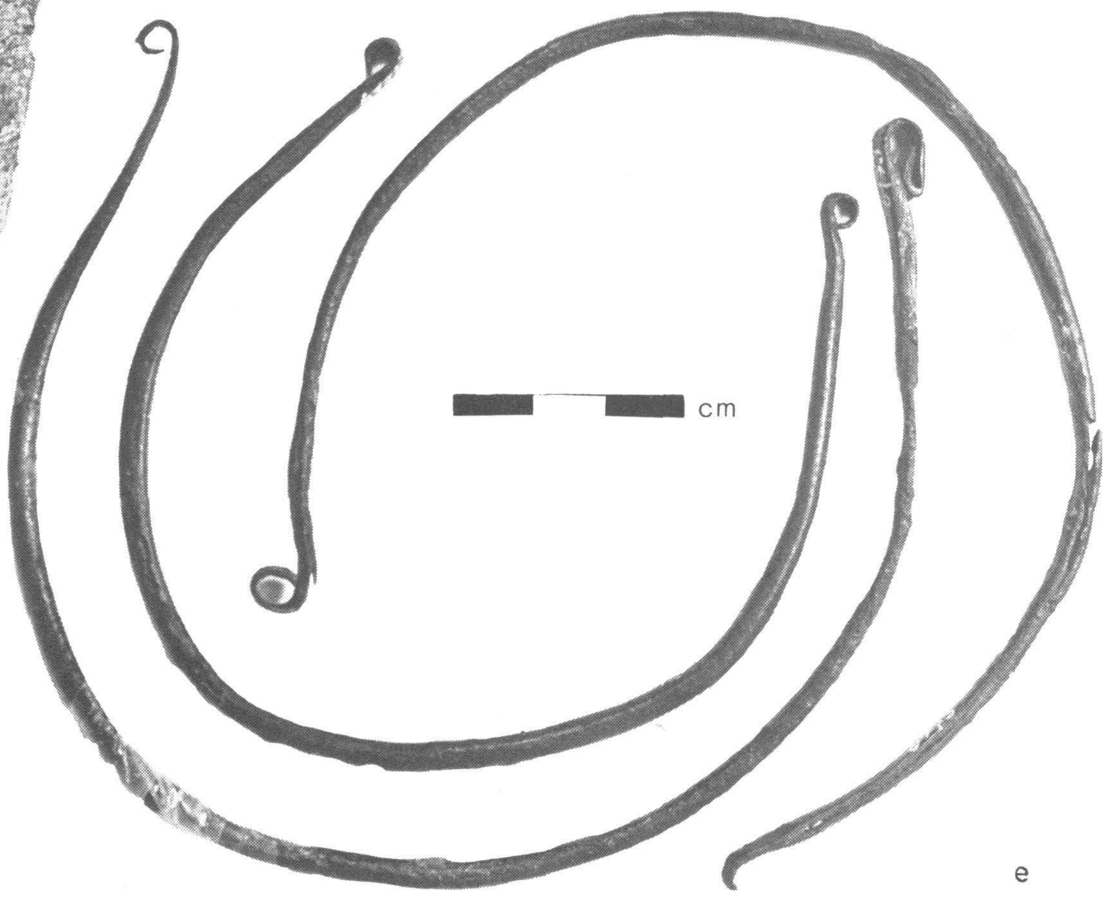
c



d



f



e

Abbreviations used in Appendices.

* Denotes securely associated finds.
F.U. Denotes that the exact find site is unknown.
Old Grouping (in App.II) Refers to grouping after Sangmeister and Strahm (1974,p248)
New Grouping (in App.II) Refers to grouping achieved by discriminant and cluster analysis.
T (in App.II) = Axes of type Thayngen.
B (in App.II) = Axes of type Bevaix.
R (in App.II) = Axes of type Robenhausen.
A.,G.,S. Denote Austria, Germany and Switzerland,respectively,when one catalogue serves all three countries.
Numbers preceding site names in App. II & IVa are those used for discriminant and cluster analysis.
Number in parenthesis after site denotes number of objects of that type found at that site.
Second analysis number in parenthesis (underneath first analysis) denotes duplicate analysis of artifact is available, but was not used in cluster analysis to avoid overweighting.

APPENDIX I

Radiocarbon dates used in Table 2 not collated by Pape (1980+).

^{14}C Dates bp	(bc)	SD	Lab.No.	Site		Reference
ALTHEIM						
5240	(3290)	± 40	GrN 7160	Sengkofen,Germany		Lanting & Mook,1977+,63.
PFYN						
4650	(2700)	-	K ?	Weier III,	Switzerland	Guyan, 1976.
4940	(2990)	-	K ?	Weier II,	"	"
5030	(3080)	-	K ?	Weier I ,	"	"
CORTAILLOD						
4950	(3000)	± 90	B 115/2	Burgäschisee-Süd,	"	Oeschger,1967,157ff
4750	(2800)	±100	B 116/2	"	"	"
4910	(2960)	±260	-	Petit Chasseur,	"	Gallay,1972
4830	(2880)	± 90	-	"	"	"
4750	(2800)	±100	B 234	St.Leonard,	"	Sauter _et al_,1971
5150	(3200)	±120	-	Vallon des Vaux	"	Sitterding,1972,89
4930	(2980)	± 40	GrN 5601	"	"	RC 14,1972,72.
MONDSEE						
4940	(2990)	±120	VRI 311	Scharfling I,	Austria	RC,16,1974,281.
3870	(2920)	±100	VRI 312	Scharfling II,	"	"
4660	(2710)	± 90	VRI 313	Scharfling III,	"	"
4780	(2830)	± 90	VRI 314	Scharfling IV,	"	"
4350	(2400)	± 90	VRI 331	Mooswinkl,	"	RC,17,1975, 252.
4260	(2310)	± 90	VRI 332	"	"	"
4430	(2480)	±100	VRI 333	"	"	"
4390	(2440)	± 80	VRI 355	Misling II,	"	RC,18,1976
4710	(2760)	± 90	VRI 356	Misling II	"	"
4610	(2660)	± 90	VRI 357	Misling II	"	"
4450	(2500)	±100	VRI 358	Misling II	"	"
Baden Boleráz						
4775	(2825)	± 60	Bln 1396	Hlinsko,	Moravia	Quitta,pers.comm.
4675	(2725)	± 60	Bln 1396a	"	"	"
4670	(2720)	± 45	Bln 6941	"	"	"
4670	(2720)	± 40	GrN 6942	"	"	"
4690	(2740)	±240	DIC 364	Bronocice,	Poland (+TRB)	"
4580	(2630)	± 50	Bln 1314	Inowroclaw,	" "	"
HORGEN						
5280	(3330)	±120	B ?	Breitingerstr.,	Switzerland	Drack,1961.
4332	(2382)	± 70	GrN 949	Lac Chalain,	"	Science,1958,128,1553.
5082	(2132)	±135	GrN 670	"	"	"
4270	(2320)	±150	-	Fällanden-Riedspitz	"	Zimmermann,1966+.

bp	^{14}C Dates (bc)	SD	Lab.No.	Site	Reference
LÜSCHERZ					
4960	(3010)	±140	Ny 145	Clairvaux,France	Boisaubert et al,1974.
4640	(2690)	±270	Ly 384	" "	"
4450	(2500)	-	Ly 802	" "	"
CHAM					
4430	(2480)	± 45	GrN 7556	Hienheim, Germany	Modderman, in prep (Bakels, pers.comm.)
4305	(2355)	± 35	GrN 8689	" "	"
SAÔNE - RHÔNE (AUVERNIER, PURE, i.e. not mixed with Corded Ware)					
3970	(2020)	±100	B 2213	Yverdon, Switzerland	Strahm,pers.comm.
4300	(2350)	±110	B 2215	" "	"
4100	(2150)	±120	B 2207	" "	"
4090	(2140)	± 90	B 2212	" "	"
CLASSICAL/LATE BADEN					
4520	(2570)	± 40	GrN 6940	Ossarn, Austria	Ruttkay,1975.
4455	(2505)	± 80	Bln 556	Podolíc, Czechoslovakia	Quitta,pers.comm.
4200	(2250)	±100	Bln 836	Iwanowîce, Poland	"
4380	(2430)	± 60	Bln 1376	Szeghalom,Hungary	"
4350	(2400)	± 45	Bln 1637	Szigetcsép, "	"
4520	(2570)	±160	A 246	Mogyrosdomb, "	"
4290	(2340)	± 80	Bln 350	Hissar,Jugoslavia	"
4175	(2225)	± 60	Bln 1450	Karamani, "	"
4345	(2395)	±110	Z 305	Veliki Mah, "	"
4360	(2410)	± 60	GrN 7351	Gomolava, "	Mook, pers.comm.
CORDED WARE					
4350	(2400)	± 90	B 2929b	Zürich Pressehaus,Switzl.	Ruoff,1978 +.
4180	(2230)	± 60	B 2930a	" "	"(Sakellaridis, pers. comm.).

APPENDIX II - LIST OF FLAT AXES,SWITZERLAND AND LAKE CONSTANCE.

	SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	GROUPING OLD(NEW)	ANALYSIS NO.
01*	CHAM,ST.ANDREAS	FIG. 4 a	ZUG	6000(old), 56/228(new)		T(T)	SAM 2844
02*	WETZIKON,ROBENHAUSEN	FIG. 3 a	ZÜRICH	469 - 1 -		T(R)	-
03*	ZÜRICH,WOLLISHOFEN,	FIG. 3 b	ZÜRICH	1234		T(R)	-
04*	ZÜRICH,WOLLISHOFEN,	FIG. 3 c	ZÜRICH	1233		T(R)	-
05*	ZÜRICH,BAUSCHANZE	FIG. 3 d	ZÜRICH	1003 -11-		T(R)	-
06	DÜRNTEN		ZÜRICH	2336 a-1-		-	SAM 794a
07	GENEVA		GENEVA	8637		-	BAR 29
08	BEX		LAUSANNE	CT 1529		-	SAM 7280
09*	DIETIKON,SENNE	FIG. 4 b	ZÜRICH	2273		T(T)	-
10	CORSIER		GENEVA	7465		-	BAR 31
11*	LIMMAT	FIG. 4 c	ZÜRICH	2243		T(T)	-
12*	RISCH-SCHWARZBACH,	FIG. 3 e	ZUG	9800		B(R)	SAM 2845
13*	MÖNCHALTDORF	FIG. 4 d	ZÜRICH	44661		T(T)	-
14	CHEVROUX		LAUSANNE	9845 II		B(B)	-
15*	HITZKIRCH,SEEMATTE	4 e	HITZKIRCH	185		T(T)	SAM 7293
16	BEVAIX		NEUCHÂTEL	BX177(new),Bx3003(old)		-	BAR66, SAM 22248
17	SEEHAUSEN		-	-	ANTIQUA,1885,T.20,4		-
18	SIPPLINGEN,GERMANY		STUTTGART	-	ANTIQUA,1885,T.20.I		-
19*	VINELZ	FIG. 4 f	BERN	21118		B(T)	SAM 2787
20	VULLY-LE-BAS		FREIBURG	9003			-
21	ZUG-OTTERSWIL		ZUG	-	SAM II		SAM 2846
22	ZÜRICH-SEE		COLL. L. GAUTHIER				-
23	F.U. (IN KT. ZÜRICH)		ZÜRICH	-	ANTIQUA, 1885,T.21,5		-
24	TREYTAL, BEVAIX	FIG. 5 a	ZÜRICH	L4788		B(B)	-
25	EHRENDINGEN		ZÜRICH	2335a-1-			-
26	HALLAU		ZÜRICH	-	OSBORNE, ANTIQUA,1884 T.8.1		-
27	F.U.		NEUCHÂTEL	855			-
28	ST. BLAISE		ZÜRICH	-	GROSS, 1883,T.X,9		-
29	TREYTAL		NEUCHÂTEL	-	VOUGA, 1934,T.24,89		-
30	TREYTAL		NEUCHÂTEL	-	ANTIQUA, 1885,T.25.7		-
31	F.U.		NEUCHÂTEL	1510			SAM 22242
32	VULLY-LE-BAS		NEUCHÂTEL	-	SCHWAB, 1970,ABB.1,2		-
33	WETZIKON,ROBENHAUSEN (WOODEN MODEL)		ZÜRICH	-	MESSIKOMER, 1913, T.17,4		-
34	LANGENBRUCK		LIESTAL	-			-
35	SION		LIESTAL	-	HEIERLI, 1901, ABB.111a		-

APPENDIX II(contd) - LIST OF FLAT AXES, SWITZERLAND AND LAKE CONSTANCE.

	SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	GROUPING OLD(NEW)	ANALYSIS NO.
36	PREZ-VERS-NOREAZ		BERN	29900 (NOW LOST)			-
37	NUSSDORF-MAURACH, G		STUTTGART	A3091			O&W98
38	NUSSDORF-MAURACH ,G.		STUTTGART	A3093			O&W120
39	THAYNGEN		SCHAFFHAUSEN	-	DRACK,1969,ABB.15,6(WRONG FIG.)		O&W99
40	NUSSBACH-MAURACH, G		STUTTGART	A3092			O&W307
41*	VINELZ		BERN	5188			-
42	TRACHSELWALD		BERN	18926			SAM 2862
43	VULLY-LE-BAS		FREIBURG	9001			-
44	STEIN AM RHEIN		SCHAFFHAUSEN	-	ANTIQUA, 1885,87		-
45	GENEVA		GENEVA	8636			SAM 707, BAR 28
46	ST. BLAISE	FIG. 3 f	NEUCHÂTEL	SB40		B(R)	SAM 22268, BAR 61
47*	AUVERNIER	FIG. 4 g	NEUCHÂTEL	1509		T(T)	SAM 22264
48*	ZÜRICH I QUAIBRUCKE		ZÜRICH	9483		T(T)	-
49*	KATZENSEE		-	-	ANTIQUA, 1885,T.21.2	T(T)	-
50*	THAYNGEN		-	-	SAM I,OTTO & WITTER,1952		SAM 099 O&W 99
51*	HORW		COLLECTION LANG		AMREIN, 1939, ABB.31	T(T)	-
52*	EGOLZWIL 4	FIG.4 h	LUZERN	-	SANGMEISTER & STRAHM 1974	T(T)	-
53	MONT-SUR-ROLLE		LAUSANNE	CT 1777		B(B)	-
54	VALLAMEND	FIG.5 b	BERN	9964		B(B)	SAM 2785
55	F.U., LAKE NEUCHÂTEL	FIG.5 c	NEUCHÂTEL	84	(COLL.ARENSE;BEAU)	- (B)	SAM 22243
56	CONCISE		COLOGNE	5043		B(R)	O&W 1184
57	ESCHENZ	FIG.5 d	FRAUENFELD	9366		B(B)	SAM 16600
58	KREUZLINGEN,GERMANY		CONSTANCE	-	REINERTH, 1926	B(B)	-
59	ESTAVAYER	FIG.3 g	BERN	8550		B(R)	-
60	GRENG		BERN	-	SCHWAB, 1970, ABB.2,5	B	-
62	PRÉFARGIER	FIG.3 h	CONCISE(COLL.MEUREN)		ANTIQUA, 1883,T.1213	B(R)	-
63	GRENG		BERN	-	SCHWAB, 1970, ABB.2,1	B	SAM 2860
64	GRENG		BERN	-	SCHWAB,1970, ABB.2,2		-
65	GRENG		BERN	-	SCHWAB, 1970 ABB.2,3		-
66	GRENG		BERN	-	SCHWAB, 1970 ABB.2,4		-
	FULLY		GENEVA	B5730	SAM II		SAM 7073
	GROSSAFFOLTERN		BERN	28187	SAM II		SAM 2867
	MONT		LAUSANNE	CT/1777	SAM II		SAM 7279
	F.U. (LAKE CONSTANCE)		COLL. LANG;HORN-STAAD		PERS. COMM. C. STRAHM		-

APPENDIX III

DATAFILE OF MEASUREMENTS OF ALL SWISS FLAT AXES

NO	L	W1	W2	W3	T	WEIGHT
01.	9.50	1.80	2.40	4.10	14.10	199.00
02.	6.90	2.10	2.55	3.40	5.50	78.20
03.	7.60	2.40	2.70	4.00	7.00	122.10
04.	8.00	2.20	2.80	3.40	6.00	128.20
05.	5.90	1.90	2.60	3.40	6.00	81.80
06.	23.70	2.70	4.05	9.00		
07.	8.86	2.90	3.20	4.60	13.70	303.10
08.	12.90	3.40	4.25	6.40	11.80	437.40
09.	10.00	1.90	2.50	4.00	11.00	183.60
10.	10.44	2.30	3.25	3.90	10.00	191.90
11.	10.25	1.90	2.50	4.00	12.00	219.20
12.	8.70	2.40	3.00	3.70	8.20	134.00
13.	12.90	1.80	2.90	5.30	14.80	349.60
14.	10.77	2.34	4.30	5.70	13.10	307.7
15.	8.20	2.00	2.40	3.85	12.10	150.00
16.	9.30	4.10	4.50	5.10	13.00	370.00
17.	9.50	2.80	4.20	6.00	10.01	
18.	8.20	1.40	2.60	3.00	10.01	
19.	12.00	2.20	3.20	4.35	10.50	
20.	12.30	2.20	4.10	5.50	10.00	367.50
21.	10.77	1.50	3.21	4.74	9.00	36.00
22.	8.20	2.90	3.90	4.90	9.00	
23.	8.50	1.50	3.00	4.50	10.50	393.00
24.	13.80	2.63	3.95	4.80	11.80	
25.	12.85	2.25	3.90	7.20	10.50	393.60
26.	11.60	4.20	6.00	7.00	0.00	0.00
27	16.50	2.60	4.40	8.50	9.00	0.00
28.	6.00	2.80	3.40	5.00	0.00	0.00
29	8.60	3.80	4.20	5.20	10.00	0.00
30.	0.00	0.00	4.05	5.85	0.00	0.00
31	17.60	4.40	6.00	8.50	10.00	
32.	17.80	3.80	5.00	8.00	10.00	0.00
33	13.80	3.00	4.00	5.00	0.00	0.00
34.	9.10	2.00	3.10	4.00	9.00	0.00
35	12.20	1.20	1.20	4.20	0.00	0.00
36.	8.00	1.60	2.20	3.40	0.00	0.00
37	7.50	2.70	3.90	4.80	15.00	0.00
38.	6.60	1.50	2.25	2.85	12.00	0.00
39	21.80	2.00	4.20	7.20	0.00	0.00
40.	6.20	1.00	1.60	1.80	6.00	0.00
41.	10.20	1.90	2.40	2.90	1.30	
42.	14.30	2.00	2.70	4.00	11.00	
43.	18.00	3.90	5.10	8.20	9.50	727.50
44.	16.70	1.60	4.10	6.50	6.00	
45.	23.00	5.15	3.21	10.70	12.00	447.90
46.	8.40	2.20	3.60	4.20	10.01	220.00
47.	10.70	1.90	3.00	4.30	11.50	
48.	12.40	2.30	2.80	3.80	10.01	
49.	12.30	1.80	2.40	3.98	10.50	
50.	10.90	1.00	2.10	3.60	10.01	
51.	10.20	1.00	1.90	3.10	11.00	
52.	12.95	2.35	3.00	4.70	15.00	
53.	10.10	2.70	4.15	5.85	9.50	
54.	16.30	3.10	4.35	6.25	13.00	
55.	11.35	2.40	3.60	5.40	11.50	
56.	6.40	2.20	3.00	3.60	6.00	
57.	10.30	3.30	4.25	5.50	9.50	
58.	10.60	2.50	3.20	4.40	7.00	
59.	6.20	3.10	3.60	4.30	6.50	
60.	14.80	2.30	4.00	5.60	10.01	
62.	7.35	2.60	3.40	3.85	10.01	
63.	7.50	1.60	2.40	2.60	7.00	
64.	7.40	2.00	2.40	3.40	10.01	
65.	10.80	1.60	2.60	4.10	10.01	
66.	12.20	1.80	3.40	5.60	8.00	

APPENDIX IVa - LIST OF FLAT AXES, AUSTRIA AND LOWER BAVARIA.

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
A01 ATTERSEE		VÖCKLABRUCK	637		SAM 14470
A02 ATTERSEE	FIG. 9 b	VÖCKLABRUCK	636		SAM 14467
A03 ATTERSEE	FIG. 9 c	VÖCKLABRUCK	619(A114)		SAM 14466
A04 AUFHAM		VÖCKLABRUCK	638		SAM 14469
A05 GÖSTING		GRAZ	15209		SAM 2481
A06 KRONSTORF		LINZ	4419		O&W 235, BAR 97
A07 LANDFRIEDSTETTEN		WIESELBURG	123		-
A08 LANA-GAULSCHLUCHT		MERAN	92		-
A09 LINZ-ST. PETER	FIG. 9 e	LINZ	4796		BAR 95
A10 MISLING		VÖCKLABRUCK	M115		-
MISLING		VÖCKLABRUCK	613	SAM III	SAM 14465
A11 MISLING		COLL. SCHMIDT		WILLVONSEDER, 1968 T.22.11&22,13	-
A12 MISLING		COLL. SCHMIDT			-
A13 MONDSEE		VIENNA	6555		SAM 4350
A14 MONDSEE		LINZ	6565(A8087)		SAM 4347
A15 MONDSEE		MONDSEE	-		-
A16 MONDSEE		UNI. VIENNA	-		-
A17 MONDSEE		UNI. VIENNA	6564		SAM 4345
A18 MONDSEE		UNI. VIENNA	6566		SAM 4349
A19 MONDSEE		UNI. VIENNA	6558		SAM 4348
MONDSEE		UNI. VIENNA	6562	SAM II	SAM 4340
MONDSEE (FRAGMENT)		UNI. VIENNA	6561	SAM II	SAM 4341, O&W 234
MONDSEE		UNI. VIENNA	6563	SAM II	SAM 4342
MONDSEE		UNI. VIENNA	6560	SAM II	SAM 4343
MONDSEE		UNI.VIENNA	6557	SAM II	SAM 4344
MONDSEE		UNI.VIENNA	6556	SAM II	SAM 4346
MONDSEE		UNI. VIENNA	6559	SAM II	SAM 4351
A20 ATTERSEE		VIENNA	61264		O&W 233
A21 MURAU		GRAZ	14904		-
A22 PETZENKIRCHEN		WIESELBURG	30		-
A23 PÖSHALS	FIG. 9 a	GRAZ	11550		SAM 2474; O&W 6
A24 PREIKLWALD		GRAZ	1094		-
A25 PUSCHACHER		VÖCKLABRUCK	322 PU		-
A26 RAINBERG		SALZBURG	2659	OTTO & WITTER, 1952	O&W 334
A27 RAINBERG		SALZBURG	2658	OTTO & WITTER, 1952	O&W 335
RAINBERG		SALZBURG	2660	OTTO & WITTER, 1952	O&W 352
RETZ		RETZ	291	SAM II	SAM 6373

APPENDIX IVa (contd) - LIST OF FLAT AXES, AUSTRIA AND LOWER BAVARIA.

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
A28 SCHLÖGELSBACH		VIENNA	1547		O&W 315
A29 SEEWALCHEN		VÖCKLABRUCK	140		-
A30 SEEWALCHEN		VIENNA	37463	OTTO & WITTER 1952,	SAM 3612, O&W 232
A31 SEEWALCHEN		COLL. SCHMIDT		WILLVONSEDER, 1968 T.22,12	-
A32 SEEWALCHEN		VIENNA	-	WILLVONSEDER, 1968, T.21,11	-
SPITZ		VIENNA	45829	SAM II	SAM 3780
A33 ST. LORENZ		-	-	OFFENBERGER, 1973, ABB. 64	-
A34 STOLLHOF		WIEN	13794		SAM 4925
A35 STOLLHOF		WIEN	13795		SAM 4926
A36 UNTERWÖLBLING		ASPARN	2547		-
A37 WEYREGG		VIENNA	61264		SAM 3613
A38 WEYREGG		VÖCKLABRUCK	-	REITINGER, 1968, 470	-
A39 ZWERNDORF		STILLFRIED	989	WILLVONSEDER, 1933, ABB.1.5	-
A40 F.U.		VIENNA	17846		SAM 3757
A41 F.U.		VIENNA	16156		SAM 3659
A42 F.U.		VIENNA	17855		SAM 3642
A43 F.U.		VIENNA	15025		SAM 3753
A44 F.U.		VIENNA	17849		SAM 3638
A45 F.U.		VIENNA	17842		-
A46 F.U. (UPPER AUSTRIA)		VIENNA	17854		SAM 3640
A47 UPPER AUSTRIA		ASHMOLEAN	1927:1489		-
A48 F.U.		VIENNA	17425		SAM 3669
A49 F.U.		VIENNA	16155		SAM 3754
A50 F.U. 'HUNGARY?'		GENEVA	B1003		BAR 44
A51 F.U.		ASHMOLEAN	1927:1490		-
A52* ALTHEIM		MUNICH	StS 1919		SAM 8, O&W 278
A53 HARTBERG	FIG. 9 d	GRAZ	14915		-
A54 AUHÖGL		-	-	RITTER,1963,275 DRIEHAUS,1960,T.44	-
A55 F.U.		ASHMOLEAN	1927:1491		-
A56 PLATTENSEE, AUSTRIA		GENEVA	B5330		BAR 42
A57 HARGELSBERG		-	-	HABERMEIER,1974(1973)ABB.31	-
F.U.?SLOVAKIA		VIENNA	17843	SAM II	SAM 3633
F.U.		VIENNA	17853	SAM II	SAM 3641
F.U.		VIENNA	16159	SAM II	SAM 3660
F.U.		VIENNA	16158	SAM II	SAM 3661
F.U.		VIENNA	16157	SAM II	SAM 3667

APPENDIX IVb - AXE HAMMERS & ADZE AXES; AUSTRIA

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
LINZ-ST. PETER	FIG. 9 g	LINZ	A4795		BAR 96
PUCH		-	-	PITTIONI, 1954, FIG. 136	-
STEINDORF		-	-	PITTIONI, 1954, FIG. 141	-
ZWERNDORF* (copy)	FIG. 9 f	VIENNA	6250		-
F.U.		MÖDLING	U5		BAR 104
F.U.?UPPER AUSTRIA		LINZ	A3137		BAR 102

DATAFILE OF MEASUREMENTS OF ALL AUSTRIAN FLAT AXES

NO	L	W1	W2	W3	T	WEIGHT
A01	10.50	2.65	3.50	4.90	10.00	0.00
A02	9.50	3.00	3.70	5.00	8.00	0.00
A03	11.50	2.60	3.40	4.40	8.00	0.00
A04	9.00	2.70	4.00	4.70	7.00	0.00
A05	13.00	2.80	4.10	4.60	8.00	284.00
A06	9.20	2.60	3.30	4.20	7.50	160.00
A07	18.50	3.91	5.00	5.61	13.20	790.00
A08	13.80	1.95	3.00	6.15	14.25	400.00
A09	18.15	1.45	2.70	3.90	13.00	370.00
A10	6.40	2.20	2.90	3.85	6.80	0.00
A11	5.70	1.65	3.15	3.75	0.00	0.00
A12	5.70	1.80	2.70	3.45	0.00	0.00
A13	4.93	1.80	2.53	3.13	0.00	0.00
A14	8.80	3.40	4.00	5.03	8.50	200.00
A15	5.30	1.90	2.90	3.80	7.20	0.00
A16	8.38	3.90	4.05	4.30	3.60	70.00
A17	7.00	2.30	2.90	3.30	5.20	57.00
A18	7.66	2.40	2.80	4.85	9.90	160.00
A19	7.00	2.65	3.60	4.57	7.70	115.00
A20	7.80	2.60	3.00	4.00	0.00	0.00
A21	12.40	2.60	3.00	4.60	7.00	247.00
A22	7.60	2.40	2.20	3.05	6.40	70.00
A23	5.65	2.20	2.70	3.35	7.50	84.00
A24	11.70	3.30	3.90	4.40	5.00	147.00
A25	9.50	3.25	4.35	5.40	7.00	0.00
A26	14.60	2.12	2.80	4.40	12.00	0.00
A27	15.00	2.20	3.20	4.40	12.00	0.00
A28	8.40	2.00	3.40	4.00	4.00	0.00
A29	7.20	2.30	3.70	4.70	7.00	0.00
A30	9.45	2.85	3.60	4.80	0.00	0.00
A31	5.78	1.80	3.08	3.60	0.00	0.00
A32	8.70	2.55	3.45	4.35	0.00	0.00
A33	7.60	2.60	3.20	4.20	6.00	0.00
A34	14.00	2.10	3.70	5.40	16.80	527.00
A35	16.60	2.20	3.40	4.00	22.30	744.00
A36	8.60	1.65	3.55	3.60	9.10	0.00
A37	8.71	2.50	3.40	4.40	8.80	163.00
A38	8.70	2.70	3.75	4.58	0.00	0.00
A39	7.00	1.80	2.60	3.40	0.00	98.00
A40	13.90	4.40	5.40	5.50	13.50	602.00
A41	12.30	3.40	4.10	4.60	11.80	372.00
A42	13.00	2.40	3.00	5.70	13.60	423.00
A43	14.50	1.60	2.65	5.50	15.30	288.00
A44	12.50	2.00	2.40	4.10	6.80	145.00
A45	18.90	2.40	3.70	4.40	21.30	882.00
A46	6.63	1.80	2.40	2.75	7.40	64.00
A47	7.95	3.80	4.20	4.70	3.00	95.00
A48	12.20	2.80	4.15	4.50	12.00	0.00
A49	15.65	7.80	9.00	10.00	11.50	0.00
A50	9.45	3.80	4.50	5.10	12.40	335.60
A51	12.20	6.10	6.90	7.40	9.00	580.00
A52	5.80	1.80	2.40	3.60	6.00	0.00
A53	13.40	1.95	3.35	5.50	15.00	467.00
A54	9.15	2.10	2.48	3.75	5.00	0.00
A55	11.60	3.45	4.60	5.40	12.50	590.00
A56	12.60	2.90	3.55	3.60	4.00	110.70
A57	9.40	1.50	3.20	3.60	9.00	0.00

APPENDIX VIa - LARGE AND SMALL FLAT DAGGERS WITH STRAIGHT HAFTING PLATE -SWITZERLAND.

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
AUVERNIER		BERN	5546		-
BEVAIX (2)		NEUCHÂTEL	-		-
CHEVROUX		LAUSANNE	19039 II		-
CHEVROUX		LAUSANNE	9975 II		-
CORCELETTES		BERN	25600		-
CORCELETTES		BERN	25601		SAM 2963
ESTAVAYER		BERN	89/11-1/28		-
ESTAVAYER		NEUCHÂTEL	EST 17		BAR 70, (SAM 22237)
FONT		?	-	SCHWAB,1970,FIG.4,4; ANTIQUA,1885,T25,1	-
GREIFENSEE 'STOREN'		ZÜRICH	35982		-
LÜSCHERZ		BERN	18648		SAM 2924
LÜSCHERZ		ZÜRICH	8913		-
MÖRIGEN		BERN	7830		SAM 3031
MÖRIGEN		BERN	18853		SAM 2975
ONNENS		LAUSANNE	-		BAR 27
PORTALBAN		COLL. BECK	-	SCHWAB,1970,FIG.4,5; ANTIQUA,1883.	-
VERSOIX		GENEVA	B5801		BAR 35
VERSOIX		GENEVA	9147		BAR 34
VINELZ*	FIG. 11b	ZÜRICH	8991		-
VINELZ*		BERN	-		-
VINELZ*		BERN	-		-
VINELZ*		BERN	5180		SAM 2836
VINELZ*		BERN	5181		SAM 2837
VINELZ*		BERN	5184		-
YVONAND/PEUPLERAIE *	FIG. 11a	?NEUCHÂTEL	-	NOT YET CATALOGUED	BAR 88, (SAM 22050)
F.U.		NEUCHÂTEL	528		-

APPENDIX VIb - FLAT DAGGERS WITH CONCAVE HAFTING PLATE - SWITZERLAND

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
FONT		ESTAVAYER	-	SCHWAB, 1970, FIG. 4,1	-
FONT		COLL. BECK	-	ANTIQUA, 1885, T.14,10	-

APPENDIX VIc - FLAT DAGGERS WITH ROUND HAFTING PLATE - AUSTRIA

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
ATTERSEE	FIG. 11 d	VÖCKLABRUCK	458		-
GREIN, DANUBE		-	-	WILLVONSEDER, 1968, 218	-
LANGENSTEINER WAND*		STEYR	-	KNEIDINGER, 1942, T.IV,52	-
MONDSEE		UNI. VIENNA	6571		-
OBER ELSARN		LANGENLOIS	59		-
SCHNEIDERLOCH		GRAZ	12029		-
SEEWALCHEN, ATTERSEE	FIG. 11 e	VIENNA	62383		SAM 3616
SEEWALCHEN, ATTERSEE		VIENNA	35611		SAM 3614
SEEWALCHEN, ATTERSEE		COLL. SCHMIDT		WILLVONSEDER, 1968, T.23,4	-
SEEWALCHEN, ATTERSEE		COLL. SCHMIDT		WILLVONSEDER, 1968, T.23,7	-
SEEWALCHEN, ATTERSEE		COLL. SCHMIDT		WILLVONSEDER, 1968, T.23,5	-
WEYREGG, ATTERSEE		COLL. SCHMIDT		WILLVONSEDER, 1968, T.23,6	-
WIESELBURG		ASPARN/ZAYA	8663		-

APPENDIX VId - FLAT DAGGERS WITH ROUND HAFTING PLATE -SWITZERLAND

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
AUVERNIER		NEUCHÂTEL	166		BAR 86
AUVERNIER		NEUCHÂTEL	AUV. 915		BAR 93
BEVAIX		NEUCHÂTEL	BX 155		BAR 67, (SAM 22231)
CHAMPREVEYRES		GENEVA	B 2684		BAR 46
CHEVROUX		LAUSANNE	19279 II		-
CHEVROUX		LAUSANNE	16636 II		-
CONCISE		LAUSANNE	26792 I		BAR 13
CORCELETTES		BERN	23599		-
CORCELETTES		BERN	25599		SAM 2962
ESTAVAYER		GENEVA	B5247		SAM 7046, BAR 36
ESTAVAYER		BERN	89/11-1/30		-
FONT		FREIBURG	1379		-
GEROLFINGEN		GENEVA	B 727		SAM 7104
HAUTERIVE		NEUCHÂTEL	HR 427 (OLD:H 156)		BAR 71
LÜSCHERZ		ZÜRICH	8914		-
MÖRIGEN		BERN	7653		SAM 3039
SCHLEINIKON		ZÜRICH	21849		-
SCHMITTEN		FREIBURG	1248		SAM 7164

APPENDIX VIe - LARGE FLAT DAGGERS WITH ROUND HAFTING PLATE - SWITZERLAND

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
CONCISE		NEUCHÂTEL	CONC 61 (49 OLD)		BAR 64
LA RAISSE		NEUCHÂTEL	CONC 844		-
SUTZ LATTRIGEN	FIG. 11 c	ZÜRICH	8989		-

APPENDIX VIf-FLAT DAGGERS WITH TRAPEZOIDAL HAFTING PLATES-AUSTRIA & SWITZERLAND

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
CHEVROUX, S		LAUSANNE	16075 II		-
BEVAIX FRAGMENT,S.		NEUCHÂTEL	BEVAIX 4619		-
ESTAVAYER		FREIBURG	5211		-
SUTZ-LATTRIGEN, S		BERN	3411		SAM 2923
MONDSEE, A		LINZ	6573 (A8086)		-

APPENDIX VIg - UNCERTAIN TYPES OF FLAT DAGGERS - SWITZERLAND

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
GEROLFINGEN		ZÜRICH	9000 (HAFTING PLATE BROKEN)		-
MORGES		LAUSANNE	25214 (2303) (HAFTING PLATE BROKEN)		BAR 25
ST. BLAISE		GENEVA	B4207 (SO-CALLED 'KERBDOLCH')		SAM 7108; BAR 37
VALAIS		GENEVA	B3442 (HAFTING PLATE BROKEN)		BAR 33

APPENDIX VIh - UNCERTAIN TYPES OF DAGGERS - AUSTRIA & SWITZERLAND (ANALYSED BY STUTTGART, BUT COULD NOT BE FOUND IN MUSEUMS)

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
F.U.? ATTERSEE		VÖCKLABRUCK	458 AS	SAM III	SAM 14472
BEVAIX		BIEL	BX 1806	SAM II	SAM 3113
CHEVROUX		BERN	25657	SAM II	SAM 22241
ESTAVAYER		GENEVA	B5247	SAM II	SAM 7046
GEROLFINGEN		GENEVA	B727	SAM II	SAM 7104, BAR 45
GEROLFINGEN		BERN	19606	SAM II	SAM 2922
GRENG (FRAGMENT)		MURTEN	404	SCHWAB,1970, ABB.4, 17	-
GRENG (FRAGMENT)		BIEL	G 1795	SAM II	SAM 3112
MÖRIGEN		BIEL	MO 1647	SAM II	SAM 3115
MÖRIGEN		BERN	7610	SAM II	SAM 3036
MÖRIGEN		BERN	7652	SAM II	SAM 3038
MÖRIGEN		BERN	7837	SAM II	SAM 3043
MÖRIGEN (FRAGMENT)		BERN	18852	SAM II	SAM 2974
NEUCHÂTEL, LA COUDRE		BERN	2520	SAM II	SAM 3032
PORT		BERN	27618	SAM II	SAM 2937
SCHWARZBACH		ZUG	7321	SAM II	SAM 2848
SUTZ-LATTRIGEN		BERN	32423	SAM II	SAM 2820
SUTZ-LATTRIGEN		BERN	3184	SAM II	SAM 2832
THUN		BERN	10342	SAM II	SAM 2831
F.U.		NEUCHÂTEL	-	SAM III	SAM 22244

APPENDIX VIIa - DAGGERS WITH MIDRIB-SWITZERLAND

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
AIGUILLES DES BAULMES		GENEVA	B5159		BAR 47
AUVERNIER		NEUCHÂTEL	572		-
BEVAIX		NEUCHÂTEL	BX 154		BAR 69 (SAM 22230)
BRÜGG		BERN	29596		SAM 2943
CHAMPREVEYRES		NEUCHÂTEL	-		-
CHAMPS DE VEX VALLAIS		GENEVA	B795		BAR 49
CHEVROUX		LAUSANNE	16636 II		BAR 8
CHEVROUX		LAUSANNE	20726 II		BAR 7
COLOMBIER		NEUCHÂTEL	COL 29?21(NEW)2190(OLD)		-
COLOMBIER		NEUCHÂTEL	COL 20 (NEW)COL1873(OLD)		SAM 22234, BAR 76
COLOMBIER		NEUCHÂTEL	COL 17		BAR 75
COLOMBIER		NEUCHÂTEL	COL 27		BAR 73
ESTAVAYER		NEUCHÂTEL	ESTAV 4		-
ESTAVAYER		FREIBURG	5220		-
EAUX VIVES		GENEVA	B1129		BAR 48
FONT		COLL. BECK	-		-
LÜSCHERZ		BERN	3782		SAM 2931
LÜSCHERZ		BERN	3986		SAM 2929
MÖRGES		LAUSANNE	25213		BAR 26
MÖRIGEN		BERN	7648		SAM 3037
MÖRIGEN		NEUCHÂTEL	MOR 21(MÖRIGEN 103(OLD))		BAR 72
PORTALBAN		NEUCHÂTEL	572		-
PORTALBAN		NEUCHÂTEL	PT 2 (P 29)		BAR 78
PORTALBAN	(3)	COLL. BECK	-		-
ST. BLAISE		NEUCHÂTEL	SB 39		BAR 60, (SAM 22238)
ST. BLAISE		ZÜRICH	8995		-
VINELZ*	FIG.11 f	BERN	5195		SAM 2842
VINELZ*	FIG.11 g	BERN	5175		SAM 2834
VINELZ*	FIG.11 h	BERN	5183		SAM 2838
FU.		NEUCHÂTEL	1132		-

APPENDIX VIIb - DAGGERS WITH MIDRIB AND ROUND HAFTING PLATES - AUSTRIA

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
CARNUNTUM		CARNUNTUM	2145		-
BUCHORT, ATTERSEE		-	-		-
LORCH		ENNS	P48		-
MONDSEE		UNI VIENNA	6569		O&W 256
WEYEREGG, ATTERSEE	FIG. 11 i	VIENNA	1658		SAM 3617
WIESELBURG		ASPARN/ZAYA	4320		-
EU.		CARNUNTUM	2147		-

APPENDIX VIIc-DAGGERS WITH MIDRIB AND TRAPEZOIDAL HAFTING PLATES-AUSTRIA AND SWITZERLAND

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
MONDSEE,A		UNI VIENNA	6574		-
MONDSEE, A		UNI VIENNA	6572		-
MÖRIGEN,S		BERN	7610		-
PRÈS LYON,S		GENEVA	B3415		BAR 53
WEYREGG, ATTERSEE, A	FIG.11 k	VIENNA	1657		SAM 3615
EU, A		CARNUNTUM	2146		-

APPENDIX VIId - TANGED DAGGERS - AUSTRIA & SWITZERLAND

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
WIEN XXII-ASPERN,A	FIG.10g,PL.1a	ASPARN/ZAYA	14853		BAR 103
COLOMBIER,S	FIG.10 d	NEUCHÂTEL	COL 18 (525 OLD)		SAM 22233,BAR 77
FONT,S		NEUCHÂTEL	-	SCHWAB, 1970,ABB.2,12	-
LÜSCHERZ,S	FIG. 10 c	ZÜRICH	8911		-
MONRUZ,S		BERN	9520 (OR KNIFE?)		-
ST. BLAISE,S	FIG. 10 e	ZÜRICH	19709		-
ST. BLAISE,S	FIG. 10 f	ZÜRICH	19708		-
ST. BLAISE,S	FIG. 10a	NEUCHÂTEL	SB44		BAR 63, (SAM22239)

APPENDIX VIIIa - KNIVES - AUSTRIA

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
ATTERSEE (4)		COLL. SCHMIDT	(LOST)	WILLVONSEDER, 1968, T.23,8,9,14,16	-
KALTENLEUTGEBEN		COLL. FICHTINGER	(LOST)	MICHNA, 1929, ABB.1,2	-
LANGENSTEINER WAND*		STEYR	-	REITINGER, 1968, P.339	-
MONDSEE		UNI VIENNA	6568		-
PAURA*		BAD WIMSBACH-NEYDHARDING		BENINGER, 1961,63	-
RAINBERG (2)		-	-	HELL & KOBLITZ, 1918, ABB.13,2&3	-
RAINBERG (2)		-	-	HELL, 1943, FIG.2,2&,5	-
RAINBERG		SALZBURG	HELL 304	SAM III	SAM 14477
RAINBERG		SALZBURG	HELL 304	SAM III	SAM 14478
SEEWALCHEN, ATTERSEE		VIENNA	62385		O&W 255
SEEWALCHEN, ATTERSEE	(8)	COLL. SCHMIDT	(LOST)	WILLVONSEDER, 1968, T.23,1-3,10-13,15	-
SEEWALCHEN, ATTERSEE		VIENNA	-	WILLVONSEDER, 1968, T.21,13	-
SEEWALCHEN, ATTERSEE	FIG. 10m	VÖCKLABRUCK	629		SAM 14473
SEEWALCHEN, ATTERSEE	FIG. 10l	VIENNA	62384		SAM 4895
ST. JACOB		GRAZ	11417		O&W 87

APPENDIX VIIIb - KNIVES - SWITZERLAND

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
BEVAIX		NEUCHÂTEL	156		BAR 68 (SAM 22232)
ERLENHÖLZLI	FIG. 10 k	ZÜRICH	42749		-
ESTAVAYER		NEUCHÂTEL	ESTAV. 10		-
ESTAVAYER		NEUCHÂTEL	8		-
FONT		NEUCHÂTEL	-	SCHWAB, 1970, ABB.2,11	-
GEROLFINGEN		BERN	19606	(OR SHEET COPPER?)	-
MONRUZ	FIG. 10 i	BERN	9520	(OR DAGGER?)	-
MORGES		LAUSANNE	25213		-
ST. BLAISE	FIG. 10 h	ZÜRICH	8994		-

APPENDIX IXa - PINS (ROLLENNADEL)-SWITZERLAND

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
AUVERNIER/BRISE-LAME*		-	-	STRAHM 1975a, 19	-
CORCELLE PRÈS CONCISE		LAUSANNE	27457 I		-
YVERDON AV. DES SPORTS		YVERDON	-		-
YVONAND/GEILINGER*	FIG. 12 a	YVERDON	-		BAR 90, (SAM 22140)
YVONAND/GEILINGER*	FIG. 12 b	YVERDON	-		SAM 22141

APPENDIX IXb - AWLS WITH ROUND SHAFTS - AUSTRIA & SWITZERLAND

RAINBERG,A.		-	-	HELL, 1943, ABB.2,4	-
CHEVROUX,S.		LAUSANNE	16835		-
ESTAVAYER,S.		-	-	SCHWAB, 1970, ABB.1,10	-
PORTALBAN,S.		NEUCHÂTEL	-	SCHWAB, 1970, ABB.2,7	-
VINELZ,S.*	FIG. 12 i	BERN	5176		-
VINELZ,S.*		BERN	-	STRAHM, 1971a, FIG.25,12	-

AWLS OF UNCERTAIN TYPE- AUSTRIA & SWITZERLAND

CORTAILLOD, S		BIEL	Cd 970	SAM II	SAM 3156
MÖRIGEN, S		BERN	7777	SAM II	SAM 3041
PRÜCKLERMAUER*, A (2)		STEYR?	-	MITTERKALKGRUBER, 1954	-

APPENDIX IXc - AWLS WITH SQUARE SHAFTS AND POINTED ENDS

AUSTRIA

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
ATTERSEE		COLL. SCHMIDT	LOST	WILLVONSEDER, 1968, T.25	-
OBER-ELSARN		LANGENLOIS	62		-
SEEWALCHEN		VÖCKLABRUCK	543		-
SEEWALCHEN		VIENNA	62386		-
SEEWALCHEN		VIENNA	37465		-
SEEWALCHEN	FIG.12g	VIENNA	62386		SAM 4898
SEEWALCHEN		VIENNA	62386	SAM II	SAM 4899
SEEWALCHEN		VIENNA	-	WILLVONSEDER, 1968, T.24,12	-
SEEWALCHEN		VIENNA	-	WILLVONSEDER, 1968, T.24,11	-
SEEWALCHEN		VIENNA	37465	SAM II	SAM 4900
SEEWALCHEN		VIENNA	37466		SAM 4901
SEEWALCHEN		VIENNA	1511	SAM II	SAM 4896
SEEWALCHEN	FIG.12c	VIENNA	1511	SAM II	SAM 4897

GERMANY

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
ALTHEIM *	(3) Fig.12d,e	MUNICH	1919.601-604		SAM 7
WALLERFING-BACHLING *		-	-	SIEGROTH, 1972, FIG.10,8	-
HANGNAU	(6)	UNTERUHLDINGEN	(IN SHOWCASE;NUMBER NOT OBTAINABLE)		-

APPENDIX IXc (contd.) - AWLS WITH SQUARE SHAFTS AND POINTED ENDS

SWITZERLAND

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
AUVERNIER/LA SAUNERIE *		NEUCHÂTEL	AUV. 2250		BAR 89 (SAM 22224)
AUVERNIER/LA SAUNERIE		NEUCHÂTEL	AUV. 2780		SAM 22223
AUVERNIER		BERN	8438		SAM 3054
BEVAIX		NEUCHÂTEL	BX 49		SAM 22228
BEVAIX		NEUCHÂTEL	BX 76		SAM 22229
CHEVROUX (12)		LAUSANNE	16028 II		-
CONCISE (7)		LAUSANNE	23762		-
CORCELETTES, GRANSON		BIEL	Cs1913		SAM 3151
ESTAVAYER		NEUCHÂTEL	ESTAVAYER 6		SAM 22235
ESTAVAYER		NEUCHÂTEL	ESTAVAYER 11		SAM 22236
LÜSCHERZ		ZÜRICH	8915		-
LÜSCHERZ		BERN	3987		SAM 2927
MÖRIGEN		BERN	7685		SAM 3040
MÖRIGEN		BERN	23380		SAM 3033
MOOSEEDORF		BERN	9945		SAM 3049
ST. BLAISE		ZÜRICH	19712		-
SUTZ		BERN	4891		SAM 2932
VINELZ *		BERN	5198	(PROB. CHISEL)	SAM 2843
VINELZ *		BERN	-	STRAHM 1971a, FIG.25,11	-
VINELZ *		BERN	5196		SAM 3089
VINELZ *		BERN	5193		SAM 3088
VINELZ *	FIG. 12 f	BERN	5192		SAM 3087
VINELZ *		BERN	5178		SAM 2835
VINELZ *		BERN	5169		SAM 2833
VINELZ *	FIG. 12 h	ZÜRICH	8990.		-
YVERDON		YVERDON	-		-
ZUG/SUMF		ZUG	1516		-
ZUG/SUMF		ZUG	398		-
ZUG/SUMF		ZUG	397		-
ZÜRICH/GROSSER HAFFNER *		ZÜRICH	1035-17		-
ZÜRICH/WOLLISHOFEN		ZÜRICH	1190-90		-
ZÜRICH/UTOQUAI		-	-	STRAHM, 1971a, T.27,1	-

APPENDIX X - CHISELS OF SOUTHERN GERMANY & SWITZERLAND

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
BURGÄSCHISEE-SÜD	FIG. 12 k	BERN	50494		SAM 3090
CHEVROUX		BERN	25749		SAM 2953
CHEVROUX		BERN	-		-
CHEVROUX		BERN	25750		SAM 2954
CHEVROUX		LAUSANNE	10291		BAR 2
CHEVROUX		LAUSANNE	20044 II		BAR 3
CHEVROUX		LAUSANNE	16135 II (AWL)		BAR 4
CHEVROUX		LAUSANNE	19783 II		BAR 5
CHEVROUX		LAUSANNE	15981 II		BAR 6
CHEVROUX		LAUSANNE	15976 II		BAR 11
CONCISE		NEUCHÂTEL	Conc 62 (853 old)		BAR 65
CONCISE		BIEL	Ce 1694		SAM 3155
CONCISE (7)		LAUSANNE	28564 I		BAR 17-23
CORCELETTES		LAUSANNE	-		BAR 24
ESTAVAYER		BERN	8647		SAM 3058
FAULENSEE, SPIEZ		BERN	8998		-
GEROLFINGEN		COLMAR	-		SAM 18029
GEROLFINGEN		ZÜRICH	8999		-
HAGNAU (2)		UNTERUHLDINGEN			-
LÜSCHERZ		BERN	18645		SAM 2926
MÖRIGEN		BERN	7819	SAM II ('AWL')	SAM 3042
MÖRIGEN		BERN	23379	SAM II ('AWL')	SAM 3044
ONNENS		LAUSANNE	28430 III		-
PORT, STATION SPERS		BERN	27677		SAM 2941
ST. BLAISE		NEUCHÂTEL	19710		-
VINELZ *	FIG. 12 e	BERN	5194	SAM II('AWL')	SAM 2841
VINELZ *	FIG. 12 m	BERN	5187		SAM 2839 ('AWL')
VINELZ *	FIG. 12 n	BERN	44357		-
VINELZ *		BERN	5196?		-
VINELZ*		BERN	5198		SAM 2843
ZUG, SUMPF		ZUG	1560		-

APPENDIX X (contd.). CHISELS NOT FOUND IN MUSEUMS BUT ANALYSED BY STUTTGART

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
AUVERNIER		BERN	8441	SAM II	SAM 3055
CORCELETTES, GRANSON		BIEL	CS 1917	SAM II	SAM 3153
CORCELETTES, GRANSON		BIEL	CS 1914	SAM II	SAM 3149
CORTAILLOD		BIEL	CD 972	SAM II	SAM 3150
CORTAILLOD		BIEL	CD 974	SAM II	SAM 3152
CORTAILLOD		BIEL	CD 973	SAM II	SAM 3154
CORTAILLOD		BIEL	CD 967	SAM II	SAM 3157
ESTAVAYER		BERN	8544	SAM II	SAM 3078
MÖRIGEN		BERN	7536	SAM II	SAM 2925
F.U. LAKE NEUCHÂTEL		BERN	9525	SAM II	SAM 3046
F.U.		VIENNA	15024	SAM II	SAM 3690

APPENDIX XI - RING-BEADS - SWITZERLAND

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
BAULMES,* ABRI DE LA CURE	(1)	NEUCHÂTEL,	B168 (PRIVATE)		SAM 21674
BURGÄSCHISEE-SÜD*	(56)	BERN	13360		SAM 2987-3026
CONCISE	(1)	NEUCHÂTEL	27457		-
CORTAILLOD	(?1)	BOUDRY	-		-
GEROLFINGEN	(12) FIG.13 a-d	BERN	3039-3054		-
GEROLFINGEN	(8)	BERN	3054		-
GEROLFINGEN	(1)	BERN	27451		SAM 3100
GEROLFINGEN	(1)	BERN	27452		-
GEROLFINGEN	(10)	BERN	27429-438		-
GEROLFINGEN	(5)	BERN	18638-42		-
GEROLFINGEN	(4)	BERN	-	SAM II	SAM 3092-3096
ESTAVAYER	(1)	ZÜRICH	23196		-
FONT	(2)	COLL. BECK			-
LÜSCHERZ	(1)	-	-	FORRER, ANTIQUA 1885	-
MARIN-EPARNIER	(25) FIG.13 e	COLL.BARDEL-THORENS (NOW LOST)		FORRER,1885	-
MÖRIGEN	(1)	BERN	4397		-
SUTZ	(1)	COLL. IRLET			-
VINELZ*	(1)	BERN	-	STRAHM, 1971, FIG. 25,23	-

BICONIAL BEADS - SWITZERLAND

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
ESTAVAYER	(12) FIG.13i,f	ZÜRICH	23196		-
ESTAVAYER	(1) FIG.13 h	ZÜRICH	36003		-
ESTAVAYER-FONT	(1)	ESTAVAYER	-	SCHWAB, 1970, FIG. 3,24	-
FONT	(2) FIG.13k	COLL. BECK	-	SCHWAB, 1970, FIG. 3,23,27	-
GEROLFINGEN	(5)	BERN	27439-53		-
GEROLFINGEN	(1)	BERN	3054		-
MUNTELIER	(1)	FREIBURG	2575		-
ST.BLAISE	(1) FIG.13 l	COLL. ZINTGRAFF,ST. BLAISE,		MUNRO, 1890,FIG. 8,18	-
VINELZ*	(46) FIG.13g	BERN	5236		SAM 2876-2921

APPENDIX XII - TUBES OF SHEET COPPER - AUSTRIA AND SWITZERLAND

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
CHEVROUX, S (1)		LAUSANNE	17190 II		BAR 12
CORCELLES, S (4)		LAUSANNE	27457 I		BAR 15
CONCISE, S (1)		LAUSANNE	-		-
LÖDERSDORF, A (1)		GRAZ	10557		SAM 2478
VINELZ, S* (1)	FIG 13 m	BERN	5190		-
YVERDON, S (1)		YVERDON, COLL. KRATTINGER			-
ZUG, SUMPF, S (1)		ZUG	1568		-

APPENDIX XIII - SPIRAL CYLINDERS

AUSTRIA

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
LÖDERSDORF		GRAZ	10558		SAM 2477
STOLLHOF (7)		VIENNA	13796		SAM 4936-4942
STOLLHOF		VIENNA	13796	SAM II	SAM 6643
STOLLHOF		VIENNA	13796	SAM II	SAM 6644
STOLLHOF (4)		BADEN	243-245,247	SAM II	SAM 6087-6090
UNTERWÖLBLING		ASPARN/ZAYA	-		-
E.U., NEAR CARNUNTUM(6)		CARNUNTUM	1898		-

SWITZERLAND

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
CHEVROUX		LAUSANNE	12205 II	BAND: FLAT	-
CHEVROUX		LAUSANNE	-	BAND FLAT	BAR 14
CHEVROUX		LAUSANNE	20059	BAND: TRIANGULAR	-
CONCISE		LAUSANNE	24720 I		-
CORCELLE		LAUSANNE	27457 I		-
GEROLFINGEN (3)		BERN	-	SAM II	SAM 3097-3099
VINELZ*	FIG. 13 n	BERN	5192		-
ZUG, SUMPF (4)		ZUG	404-407	BAND: TRIANGULAR	-
ZUG, SUMPF (2)		ZUG	409, 410	BAND: FLAT	-
ZUG, SUMPF (2)		ZUG	1569,1609	BAND: FLAT 8mm WIDE	-

APPENDIX XIV - SINGLE SPIRALS - AUSTRIA

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
ATTERSEE		VÖCKLABRUCK	641 AS		-
ATTERSEE		COLL. SCHMIDT (LOST)		WILLVONSEDER, 1968, T.19,18	-
BADEN-KÖNIGSHÖHLE*		BADEN	1458	KYRLE,1924	-
HALLWANG		SALZBURG	5785		O&W 465
MONDSEE		INST. VIENNA	6580	OTTO & WITTER, 1952	O&W 253
MONDSEE		INST. VIENNA	6581		-
MONDSEE		INST. VIENN	6582		-
WIEN-JIRAWETZ* 1)	PL. 1 b	VIENNAVIENNA	78.950-68		-
F.U.		CARNUNTIUM	1898		-

SWITZERLAND

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
NIEDERWIL, GACHNANG*	PL. 1, c,d	PRIVATE COLL.	-		-
NIEDERWIL, GACHNANG* (COPY)		ZÜRICH	48482		-
LÜSCHERZ	FIG. 13 o	BERN	44358		-
VALLON DES VAUX *		-	-	SITTERDING, 1972, 32&86	-
					-

PIECES OF 'WIRE' - AUSTRIA

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
OSSARN*		VIENNA	60855		-
SEEWALCHEN, ATTERSEE		VIENNA	-	WILLVONSEDER, 1968,T.24,19	-

1) Full designation : Wien 21, Leopoldau,Sandgrube Jirawetz.

APPENDIX XV - SPECTACLE SPIRALS

AUSTRIA

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
STOLLHOF (6)		VIENNA	13792 & 13793		SAM 4927-4932

GERMANY

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
'BODENSEE'		-	-	SPINDLER, 19718 FIG. 8a	-
HAGNAU		UNTERUHLDINGEN			-

SWITZERLAND

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
AUVERNIER		ZÜRICH	48706		-
CHEVROUX		BOUDRY	-		-
CONCISE		YVERDON	1564		SAM 7790
CONCISE		LAUSANNE	-		BAR 10
CONCISE		ZÜRICH	59622		-
CORCELETTES		ZÜRICH	-	GROSS, 1883, T.23,12	-
CORCELETTES, GRANDSON		ZÜRICH	9252		-
CORTAILLOD		-	-	MUNRO, 1890, T.10,7	-
ESTAVAYER	FIG. 13 q	COLL. BECK	-	FORRER, 1885, T.14,8	-
FONT	FIG. 13 p	FREIBURG	1455		-
GALS, ST. JOHANN		BERN	22535		-
MÖRIGEN (OF GOLD)		-	-	STRAHM, PERSONAL COMM.	-
MOOSSEEDORF		BERN	30091		-
'NEUCHÂTEL', LAKE		COLOGNE	-	SPINDLER, 1971, FIG. 13	-

APPENDIX XVI - PENDANTS - GERMANY AND SWITZERLAND

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
ALTHEIM*,G	FIG. 13 r	MUNICH	1919.600		SAM 9
ST. BLAISE,S.	FIG. 13 v	NEUCHÂTEL	SB38		BAR 62
VINELZ*,S. (2)		BERN	5185,5186		-
VINELZ*,S.	FIG. 13 s	BERN	5172		-
VINELZ*,S.	FIG. 13 t	BERN	5182		SAM 3086
VINELZ,* FRAGMENT	FIG. 13 n	BERN	5189		-
VINELZ,* FRAGMENT		BERN	5179		-
VINELZ,* FRAGMENT		ZÜRICH	8992		-

APPENDIX XVIIa -LIST OF ÖSENHALSRINGE - AUSTRIA .

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
BADEN-KÖNIGHÖHLE *	FIG.14 a	BADEN		LADENBAUER-OREL,1954	SAM 6080
LEOBERSDORF* (2)		VIENNA	623&624		SAM 3731 & 3730
LICHTENWÖRTH* (3)	FIG.14b,PL.1e	ASPARN/ZAYA	6173		SAM 4638-4639
LICHTENWÖRTH*		-	-	PITTIONI 1954	-
LICHTENWÖRTH* FRAGM. (2)		ASPARN/ZAYA		SAM II	SAM 4636-4637
MAXGLAN, GLANHOFEN (2)		SALZBURG	5784 & 5784A		O&W 155 & 446
ST. PANTALEON		WIESELBURG	31		-

APPENDIX XVIIb - ÖSENBÄNDER - SWITZERLAND

CONCISE		LAUSANNE	-	STRAHM, 1971, FIG. 35,2	-
F.U.	FIG. 14 c	NEUCHÂTEL	1452	STRAHM, 1971, FIG. 35,1	SAM 22240

APPENDIX XVIII - LIST OF SICKLE-KNIVES - AUSTRIA

MICHELDORF (4)	FIG. 14 e	LINZ	A616,618,625,626		BAR91,92,98,99, O&W 401,1049
PAURA*	FIG. 14 d	WYMBSBACH-NEYDHARDING		BENINGER, 1961, FIG. 11,3	-
PAURA, *FRAGMENT		WYMBSBACH-NEYDHARDING		BENINGER, 1961,	-
RAINBERG		SALZBURG	-	HELL & KOBLITZ, 1918	-
SEEWALCHEN		VÖCKLABRUCK	105 S		-
STOLLHOF		VIENNA	13798 (5)		SAM 4943

APPENDIX XIXa - LIST OF FISH HOOKS - AUSTRIA, GERMANY AND SWITZERLAND

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
ATTERSEE,A.	(7)	COLL.SCHMIDT		WILLVONSEDER,1969,T.22,1-7	-
CORTAILLOD,S.		-	-	MUNRO, 1890, FIG. 10,2	-
MONDSEE,A.		-	-	MUNRO, 1890, FIG. 39,14	-
PAURA*,A.	FIG.14 f	WIMSBACH-NEYDHARDING		BENINGER,1961,FIG. 11,4	-
SEEWALCHEN,A.	(5)	VÖCKLABRUCK	-	WILLVONSEDER,1969,T.24,5-9	-
?SEEWALCHEN,A.	(5)	VIENNA	-	WILLVONSEDER,1969,T.24,14-18	-
UNTERUHLDINGEN,S		-	-	MUNRO,1890,FIG.32,12&19.	-

APPENDIX XIXb - LIST OF UNIDENTIFIED METAL PIECES -AUSTRIA,GERMANY & SWITZERLAND

SITE	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
ALTHEIM*,G.	MUNICH	19/601		-
BURGSTALL,A.	HELL-SALZBURG		OTTO & WITTER,1952,	O&W 1313
COLOMBIER,S.	NEUCHÂTEL	COL 22 (P24)		BAR 74
CONCISE,S.	LAUSANNE	25584 I		BAR 16
ESCHEN, S.	ZÜRICH	40275	(BELONGS TO PFYN GROUP)	-
PAURA, A*	WIMSBACH-NEYDHARDING		BENINGER, 1961, 74	-
KLINGELBERG,A.	HELL-SALZBURG		OTTO & WITTER,1952,	O&W 1297
LANGENSTEINER WAND*,A.	STEYR	-	REITINGER,1968,227	-
MAXGLAN, A.	-	-	HELL,1952b (BELONGS TO	-
		-	MÜNCHSHÖFENER GROUP?)	
MUHLBACHGRABEN, A.	LINZ	-	REITINGER,1968,104	-
RAINBERG,A.	-	-	HELL,1943,FIG.2,6	-
REBENSTEINER MAUER*,A.	LINZ	-	REITINGER,1968,104	-
SONNBICHL*,A.	LINZ	-	REITINGER,1968,104	-
WEYREGG,A.	COLL.SCHMIDT	-	REITINGER,1968,468-9	-

APPENDIX XXa - LIST OF PIECES OF METAL OR BUN INGOT AND DROPLETS OF METAL -

AUSTRIA

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
FREINBERG	(2) FIG 14 g	LINZ	A2295&2296		-
GLANEGG		SALZBURG	57896		-
HALLSTATT		LINZ	A2281		-
HEINRICHSBRUCH		LINZ	A2994		-
KIENBERGWAND/MONDSEE(2)		SALZBURG	9137		-
LAIDEREGG/BISCHOFSHOFEN(2)		SALZBURG	1413&1414		-
MATTSEE		HELL-SALZBURG			-
MAXGLAN		HELL-SALZBURG		OTTO & WITTER,1952	O&W 1273
MITTERBERG		HELL-SALZBURG	1720		-
MITTERSEE		HELL-SALZBURG	5312		-
MONDSEE		-	-	FRANZ & WENINGER,1927	-
MONDSEE (DROPLET)	Pl. 1f	-	-	FRANZ & WENINGER,1927	-
MONDSEE (DROPLET)		UNIV. VIENNA	-		-
MÜHLDORF		LINZ	A2283		-
PAURA	(8)	-	-	BENINGER,1961,P.73,74,85,87	-
PRÜCKLERMAUER*		LINZ	-	REITINGER,1968,227	-
RABENSTEIN LUEG		HELL-SALZBURG	-	OTTO & WITTER,1952	O&W.1269
SCHEFFAU		HELL-SALZBURG	-	OTTO & WITTER,1952	O&W 1250
SEEWALCHEN	(3)	VIENNA	62393		-
ST. GEORGEN/PINZGAU		SALZBURG	1408		-
'TRAUNMÜNDUNG & UNTERACH		SALZBURG	A8084	REITINGER, 1968,431	-

GERMANY

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
ALTHEIM*		MUNICH	1919:599-604		SAM 10

SWITZERLAND

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM	ANALYSIS NO.
AESCHI/SPIEZ		BERN	9850		-
BRÜGG/ZIHL		-	-	SAMII	SAM 2940
BRÜGG/ZIHL		-	-	SAM II	SAM 2939
FELDKIRCH/BLASENBERG		BREGENZ	PR.41.1-41.3		-
MÜNCHENBUCHSEE		BERN	9848		-
TSCHUGG	(2)	BERN	9851&9853		-

APPENDIX XXb - LIST OF CRUCIBLES

AUSTRIA

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM
BISAMBERG*, FRAGMENTS		-	-	RUTTKAY, IN PRESS
PRÜCKLERMAUER*		LINZ		REITINGER, 1968, 227
MONDSEE, WITH HANDLES, ROUND		-	-	FRANZ & WENINGER, 1927
MONDSEE, FRAGMENTS (5)		-	-	FRANZ & WENINGER, 1927
MONDSEE, WITH HANDLE, RECTANGULAR		-	-	FRANZ & WENINGER, 1927
MONDSEE, WITH 2 HANDLES		-	-	FRANZ & WENINGER, 1927
MONDSEE (4)		-	-	FRANZ & WENINGER, 1927
MONDSEE, 1 THICKWALLED CLAY PIECE		-	-	FRANZ & WENINGER, 1927
MONDSEE, WITH HANDLE		UNIV. VIENNA	-	REITINGER, 1968, FIG.32
MONDSEE, WITH HANDLE		LINZ	-	REITINGER, 1968, 430
WEYREGG, WITH HANDLE		VIENNA	-	
WEYREGG, WITH HANDLE		VIENNA	20566	
WEYREGG, FRAGMENT		UNI. VIENNA	8688	
SEEWALCHEN, FRAGMENT		COLL. SCHMIDT		WILLVONSEDER, 1968, T.30,8
SEEWALCHEN, WITH HANDLE		COLL. SCHMIDT		WILLVONSEDER, 1968, T.30,7
SEEWALCHEN, HANDLE		COLL. SCHMIDT		WILLVONSEDER, 1968, T.30,6

SWITZERLAND

SITE	ILLUSTRATION	MUSEUM	INVENTORY NO.	REFERENCE IF NOT FOUND IN MUSEUM
HORGEN/DAMPFSCHIFFWEG* (2)		ZÜRICH	-	SANGMEISTER & STRAHM, 1974
NIEDERWIL, GACHNANG*		-	-	WATERBOLK & VAN ZEIST, 1966
MANNEDORF		-	-	ANTIQUA, 1885, 87
PFÄFFIKON, IRGENHAUSEN		-	-	FORRER, 1885, 103
STÄFA, UREIKON		-	-	WINIGER, 1971, T.80, 45-46
WETZIKON-ROBENHAUSEN* (10)		-	-	WYSS, 1969, 136 AND FIG.17,3
ZÜRICH-ENGE, BREITINGERSTRASSE*		-	-	SANGMEISTER & STRAHM, 1974

APPENDIX XXI. DATAFILE WITH RESULTS OF ANALYSES CARRIED OUT BY OTTAWAY

NUMBER OF SAMPLE		SN	PB	AS	SB	AG	NI	BI	AU	ZN	CO	FE
BAR	2	0.00	-.100	1.200	0.200	0.170	-.100	-.1000	0.0080	0.000	0.0280	-.100
BAR	3	11.00	0.170	0.130	0.037	0.000	0.550	0.0091	0.0052	0.000	0.0150	0.200
BAR	4	7.10	0.390	0.610	0.260	0.000	0.085	0.0280	0.0120	0.000	0.1100	0.150
BAR	5	9.70	0.540	0.660	0.180	0.130	0.370	0.0120	0.0170	0.000	0.2100	0.096
BAR	6	13.00	0.850	0.490	0.190	0.000	0.470	0.0000	0.0110	0.000	0.1900	0.040
BAR	7	0.00	0.040	1.100	0.096	0.650	0.720	0.0044	0.0012	0.000	0.0000	0.028
BAR	8	0.00	0.009	0.750	0.066	0.180	0.660	0.0048	0.0009	0.000	0.0000	0.250
BAR	9	0.00	0.002	-.100	-.100	-.100	0.240	0.0076	-.1000	-.100	-.1000	0.580
BAR	10	0.00	-.100	0.036	0.004	0.023	-.100	-.1000	0.0090	0.020	0.0033	0.190
BAR	11	3.80	1.000	0.000	1.200	0.250	0.390	0.0460	0.3600	0.000	0.0730	0.029
BAR	12	7.80	0.620	0.130	0.710	0.130	0.370	0.0350	0.0039	0.000	0.5000	0.053
BAR	13	0.00	0.051	2.600	0.060	0.012	2.600	0.0003	0.0000	0.130	0.0330	0.048
BAR	14	21.00	0.230	0.100	0.260	0.120	0.000	0.0052	0.0100	0.120	0.0280	1.100
BAR	15	0.00	0.000	0.000	0.004	0.003	0.000	0.0030	0.0005	0.000	0.0008	0.110
BAR	16	3.10	0.810	0.390	0.620	0.094	0.280	0.0200	0.0110	0.031	0.0610	0.027
BAR	17	0.00	0.056	-.100	1.600	0.230	0.036	0.0300	-.1000	0.120	0.1500	0.046
BAR	18	11.00	1.600	2.000	0.510	0.150	0.290	0.0180	0.0110	0.000	0.1900	0.033
BAR	19	14.00	0.510	1.200	0.530	0.200	0.073	0.1600	0.0000	0.600	0.0096	0.170
BAR	20	0.00	0.028	0.000	0.007	0.026	0.036	0.0089	0.0000	0.000	0.0028	0.031
BAR	21	7.00	0.370	1.700	0.790	0.260	0.630	0.0052	0.0073	0.260	0.3200	0.045
BAR	22	33.00	0.530	0.320	0.230	0.081	0.085	0.0070	0.0051	0.120	0.0500	0.034
BAR	23	21.00	0.180	0.230	0.200	0.079	0.023	0.0061	0.0000	0.130	0.0100	0.097
BAR	24	7.50	0.370	0.100	0.310	0.110	0.210	0.0023	0.0085	0.000	0.0800	0.025
BAR	25	0.00	0.099	0.000	0.210	0.140	-.100	-.1000	0.0000	0.370	0.0060	-.100
BAR	26	0.00	0.094	0.000	0.000	0.000	0.077	0.0120	0.0000	0.000	0.0340	0.025
BAR	27	0.00	0.410	0.370	0.130	0.054	0.084	0.0008	0.0078	0.130	0.0010	0.280
BAR	28	0.00	0.005	3.700	0.006	0.018	0.095	0.0033	0.0000	0.130	0.0030	0.660
BAR	29	0.00	0.000	0.250	0.074	0.093	0.049	0.0000	0.0000	0.000	0.0030	0.078
BAR	30	0.00	0.008	0.000	1.500	2.200	-.100	0.0140	0.0049	0.000	0.0330	0.380
BAR	31	0.00	0.025	0.000	0.590	4.500	0.021	0.0120	0.0029	0.000	0.0050	0.044

APPENDIX XXI (CONTD).

NUMBER OF SAMPLE		SN	PB	AS	SB	AG	NI	BI	AU	ZN	CO	FE
BAR	32	0.00	0.009	-.100	1.900	2.900	0.690	0.0450	-.1000	0.000	0.0360	0.000
BAR	33	35.00	0.370	0.180	0.099	0.190	0.028	0.0510	0.1000	0.000	0.0650	0.170
BAR	34	0.00	0.230	0.093	0.300	0.110	0.056	0.0091	0.0130	0.000	0.0007	0.026
BAR	35	38.00	0.009	0.170	0.021	0.370	0.000	0.0074	0.0070	0.000	0.0010	0.000
BAR	36	0.00	-.100	0.780	0.000	0.000	-.100	-.1000	0.0009	0.000	0.0040	-.100
BAR	37	0.00	0.033	2.600	0.026	0.056	0.023	0.0057	0.0000	0.000	0.0006	0.074
BAR	38	5.00	0.590	0.000	0.220	0.550	0.039	0.0086	0.0080	0.000	0.0010	0.026
BAR	39	0.00	-.100	0.760	0.870	0.050	-.100	-.1000	0.0180	0.960	0.0160	-.100
BAR	40	0.00	0.041	0.530	0.420	0.046	0.058	0.0050	0.0081	0.500	0.0000	0.000
BAR	41	0.00	0.098	0.039	0.180	0.000	0.005	0.0120	0.0047	0.290	0.0000	0.370
BAR	42	0.00	-.100	3.000	0.140	0.000	-.100	-.1000	0.0130	0.000	0.0000	-.100
BAR	43	0.00	0.014	0.130	0.200	0.000	0.008	0.0077	0.0061	0.250	0.0000	0.110
BAR	44	0.00	0.034	0.500	0.350	0.000	0.000	0.0065	0.0160	0.660	0.0000	0.004
BAR	45	0.00	-.100	0.350	1.300	0.110	0.017	-.1000	0.1100	0.980	0.0120	-.100
BAR	46	0.20	0.120	0.320	0.780	0.000	0.330	0.0098	0.0280	0.660	0.0000	0.053
BAR	47	0.10	-.100	0.400	0.480	0.000	-.100	-.1000	0.0100	0.710	0.0490	-.100
BAR	48	0.00	0.270	0.900	0.370	0.000	0.100	0.0039	0.0490	0.180	0.0000	0.000
BAR	49	15.00	0.000	0.130	0.091	0.046	0.120	0.0710	0.0046	0.280	0.0025	0.000
BAR	50	4.80	0.170	0.000	0.210	0.000	0.028	0.0028	0.0044	0.650	0.0100	0.600
BAR	51	2.00	0.008	0.140	0.130	0.000	0.510	0.0077	0.0000	-.100	0.0000	0.000
BAR	52	3.80	0.092	0.051	0.024	0.000	0.000	0.0000	0.0043	0.910	0.0000	0.084
BAR	53	1.90	0.011	0.210	0.060	0.008	0.047	0.0000	0.0073	0.270	0.0340	0.024
BAR	54	-0.10	0.020	-.100	-.100	-.100	0.079	0.0060	-.1000	-.100	-.1000	0.330
BAR	55	3.20	1.600	0.059	0.170	0.130	0.018	0.0130	0.0840	1.800	0.0070	0.110
BAR	60	3.30	0.068	0.390	0.000	0.000	0.070	0.0010	0.0000	0.860	0.0000	0.001
BAR	61	2.40	0.000	0.000	0.000	0.000	0.019	0.0025	0.0000	0.590	0.0000	0.000
BAR	62	1.90	0.043	0.000	1.600	0.980	0.000	0.0000	0.0000	1.500	0.0130	0.000
BAR	63	0.00	0.004	1.700	0.071	0.000	1.200	0.0059	0.0000	0.000	0.0130	0.050
BAR	64	0.00	0.000	0.020	0.000	0.006	0.039	0.0068	0.0014	0.000	0.0007	0.025
BAR	65	0.00	0.092	0.020	0.000	0.008	0.043	0.0000	0.0004	0.000	0.0009	0.029

APPENDIX XXI (CONTD.).

NUMBER OF SAMPLE	SN	PB	AS	SB	AG	NI	BI	AU	ZN	CO	FE
BAR 66	0.00	0.006	0.000	0.250	0.830	0.042	0.0050	0.0008	0.000	0.0012	0.020
BAR 67	0.00	0.004	0.000	0.000	0.004	0.320	0.0045	0.0005	0.000	0.0012	0.028
BAR 68	0.00	0.001	0.910	0.000	0.006	0.039	0.0170	0.0003	0.000	0.0009	0.026
BAR 69	0.00	0.170	2.700	0.051	0.014	0.041	0.0031	0.0032	0.000	0.0020	0.063
BAR 70	0.00	0.000	0.990	0.190	0.130	0.700	0.0097	0.0004	0.000	0.0045	0.000
BAR 71	3.00	0.280	0.086	0.410	0.044	0.013	0.0230	0.0017	0.000	0.0044	0.220
BAR 72	12.00	0.009	0.470	0.310	0.160	0.670	0.0089	0.0007	0.000	0.0000	0.500
BAR 73	11.00	0.280	0.240	0.100	0.019	0.270	0.0180	0.0053	0.000	0.0190	0.530
BAR 74	7.10	0.840	0.540	0.560	0.082	0.840	0.0068	0.0120	0.000	0.1700	0.055
BAR 75	13.00	0.027	0.460	0.200	0.190	0.046	0.0100	0.0024	0.000	0.0000	0.000
BAR 76	12.00	0.063	0.440	0.220	0.190	0.093	0.0180	0.0022	0.000	0.0000	0.009
BAR 77	0.00	0.011	0.046	0.260	0.850	0.093	0.0037	0.0004	0.000	0.0000	0.046
BAR 78	9.00	0.058	0.510	0.030	0.010	0.240	0.0120	0.0026	0.250	0.0140	0.110
BAR 79	6.70	0.028	0.190	0.200	0.025	0.000	0.0021	0.0008	0.000	0.0000	0.000
BAR 80	0.00	0.230	2.300	5.600	0.057	3.700	0.0250	0.0250	0.000	0.4700	1.500
BAR 81	0.00	0.410	-.100	-.100	-.100	4.000	0.0180	-.1000	0.000	-.1000	0.024
BAR 82	8.90	0.053	0.034	0.053	0.063	0.040	0.0042	0.0120	0.000	0.0017	0.260
BAR 83	5.40	0.018	0.047	0.150	0.052	0.290	0.0081	0.0020	0.000	0.0018	0.035
BAR 84	5.20	0.200	0.000	0.560	0.390	0.066	0.0064	0.0021	0.000	0.0045	0.240
BAR 85	0.00	0.000	0.000	0.008	0.010	0.180	0.0110	0.0013	0.000	0.0038	0.048
BAR 86	0.00	0.075	0.000	2.100	0.540	1.100	0.0037	0.0100	0.000	0.1400	0.140
BAR 87	6.50	0.380	1.600	0.390	0.026	0.110	0.0190	0.0000	0.000	0.0032	0.049
BAR 88	0.00	0.000	0.000	0.000	0.011	0.260	0.0074	0.0089	0.000	0.0024	0.110
BAR 89	0.00	0.027	0.830	0.210	0.320	1.000	0.0140	0.0035	0.000	0.0024	0.590
BAR 90	0.00	0.019	0.590	0.000	0.066	0.037	0.0510	0.0000	0.000	0.0005	0.710
BAR 91	0.00	0.026	3.000	0.045	0.003	1.400	0.0032	0.0000	0.000	0.0220	0.160
BAR 92	2.70	0.000	0.560	0.078	0.005	0.097	0.0130	0.0000	0.000	0.0069	0.150
BAR 93	0.00	0.056	0.930	2.100	-.100	0.900	0.0019	0.0072	0.000	-.1000	0.087
BAR 95	0.00	0.000	0.000	0.000	0.000	0.019	0.0025	0.0020	0.031	0.0004	0.580
BAR 96	0.00	0.023	0.000	0.002	0.003	0.027	0.0019	0.0004	0.032	0.0006	0.000

APPENDIX XXI (CONTD.).

NUMBER OF SAMPLE	SN	PB	AS	SB	AG	NI	BI	AU	ZN	CO	FE
BAR 97	0.00	0.013	1.100	0.005	0.004	0.062	0.0130	0.0000	0.032	0.0004	0.055
BAR 98	0.00	0.000	0.740	0.007	0.011	0.066	0.0082	0.0063	0.045	0.0040	0.044
BAR 99	0.00	0.280	2.500	0.026	0.004	0.034	0.0051	0.0000	0.044	0.0007	0.051
BAR 100	0.00	0.000	0.043	0.004	0.005	0.032	0.0150	0.0000	0.032	0.0290	0.082
BAR 101	0.00	0.062	0.750	0.016	0.008	0.000	0.0160	0.0000	0.039	0.0007	0.130
BAR 102	0.00	0.013	0.000	0.003	0.001	0.042	0.0100	0.0020	0.036	0.0010	0.049
BAR 103	0.00	0.140	-.100	0.032	0.075	0.098	0.0076	-.1000	0.031	0.0004	0.110
BAR 104	0.00	0.009	0.013	0.003	0.006	0.063	0.0140	0.0046	0.027	0.0006	0.300
BAR 106	0.00	0.000	1.400	0.012	0.009	0.019	0.0051	0.0054	0.000	0.0002	0.038
BAR 107	0.00	0.000	0.000	0.066	0.240	0.042	0.0380	0.0037	0.000	0.0005	0.032
BAR 108	15.00	0.710	0.026	0.015	0.022	0.240	0.0120	0.0034	0.000	0.0010	0.027
BAR 109	14.00	1.000	0.026	0.019	0.023	0.015	0.0230	0.0036	0.000	0.0010	0.000
BAR 110	3.10	0.170	0.110	0.078	0.180	0.000	0.0096	0.0056	0.000	0.0040	0.100
BAR 111	3.20	0.200	0.110	0.079	0.180	0.000	0.0092	0.0054	0.000	0.0040	0.086
BAR 112	4.90	7.300	0.000	0.260	0.000	0.530	0.0028	0.0000	5.500	0.0030	0.064
BAR 113	4.30	7.600	0.000	0.260	0.003	0.700	0.0064	0.0000	5.000	0.0030	0.092
BAR 114	0.00	0.000	0.000	0.001	0.000	0.026	0.0000	0.0003	0.000	0.0050	0.760

ALL RESULTS ARE IN PERCENT BY WEIGHT.
METHOD OF ANALYSIS FOR PB,NI,BI & FE WAS ATOMIC ABSORPTION SPECTROSCOPY.
FOR ALL OTHER ELEMENTS THE METHOD WAS NEUTRON ACTIVATION ANALYSIS.
MISSING VALUES ARE DENOTED BY -.100. FOR KEY TO ANALYSIS/ARTIFACT CF APPENDIX XXII.

APPENDIX XXII - List of artifacts analysed by B.S. Ottaway (Key to App. XXI).

Anal. No.	Site	Museum	Inventory no.	Type of artifact
BARB02	Chevroux	Lausanne	10291	Chisel
03	"	"	20044II	"
04	"	"	16135II	"
05	"	"	19783II	"
06	"	"	15981II	"
07	"	"	20726II	dagger with midrib
08	"	"	16636II	" " "
09	"	"	20726II	rivet of dagger Anal No. 07
10	Concise	"	-	spectacle spiral
11	Chevroux	"	15976II	chisel
12	"	"	17190II	tube of sheet copper
13	Concise	"	26792I	flat dagger
14	Chevroux	"	-	spiral cylinder
15	Corcelle	"	27457I	tube of sheet copper
16	Concise	"	25584I	fragment
17	"	"	25562I (Concise B 1896)	chisel
18	"	"	26546I	"
19	"	"	27780I	"
20	"	"	27781I (1899)	"
21	"	"	25570I (1896)	"
22	"	"	24050I (Concise B)	"
23	"	"	28564I	"
24	Corcellettes	"	-	"
25	Morges	"	2303 (25214)	flat dagger
26	"	"	25213	" "
27	Onnens	"	-	" "
28	Geneva, Gas Station	Geneva	8636	flat axe
29	"	"	8637	" "
30	"	"	8638	flanged axe
31	Corsier	"	7465	flat axe
32	'Valais'	"	B5653	dagger with midrib
33	"	"	B3442	flat dagger
34	Versoix	"	9147	" "
35	"	"	B5801	" "
36	Estavayer	"	B5247	" "
37	St. Blaise	"	B4207	" "
38	'Lac de Bienne'	"	13256	flanged axe

APPENDIX XXII contd. (1)

Anal. No.	Site	Museum	Inventory No.	Type of artifact
39	'Pierre a Niton'	Geneva	B1395	flanged axe
40	Fully	"	B5730	" "
41	St. Prex	"	8506	" "
42	Plattensee	"	B5330	flat axe
43	'Hungary'	"	B1001	" "
44	'?Hungary'	"	B1003	" "
45	Gerolfingen, Oefeli	"	B727	flat dagger
46	Champreveyres	"	B2684	" "
47	Aiguilles des Baulmes	"	B5159	dagger with midrib
48	Eaux Vives	"	B1189	" " "
49	Champs de Vex Valais	"	B795	" " "
50	Sion	Prehist.Inst.Geneva	PeI	awl
51	"	" " "	-	Löffelbeil
52	"	" " "	-	"
53	près Lyon	Geneva	B3415	dagger with midrib
54	Pompaples	"	B5536	" " "
55	La Balmes	"	E321	Belt buckle (medieval)
60	St. Blaise	Neuchâtel	SB39	dagger with midrib
61	"	"	SB40	flat axe
62	"	"	SB38	pendant
63	"	"	-	flat dagger
64	Concise	"	Conc61(49)	" "
65	"	"	Conc62(853)	chisel
66	Bevaix	"	Bx177(Bx3003)	flat axe
67	"	"	Bx155	flat dagger
68	"	"	Bx156	flat dagger/knife
69	"	"	Bx154(3023)	dagger with midrib
70	Estavayer	"	Est 17	flat dagger
71	Hauterive	"	Hr427(H156)	" "
72	Mörigen	"	Mör21 (M103)	dagger with midrib
73	Colombier	"	Col 27 (2190)	" " "
74	"	"	Col122 (P24)	awl
75	"	"	Col17 (P190)	dagger with midrib
76	"	"	Col 20 (Col1873)	" " "
77	"	"	Col 18 (525)	flat dagger/knife
78	Portalban	"	Pt2 (P29)	dagger with midrib

APPENDIX XXII contd. (2)

Anal No.	Site	Museum	Inventory No.	Type of Artifact
79	FU	Neuchâtel	-	flanged axe
80	Salez	"	SG2	"
81	"	"	SG1	"
82	Ins	"	-	"
83	Fribourg	"	Fribourg 1	"
84	Sugiez, Fully le bas	"	Sug 4	"
85	Portalban	"	Pt3	"
86	Auvernier	"	Auv 915	flat dagger (reddish zone cf. Anal No. 93 for golden zone.
87	Auvernier	Neuchâtel	Auv 916	dagger with midrib
88	Yvonand*	"?	-	flat dagger, exc. 1973
89	Auvernier*	"	Auv 2250	awl
90	Yvonand*	Yverdon	-	pin awl, awl exc. 1974
91	Michelsdorf	Linz	616	sickle
92	"	"	626	"
93	Auvernier	Neuchâtel	Auv 915	flat dagger from golden zone
95	Linz St. Peter	Linz	A4796	large massive axe
96	"	"	A4795	shafthole axe
97	Kronstorf	"	A4419	flat axe
98	Michelsdorf	"	618	sickle
99	"	"	625	"
100	Mühldorf	"	A2283	bun ingot
102	'Upper Austria'	"	A3137	adze axe
103	Wien-Essling, Asparn	Asparn	14853	tanged dagger
104	Mödling	Mödling	U5	hammer axe (with shafthole)
106	Villa Nova di San Pedro	Arch. Dept. Edinb. Univ.	-	awl
107	"	"	-	"
108	Standard H1	Washington	-	
109	Standard H1	"	-	
110	Standard H2	"	-	
111	Standard H2	"	-	
112	Standard H3	"	-	
113	Standard H3	"	-	
114	Rudna Glava (ore)	-	-	

Identification of objects in Appendix XXI. Figures in parenthesis are old inventory numbers.

APPENDIX XXIII CONVERSION OF NON-NUMERICAL SYMBOLS USED BY OTTO & WITTER AND SAM TO NUMERICAL VALUES

	0.01% (except Bi & Au)	TRACE		+	++	+++	⩾0.05%	⩾1.0%	⩾10%
		SAM	O&W						
Sn	-	0.01	0.01						15
Pb	0.005	0.002	0.005						15
As	0.004	0.002	0.005						
Sb	0.004	0.002	0.005						
Ag	0.005	0.002	0.005						
Ni	0.005	0.002	0.005						
Bi	0.0005	0.0002	0.001						
Au	-	0.0002	0.0002	0.0003					
Zn	0.005	0.002	0.005						
Co	-	0.005	0.005	0.008	0.03	0.05			
Fe	-	0.001	0.001	0.02	0.03		1.5	3.0	

Appendix XXIV

Anal.No	Sn	Pb	As	Sb	Ag	Ni	Bi	Au	Zn	Co	Fe	Artifact	Site	Museum	Inv.No
SAM 7	12.00	0.700	0.360	0.200	0.070	0.310	0.0010	0.0000	0.010	0.0100	0.150	* 'Awl'	Altheim	Munich	1919.604
SAM 2820	4.20	0.000	0.810	0.570	0.190	1.250	0.0000	0.0000	0.000	0.0000	0.000	Dagger	Sutz-Lattrigen	Bern	32423
SAM 2831	15.00	0.000	0.050	0.130	0.029	0.002	0.0050	0.0000	0.000	0.0000	0.000	"	Thun,Renzenbühl	"	10342
SAM 2848	15.00	0.000	0.610	0.150	0.063	0.600	0.0020	0.0000	0.000	0.0000	0.050	"	Hünenberg,Schwarzbach	Zug	7321
SAM 2867	4.50	0.000	0.010	0.270	0.120	0.025	0.0005	0.0000	0.000	0.0000	0.000	Flat axe	Grossaffoltern	Bern	28187
SAM 2932	15.00	0.000	0.290	0.030	0.015	0.240	0.0005	0.0000	0.000	0.0000	0.029	Square awl	Sutz-Lattrigen	"	4891
SAM 2937	4.90	0.000	1.450	3.000	0.710	2.600	0.0002	0.0000	0.000	0.0000	0.000	Dagger	Port,St. Spers	"	27618
SAM 2940	15.00	0.000	0.065	0.000	0.005	0.290	0.0002	0.0000	0.000	0.0080	3.000	'Gussbrocken'	Brügg, Zihl	"	40079
SAM 2943	15.00	0.340	0.170	0.100	0.036	0.048	0.0130	0.0000	0.000	0.0000	0.000	Dagger	Brügg	"	29596
SAM 2974	15.00	3.000	0.620	0.020	0.005	0.810	0.0000	0.0000	0.000	0.0000	0.000	", fragm.	Mörigen	"	18852
SAM 2975	7.20	0.000	0.060	0.120	0.080	0.000	0.0020	0.0000	0.000	0.0000	0.000	"	"	"	18853
SAM 3031	6.10	1.000	0.950	0.580	0.140	0.310	0.0000	0.0000	0.000	0.0000	0.000	", fragm.	"	"	7830
SAM 3038	8.80	0.000	0.030	0.140	0.029	0.042	0.0020	0.0000	0.000	0.0000	0.000	"	"	"	7652
SAM 3039	2.90	0.000	0.139	0.200	0.044	0.028	0.0020	0.0000	0.000	0.0000	0.000	"	"	"	7653
SAM 3040	5.20	0.270	0.440	0.610	0.034	0.029	0.0180	0.0000	0.000	0.0000	0.001	Square awl	"	"	7685
SAM 3043	15.00	0.000	0.740	0.170	0.016	0.260	0.0005	0.0000	0.000	0.0000	0.430	Dagger	"	"	7837
SAM 3054	6.10	0.880	1.050	1.200	0.700	0.920	0.0230	0.0000	0.000	0.0080	0.001	Square awl	Auvernier	"	8438
SAM 3055	9.40	1.050	0.780	1.550	0.740	0.600	0.0170	0.0000	0.000	0.0080	0.013	Square chisel	"	"	8441
SAM 3058	2.10	0.470	0.940	1.300	0.320	0.860	0.0480	0.0000	0.000	0.0000	0.000	" "	Estavayer	"	8647
SAM 3078	10.00	0.640	0.390	0.720	0.100	0.200	0.0120	0.0000	0.000	0.0160	0.730	" "	"	"	8544
SAM 3097	10.00	2.200	0.030	0.080	0.066	0.058	0.0170	0.0000	0.000	0.0000	0.002	Spiral cylinder	Täuffelen,Gerolfingen	"	-
SAM 3098	10.00	1.500	0.020	0.060	0.017	0.087	0.0005	0.0000	0.000	0.0000	0.011	" "	" "	"	-
SAM 3099	10.00	0.170	0.040	0.060	0.005	0.000	0.0060	0.0000	0.000	0.0000	0.015	" "	" "	"	-
SAM 3112	2.75	0.130	0.002	0.000	0.029	0.100	0.0002	0.0000	0.000	0.0000	0.001	Dagger	Oreng	"Biel	01795
SAM 3113	2.10	6.100	0.650	0.940	0.300	0.260	0.0002	0.0000	0.000	0.0000	0.000	"	Bevaix	"	Bx1806
SAM 3149	10.00	12.000	1.100	2.150	1.700	0.350	0.0210	0.0000	0.000	0.0050	0.007	Chisel	Grandson,Corcelettes	"	Cs1914
SAM 3151	10.00	0.000	0.320	0.100	0.044	0.150	0.0005	0.0000	0.000	0.0000	0.067	Square awl	" "	"	Cs1913
SAM 3152	4.30	3.300	1.170	2.750	0.880	0.870	0.3100	0.0002	0.000	0.0080	0.001	Square chisel	Cortaillod	"	Cd974
SAM 3153	10.00	2.130	0.180	0.540	0.076	0.065	0.0080	0.0000	0.000	0.0000	0.057	" "	Grandson,Corcelettes	"	Cs1917
SAM 3154	10.00	15.000	0.620	1.750	0.230	0.530	0.0100	0.0000	0.000	0.0080	0.000	" "	Cortaillod	"	Cd973
SAM 3155	10.00	2.150	0.830	0.450	0.110	0.340	0.0060	0.0000	0.000	0.0080	0.007	" "	Concise	"	Ce1694
SAM 3156	10.00	0.440	0.820	0.660	0.076	0.110	0.0000	0.0000	0.000	0.0000	0.110	Awl	Cortaillod	"	Cd970
SAM 3157	10.00	0.170	0.820	0.200	0.046	0.190	0.0120	0.0000	0.000	0.0000	0.074	Square chisel	"	"	Cd967
SAM 3614	10.00	0.000	0.990	0.040	0.002	0.250	0.0002	0.0000	0.000	0.0000	0.230	Dagger	Seewalchen	Wien	35611
SAM 3616	15.00	0.160	0.510	0.100	0.002	0.210	0.0140	0.0000	0.000	0.0000	1.500	"	"	"	62383
SAM 4635	5.30	0.005	0.260	0.270	0.005	0.240	0.0009	0.0000	0.000	0.0000	0.030	Spiral arm ring	Lichtenwörth	Asparn	4313
SAM 4898	7.30	0.000	0.900	0.060	0.005	0.290	0.0002	0.0000	0.000	0.0000	0.020	Awl	Seewalchen	Wien	62386
SAM 4899	10.00	0.000	0.380	0.040	0.002	0.340	0.0002	0.0000	0.000	0.0000	0.020	"	"	"	62386
SAM 4900	9.00	0.000	0.360	1.020	0.002	0.310	0.0000	0.0000	0.000	0.0000	0.030	"	"	"	37465
SAM 4901	8.70	0.009	0.080	0.003	0.150	0.000	0.0005	0.0000	0.000	0.0000	0.020	"	"	"	37466
SAM 6087	15.00	0.002	0.970	0.080	0.030	0.290	0.0000	0.0000	0.000	0.0000	0.001	Spiral cylinder	Stollhof	Baden	243-245
SAM 6088	6.20	0.050	0.620	0.210	0.150	0.490	0.0110	0.0000	0.000	0.0000	0.020	" "	"	"	247-250
SAM 6089	9.40	1.300	0.140	0.240	0.270	0.020	0.0150	0.0002	0.000	0.0000	0.020	" "	"	"	251
SAM 6090	10.00	0.007	0.200	0.100	0.020	0.320	0.0000	0.0000	0.000	0.0000	0.020	" "	"	"	246
SAM 7051	2.40	7.600	0.350	0.190	0.090	0.230	0.0000	0.0000	0.000	0.0000	0.000	Flat axe	Genf,Crêts St.Laurent	Genf	8636

Appendix XXIV contd. (1)

SAM	7164	4.10	0.005	0.320	0.260	0.270	2.000	0.0000	0.0000	0.000	0.0000	0.000	Dagger	Täuffelen,Gerolfingen	Genf	B727
SAM	7164	2.50	0.030	1.900	2.500	0.730	1.450	0.0000	0.0000	0.000	0.1000	0.000	"	Schmitten,Lanthen	Fribourg	1248
[illegible]	177	12.00	0.005	0.005	0.050	0.100	0.030	0.0010	0.0000	0.000	0.0050	0.000	Ring	Unterwölbling	Wien	51781
[illegible]	401	3.20	0.005	0.170	0.005	0.005	0.070	0.0000	0.0003	0.000	0.0050	0.000	Sickle	Micheldorf	Linz	A625
[illegible]	1049	5.00	0.005	0.500	0.200	0.010	0.800	0.0010	0.0000	0.000	0.0050	2.000	"	"	"	626
[illegible]	1269	4.00	0.005	0.010	0.005	0.005	0.400	0.0010	0.0000	0.000	0.0050	0.001	Pickaxe	Mitterberg (mine)	Salzburg	303
[illegible]	1273	10.50	0.050	0.050	0.100	0.030	0.500	0.0010	0.0000	0.000	0.0050	0.100	Piece of metal	Maxglan	Hell-Salzburg	
BAR	3	11.00	0.170	0.130	0.037	0.000	0.550	0.0091	0.0052	0.000	0.0150	0.200	Chisel	Chevroux	Lausanne	20044II
BAR	4	7.10	0.395	0.010	0.260	0.000	0.085	0.0280	0.0120	0.000	0.1100	0.150	"	"	"	16135II
BAR	5	9.70	0.540	0.660	0.130	0.130	0.370	0.0120	0.0170	0.000	0.2100	0.096	"	"	"	19783II
BAR	6	13.00	0.850	0.490	0.190	0.000	0.470	0.0000	0.0110	0.000	0.1900	0.040	"	"	"	15981II
BAR	11	3.80	1.000	0.000	1.200	0.250	0.390	0.0460	0.3600	0.000	0.0730	0.029	"	"	"	15976II
BAR	12	7.80	0.620	0.130	0.710	0.130	0.370	0.0350	0.0039	0.000	0.5000	0.053	Tube of sheet copper	"	"	17190II
BAR	14	21.00	0.230	0.100	0.260	0.120	0.000	0.0052	0.0100	0.120	0.0280	1.100	Spiral cylinder	"	"	-
BAR	16	3.10	0.810	0.390	0.620	0.094	0.280	0.0200	0.0110	0.031	0.0610	0.027	Fragment	Concise	"	255841
BAR	18	11.00	1.000	2.000	0.510	0.150	0.290	0.0180	0.0110	0.000	0.1900	0.033	Chisel	"	"	26546I
BAR	19	14.00	0.510	1.200	0.530	0.200	0.073	0.1600	0.0000	0.600	0.0096	0.170	"	"	"	27780I
BAR	21	7.00	0.370	1.700	0.790	0.260	0.630	0.0052	0.0073	0.260	0.3200	0.045	"	"	"	25570I
BAR	22	33.00	0.530	0.320	0.230	0.081	0.085	0.0070	0.0051	0.120	0.0500	0.034	"	"	"	24050I
BAR	23	21.00	0.180	0.230	0.200	0.079	0.023	0.0061	0.0000	0.130	0.0100	0.097	"	"	"	28564I
BAR	24	7.50	0.370	0.100	0.310	0.110	0.210	0.0023	0.0085	0.000	0.0800	0.025	"	Corcelettes	"	-
BAR	33	35.00	0.370	0.130	0.099	0.190	0.028	0.0510	0.1000	0.000	0.0650	0.170	Flat dagger	Valais	Geneva	B3442
BAR	35	38.00	0.009	0.170	0.021	0.370	0.000	0.0074	0.0070	0.000	0.0010	0.000	" "	Versoix	"	B5801
BAR	49	15.00	0.000	0.130	0.091	0.046	0.120	0.0710	0.0046	0.280	0.0025	0.000	Dagger	Champs Vex Valais	"	B795
BAR	50	4.80	0.170	0.000	0.210	0.000	0.028	0.0028	0.0044	0.650	0.0100	0.600*	Awl	Sion	P.Inst.Genf	PeI
BAR	60	3.30	0.008	0.390	0.000	0.000	0.070	0.0010	0.0000	0.860	0.0000	0.001	Dagger	St.Blaise	Neuchâtel	SB39
BAR	61	2.40	0.000	0.000	0.000	0.000	0.019	0.0025	0.0000	0.590	0.0000	0.000	Flat axe	"	"	SB40
BAR	71	3.60	0.230	0.080	0.410	0.044	0.013	0.0230	0.0017	0.000	0.0044	0.220	Flat dagger	Hauterive	"	Hr427
BAR	72	12.00	0.009	0.470	0.310	0.160	0.670	0.0089	0.0007	0.000	0.0000	0.500	Dagger	Mörigen	"	Mor21
BAR	73	11.00	0.260	0.240	0.100	0.019	0.270	0.0180	0.0053	0.000	0.0190	0.530	"	Colombier	"	Col27
BAR	74	7.10	0.340	0.540	0.560	0.082	0.340	0.0068	0.0120	0.000	0.1700	0.055	Awl	"	"	Col122
BAR	75	13.00	0.027	0.460	0.200	0.190	0.046	0.0100	0.0024	0.000	0.0000	0.000	Dagger	"	"	Col17
BAR	76	12.00	0.003	0.440	0.220	0.190	0.093	0.0180	0.0022	0.000	0.0000	0.009	"	"	"	Col20
BAR	77	9.00	0.058	0.510	0.030	0.010	0.240	0.0120	0.0026	0.250	0.0140	0.110	"	Portalban	"	Pt2
BAR	87	6.50	0.380	1.000	0.390	0.026	0.110	0.0190	0.0000	0.000	0.0032	0.049	"	Auvernier	"	Auv916
BAR	92	2.70	0.000	0.560	0.078	0.005	0.097	0.0130	0.0000	0.000	0.0069	0.150	Sickle	Michelsdorf	Linz	626

Appendix XXV (Data file of copper artifacts)

FILE IDENTIFIER : CU362

* = securely associated

Anal.No	Sn	Pb	As	Sb	Ag	Ni	Bi	Au	Zn	Co	Fe		Artifact	Site	Mus.	Inv.No
SAM 8	0.00	0.002	0.170	0.002	0.020	0.010	0.0010	0.0000	0.000	0.0000	0.000	*	flat axe	Altheim	München	1919.599
SAM 9	0.00	0.060	1.150	0.020	0.050	0.050	0.0020	0.0000	0.000	0.0000	0.000	*	sheetmetal piece	"	"	".600
SAM 10	0.00	0.080	1.750	0.050	0.100	0.070	0.0090	0.0000	0.000	0.0000	0.000	*	'Gusstück'	"	"	?
SAM 794a	0.20	1.300	0.000	0.100	0.030	0.090	0.0010	0.0000	0.000	0.0000	0.000		flat axe	Dürnten	Zürich	2336 a-1?
SAM 2474	0.00	0.000	0.000	0.007	0.016	0.000	0.0000	0.0000	0.000	0.0000	0.000		flat axe	Pöls,Judenberg	Graz	11550
SAM 2475	0.00	0.019	0.500	0.066	0.011	0.005	0.0005	0.0002	0.000	0.0000	0.000		ring	Lödersdorf	"	10553
SAM 2477	0.00	0.017	0.450	0.060	0.016	0.005	0.0010	0.0002	0.000	0.0000	0.001		spiral cylinder	"	"	10558
SAM 2478	0.00	0.000	0.940	0.050	0.016	0.005	0.0020	0.0002	0.000	0.0000	0.001		tube	"	"	10557
SAM 2481	0.00	0.005	1.200	0.030	0.014	0.002	0.0020	0.0002	0.000	0.0000	0.001		flat axe	Graz,Gösting	"	15209
SAM 2776	0.00	0.000	0.020	0.010	0.072	0.120	0.0005	0.0000	0.000	0.0000	0.001		'Gusskuchen'	Feldkirch,Blasenbg.	Bregenz	41.3
SAM 2777	0.00	0.000	0.004	0.030	0.035	0.100	0.0005	0.0000	0.000	0.0000	0.300		"	"	"	41.2
SAM 2778	0.00	0.000	0.160	0.100	0.062	0.270	0.0020	0.0000	0.000	0.0000	1.300		"	"	"	41.1
SAM 2785	0.00	0.000	0.000	0.150	1.750	0.002	0.0005	0.0000	0.000	0.0000	0.000		flat axe	Vallamand	Bern	9964
SAM 2787	0.00	0.000	0.000	0.250	0.700	0.002	0.0005	0.0000	0.000	0.0000	0.000	*	"	Vinelz	"	21118
SAM 2332	0.00	0.000	0.370	0.002	0.026	0.000	0.0240	0.0000	0.000	0.0000	0.000		dagger	Sutz-Lattrigen	"	3184
SAM 2333	0.00	0.000	0.000	0.000	0.002	0.099	0.0000	0.0000	0.000	0.0000	0.000	*	awl	Vinelz	"	5169
SAM 2334	0.00	0.000	0.300	0.100	0.037	0.670	0.0005	0.0000	0.000	0.0000	0.000	*	dagger	"	"	5175
SAM 2335	0.00	0.000	0.000	0.000	0.005	0.540	0.0000	0.0000	0.000	0.0000	0.000	*	awl(square)	"	"	5178?
SAM 2336	0.00	0.000	0.000	0.000	0.005	0.160	0.0000	0.0000	0.000	0.0000	0.000	*	dagger	"	"	5180
SAM 2337	0.00	0.000	0.000	0.000	0.005	0.520	0.0000	0.0000	0.000	0.0000	0.000	*	"	"	"	5181
SAM 2338	0.00	0.000	3.100	0.090	0.000	2.700	0.0010	0.0000	0.000	0.0000	0.000	*	"	"	"	5183
SAM 2339	0.00	0.000	0.002	0.100	0.005	0.430	0.0000	0.0000	0.000	0.0000	0.000	*	awl(square)(chisel)	"	"	5187
SAM 2341	0.00	0.000	0.000	0.000	0.002	0.160	0.0000	0.0000	0.000	0.0000	0.000	*	" " "	"	"	5194
SAM 2342	0.00	0.000	3.400	0.000	0.019	0.047	0.0830	0.0000	0.000	0.0000	0.000	*	dagger	"	"	5195
SAM 2343	0.00	0.000	0.280	0.390	0.220	2.000	0.0020	0.0000	0.000	0.0000	0.000	*	awl(square)	"	"	5198
SAM 2344	0.00	0.000	0.000	2.700	0.086	0.000	0.0080	0.0000	0.000	0.0000	0.000	*	flat axe	Cham,St.Andreas	Zug	56/228
SAM 2345	0.00	0.000	0.002	0.002	0.016	0.090	0.0005	0.0000	0.000	0.0000	0.000	*	"	Hünenberg,Schwarzbach	"	9800
SAM 2346	0.00	0.000	0.740	0.002	0.025	0.000	0.0030	0.0000	0.000	0.0000	0.000		" (fragm)	Zug,Otterswil?	Zug	-
SAM 2360	0.00	0.000	0.740	0.020	0.000	0.000	0.0005	0.0000	0.000	0.0000	0.000		flat axe (roughout)	Greng	Bern	18891
SAM 2362	0.69	0.000	0.090	0.007	0.016	0.005	0.0000	0.0000	0.000	0.0000	0.000		"	Trachselwald	"	18926
SAM 2376	0.00	0.000	0.000	0.000	0.002	0.002	0.0000	0.0000	0.000	0.0000	0.000	*	bead (biconical)	Vinelz	"	5236u
SAM 2377	0.00	0.000	0.000	0.000	0.000	0.098	0.0000	0.0000	0.000	0.0000	0.000		"	"	"	" d
SAM 2378	0.00	0.000	0.000	0.000	0.002	0.092	0.0000	0.0000	0.000	0.0000	0.000					
SAM 2379	0.00	0.000	0.000	0.000	0.000	0.100	0.0000	0.0000	0.000	0.0000	0.000					
SAM 2380	0.00	0.000	0.000	0.000	0.000	0.100	0.0000	0.0000	0.000	0.0000	0.000					
SAM 2381	0.00	0.000	0.000	0.020	0.058	0.000	0.0090	0.0000	0.000	0.0000	0.000					
SAM 2382	0.00	0.000	0.000	0.000	0.002	0.069	0.0000	0.0000	0.000	0.0000	0.000					
SAM 2383	0.00	0.000	0.000	0.000	0.000	0.090	0.0000	0.0000	0.000	0.0000	0.000					
SAM 2384	0.00	0.000	0.000	0.000	0.000	0.000	0.0000	0.0000	0.000	0.0000	0.000					
SAM 2385	0.00	0.000	0.000	0.000	0.000	0.110	0.0000	0.0000	0.000	0.0000	0.000					
SAM 2386	0.00	0.000	0.000	0.000	0.000	0.002	0.0000	0.0000	0.000	0.0000	0.000					
SAM 2387	0.00	0.000	0.000	0.000	0.000	0.035	0.0000	0.0000	0.000	0.0000	0.000					
SAM 2388	0.00	0.000	0.000	0.000	0.000	0.032	0.0000	0.0000	0.000	0.0000	0.000					
SAM 2389	0.00	0.000	0.000	0.000	0.002	0.073	0.0000	0.0000	0.000	0.0000	0.000					
SAM 2390	0.00	0.000	0.000	0.000	0.000	0.033	0.0000	0.0000	0.000	0.0000	0.000					

Appendix XXV contd.(1)

SAM 2391	0.00	0.000	0.000	0.000	0.000	0.076	0.0000	0.0000	0.000	0.0000	0.000			
SAM 2393	0.00	0.000	0.000	0.000	0.000	0.034	0.0000	0.0000	0.000	0.0000	0.000			
SAM 2894	0.00	0.000	0.000	0.000	0.000	0.086	0.0000	0.0000	0.000	0.0000	0.000			
SAM 2895	0.00	0.000	0.000	0.000	0.000	0.030	0.0000	0.0000	0.000	0.0000	0.000			
SAM 2896	0.00	0.000	0.000	0.000	0.000	0.084	0.0000	0.0000	0.000	0.0000	0.000			
SAM 2897	0.00	0.000	0.000	0.000	0.000	0.063	0.0000	0.0000	0.000	0.0000	0.000			
SAM 2898	0.00	0.000	0.000	0.000	0.000	0.002	0.0000	0.0000	0.000	0.0000	0.000			
SAM 2899	0.00	0.000	0.000	0.000	0.000	0.002	0.0000	0.0000	0.000	0.0000	0.000			
SAM 2900	0.00	0.000	0.000	0.000	0.000	0.072	0.0000	0.0000	0.000	0.0000	0.000			
SAM 2901	0.00	0.000	0.000	0.000	0.000	0.076	0.0000	0.0000	0.000	0.0000	0.000			
SAM 2902	0.00	0.000	0.000	0.000	0.000	0.076	0.0000	0.0000	0.000	0.0000	0.000			
SAM 2903	0.00	0.000	0.000	0.000	0.000	0.076	0.0000	0.0000	0.000	0.0000	0.000			
SAM 2904	0.00	0.000	0.000	0.000	0.000	0.065	0.0000	0.0000	0.000	0.0000	0.000			
SAM 2905	0.00	0.000	0.000	0.000	0.000	0.079	0.0000	0.0000	0.000	0.0000	0.000			
SAM 2906	0.00	0.000	0.000	0.000	0.000	0.077	0.0000	0.0000	0.000	0.0000	0.000			
SAM 2907	0.00	0.000	0.000	0.000	0.000	0.079	0.0000	0.0000	0.000	0.0000	0.000			
SAM 2908	0.00	0.000	0.000	0.000	0.000	0.072	0.0000	0.0000	0.000	0.0000	0.000			
SAM 2909	0.00	0.000	0.000	0.000	0.000	0.110	0.0000	0.0000	0.000	0.0000	0.000			
SAM 2910	0.00	0.000	0.000	0.000	0.000	0.000	0.0000	0.0000	0.000	0.0000	0.000			
SAM 2911	0.00	0.000	0.000	0.000	0.000	0.002	0.0000	0.0000	0.000	0.0000	0.000			
SAM 2912	0.00	0.000	0.000	0.000	0.000	0.110	0.0000	0.0000	0.000	0.0000	0.000			
SAM 2913	0.00	0.000	0.000	0.000	0.000	0.096	0.0000	0.0000	0.000	0.0000	0.000			
SAM 2914	0.00	0.000	0.000	0.000	0.000	0.100	0.0000	0.0000	0.000	0.0000	0.000			
SAM 2915	0.00	0.000	0.000	0.000	0.000	0.110	0.0000	0.0000	0.000	0.0000	0.000			
SAM 2916	0.00	0.000	0.000	0.000	0.000	0.100	0.0000	0.0000	0.000	0.0000	0.000			
SAM 2917	0.00	0.000	0.000	0.000	0.000	0.000	0.0000	0.0000	0.000	0.0000	0.000			
SAM 2918	0.00	0.000	0.000	0.000	0.000	0.000	0.0000	0.0000	0.000	0.0000	0.000			
SAM 2919	0.00	0.000	0.000	0.000	0.000	0.110	0.0000	0.0000	0.000	0.0000	0.000			
SAM 2920	0.00	0.000	0.000	0.000	0.000	0.002	0.0000	0.0000	0.000	0.0000	0.000			
SAM 2921	0.00	0.000	0.000	0.000	0.000	0.098	0.0000	0.0000	0.000	0.0000	0.000			
SAM 2922	0.00	0.000	0.690	0.020	0.082	0.082	0.0340	0.0000	0.000	0.0000	0.000	daggerblade	Gerolfingen,Täuffelen	Bern 19606
SAM 2923	0.00	0.000	1.150	0.010	0.019	0.000	0.0005	0.0000	0.000	0.0000	0.000	dagger	Sutz-Lattrigen	"3411
SAM 2924	0.00	0.000	0.000	0.000	0.000	0.110	0.0000	0.0000	0.000	0.0000	0.000	"	Lüscherz	" 18648
SAM 2925	0.00	0.000	2.400	0.002	0.005	0.000	0.0010	0.0000	0.000	0.0000	0.000	chisel	Mörigen	" 7536
SAM 2926	0.00	0.000	0.560	0.160	0.091	0.000	0.0160	0.0000	0.000	0.0000	0.000	"	Lüscherz	" 18645
SAM 2927	0.00	0.000	0.000	0.000	0.010	0.420	0.0330	0.0000	0.000	0.0000	1.500	awl	"	" 3987
SAM 2929	0.00	0.000	4.400	0.000	0.010	0.000	0.0780	0.0000	0.000	0.0000	0.000	dagger	Lüscherz	" 3986
SAM 2931	0.00	0.000	0.920	0.410	0.049	2.100	0.0000	0.0000	0.000	0.0000	0.000	"	"	" 3782
SAM 2939	0.02	0.100	3.000	0.060	0.027	2.300	0.0780	0.0002	0.000	0.0300	2.000	'Gussbrocken'	Brügg,Zihl	"40083
SAM 2941	0.00	0.000	0.440	0.002	0.000	0.005	0.0005	0.0000	0.000	0.0000	0.000	chisel	Port,St.Spers	" 27677
SAM 2953	0.00	0.000	0.510	0.020	0.005	0.000	0.0002	0.0000	0.000	0.0000	0.000	"	Chevroux	" 25749
SAM 2954	0.00	0.000	0.240	0.002	0.005	0.250	0.0005	0.0000	0.000	0.0000	0.000	"	"	" 25750
SAM 2962	0.00	0.000	0.250	0.060	0.011	0.110	0.0040	0.0000	0.000	0.0000	0.000	dagger	Granson,Corcelettes	" 25599
SAM 2963	0.00	0.000	1.800	0.730	0.570	2.300	0.0020	0.0000	0.000	0.0010	0.000	"	" "	"25601
SAM 2987	0.00	0.000	0.680	0.008	0.045	0.000	0.0005	0.0000	0.000	0.0000	0.000	* bead,(cylindrical)	Burgäschisee-Süd	Bern13360
SAM 2988	0.00	0.000	0.260	0.030	0.032	0.000	0.0005	0.0000	0.000	0.0000	0.000			
SAM 2989	0.00	0.000	0.630	0.070	0.023	0.000	0.0010	0.0000	0.000	0.0000	0.000			
SAM 2990	0.00	0.000	0.770	0.008	0.064	0.000	0.0010	0.0000	0.000	0.0000	0.000			
SAM 2991	0.00	0.000	0.790	0.008	0.040	0.000	0.0030	0.0000	0.000	0.0000	0.000			
SAM 2992	0.00	0.013	0.640	0.002	0.017	0.000	0.0020	0.0000	0.000	0.0000	0.000			
SAM 2993	0.00	0.000	0.840	0.006	0.120	0.000	0.0010	0.0000	0.000	0.0000	0.000			
SAM 2994	0.00	0.000	0.400	0.050	0.016	0.000	0.0005	0.0000	0.000	0.0000	0.000			
SAM 2995	0.00	0.000	0.190	0.030	0.018	0.000	0.0005	0.0000	0.000	0.0000	0.000			

Appendix XXV . contd.(2)

SAM 2996	0.00	0.000	0.240	0.030	0.018	0.000	0.0005	0.0000	0.000	0.0000	0.000					
SAM 2997	0.00	0.000	0.340	0.040	0.022	0.000	0.0005	0.0000	0.000	0.0000	0.000					
SAM 2998	0.00	0.000	0.230	0.030	0.042	0.000	0.0005	0.0000	0.000	0.0000	0.000					
SAM 2999	0.00	0.000	0.230	0.040	0.044	0.000	0.0002	0.0000	0.000	0.0000	0.000					
SAM 3000	0.00	0.000	0.220	0.040	0.046	0.000	0.0005	0.0000	0.000	0.0000	0.000					
SAM 3001	0.00	0.000	0.900	0.010	0.077	0.000	0.0020	0.0000	0.000	0.0000	0.000					
SAM 3002	0.00	0.000	0.190	0.040	0.039	0.000	0.0005	0.0000	0.000	0.0000	0.000					
SAM 3003	0.00	0.017	0.820	0.010	0.072	0.000	0.0020	0.0000	0.000	0.0000	0.000					
SAM 3004	0.00	0.000	0.620	0.020	0.020	0.000	0.0020	0.0000	0.000	0.0000	0.000		(ring)			
SAM 3005	0.00	0.000	0.190	0.020	0.005	0.000	0.0020	0.0000	0.000	0.0000	0.000					
SAM 3006	0.00	0.000	0.600	0.005	0.005	0.000	0.0002	0.0000	0.000	0.0000	0.000					
SAM 3007	0.00	0.000	0.390	0.005	0.005	0.000	0.0005	0.0000	0.000	0.0000	0.000					
SAM 3008	0.00	0.000	0.260	0.030	0.027	0.000	0.0040	0.0000	0.000	0.0000	0.000					
SAM 3009	0.00	0.000	0.520	0.030	0.027	0.000	0.0020	0.0000	0.000	0.0000	0.000					
SAM 3010	0.00	0.000	0.520	0.030	0.018	0.000	0.0010	0.0000	0.000	0.0000	0.000					
SAM 3011	0.00	0.000	0.540	0.015	0.005	0.000	0.0000	0.0000	0.000	0.0000	0.000					
SAM 3012	0.00	0.000	0.520	0.007	0.005	0.000	0.0002	0.0000	0.000	0.0000	0.000					
SAM 3013	0.00	0.000	0.540	0.020	0.014	0.000	0.0005	0.0000	0.000	0.0000	0.000					
SAM 3014	0.00	0.000	0.500	0.007	0.005	0.000	0.0002	0.0000	0.000	0.0000	0.000					
SAM 3015	0.00	0.000	0.580	0.030	0.019	0.000	0.0030	0.0000	0.000	0.0000	0.000					
SAM 3016	0.00	0.000	0.430	0.040	0.044	0.000	0.0020	0.0000	0.000	0.0000	0.000					
SAM 3017	0.00	0.000	0.740	0.005	0.005	0.000	0.0002	0.0000	0.000	0.0000	0.000					
SAM 3018	0.00	0.000	0.700	0.005	0.005	0.000	0.0002	0.0000	0.000	0.0000	0.000					
SAM 3019	0.00	0.000	0.580	0.015	0.010	0.000	0.0000	0.0000	0.000	0.0000	0.000					
SAM 3020	0.00	0.000	0.600	0.007	0.010	0.000	0.0002	0.0000	0.000	0.0000	0.000					
SAM 3021	0.00	0.000	0.850	0.030	0.056	0.000	0.0020	0.0000	0.000	0.0000	0.000					
SAM 3022	0.00	0.000	1.100	0.020	0.076	0.000	0.0030	0.0000	0.000	0.0000	0.000					
SAM 3023	0.00	0.000	0.850	0.002	0.150	0.000	0.0020	0.0000	0.000	0.0000	0.000					
SAM 3024	0.00	0.000	1.100	0.002	0.058	0.000	0.0030	0.0000	0.000	0.0000	0.000					
SAM 3025	0.00	0.000	0.190	0.060	0.074	0.000	0.0002	0.0000	0.000	0.0000	0.000					
SAM 3026	0.00	0.000	1.150	0.010	0.110	0.000	0.0030	0.0000	0.000	0.0000	0.000					
SAM 3027	0.01	0.002	0.050	0.002	0.020	0.240	0.0140	0.0000	0.000	0.0000	0.360		'Gussbrocken'	Tschugg	Bern	9851
SAM 3028	0.00	0.002	0.160	0.090	0.000	0.072	0.0210	0.0000	0.000	0.0000	0.370		"	"	"	9853
SAM 3032	0.00	0.000	0.004	0.440	0.190	0.000	0.0020	0.0000	0.000	0.0000	0.000		dagger	Neuchâtel,LaCoudre	"	9520
SAM 3033	0.00	0.000	0.020	0.002	0.020	0.002	0.0005	0.0000	0.000	0.0000	0.000		awl(square)	Mörigen	"	23380
SAM 3036	0.57	0.000	0.640	0.570	0.360	0.056	0.0000	0.0000	0.000	0.0000	0.000		dagger	"	"	7610
SAM 3037	0.33	0.000	0.006	0.080	0.014	0.000	0.0005	0.0000	0.000	0.0000	0.000		"	"	"	7648
SAM 3041	1.15	0.210	0.350	0.600	0.031	0.026	0.0070	0.0000	0.000	0.0000	0.000		awl	"	"	7777
SAM 3042	0.56	0.250	0.250	0.510	0.068	0.025	0.0060	0.0000	0.000	0.0000	0.000		"(square)	"	"7	7819
SAM 3044	0.00	0.000	1.250	0.020	0.081	0.000	0.0000	0.0000	0.000	0.0000	0.000		" "	"	"	23379
SAM 3046	0.00	0.000	0.340	0.000	0.120	0.000	0.0090	0.0000	0.000	0.0000	0.000		chisel	F.U.Lake Neuchâtel	"	9525
SAM 3049	0.00	0.000	0.000	0.000	0.002	0.130	0.0005	0.0000	0.000	0.0000	0.000		awl(square)	Moosseedorf	"	9945
SAM 3063	0.00	0.016	0.280	0.170	0.280	1.250	0.0130	0.0000	0.000	0.0000	1.300		'Gussbrocken'	Münchenbuchsee,Zielwald	"	9848
SAM 3066	0.00	0.028	0.240	0.120	0.015	0.002	0.0290	0.0000	0.087	0.0070	3.000		"	Aeschi	Bern	9850
SAM 3086	0.00	0.000	0.000	0.000	0.000	0.120	0.0000	0.0000	0.000	0.0000	0.000	*	pendant	Vinelz	"	5182
SAM 3087	0.00	0.000	0.000	0.000	0.005	0.190	0.0000	0.0000	0.000	0.0000	0.000	*	awl(square)	"	"	5192
SAM 3088	0.00	0.000	0.760	0.290	0.500	1.400	0.0000	0.0000	0.000	0.0000	0.000	*	"	"	"	5193
SAM 3089	0.00	0.000	0.000	0.000	0.005	0.035	0.0000	0.0000	0.000	0.0000	0.000	*	awl	"	"	5196
SAM 3090	0.00	0.044	2.500	0.007	0.005	0.030	0.0030	0.0000	0.000	0.0000	0.000	*	chisel(square)	Burgäschisee Süd	"	50494
SAM 3092	0.00	0.005	1.400	0.000	0.005	0.010	0.0000	0.0000	0.000	0.0000	0.001		bead(cylindrical)	Gerolfingen	"	-
SAM 3093	0.00	0.000	1.200	0.000	0.002	0.000	0.0000	0.0000	0.000	0.0000	0.000					
SAM 3094	0.00	0.000	1.400	0.000	0.002	0.000	0.0000	0.0000	0.000	0.0000	0.000					

Appendix XXV contd.(3)

SAM 3095	0.00	0.010	1.650	0.000	0.005	0.016	0.0000	0.0000	0.000	0.0000	0.000					
SAM 3096	0.00	0.000	1.050	0.000	0.000	0.000	0.0000	0.0000	0.000	0.0000	0.000					
SAM 3100	0.00	0.030	1.450	0.000	0.005	0.010	0.0000	0.0000	0.000	0.0000	0.000					27451
SAM 3115	0.00	0.000	2.400	0.004	0.010	0.002	0.0020	0.0000	0.000	0.0000	0.000		dagger	Mörigen	Biel	Mo1647
SAM 3150	1.75	2.500	0.370	0.690	0.160	0.120	0.0070	0.0000	0.000	0.0000	0.000		chisel(square)	Cortaillod	"	Cd972
SAM 3612	0.00	0.000	0.370	0.002	0.013	0.002	0.0005	0.0000	0.000	0.0000	0.001		flat axe	Seewalchen	Wien	37463
SAM 3613	0.00	0.000	0.810	0.002	0.002	0.002	0.0005	0.0000	0.000	0.0000	0.000		"	Weyregg	"	61264
SAM 3615	0.00	0.000	1.950	0.040	0.002	0.002	0.0020	0.0000	0.000	0.0000	0.000		dagger	"	"	1657
SAM 3617	0.01	0.000	1.150	0.010	0.029	0.002	0.0010	0.0000	0.000	0.0000	0.000		"	"	"	1658
SAM 3633	0.00	0.000	0.000	0.800	0.190	0.000	0.0350	0.0000	0.000	0.0000	0.000		flat axe	F.U.?Slovakia	"	17843
SAM 3638	0.00	0.000	0.000	0.000	0.005	0.000	0.0000	0.0000	0.000	0.0000	0.000		"	F.U.	"	17849
SAM 3640	0.00	0.000	0.650	0.120	0.002	0.021	0.0170	0.0000	0.000	0.0000	0.000		"	F.U.UpperAustria	"	17854
SAM 3641	0.00	0.000	0.000	0.000	0.002	0.000	0.0000	0.0000	0.000	0.0000	0.029		"	F.U.	"	17853
SAM 3642	0.00	0.000	0.000	0.000	0.011	0.000	0.0000	0.0000	0.000	0.0000	0.000		"	F.U.	"	17855
SAM 3659	0.00	0.000	0.190	0.120	0.056	0.000	0.0000	0.0000	0.000	0.0000	0.000		"	F.U.	"	16156
SAM 3660	0.00	0.000	0.000	0.000	0.000	0.000	0.0000	0.0000	0.000	0.0000	0.000		"	F.U.	"	16159
SAM 3661	0.00	0.000	0.620	0.040	0.035	0.000	0.0005	0.0000	0.000	0.0000	0.000		"	F.U.	"	16158
SAM 3667	0.00	0.000	0.000	0.000	0.032	0.000	0.0000	0.0000	0.000	0.0000	0.000		"	F.U.	"	16157
SAM 3669	0.00	0.000	0.400	0.010	0.010	0.002	0.0005	0.0000	0.000	0.0000	0.000		"	F.U. ?Moravia	"	17425
SAM 3690	0.00	0.000	0.000	0.000	0.002	0.000	0.0000	0.0000	0.000	0.0000	0.000		chisel	F.U.	"	15024
SAM 3730	0.00	0.000	0.020	0.020	0.002	0.000	0.0005	0.0000	0.000	0.0000	0.056	*	Ösenhalsring	Leobersdorf	"	624
SAM 3731	0.00	0.000	0.150	0.020	0.002	0.000	0.0020	0.0000	0.000	0.0000	0.000	*	"	"	"	623
SAM 3753	0.00	0.000	0.000	0.000	0.002	0.000	0.0000	0.0000	0.000	0.0000	0.000		flat axe	F.U.	"	15025
SAM 3754	0.00	0.002	2.500	0.002	0.019	0.000	0.0060	0.0000	0.000	0.0000	0.000		"	F.U.	"	16155
SAM 3757	0.00	0.000	2.150	0.008	0.020	0.002	0.0030	0.0000	0.000	0.0000	0.000		"	F.U.	"	17846
SAM 3770	0.00	0.000	1.650	1.650	2.200	0.022	0.0580	0.0000	0.000	0.0000	0.000		Ösenhalsring(frag)	Mondsee	"	38771
SAM 3771	0.00	0.000	1.300	0.980	1.550	0.002	0.0260	0.0000	0.000	0.0000	0.016		"	"	..	
SAM 3772	0.00	0.000	1.4[illegible]	1.400	1.900	0.002	0.1700	0.0000	0.000	0.0000	0.000					
SAM 3773	0.00	0.000	1.800	1.350	0.720	0.002	0.1200	0.0000	0.000	0.0000	0.000					
SAM 3774	0.00	0.000	1.700	1.100	0.920	0.000	0.2200	0.0000	0.000	0.0000	0.000					
SAM 3775	0.00	0.000	1.100	0.960	0.850	0.000	0.1200	0.0000	0.000	0.0000	0.000					
SAM 3776	0.00	0.000	1.450	1.200	0.970	0.000	0.3000	0.0000	0.000	0.0000	0.000					
SAM 3780	0.00	0.000	0.000	0.000	0.002	0.000	0.0000	0.0000	0.000	0.0000	0.000		flat axe	Spitz	Wien	45829
SAM 4340	0.00	0.020	0.590	0.030	0.066	0.005	0.0240	0.0000	0.000	0.0000	0.000		"	Mondsee	Inst."	6562
SAM 4341	0.00	0.000	0.250	0.006	0.005	0.005	0.0005	0.0000	0.000	0.0000	0.000		" (fragm)	"	" "	6561
SAM 4342	0.00	0.005	0.270	0.002	0.017	0.005	0.0005	0.0000	0.000	0.0000	0.000		" "	"	" "	6563
SAM 4343	0.00	0.005	0.720	0.020	0.016	0.005	0.0030	0.0000	0.000	0.0000	0.000		"	"	" "	6560
SAM 4344	0.00	0.076	1.350	0.020	0.005	0.010	0.0000	0.0000	0.000	0.0000	0.001		"	"	" "	6557
SAM 4345	0.00	0.000	0.230	0.020	0.026	0.005	0.0020	0.0000	0.000	0.0000	0.000		"	"	" "	6564
SAM 4346	0.00	0.000	0.240	0.009	0.005	0.000	0.0005	0.0000	0.000	0.0000	0.000		"	"	" "	6556
SAM 4347	0.00	0.000	0.350	0.002	0.005	0.000	0.0005	0.0000	0.000	0.0000	0.000		"	"	" "	6565
SAM 4348	0.00	0.000	0.160	0.020	0.170	0.010	0.0040	0.0000	0.000	0.0000	0.000		"	"	" "	6558
SAM 4349	0.00	0.002	1.070	0.020	0.038	0.005	0.0030	0.0000	0.000	0.0000	0.000		"	"	" "	6566
SAM 4350	0.00	0.005	1.150	0.030	0.005	0.020	0.0030	0.0000	0.000	0.0000	0.000		" (small)	"	" "	6555
SAM 4351	0.00	0.070	2.550	0.060	0.010	0.010	0.0000	0.0000	0.000	0.0000	0.000		" "	"	" "	6559
SAM 4439	0.00	0.000	1.650	1.750	0.540	0.000	0.0720	0.0000	0.000	0.0000	0.000		Ösenhalsring	Jedenspeigen	WienLM	8076(Asparn)
SAM 4636	0.00	0.000	0.002	0.030	0.010	0.000	0.0050	0.0000	0.000	0.0000	0.000	*	"	Lichtenwörth	" "	6173 "
SAM 4637	0.00	0.000	0.002	0.030	0.010	0.000	0.0080	0.0000	0.000	0.0000	0.000	*	"	"	" "	6173 "
SAM 4638	0.00	0.000	0.040	0.080	0.060	0.002	0.0005	0.0000	0.000	0.0000	0.000	*	"	"	" "	" "
SAM 4639	0.00	0.000	0.000	0.000	0.002	0.430	0.0000	0.0000	0.000	0.0000	0.000	*	"	"	" "	" "
SAM 4395	0.00	0.002	0.860	0.030	0.005	0.010	0.0005	0.0000	0.000	0.0000	0.000		knife	Seewalchen	Wien	62384

SAM 4896	0.00	0.000	0.020	0.020	0.040	0.002	0.0005	0.0000	0.000	0.0000	0.000	*	awl(square)	"	"	1511
SAM 4897	0.00	0.000	0.150	0.020	0.014	0.002	0.0005	0.0000	0.000	0.0000	0.000	*	" "	"	"	"
SAM 4925	0.00	0.000	0.000	0.000	0.002	0.000	0.0000	0.0000	0.000	0.0000	0.000		flat axe	Stollhof	"	13794
SAM 4926	0.00	0.000	0.002	0.040	0.005	0.000	0.0060	0.0000	0.000	0.0000	0.000		"	"	"	95
SAM 4927	0.00	0.000	0.000	0.002	0.002	0.000	0.0005	0.0000	0.000	0.0000	0.000		spectacle spiral	"	"	13793(16)
SAM 4928	0.00	0.000	0.000	0.002	0.002	0.000	0.0005	0.0000	0.000	0.0000	0.000					
SAM 4929	0.00	0.000	0.000	0.000	0.040	0.000	0.0000	0.0000	0.000	0.0000	0.000					
SAM 4930	0.00	0.000	0.000	0.000	0.050	0.000	0.0000	0.0000	0.000	0.0000	0.000					
SAM 4931	0.00	0.000	0.000	0.000	0.002	0.000	0.0000	0.0000	0.000	0.0000	0.000					
SAM 4932	0.00	0.000	0.000	0.000	0.020	0.000	0.0000	0.0000	0.000	0.0000	0.000					
SAM 4933	0.00	0.000	0.000	0.000	0.005	0.000	0.0000	0.0000	0.000	0.0000	0.000		spiral bracelet	"	"	13797
SAM 4934	0.00	0.000	0.000	0.000	0.002	0.000	0.0000	0.0000	0.000	0.0000	0.000		"	"	"	" (1)
SAM 4936	0.00	0.000	0.000	0.000	0.002	0.000	0.0000	0.0000	0.000	0.0000	0.000		spiral cylinder	"	"	13796(13)
SAM 4937	0.00	0.000	0.000	0.000	0.005	0.002	0.0000	0.0000	0.000	0.0000	0.000					
SAM 4938	0.00	0.000	0.000	0.000	0.002	0.000	0.0000	0.0000	0.000	0.0000	0.000					
SAM 4939	0.00	0.000	0.000	0.000	0.005	0.000	0.0000	0.0000	0.000	0.0000	0.000					
SAM 4940	0.00	0.000	0.000	0.000	0.005	0.002	0.0000	0.0000	0.000	0.0000	0.000					
SAM 4941	0.00	0.000	0.000	0.000	0.005	0.005	0.0000	0.0000	0.000	0.0000	0.001					
SAM 4942	0.00	0.000	0.000	0.000	0.005	0.002	0.0000	0.0000	0.000	0.0000	0.001					
SAM 4943	0.00	0.000	0.000	0.000	0.080	0.000	0.0000	0.0000	0.000	0.0000	0.000		sichel	Stollhof	Wien	13798
SAM 5190	0.00	0.000	1.700	1.350	0.930	0.000	0.0650	0.0000	0.000	0.0000	0.000		spiral bracelet	Palterndorf	"	45698
SAM 5191	0.00	0.000	1.400	1.550	0.930	0.002	0.0570	0.0000	0.000	0.0000	0.000		"	"	"	"
SAM 6080	0.00	0.000	0.000	0.020	0.005	0.000	0.0000	0.0000	0.000	0.0000	0.000	*	Ösenhalsring	Baden Königshöhle	Baden	-
SAM 6373	0.00	0.000	0.000	0.460	0.190	0.000	0.0500	0.0000	0.000	0.0000	0.001		flat axe	Retz,Spittelmais	Retz	291
SAM 6643	0.00	0.000	0.000	0.000	0.002	0.000	0.0000	0.0000	0.000	0.0000	0.000		spiral cylinder	Stollhof	Wien	13796
SAM 6644	0.00	0.000	0.000	0.000	0.005	0.000	0.0000	0.0000	0.000	0.0000	0.001		"	"	"	"
SAM 7046	0.00	0.000	1.550	0.000	0.005	0.020	0.0060	0.0000	0.000	0.0000	0.000		dagger	Estavayer	Genf	B5247
SAM 7073	0.01	0.000	0.720	0.110	0.160	0.100	0.0000	0.0000	0.000	0.0000	0.001		axe	Fully	"	B5730
SAM 7108	0.00	0.000	0.540	0.002	0.002	0.002	0.0080	0.0000	0.000	0.0000	0.000		dagger	St.Blaise	"	B4207
SAM 7279	0.00	0.002	1.400	0.080	0.010	0.030	0.0130	0.0000	0.000	0.0000	0.020		axe	Mont	Lausanne	CT/1777
SAM 7280	0.00	0.002	0.090	0.040	0.100	0.002	0.0050	0.0000	0.000	0.0000	0.001		flat axe	Bex	"	CT/1529
SAM 7293	0.00	0.000	2.100	0.000	0.002	0.010	0.0005	0.0000	0.000	0.0000	0.001	*	flat axe	Hitzkirch,Seematte	Hitzkirch	185
SAM 7790	0.00	0.000	0.000	0.000	0.005	0.540	0.0000	0.0000	0.000	0.0000	0.000		spectacle spiral	Concise	Yverdon	1564
SAM14465	0.00	0.000	0.150	0.002	0.005	0.000	0.0002	0.0000	0.000	0.0000	0.000		flat axe	Misling	Vöcklabruck	613
SAM14466	0.00	0.002	2.200	0.020	0.005	0.005	0.0070	0.0000	0.002	0.0000	0.000		"	Attersee	"	A619
SAM14467	0.00	0.000	0.230	0.002	0.002	0.000	0.0002	0.0000	0.000	0.0000	0.000		"	F.U.Attersee	"	636AS
SAM14469	0.00	0.000	0.230	0.020	0.002	0.005	0.0002	0.0000	0.000	0.0000	0.000		"	Aufham	"	638Au
SAM14470	0.00	0.000	0.460	0.002	0.005	0.000	0.0030	0.0000	0.000	0.0000	0.000		"	F.U.Attersee	"	637 AS
SAM14472	0.00	0.040	0.460	0.020	0.010	0.005	0.0080	0.0000	0.000	0.0000	0.000		dagger	F.U. "	"	458AS
SAM14473	0.00	0.005	0.710	0.020	0.005	0.005	0.0002	0.0000	0.000	0.0000	0.001		knife	Seewalchen	"	S629
SAM14475	0.00	0.210	0.160	0.100	0.110	0.020	0.0210	0.0000	0.000	0.0000	0.000		ring	Salzburg,Rainberg	Salzburg	Hell305
SAM14477	0.01	0.000	0.550	0.020	0.040	0.005	0.0002	0.0000	0.000	0.0000	0.001		knife	" "	"	" 304
SAM14478	0.00	[illegible]	0.170	0.090	0.000	0.000	0.0002	0.0000	0.000	0.0000	0.000		knife	"	"	Hell
SAM14479	0.00	0.090	0.000	0.040	0.250	0.000	0.0130	0.0000	0.000	0.0000	0.001		ring (fragm)	"	"	"
SAM16600	0.00	0.120	0.002	0.040	0.100	0.000	0.0080	0.0000	0.000	0.0000	0.000		flat axe	Eschenz	Frauenfeld	9366
SAM18029	0.00	0.000	0.610	0.006	0.002	0.000	0.0002	0.0000	0.000	0.0000	0.020		chisel(square)	Gerolfingen	Colmar	-
SAM21674	0.00	0.002	1.250	0.002	0.002	0.000	0.0000	0.0000	0.000	0.0000	0.000	*	bead (flat ring)	Baulmes	private	B/68
SAM22141	0.00	0.000	0.730	0.000	0.094	0.000	0.0160	0.0000	0.000	0.0000	0.000	*	'Rollennadel'	Yvonand	Vieil,Yverdon	
SAM22223	0.02	0.005	0.080	0.160	0.500	0.260	0.0080	0.0000	0.000	0.0000	0.000	*	awl	Auvernier,Saunerie	Neuchâtel	Auv2780
SAM22228	0.00	0.000	0.000	0.000	0.019	0.480	0.0000	0.0000	0.000	0.0000	0.000		"	Bevaix	"	Bx49
SAM22229	0.00	0.100	0.000	0.520	1.400	0.040	0.0002	0.0000	0.000	0.0000	0.000		"	"	"	Bx76

Appendix XXV contd.(5)

SAM22233	0.00	0.050	0.000	0.500	1.800	0.200	0.0040	0.0000	0.000	0.0000	0.000	knife/dagger	Colombier	"	Col18
SAM22234	0.00	0.160	0.000	0.790	1.300	0.110	0.0240	0.0000	0.000	0.0000	0.000	"	"	"	Col20
SAM22235	0.00	0.040	0.000	0.000	0.100	0.020	0.0070	0.0000	0.000	0.0000	0.000	awl	Estavayer	"	Est.6
SAM22236	0.00	0.000	0.040	0.000	0.005	0.160	0.0000	0.0000	0.000	0.0000	0.000	"	"	"	Est 11
SAM22240	0.00	0.000	0.000	0.000	0.120	0.017	0.0040	0.0000	0.000	0.0000	0.000	'Ösenband'	F.U.	"	1452
SAM22241	0.00	0.100	2.300	0.000	0.070	0.020	0.0060	0.0000	0.000	0.0000	0.000	dagger	Chevroux	Bern	25657
SAM22242	0.00	0.000	0.930	0.000	0.091	0.005	0.0002	0.0000	0.000	0.0000	0.000	flat axe	F.U.	Neuchâtel	1510
SAM22243	0.00	0.000	1.700	0.000	0.006	0.000	0.0000	0.0000	0.000	0.0000	0.000	flat axe	F.U.	"	Col.Beau 84
SAM22244	0.01	0.000	4.200	0.000	0.007	0.024	0.1900	0.0000	0.000	0.0000	0.000	dagger	F.U.	"	
SAM22249	0.00	0.000	0.000	0.000	0.040	0.500	0.0002	0.0003	0.000	0.0000	0.000	axe	Delley,Portalban	"	Pt3
SAM22264	0.00	0.076	0.000	0.360	1.400	0.018	0.0090	0.0000	0.000	0.0000	0.000	flat axe	Auvernier	"	1509
SAM23056	0.04	0.000	0.000	0.000	0.013	0.000	0.0000	0.0000	0.000	0.0000	0.000				
O&W 6	0.00	0.005	0.000	0.000	0.005	0.005	0.0000	0.0000	0.000	0.0000	0.000	flat axe	Pölshals,Styria	Graz	11530
O&W 87	0.01	0.005	0.000	0.000	0.010	0.005	0.0000	0.0000	0.000	0.0000	0.000	knife	St.Jacob,Marburg	"	11417
O&W 98	0.00	0.000	0.005	0.000	0.130	0.005	0.0020	0.0005	0.000	0.0000	0.005	flat axe (frag)	Nussdorf-Maurach	Stuttgart	A3091
O&W 99	0.00	0.000	0.000	0.005	0.200	0.005	0.0020	0.0000	0.000	0.0000	0.000	* "	Thayngen Weiher	Schaffhausen	
O&W 120	0.00	0.000	0.000	0.200	0.300	0.005	0.0020	0.0000	0.000	0.0000	0.000	" (small)	Nussdorf-Maurach	Stuttgart	A3093
O&W 155	0.01	0.005	0.000	0.000	0.010	0.040	0.0020	0.0000	0.000	0.0050	0.050	ring	Maxglan	Salzburg	5784a
O&W 232	0.00	0.005	1.200	0.000	0.005	0.005	0.0020	0.0000	0.000	0.0000	0.000	flat axe	Seewalchen	Wien	37463
O&W 233	0.00	0.005	0.900	0.000	0.005	0.000	0.0020	0.0000	0.000	0.0000	0.000	"	Attersee	"	61264
O&W 234	0.01	0.005	0.160	0.005	0.005	0.005	0.0020	0.0005	0.000	0.0000	0.000	" (fragm.)	Mondsee	Inst."	6561
O&W 235	0.00	0.005	1.000	0.000	0.005	0.005	0.0000	0.0000	0.000	0.0000	0.000	"	Kronstorf,Enns	Linz	A4419
O&W 253	0.00	0.005	0.150	0.005	0.005	0.005	0.0020	0.0000	0.000	0.0000	0.000	single spiral	Mondsee	Inst.Wien	6580
O&W 254	0.00	0.005	2.300	0.000	0.005	0.005	0.0020	0.0000	0.000	0.0000	0.000	spiral ring	Lödersdorf	Graz	
O&W 255	0.00	0.005	1.300	0.005	0.005	0.005	0.0020	0.0000	0.000	0.0000	0.000	knife	Attersee	Wien	62385
O&W 256	0.00	0.005	4.100	0.000	0.005	0.005	0.0020	0.0000	0.000	0.0000	0.000	dagger(fragm)	Mondsee	Inst.Wien	6569
O&W 278	0.00	0.005	0.300	0.005	0.030	0.005	0.0020	0.0003	0.000	0.0000	0.005	flat axe	Altheim	München	1919.599
O&W 307	0.00	0.005	0.200	0.005	0.130	0.005	0.0020	0.0000	0.000	0.0000	0.000	"	Nussdorf-Maurach	Stuttgart	A3092
O&W 315	0.00	0.020	2.800	0.000	0.005	0.005	0.0020	0.0000	0.000	0.0000	0.005	"	Schlögelsbach,Kilb	Wien	1547
O&W 334	0.01	0.100	1.600	0.005	0.080	0.005	0.0020	0.0005	0.000	0.0000	0.000	"	Rainberg	Salzburg	2659
O&W 335	0.01	0.100	1.000	0.005	0.200	0.005	0.0100	0.0000	0.000	0.0000	0.000	"	"	"	2658
O&W 352	0.01	0.005	1.100	0.100	0.080	0.005	0.0020	0.0005	0.000	0.0000	0.000	"	"	"	2660
O&W 446	0.01	0.005	2.200	2.800	0.600	0.040	0.1400	0.0000	0.000	0.0000	0.000	'Ösenring'	Maxglan	"	5784
O&W 465	0.00	0.000	0.600	0.600	0.700	0.005	0.0020	0.0000	0.000	0.0000	0.005	spiral	Hallwang	"	5785
O&W 634	0.03	0.010	1.200	1.100	1.300	0.005	0.0100	0.0000	0.000	0.0000	0.000	'Ösenring'?fragm	Mondsee	Wien	38772
O&W 1183	0.01	0.000	0.000	0.000	0.000	0.500	0.0000	0.0003	0.000	0.0050	0.005	double axe	Lüscherz	Zürich	
O&W 1184	0.01	0.005	0.000	0.000	0.005	0.070	0.0020	0.0000	0.000	0.0000	0.050	flat axe	Concise	Koln	5043
O&W 1207	0.50	0.005	0.005	0.000	0.005	0.100	0.0000	0.0000	0.000	0.0050	0.005	'Rippenbarren'	Mühlviertel	Linz	A702
O&W 1242	0.01	0.005	0.005	0.000	0.005	0.005	0.0000	0.0000	0.000	0.0050	0.310	'Gusskuchen'	Mühldorf,Upper A.	Linz	A2283
O&W 1248	0.00	0.000	0.050	0.000	0.000	0.005	0.0000	-0.1000	0.000	0.0050	0.230	"	Laideregg,Bischofsh.	Salzburg	1413 1414
O&W 1249	0.00	0.000	0.500	0.000	0.000	0.005	0.0000	-0.1000	0.000	0.0000	0.230	"			
O&W 1269	0.01	0.005	3.000	0.700	0.010	2.140	0.0080	0.0000	0.000	0.0050	3.240	'Metalstück'	Rabenstein,Lueg	Hell Salzburg	
O&W 1296	0.01	0.005	1.000	0.005	0.005	0.750	0.0020	0.0000	0.000	0.0050	0.140	'Gusskuchen'	Glanegg	Salzburg	5789b
O&W 1297	0.01	0.005	0.200	0.050	0.005	0.750	0.0020	0.0000	0.000	0.0050	0.750	'Metallstück'	Klingelberg,Pongau	Hell Salzburg	
O&W 1298	0.02	0.030	0.600	0.050	0.160	1.250	0.0020	0.0008	0.000	0.0100	3.150	'Gusskuchen'	Freinberg,Linz	Linz	A2296
O&W 1299	0.01	0.005	1.500	0.100	0.005	0.300	0.0020	0.0000	0.000	0.0050	0.000	"	Kienbergwand,Mondsee	Hell Salzbg.	
O&W 1300	0.01	0.000	0.300	0.005	0.005	0.350	0.0000	0.0000	0.000	0.0050	0.005	"	" "	Salzburg	937
O&W 1311	0.01	0.005	0.005	0.000	0.030	0.050	0.0000	0.0000	0.000	0.0050	1.020	"	Traunmündung	Linz	A2292
O&W 1312	0.01	0.005	0.005	0.000	0.005	0.250	0.0020	0.0000	0.000	0.0050	0.200	"	Mattsee	Hell Salzburg	
O&W 1313	0.01	0.005	0.005	0.000	0.005	0.100	0.0020	0.0000	0.000	0.0050	0.300	'Metallstück'	Burgstall, Pinzgau	" "	
O&W 1314	0.02	0.050	0.005	0.000	0.020	0.050	0.0060	0.0000	0.000	0.0050	0.830	'Gusskuchen'	St.Georgen "	Salzburg	1408

Appendix XXV · contd.(6)

0&U	1315	0.01	0.005	0.005	0.005	0.005	1.500	0.0020	0.0000	0.000	0.0050	3.360	"	Mittersee,Hallwang	"	5312
0&U	1316	0.01	0.005	0.005	0.000	0.005	0.040	0.0020	0.0000	0.000	0.0000	0.820	"	Hallstatt	Linz	A2281
0&U	1319	0.01	0.005	0.005	0.005	0.005	0.320	0.0020	0.0003	0.000	0.0050	1.140	"	Freinberg,Linz	"	A2295
0&U	1321	0.01	0.005	0.010	0.005	0.010	0.500	0.0020	0.0008	0.000	0.0100	0.005	"	Mitterberg	Salzburg	1720
BAR	2	0.00	-0.100	1.200	0.200	0.170	-0.100	-0.1000	0.0080	0.000	0.0280	-0.100	Chisel	Chevroux	Lausanne	10291
BAR	7	0.00	0.040	1.100	0.096	0.650	0.720	0.0044	0.0012	0.000	0.0000	0.028	Dagger	"	"	20726 II
BAR	8	0.00	0.009	0.750	0.066	0.180	0.660	0.0048	0.0009	0.000	0.0060	0.250	"	"	"	16636II
BAR	9	0.00	0.002	-0.100	-0.100	-0.100	0.240	0.0076	-0.1000	-0.100	-0.1000	0.580	Rivet of dagger Bar 7	"	"	20726II
BAR	10	0.00	-0.100	0.036	0.004	0.023	-0.100	-0.1000	0.0090	0.020	0.0033	0.190	Spectacle spiral	Concise	"	-
BAR	13	0.00	0.051	2.600	0.060	0.012	2.600	0.0003	0.0000	0.130	0.0330	0.048	Flat dagger	"	"	26792I
BAR	15	0.00	0.000	0.000	0.004	0.003	0.000	0.0030	0.0005	0.000	0.0008	0.110	Tube of sheet copper	Corcelle	"	27457I
BAR	17	0.00	0.056	-0.100	1.600	0.230	0.036	0.0300	-0.1000	0.120	0.1500	0.046	Chisel	Concise	"	25562I
BAR	20	0.00	0.028	0.000	0.007	0.026	0.036	0.0089	0.0000	0.000	0.0028	0.031	"	"	"	2778II
BAR	25	0.00	0.099	0.000	0.210	0.140	-0.100	-0.1000	0.0000	0.370	0.0060	-0.100	Flat dagger	Morges	"	2303
BAR	26	0.00	0.094	0.000	0.000	0.000	0.077	0.0120	0.0000	0.000	0.0340	0.025	" "	"	"	25213
BAR	27	0.00	0.410	0.370	0.130	0.054	0.084	0.0008	0.0078	0.130	0.0010	0.280	" "	Onnens	"	-
BAR	28	0.00	0.005	3.700	0.006	0.018	0.095	0.0033	0.0000	0.130	0.0030	0.660	Flat axe	Geneva ,Gas Station	Geneva	8636
BAR	29	0.00	0.000	0.250	0.074	0.093	0.049	0.0000	0.0000	0.000	0.0030	0.078	" "	" "	"	8637
BAR	30	0.00	0.008	0.000	1.500	2.200	-0.100	0.0140	0.0049	0.000	0.0330	0.380	Flanged axe	" "	"	8638
BAR	31	0.00	0.025	0.000	0.590	4.500	0.021	0.0120	0.0029	0.000	0.0050	0.044	Flat axe	Corsier	"	7465
BAR	32	0.00	0.009	-0.100	1.900	2.900	0.690	0.0450	-0.1000	0.000	0.0360	0.000	Dagger	'Valais'	"	B5653
BAR	34	0.00	0.230	0.093	0.300	0.110	0.056	0.0091	0.0130	0.000	0.0007	0.026	Flat dagger	Versoix	"	9147
BAR	36	0.00	-0.100	0.780	0.000	0.000	-0.100	-0.1000	0.0009	0.000	0.0040	-0.100	" "	Estavayer	"	B5247
BAR	37	0.00	0.033	2.600	0.026	0.056	0.023	0.0057	0.0000	0.000	0.0006	0.074	" "	St.Blaise	"	B4207
BAR	42	0.00	-0.100	3.000	0.140	0.000	-0.100	-0.1000	0.0130	0.000	0.0000	-0.100	Flat axe	Plattensee	"	B5330
BAR	43	0.00	0.014	0.130	0.200	0.000	0.008	0.0077	0.0061	0.250	0.0000	0.110	" "	'Hungary'	"	B1001
BAR	44	0.00	0.034	0.500	0.350	0.000	0.000	0.0065	0.0160	0.660	0.0000	0.004	" "	'?Hungary'	"	B1003
BAR	45	0.00	-0.100	0.350	1.300	0.110	0.017	-0.1000	0.1100	0.980	0.0120	-0.100	Flat dagger	Gerolfingen	"	B727
BAR	46	0.20	0.120	0.320	0.780	0.000	0.330	0.0098	0.0280	0.660	0.0000	0.053	" "	Champreveyres	"	B2684
BAR	47	0.10	-0.100	0.400	0.480	0.000	-0.100	-0.1000	0.0100	0.710	0.0490	-0.100	Dagger	Aiguillles des B.	"	B5159
BAR	48	0.00	0.270	0.900	0.370	0.000	0.100	0.0039	0.0490	0.180	0.0000	0.000	"	Eaux Vives	"	B1189
BAR	53	1.90	0.011	0.210	0.060	0.008	0.047	0.0000	0.0073	0.270	0.0340	0.024	"	'près Lyon'	"	B3415
BAR	62	1.90	0.043	0.000	1.600	0.980	0.000	0.0000	0.0000	1.500	0.0130	0.000	Pendant	St. Blaise	Neuchâtel	SB38
BAR	63	0.00	0.004	1.700	0.071	0.000	1.200	0.0059	0.0000	0.000	0.0130	0.050	Flat dagger	"	"	-
BAR	64	0.00	0.000	0.020	0.000	0.006	0.039	0.0068	0.0014	0.000	0.0007	0.025	" "	"	"	Conc62
BAR	65	0.00	0.097	0.020	0.000	0.008	0.043	0.0000	0.0004	0.000	0.0009	0.029	Chisel	"	"	Conc62
BAR	66	0.00	0.006	0.000	0.250	0.830	0.042	0.0050	0.0008	0.000	0.0012	0.020	Flat axe	Bevaix	"	Bx177
BAR	67	0.00	0.004	0.000	0.000	0.004	0.320	0.0045	0.0005	0.000	0.0012	0.028	Flat dagger	"	"	Bx155
BAR	68	0.00	0.001	0.910	0.000	0.006	0.039	0.0170	0.0003	0.000	0.0009	0.026	" "/knife	"	"	Bx156
BAR	69	0.00	0.170	2.700	0.051	0.014	0.041	0.0031	0.0032	0.000	0.0020	0.063	Dagger	"	"	Bx154
BAR	70	0.00	0.000	0.990	0.190	0.130	0.700	0.0097	0.0004	0.000	0.0045	0.000	Flat dagger	Estavayer	"	Est17
BAR	77	0.00	0.011	0.046	0.260	0.850	0.093	0.0037	0.0004	0.000	0.0000	0.046	" " /Knife	Colombier	"	Col18
BAR	86	0.00	0.075	0.000	2.100	0.540	1.100	0.0037	0.0100	0.000	0.1400	0.140	" "	Auvernier	"	Auv 915
BAR	88	0.00	0.000	0.000	0.000	0.011	0.260	0.0074	0.0089	0.000	0.0024	0.110 *	" "	Yvonand	"	-
BAR	89	0.00	0.027	0.830	0.210	0.320	1.000	0.0140	0.0035	0.000	0.0024	0.590 *	Awl	Auvernier	"	Auv2250
BAR	90	0.00	0.019	0.590	0.000	0.066	0.037	0.0510	0.0000	0.000	0.0005	0.710 *	Pin/awl	Yvonand	Yverdon	-
BAR	91	0.00	0.026	3.000	0.045	0.003	1.400	0.0032	0.0000	0.000	0.0220	0.160	Sickle	Michelsdorf	Linz	616
BAR	93	0.00	0.056	0.930	2.100	-0.100	0.900	0.0019	0.0072	0.000	-0.1000	0.087	Flat dagger	Auvernier	Neuchâtel	Auv915
BAR	95	0.00	0.000	0.000	0.000	0.000	0.019	0.0025	0.0020	0.031	0.0004	0.580	Massive axe	Linz St.Peter	Linz	A4796
BAR	96	0.00	0.023	0.000	0.002	0.003	0.027	0.0019	0.0004	0.032	0.0006	0.000	Shafthole axe	" "	"	A4795
BAR	97	0.00	0.013	1.100	0.005	0.004	0.062	0.0130	0.0000	0.032	0.0004	0.055	Flat axe	Kronstorf	"	A4419

Appendix XXV contd. (7)

BAR	98	0.00	0.000	0.740	0.007	0.011	0.066	0.0082	0.0063	0.045	0.0040	0.044	Sickle	Michelsdorf	"	618
BAR	99	0.00	0.280	2.500	0.026	0.004	0.034	0.0051	0.0000	0.044	0.0007	0.051	"	"	"	625
BAR	100	0.00	0.000	0.043	0.004	0.005	0.032	0.0150	0.0000	0.032	0.0290	0.082	Bun ingot	Mühldorf	"	A2283
BAR	101	0.00	0.062	0.750	0.016	0.008	0.000	0.0160	0.0000	0.039	0.0007	0.130				
BAR	102	0.00	0.013	0.000	0.003	0.001	0.042	0.0100	0.0020	0.036	0.0010	0.049	Adze axe	'Upper Austria'	"	A3137
BAR	103	0.00	0.140	-0.100	0.032	0.075	0.093	0.0076	-0.1000	0.031	0.0004	0.110	Dagger	Wien-Essling	Aspern	14853
BAR	104	0.00	0.009	0.013	0.003	0.006	0.063	0.0140	0.0046	0.027	0.0006	0.300	Hammer axe	Mödling	Mödling	U5
AXX	1	0.00	0.000	0.010	0.000	1.000	0.050	0.0000	0.0000	0.050	0.0000	0.000	Double axe	Hüttwilen (analysis:Angeli,1953)	Frauenfeld	9067

Appendix XXVI. List of Analysis Numbers contained in Copper Clusters 1.1 - 1.5 and 2 - 10.

Copper Cluster 1.1

SAM 2776	SAM 2883	SAM 2895	SAM 2906	SAM 2919	O&W 1184
SAM 2833	SAM 2885	SAM 2896	SAM 2907	SAM 2921	
SAM 2836	SAM 2887	SAM 2897	SAM 2908	SAM 2924	
SAM 2841	SAM 2888	SAM 2900	SAM 2909	SAM 2962	
SAM 2877	SAM 2889	SAM 2901	SAM 2912	SAM 3049	
SAM 2878	SAM 2890	SAM 2902	SAM 2913	SAM 3086	
SAM 2879	SAM 2891	SAM 2903	SAM 2914	SAM 3087	
SAM 2880	SAM 2893	SAM 2904	SAM 2915	SAM 3089	
SAM 2882	SAM 2894	SAM 2905	SAM 2916	SAM22236	

Copper Cluster 1.2

SAM 2474	SAM 2918	SAM 3730	SAM 4931	SAM 4942
SAM 2845	SAM 2920	SAM 3753	SAM 4932	SAM 4943
SAM 2876	SAM 3033	SAM 3780	SAM 4933	SAM 6080
SAM 2884	SAM 3638	SAM 4638	SAM 4934	SAM 6643
SAM 2886	SAM 3641	SAM 4896	SAM 4936	SAM 6644
SAM 2898	SAM 3642	SAM 4925	SAM 4937	SAM23056
SAM 2899	SAM 3659	SAM 4927	SAM 4938	O&W 6
SAM 2910	SAM 3660	SAM 4928	SAM 4939	O&W 87
SAM 2911	SAM 3667	SAM 4929	SAM 4940	O&W 155
SAM 2917	SAM 3690	SAM 4930	SAM 4941	BAR 29

Copper Cluster 1.3

SAM 2881	SAM 4637	SAM22235	BAR 20	BAR 96
SAM 4636	SAM 4926	BAR 15	BAR 64	BAR 102

Copper Cluster 1.4

SAM 3046	SAM 7280	O&W 98	O&W 307
SAM 4348	SAM22240	O&W 99	

Copper Cluster 1.5

SAM 8	SAM 2998	SAM 3005	SAM 4341	SAM 4897	O&W 234
SAM 2988	SAM 2999	SAM 3008	SAM 4342	SAM14465	O&W 253
SAM 2995	SAM 3000	SAM 3025	SAM 4345	SAM14467	O&W 278
SAM 2996	SAM 3002	SAM 3731	SAM 4346	SAM14469	

Copper Cluster 2

SAM 2475	SAM 2987	SAM 3010	SAM 3019	SAM 7108
SAM 2477	SAM 2989	SAM 3011	SAM 3020	SAM14470
SAM 2832	SAM 2992	SAM 3012	SAM 3612	SAM14472
SAM 2846	SAM 2994	SAM 3013	SAM 3640	SAM14473
SAM 2860	SAM 2997	SAM 3014	SAM 3661	SAM14477
SAM 2922	SAM 3004	SAM 3015	SAM 3669	SAM18029
SAM 2926	SAM 3006	SAM 3016	SAM 4340	SAM22141
SAM 2941	SAM 3007	SAM 3017	SAM 4343	BAR 68
SAM 2953	SAM 3009	SAM 3018	SAM 4347	BAR 101

Copper Cluster 3

SAM 2835	SAM 2839	SAM 4639	SAM22228	O&W 1183	O&W 1321
SAM 2837	SAM 2954	SAM 7790	SAM22249	O&W 1300	BAR 67

Copper Cluster 4

SAM 2834	SAM 2939	SAM 3088	BAR 7	BAR 63
SAM 2838	SAM 2963	O&W 1269	BAR 8	BAR 70
SAM 2843	SAM 3027	O&W 1296	BAR 13	BAR 89
SAM 2931	SAM 3063	O&W 1297	BAR 36	BAR 91

Copper Cluster 5

BAR 2	BAR 25	BAR 43	BAR 47	BAR 88	BAR 104
BAR 9	BAR 26	BAR 44	BAR 48	BAR 93	
BAR 10	BAR 27	BAR 45	BAR 62	BAR 98	
BAR 17	BAR 34	BAR 46	BAR 86	BAR 100	

Copper Cluster 6

SAM 794	SAM 3036	SAM 3041	SAM 3150	SAM14479	O&W 1207
SAM 2862	SAM 3037	SAM 3042	SAM14475	SAM16600	BAR 53
					BAR 65

Copper Cluster 7

SAM 2777	SAM 3028	O&W 1248	O&W 1311	O&W 1314	O&W 1319
SAM 2778	SAM 3066	O&W 1249	O&W 1312	O&W 1315	BAR 90
SAM 2927	O&W 1242	O&W 1298	O&W 1313	O&W 1316	BAR 95

Copper Cluster 8

SAM 2844	SAM 3772	SAM 3774	SAM 3776	SAM 5190	SAM 6373
SAM 3633	SAM 3773	SAM 3775	SAM 4439	SAM 5191	O&W 446

Copper Cluster 9

SAM 2785	SAM 3771	SAM22233	O&W 465	BAR 32
SAM 2787	SAM14478	SAM22234	O&W 634	BAR 66
SAM 3032	SAM22223	SAM22264	BAR 30	BAR 77
SAM 3770	SAM22229	O&W 120	BAR 31	AXX 1

Copper Cluster 10

SAM 9	SAM 3021	SAM 3115	SAM 7279	O&W 256
SAM 10	SAM 3022	SAM 3613	SAM 7293	O&W 315
SAM 2478	SAM 3023	SAM 3615	SAM14466	O&W 334
SAM 2481	SAM 3024	SAM 3617	SAM21674	O&W 335
SAM 2842	SAM 3026	SAM 3754	SAM22241	O&W 352
SAM 2923	SAM 3044	SAM 3757	SAM22242	O&W 1299
SAM 2925	SAM 3090	SAM 4344	SAM22243	BAR 28
SAM 2929	SAM 3092	SAM 4349	SAM22244	BAR 37
SAM 2990	SAM 3093	SAM 4350	O&W 232	BAR 42
SAM 2991	SAM 3094	SAM 4351	O&W 233	BAR 69
SAM 2993	SAM 3095	SAM 4895	O&W 235	BAR 97
SAM 3001	SAM 3096	SAM 7046	O&W 254	BAR 99
SAM 3003	SAM 3100	SAM 7073	O&W 255	BAR 103

Appendix XXVII. List of Analysis Numbers contained in Bronze Clusters A - F (Sn is masked).

Bronze Cluster A

SAM 7	SAM 2974	SAM 3156	SAM 4898	SAM 6090	BAR 72
SAM 2820	SAM 3031	SAM 3157	SAM 6087	SAM 7051	BAR 87
SAM 2848	SAM 3043	SAM 3614	SAM 6088	SAM 7104	BAR 92

Bronze Cluster B

SAM 2937	SAM 3055	SAM 3113	SAM 3152	SAM 3155
SAM 3054	SAM 3058	SAM 3149	SAM 3154	SAM 7164

Bronze Cluster C

BAR 4	BAR 6	BAR 18	BAR 74
BAR 5	BAR 12	BAR 21	

Bronze Cluster D

SAM 2831	SAM 3039	SAM 3151	SAM 6089	BAR 11	BAR 75
SAM 2867	SAM 3040	SAM 3153	O&W 177	BAR 16	BAR 76
SAM 2932	SAM 3097	SAM 4635	O&W 401	BAR 24	
SAM 2943	SAM 3098	SAM 4899	O&W 1209	BAR 33	
SAM 2975	SAM 3099	SAM 4900	O&W 1273	BAR 35	
SAM 3038	SAM 3112	SAM 4901	BAR 3	BAR 71	

Bronze Cluster E

SAM 2940	SAM 3616	BAR 14
SAM 3078	O&W 1049	BAR 73

Bronze Cluster F

BAR 19	BAR 23	BAR 50	BAR 61
BAR 22	BAR 49	BAR 60	BAR 78

APPENDIX XXVIII

Element → / Code ↓	Sn	Pb	As	Sb	Ag	Ni	Bi	Au	Zn	Co	Fe
0	< 0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001	<0.0001	<0.001
1	0.03	0.003	0.003	0.003	0.003	0.003	0.0003	0.0003	0.003	0.0003	0.003
2	0.1	0.01	0.01	0.01	0.01	0.01	0.001	0.001	0.01	0.001	0.01
3	0.3	0.03	0.03	0.03	0.03	0.03	0.003	0.003	0.03	0.003	0.03
4	1.0	0.1	0.1	0.1	0.1	0.1	0.01	0.01	0.1	0.01	0.1
5	3.0	0.3	0.3	0.3	0.3	0.3	0.03	0.03	0.3	0.03	0.3
6	10.0	1.0	1.0	1.0	1.0	1.0	0.1	0.1	1.0	0.1	1.0
7	30.0	3.0	3.0	3.0	3.0	3.0	0.3	0.3	3.0	0.3	3.0
8	> 30.0	10.0	10.0	10.0	10.0	10.0	1.0	1.0	10.0	1.0	10.0
9		>10.0	> 10.0	>10.0	>10.0	>10.0	3.0	3.0	>10.0	3.0	>10.0

Identification of codes used for grouping of metal analyses.

```
         34                    SAM 2879-.                                         Copper Clusters   Boundary
 0.000   35                    SAM 2880-I                                                           Value
 0.000   68                    SAM 2914-I                                                            -0.5
 0.000   70                    SAM 2916-'-.
-0.000   32                SAM 2877-.    I-.
 0.000   75                SAM 2921-'-.  I I
-0.000   16                  SAM 2833-'-. I I
-0.000   67                    SAM 2913-'-' I
-0.006   40                    SAM 2885-.  I-.
 0.000   63                    SAM 2909-I  I I
 0.000   66                    SAM 2912-I  I I
 0.000   69                    SAM 2915-I  I I
 0.000   73                    SAM 2919-I  I I
 0.000   78                    SAM 2924-'-. I I
-0.002  140                    SAM 3049-. I-' I
-0.000  143                    SAM 3086-'-'  I
-0.027   10                          SAM 2776-'-.
-0.057   47              SAM 2893-.           I-.
 0.000   50              SAM 2896-'-.         I I
-0.000   43              SAM 2888-. I-.       I I
-0.000   45              SAM 2890-'-' I       I I
-0.000   42                SAM 2887-. I-.     I I
-0.000   48                SAM 2894-'-' I     I I
-0.000  146                    SAM 3089-'-.   I I                                      1.1
-0.000   33                    SAM 2878-. I-. I I
-0.000   38                    SAM 2883-'-' I I I
-0.005   46                SAM 2891-.     I-. I I
 0.000   55                SAM 2901-I     I I I I
 0.000   56                SAM 2902-I     I I I I
 0.000   57                SAM 2903-'-.   I I I I
-0.000   60                  SAM 2906-'-. I I I I
-0.000   59              SAM 2905-.    I-. I I I I
 0.000   61              SAM 2907-'-.  I I I I I I
-0.000   49                SAM 2895-'-. I I I I I
-0.000   44                  SAM 2889-'-' I I I I I
-0.002   54                SAM 2900-.   I-' I I I
 0.000   62                SAM 2908-'-.  I   I I I
-0.000   37                  SAM 2882-'-. I   I I I
-0.000   51                  SAM 2897-. I-'   I I I
-0.000   58                  SAM 2904-'-'     I I I
-0.023  289                          O&W 1184-'-' I
-0.077   88                              SAM 2962-'-.
-0.149   19                          SAM 2836-.     I-.
-0.000   23                          SAM 2841-'-.   I I
-0.001  256                            SAM22236-'-. I I
-0.005  144                              SAM 3087-'-' I
                                                      I
                                                      I        *******************************
                                                      I
-2.298   41 SAM 2886-.                                I-.
 0.000   52 SAM 2898-I                                I I
 0.000   53 SAM 2899-I                                I I
 0.000   65 SAM 2911-I                                I I
 0.000   74 SAM 2920-'-.                              I I
-0.000   31   SAM 2876-'-.                            I I
-0.000   39   SAM 2884-. I-.                          I I
 0.000   64   SAM 2910-I I I                          I I
 0.000   71   SAM 2917-I I I                          I I
 0.000   72   SAM 2918-I I I                          I I
 0.000  166   SAM 3660-'-' I                          I I
-0.000  170     SAM 3690-. I-.                        I I
 0.000  173     SAM 3753-I I I                        I I
 0.000  183     SAM 3780-I I I                        I I
 0.000  204     SAM 4925-I I I                        I I
 0.000  210     SAM 4931-I I I                        I I
 0.000  213     SAM 4934-I I I                        I I
 0.000  214     SAM 4936-I I I                        I I
 0.000  216     SAM 4938-I I I                        I I
 0.000  226     SAM 6643-'-' I                        I I
-0.000  161 SAM 3638-.      I-.                       I I
 0.000  212 SAM 4933-I      I I                       I I
 0.000  217 SAM 4939-'-.    I I                       I I
-0.000  227   SAM 6644-'-.  I I                       I I
-0.000  215 SAM 4937-.   I-. I I                      I I                              1.2
 0.000  218 SAM 4940-'-. I I I I                      I I
-0.000  220   SAM 4942-'-' I I I                      I I
-0.000  219       SAM 4941-'-' I                      I I
-0.001  206         SAM 4927-. I-.                    I I
 0.000  207         SAM 4928-'-' I                    I I
-0.001  265             O&W    6-'-.                  I I
-0.002  224               SAM 6080-'-.                I I
-0.004   27           SAM 2845-.     I-.              I I
-0.000  133           SAM 3033-'-.   I I              I I
-0.000    5         SAM 2474-.   I-. I I              I I
-0.000  164         SAM 3642-'-. I I I I              I I                                   contd.
-0.000  211           SAM 4932-'-' I I I              I I                                   next
-0.003  266               O&W   87-'-' I              I I                                   page
-0.021  163                 SAM 3641-. I-.            I I
-0.003  171                 SAM 3730-'-' I            I I
-0.039  264                     SAM23056-'-.          I I
-0.043  168               SAM 3667-.     I-.          I I
-0.000  208               SAM 4929-'-.   I I          I I
-0.001  209                 SAM 4930-'-.  I I         I I
-0.001  202                   SAM 4896-'-. I I        I I
-0.007  221                     SAM 4943-'-' I        I I
-0.134  165                       SAM 3659-. I-.      I I
-0.021  199                       SAM 4638-'-' I      I I
```

```
 -0.294  270             O&W  155-. I-.     I I
 -0.087  321             BAR   29-'-' I     I I                    ******************************
                                      I     I I
                                      I     I I
                                      I     I I
 -0.536  197    SAM 4636-.            I-.   I I
 -0.001  205    SAM 4926-'-.          I I   I I
 -0.006  198      SAM 4637-'-.        I I   I I
 -0.019   36        SAM 2881-'-.      I I   I I
 -0.096  314        BAR   15-. I-.    I I   I I
 -0.051  338        BAR   64-'-' I    I I   I I                          1.3
 -0.134  255          SAM22235-. I-.  I I   I I
 -0.061  316          BAR   20-'-' I  I I   I I
 -0.213  353            BAR   96-. I-' I    I I
 -0.089  359            BAR  102-'-'  I     I I
                                      I     I I
                                      I     I I                    ******************************
                                      I     I I
 -0.676  257          SAM22240-.      I-. I I
 -0.007  267          O&W   98-'-.    I I I I
 -0.017  232            SAM 7280-'-.  I I I I
 -0.048  192          SAM 4348-.  I-. I I I I                            1.4
 -0.013  268          O&W   99-'-. I I I I I
 -0.030  280            O&W  307-'-' I I I I
 -0.163  139                SAM 3046-'-' I I I
                                         I I I
                                         I I I                     ******************************
                                         I I I
 -0.862  190    SAM 4346-.                I-' I
 -0.000  237    SAM14467-'-.              I   I
 -0.000  185      SAM 4341-'-.            I   I
 -0.002  238        SAM14469-'-.          I   I
 -0.008   91      SAM 2988-.   I-.        I   I
 -0.001   99      SAM 2996-'-. I I        I   I
 -0.004  189        SAM 4345-'-' I        I   I
 -0.012  186          SAM 4342-. I-.      I   I
 -0.003  279          O&W  278-'-' I      I   I
 -0.017  111              SAM 3008-'-.    I   I
 -0.052    1        SAM    8-.       I-. I   I
 -0.001  235        SAM14465-'-.     I I I   I
 -0.004   98        SAM 2995-. I-.   I I I   I                           1.5
 -0.001  203        SAM 4897-'-' I   I I I   I
 -0.007  108        SAM 3005-.   I-. I I I   I
 -0.001  172        SAM 3731-'-. I I I I I   I
 -0.003  275          O&W  253-'-' I I I I   I
 -0.011  273              O&W  234-'-' I I   I
 -0.065  102          SAM 2999-.      I-'    I
 -0.000  103          SAM 3000-'-.    I      I
 -0.001  101            SAM 2998-'-.  I      I
 -0.002  105              SAM 3002-'-. I     I                                         Boundary
 -0.011  128                SAM 3025-'-'     I                                         Value
                                             I
                                             I                     ****************************** -6.1
                                             I
-16.573  109        SAM 3006-.               I-.
 -0.000  123        SAM 3020-'-.             I I
 -0.001  122          SAM 3019-'-.           I I
 -0.004  247            SAM18029-'-.         I I
 -0.019  107          SAM 3004-.   I-.       I I
 -0.004  118          SAM 3015-'-. I I       I I
 -0.015   95            SAM 2992-'-' I       I I
 -0.034   92              SAM 2989-. I-.     I I
 -0.006  167              SAM 3661-'-' I     I I
 -0.117   29          SAM 2860-.      I-.    I I
 -0.001  120          SAM 3017-'-.    I I    I I
 -0.003  121          SAM 3018-. I-.  I I    I I
 -0.002  241          SAM14473-'-' I  I I    I I
 -0.014   90              SAM 2987-'-. I I   I I
 -0.021   28              SAM 2846-. I-' I   I I
 -0.003  187              SAM 4343-'-'   I   I I
 -0.872  110        SAM 3007-.          I-. I I
 -0.000  169        SAM 3669-'-.        I I I I
 -0.003  156        SAM 3612-. I-.      I I I I
 -0.001  191        SAM 4347-'-' I      I I I I
 -0.020   85          SAM 2941-. I-.    I I I I
 -0.006  239          SAM14470-'-' I    I I I I
 -0.032   97          SAM 2994-.   I-.  I I I I                          2
 -0.005  100          SAM 2997-'-. I I  I I I I
 -0.011  119            SAM 3016-'-' I  I I I I
 -0.168  114      SAM 3011-.        I-. I I I I
 -0.000  116      SAM 3013-'-.      I I I I I I
 -0.003  115    SAM 3012-.  I-.     I I I I I I
 -0.000  117    SAM 3014-'-. I I    I I I I I I
 -0.001   86      SAM 2953-'-' I    I I I I I I
 -0.007  112        SAM 3009-. I-.  I I I I I I
 -0.001  113        SAM 3010-'-' I  I I I I I I
 -0.012  243            SAM14477-'-. I I I I I
 -0.081    6            SAM 2475-. I-' I I I I
 -0.005    7            SAM 2477-'-'  I I I I I
 -0.267  230                SAM 7108-. I-' I I I
 -0.075  240                SAM14472-'-'  I I I
 -5.025   15            SAM 2832-.         I-' I                                        contd.
 -0.061  184            SAM 4340-'-.       I   I                                        next
 -0.136   76              SAM 2922-'-.     I   I                                        page
 -0.334   80              SAM 2926-. I-.   I   I
 -0.074  162              SAM 3640-'-' I   I   I
 -0.367  249                SAM22141-. I-. I   I
 -0.085  342                BAR   68-'-' I I   I
 -0.595  358                    BAR  101-'-'   I
                                               I
                                               I                     ******************************
```

```
                                                            I           ******************************
                                                            I
-84.869  18                  SAM 2835-.                     I-
  0.000 234                  SAM 7790-'-.                   I
 -0.000  20                    SAM 2837-'-.                 I
 -0.005 251                    SAM22228-. I-.               I
 -0.002 262                    SAM22249-'-' I               I
 -0.015 200                        SAM 4639-'-.             I                     3
 -0.036  22                          SAM 2839-'-.           I
 -0.195  87                          SAM 2954-. I-.         I
 -0.076 341                          BAR   67-'-' I         I
 -0.436 288                          O&W 1183-.   I-.       I
 -0.045 307                          O&W 1321-'-. I I       I
 -0.069 299                            O&W 1300-'-' I       I
                                                    I       I
                                                    I       I           ******************************
                                                    I       I

 -6.187  25                    SAM 2843-.           I-.     I
 -0.015  83                    SAM 2931-'-.         I I     I
 -0.072  89                    SAM 2963-. I-.       I I     I
 -0.032 145                    SAM 3088-'-' I       I I     I
 -0.320 309                        BAR    7-'-.     I I     I
 -0.460  17                        SAM 2834-. I-.   I I     I
 -0.141 130                        SAM 3027-'-' I   I I     I
 -1.427 141                      SAM 3063-.     I-. I I     I
 -0.054 296                      O&W 1297-'-.   I I I I     I
 -0.274 310                      BAR    8-. I-. I I I I     I                     4
 -0.084 348                      BAR   89-'-' I I I I I     I
 -0.308  84                        SAM 2939-. I-' I I I     I
 -0.130 294                        O&W 1269-'-'   I I I     I
 -1.854 313                      BAR   13-.         I-' I   I
 -0.028 337                      BAR   63-'-.     I     I   I
 -0.066 350                        BAR   91-'-.   I     I   I
 -0.143  21                        SAM 2838-. I-. I     I   I
 -0.036 344                        BAR   70-'-' I I     I   I
 -0.603 295                          O&W 1296-. I-'     I   I
 -0.071 326                          BAR   36-'-'       I   I
                                                        I   I
                                                        I   I           ******************************
                                                        I   I

-15.675 308                      BAR    2-.             I-. I
  0.000 311                      BAR    9-'-.           I I I
 -1.415 346                    BAR   86-.   I-.         I I I
 -0.028 351                    BAR   93-'-. I I         I I I
 -0.125 315                      BAR   17-'-' I         I I I
 -1.514 318                        BAR   26-. I-.       I I I
 -0.036 357                        BAR  100-'-' I       I I I
 -4.500 312                  BAR   10-.         I-.     I I I
 -0.019 347                  BAR   88-'-.       I I     I I I
 -0.263 361                    BAR  104-'-.     I I     I I I                     5
 -0.576 355                      BAR   98-'-.   I I     I I I
 -1.118 331                  BAR   45-.     I-. I I     I I I
 -0.048 334                  BAR   48-'-.   I I I I     I I I
 -0.226 325                    BAR   34-'-. I I I I     I I I
 -0.327 319                      BAR   27-'-' I I I     I I I
 -3.111 329                  BAR   43-.       I-' I     I I I
 -0.038 330                  BAR   44-'-.     I   I     I I I
 -0.107 332                    BAR   46-'-.   I   I     I I I
 -0.313 317                    BAR   25-. I-. I   I     I I I
 -0.157 333                    BAR   47-'-' I I   I     I I I
 -0.402 336                        BAR   62-'-'   I     I I I
                                                  I     I I I
                                                  I     I I I           ******************************
                                                  I     I I I

 -6.738   4                        SAM  794-.     I-. I I I
 -0.008 155                        SAM 3150-'-.   I I I I I
 -1.267 245                    SAM14479-.     I-. I I I I I
 -0.084 246                    SAM16600-'-.   I I I I I I I
 -0.206 339                      BAR   65-'-. I I I I I I I
 -0.301 242                        SAM14475-'-' I I I I I I
 -4.003  30                    SAM 2862-.       I-' I I I I                       6
 -0.019 290                    O&W 1207-'-.     I   I I I I
 -0.053 135                      SAM 3037-'-.   I   I I I I
 -0.196 335                        BAR   53-'-. I   I I I I
 -0.416 136                      SAM 3041-.   I-'   I I I I
 -0.046 137                      SAM 3042-'-. I     I I I I
 -0.145 134                        SAM 3036-'-'     I I I I
                                                    I I I I
                                                    I I I I             ******************************
                                                    I I I I

-10.265 297                      O&W 1298-.         I-' I I
 -0.007 304                      O&W 1315-'-.       I   I I
 -0.129  12                  SAM 2778-.     I-.     I   I I
 -0.021 306                  O&W 1319-'-.   I I     I   I I
 -0.065  81                    SAM 2927-'-. I I     I   I I
 -0.079 142                      SAM 3066-'-' I     I   I I
 -0.473 300                    O&W 1311-.     I-.   I   I I
 -0.015 303                    O&W 1314-'-.   I I   I   I I
 -0.030 305                      O&W 1316-'-. I I   I   I I                       7
 -0.094 352                        BAR   95-'-' I   I   I I
 -0.777 131                          SAM 3028-. I-. I   I I
 -0.187 349                          BAR   90-'-' I I   I I
 -2.406 291                    O&W 1242-.         I-'   I I
 -0.016 292                    O&W 1248-'-.     I       I I
 -0.042 302                      O&W 1313-'-.   I       I I
 -0.141  11                        SAM 2777-'-. I       I I
 -0.237 301                          O&W 1312-'-. I     I I
 -0.482 293                            O&W 1249-'-'     I I
                                                        I I             ++++++++++++++++
```

```
-22.196  222               SAM 5190-.        I-. I
 -0.003  223               SAM 5191-'-.      I I I
 -0.067  196               SAM 4439-. I-.    I I I
 -0.009  285               O&W  446-'-' I    I I I
 -0.362   26                   SAM 2844-'-.  I I I
 -1.026  180               SAM 3774-.     I-. I I I
 -0.005  182               SAM 3776-'-.  I I I I I                 8
 -0.121  178             SAM 3772-.  I-. I I I I I
 -0.022  181             SAM 3775-'-. I I I I I I
 -0.053  179               SAM 3773-'-' I I I I I
 -0.646  160                 SAM 3633-. I-' I I I I
 -0.122  225                 SAM 6373-'-'  I I I I
                                           I I I I
                                           I I I I     ********************************
                                           I I I I
 -6.693  340         BAR   66-.            I-' I I
 -0.006  345         BAR   77-'-.          I   I I
 -0.029   14           SAM 2787-'-.        I   I I
 -0.120  244           SAM14478-. I-.      I   I I
 -0.059  362           AXX    1-'-' I      I   I I
 -0.218  250               SAM22223-'-.    I   I I
 -0.408  252         SAM22229-.       I-.  I   I I
 -0.013  263         SAM22264-'-.    I I   I   I I
 -0.018  253           SAM22233-'-.  I I   I   I I
 -0.065   13           SAM 2785-. I-. I I   I   I I                 9
 -0.024  323           BAR   31-'-' I I I   I   I I
 -0.169  254               SAM22234-'-' I   I   I I
 -1.311  132                 SAM 3032-. I-. I   I I
 -0.169  269                 O&W  120-'-' I I   I I
 -1.665  176             SAM 3770-.       I-'   I I
 -0.013  177             SAM 3771-'-.     I     I I
 -0.034  287               O&W  634-'-.   I     I I
 -0.106  286                 O&W  465-'-. I     I I
 -0.358  322                 BAR   30-. I-'     I I
 -0.020  324                 BAR   32-'-'       I I
                                                I I
                                                I I    ********************************
                                                I I
-53.010   79     SAM 2925-.                     I-'
 -0.000  154     SAM 3115-'-.                   I
 -0.000  276       O&W  254-'-.                 I
 -0.001  175           SAM 3757-'-.             I
 -0.005  158           SAM 3615-. I-.           I
 -0.001  233           SAM 7293-'-' I           I
 -0.011  174             SAM 3754-. I-.         I
 -0.001  236             SAM14466-'-' I         I
 -0.045  147             SAM 3090-.   I-.       I
 -0.003  281             O&W  315-'-. I I       I
 -0.010  278             O&W  256-. I-' I       I
 -0.004  327             BAR   37-'-'   I       I
 -0.271  231                 SAM 7279-. I-.     I
 -0.081  354                 BAR   97-'-' I     I
 -0.423  320                 BAR   28-.   I-.   I
 -0.198  328                 BAR   42-'-. I I   I
 -0.282  298                   O&W 1299-'-' I   I
 -1.226   24                   SAM 2842-.   I-. I
 -0.014   82                   SAM 2929-'-. I I I
 -0.105  261                     SAM22244-'-' I I
 -1.780    3               SAM   10-.       I-. I
 -0.004  258               SAM22241-'-.     I I I
 -0.014  195                 SAM 4351-'-.   I I I
 -0.051  343                   BAR   69-'-. I I I
 -0.216    2                 SAM    9-.  I-. I I I
 -0.009  188                 SAM 4344-'-. I I I I
 -0.040  282                   O&W  334-'-' I I I I
 -0.456  356                   BAR   99-.  I-' I I
 -0.033  360                   BAR  103-'-. I   I I
 -0.310  283                     O&W  335-'-'   I I
 -5.458  148               SAM 3092-.           I-'
 -0.000  150               SAM 3094-'-.         I                 10
 -0.003  277                 O&W  255-'-.       I
 -0.015  153                   SAM 3100-'-.     I
 -0.032  151                 SAM 3095-.   I-.   I
 -0.001  260                 SAM22243-'-. I I   I
 -0.013  228                   SAM 7046-'-' I   I
 -0.165   77               SAM 2923-.       I-. I
 -0.001  149               SAM 3093-'-.     I I I
 -0.002  159                 SAM 3617-'-.   I I I
 -0.009  248               SAM21674-.   I-. I I I
 -0.002  271               O&W  232-'-. I I I I I
 -0.004    9               SAM 2481-. I-' I I I I
 -0.002  194               SAM 4350-'-'   I I I I
 -0.060  125             SAM 3022-.       I-' I I
 -0.002  127             SAM 3024-'-.     I   I I
 -0.005  193               SAM 4349-'-.   I   I I
 -0.023  129               SAM 3026-. I-. I   I I
 -0.008  138               SAM 3044-'-' I I   I I
 -0.043  284                   O&W  352-'-'   I I
 -1.176  152               SAM 3096-.         I-'
 -0.001  274               O&W  235-'-.       I
 -0.012    8                 SAM 2478-'-.     I
 -0.088  157             SAM 3613-.     I-.   I
 -0.006  201             SAM 4895-'-.   I I   I
 -0.009  272               O&W  233-'-. I I   I
 -0.041   93         SAM 2990-.     I-' I     I
 -0.007   94         SAM 2991-'-.   I   I     I
 -0.011  124             SAM 3021-'-. I   I     I
 -0.018  106               SAM 3003-'-'  I     I
 -0.159  104                 SAM 3001-.   I-.  I
 -0.004  259                 SAM22242-'-. I I  I
 -0.029   96                 SAM 2993-. I-' I  I
 -0.005  126                 SAM 3023-'-'   I  I
 -0.326  229                       SAM 7073-'-'
```

Print-Out B. Run on Bronze Objects,Sn masked.   Clustering Type 7


```
                                                              Bronze Clusters            Boundary Value
          37       SAM 4898-.
 -0.002   44       SAM 6090-'-.
 -0.007   41         SAM 6087-'-.
 -0.048   45           SAM 7051-'-.
 -0.100   33           SAM 3157-. I-.                                                        -5.1
 -0.079   34           SAM 3614-'-' I
 -0.528   16             SAM 3043-. I-.                                                        |
 -0.272   81             BAR   92-'-' I                                                        |
 -0.869   12             SAM 3031-.   I-.                                                      |
 -0.148   32             SAM 3156-'-. I I                             A                        |
 -0.227   80               BAR   87-'-' I                                                      |
 -4.721    4             SAM 2848-.     I-.                                                    |
 -0.027   10             SAM 2974-'-.   I I                                                    v
 -0.161   42               SAM 6088-'-. I I
 -0.802    2           SAM 2820-.     I-' I
 -0.102   46           SAM 7104-'-.   I   I
 -0.242    1             SAM    7-'-. I   I
 -0.480   74               BAR   72-'-'   I
                                          I
                                          I     *******************************
                                          I
 -8.276   17       SAM 3054-.             I-.
 -0.030   19       SAM 3058-'-.           I I
 -0.076   18         SAM 3055-'-.         I I
 -0.333   26           SAM 3149-'-.       I I
 -0.509    7           SAM 2937-. I-.     I I
 -0.093   47           SAM 7164-'-' I     I I                         B
 -0.668   28               SAM 3152-'-.   I I
 -2.212   25             SAM 3113-.   I-. I I
 -0.040   30             SAM 3154-'-. I I I I
 -0.437   31               SAM 3155-'-' I I I
                                        I I I
                                        I I I   ******************************
                                        I I I
 -5.513   55         BAR    5-.         I-' I
 -0.056   56         BAR    6-'-.       I   I
 -0.112   58           BAR   12-'-.     I   I
 -0.200   76             BAR   74-'-.   I   I                         C
 -0.478   54               BAR    4-'-. I   I
 -0.827   61               BAR   18-. I-'   I
 -0.171   63               BAR   21-'-'     I
                                            I
                                            I   ******************************
                                            I
-16.363    3 SAM 2831-.                     I-
 -0.003   13 SAM 3038-'-.                   I
 -0.008   14   SAM 3039-'-.                 I
 -0.013   23     SAM 3099-'-.               I
 -0.036    9       SAM 2943-'-.             I
 -0.047   24       SAM 3112-. I-.           I
 -0.026   49       O&W  401-'-' I           I
 -0.137   11     SAM 2975-.     I-.         I
 -0.007   48     O&W  177-'-.   I I         I
 -0.022   40       SAM 4901-'-. I I         I
 -0.038    5         SAM 2867-'-' I         I
 -0.495   21           SAM 3097-. I-.       I
 -0.060   22           SAM 3098-'-' I       I
 -1.216   77           BAR   75-.   I-.     I
 -0.023   78           BAR   76-'-. I I     I
 -0.382   43           SAM 6089-. I-' I     I                         D
 -0.140   68           BAR   35-'-'   I     I
 -1.691    6         SAM 2932-.       I-.   I
 -0.025   27         SAM 3151-'-.     I I   I
 -0.066   36           SAM 4635-'-.   I I   I
 -0.085   38             SAM 4899-'-. I I   I
 -0.589   51           O&W 1209-.   I-' I   I
 -0.026   52           O&W 1273-'-. I   I   I
 -0.088   53             BAR    3-'-'   I   I
 -3.023   29         SAM 3153-.        I-. I
 -0.115   73         BAR   71-'-.      I I I
 -0.266   15           SAM 3040-'-.    I I I
 -0.558   39             SAM 4900-'-.  I I I
 -1.191   60             BAR   16-. I-. I I I
 -0.379   66             BAR   24-'-' I I I I
 -2.082   57               BAR   11-. I-' I I
 -0.157   67               BAR   33-'-'   I I
                                          I I
                                          I I   ******************************
                                          I I
 -7.686    8           SAM 2940-.         I-'
 -0.031   35           SAM 3616-'-.       I
 -0.068   50             O&W 1049-'-.     I
 -0.247   20             SAM 3078-. I-.   I                           E
 -0.218   59             BAR   14-'-' I   I
 -0.373   75                 BAR   73-'-. I
                                        I I
                                        I I     ******************************
                                        I I
 -5.314   71         BAR   60-.         I-'
 -0.036   72         BAR   61-'-.       I
 -0.073   70           BAR   50-'-.     I
 -0.151   79             BAR   78-'-.   I
 -0.732   64             BAR   22-. I-. I                              F
 -0.132   65             BAR   23-'-' I I
 -0.986   62               BAR   19-. I-'
 -0.270   69               BAR   49-'-'
```

```
         13  SAM 3038-.                                   Bronze Clusters            Boundary Value
 -0.015  23  SAM 3099-'-.
 -0.067  48    O&W  177-'-.
 -0.094  11    SAM 2975-. I-.                                                             -5.1
 -0.031  40    SAM 4901-'-' I
 -0.235  29        SAM 3153-'-.
 -0.528  27      SAM 3151-.   I-.
 -0.084  36      SAM 4635-'-. I I
 -0.110  38        SAM 4899-'-' I
 -0.793  21        SAM 3097-.   I-.
 -0.060  22        SAM 3098-'-. I I
 -0.276  43          SAM 6089-'-' I
 -1.105   3        SAM 2831-.     I-.
 -0.019   9        SAM 2943-'-.   I I
 -0.117   6          SAM 2932-'-. I I                         d
 -0.512  77          BAR   75-. I-' I
 -0.025  78          BAR   76-'-'   I
 -3.051  24  SAM 3112-.             I-.
 -0.018  49  O&W  401-'-.           I I
 -0.026  14    SAM 3039-'-.         I I
 -0.075   5      SAM 2867-'-.       I I
 -0.176  51        O&W 1209-'-.     I I
 -0.502  15        SAM 3040-. I-.   I I
 -0.216  73        BAR   71-'-' I   I I
 -0.809  60          BAR   16-. I-. I I
 -0.437  66          BAR   24-'-' I I I
 -0.975  39              SAM 4900-'-' I
                                      I
                                      I       ********************************
                                      I
-13.597   4 SAM 2848-.                I-
 -0.032  10 SAM 2974-'-.              I
 -0.250   1  SAM    7-'-.             I
 -0.516  74    BAR   72-'-.           I
 -0.859  52    O&W 1273-. I-.         I
 -0.050  53    BAR    3-'-' I         I
 -1.240   2      SAM 2820-. I-.       I
 -0.102  46      SAM 7104-'-' I       I
 -4.336   8 SAM 2940-.        I-.     I                       e
 -0.038  35 SAM 3616-'-.      I I     I
 -0.146  50  O&W 1049-'-.     I I     I
 -0.232  20    SAM 3078-'-.   I I     I
 -0.451  59    BAR   14-. I-. I I     I
 -0.318  75    BAR   73-'-' I I I     I
 -3.364  64  BAR   22-.     I-' I     I
 -0.068  68  BAR   35-'-.   I   I     I
 -0.126  65    BAR   23-'-. I   I     I
 -0.304  67      BAR   33-'-'   I     I
                                I     I
                                I     I       ******************************
                                I     I
 -5.304  71    BAR   60-.       I-.   I
 -0.039  72    BAR   61-'-.     I I   I
 -0.072  70      BAR   50-'-.   I I   I                       f
 -0.161  79        BAR   78-'-. I I   I
 -0.966  62        BAR   19-. I-' I   I
 -0.274  69        BAR   49-'-'   I   I
                                  I   I
                                  I         ******************************
                                  I   I
 -7.431  37    SAM 4898-.         I-. I
 -0.041  44    SAM 6090-'-.       I I I
 -0.094  33    SAM 3157-. I-.     I I I
 -0.079  34    SAM 3614-'-' I     I I I
 -0.505  16      SAM 3043-. I-.   I I I
 -0.227  41      SAM 6087-'-' I   I I I
 -0.901  12      SAM 3031-.   I-. I I I                       a
 -0.180  80      BAR   87-'-. I I I I I
 -0.263  32        SAM 3156-'-' I I I I
 -1.376  45        SAM 7051-.   I-' I I
 -0.161  81        BAR   92-'-. I   I I
 -0.335  42          SAM 6088-'-'   I I
                                    I I
                                    I I       ******************************
                                    I I
 -8.359  17  SAM 3054-.             I-'
 -0.051  19  SAM 3058-'-.           I
 -0.093  18    SAM 3055-'-.         I
 -0.341  26      SAM 3149-'-.       I
 -0.502   7      SAM 2937-. I-.     I
 -0.095  47      SAM 7164-'-' I     I                         b
 -0.660  28          SAM 3152-'-.   I
 -2.128  25        SAM 3113-.   I-. I
 -0.112  30        SAM 3154-'-. I I I
 -0.453  31          SAM 3155-'-' I I
                                  I I
                                  I I         ******************************
                                  I I
 -5.143  55  BAR    5-.           I-'
 -0.077  56  BAR    6-'-.         I
 -0.125  58    BAR   12-'-.       I
 -0.235  76      BAR   74-'-.     I
 -0.508  54        BAR    4-'-.   I                           c
 -0.817  61        BAR   18-. I-. I
 -0.179  63        BAR   21-'-' I I
 -1.398  57            BAR   11-'-'
```

Print-Out D. Discriminant Analysis on 362 Copper Analyses, grouped,a priori, by Cluster Analysis.

	ARRAY LINE	PERCENTAGE PROBABILITY	OPTIMAL SUB-GROUP OF GROUP ONE	USERS CODE	CLUSTER NUMBER
1	10	100.0	1	SAM 2776	
2	16	100.0	1	SAM 2833	
3	19	100.0	1	SAM 2836	
4	23	100.0	1	SAM 2841	
5	32	100.0	1	SAM 2877	
6	33	100.0	1	SAM 2878	
7	34	100.0	1	SAM 2879	
8	35	100.0	1	SAM 2880	
9	37	100.0	1	SAM 2882	
10	38	100.0	1	SAM 2883	
11	40	100.0	1	SAM 2885	
12	42	100.0	1	SAM 2887	
13	43	100.0	1	SAM 2888	
14	44	100.0	1	SAM 2889	
15	45	100.0	1	SAM 2890	
16	46	100.0	1	SAM 2891	
17	47	100.0	1	SAM 2893	
18	48	100.0	1	SAM 2894	
19	49	100.0	1	SAM 2895	
20	50	100.0	1	SAM 2896	
21	51	99.6	1	SAM 2897	1.1
22	54	100.0	1	SAM 2900	
23	55	100.0	1	SAM 2901	
24	56	100.0	1	SAM 2902	
25	57	100.0	1	SAM 2903	
26	58	99.8	1	SAM 2904	
27	59	100.0	1	SAM 2905	
28	60	100.0	1	SAM 2906	
29	61	100.0	1	SAM 2907	
30	62	100.0	1	SAM 2908	
31	63	100.0	1	SAM 2909	
32	66	100.0	1	SAM 2912	
33	67	100.0	1	SAM 2913	
34	68	100.0	1	SAM 2914	
35	69	100.0	1	SAM 2915	
36	70	100.0	1	SAM 2916	
37	73	100.0	1	SAM 2919	
38	75	100.0	1	SAM 2921	
39	78	100.0	1	SAM 2924	
40	88	100.0	1	SAM 2962	
41	140	100.0	1	SAM 3049	
42	143	100.0	1	SAM 3086	
43	144	100.0	1	SAM 3087	
44	146	100.0	1	SAM 3089	
45	256	100.0	1	SAM22236	
46	289	100.0	1	O&W 1184	
47	5	100.0	2	SAM 2474	
48	27	100.0	2	SAM 2845	
49	31	100.0	2	SAM 2876	
50	39	100.0	2	SAM 2884	
51	41	100.0	2	SAM 2886	
52	52	100.0	2	SAM 2898	
53	53	100.0	2	SAM 2899	
54	64	100.0	2	SAM 2910	
55	65	100.0	2	SAM 2911	
56	71	100.0	2	SAM 2917	
57	72	100.0	2	SAM 2918	
58	74	100.0	2	SAM 2920	
59	133	100.0	2	SAM 3033	
60	161	100.0	2	SAM 3638	
61	163	100.0	2	SAM 3641	
62	164	100.0	2	SAM 3642	
63	165	84.7	2	SAM 3659	
64	166	100.0	2	SAM 3660	
65	168	100.0	2	SAM 3667	
66	170	100.0	2	SAM 3690	
67	171	100.0	2	SAM 3730	
68	173	100.0	2	SAM 3753	
69	183	100.0	2	SAM 3780	
70	199	100.0	2	SAM 4638	
71	202	100.0	2	SAM 4896	1.2
72	204	100.0	2	SAM 4925	
73	206	100.0	2	SAM 4927	
74	207	100.0	2	SAM 4928	
75	208	100.0	2	SAM 4929	
76	209	100.0	2	SAM 4930	
77	210	100.0	2	SAM 4931	
78	211	100.0	2	SAM 4932	
79	212	100.0	2	SAM 4933	
80	213	100.0	2	SAM 4934	

contd.
next
page

80	213	100.0	2	SAM 4934	
81	214	100.0	2	SAM 4936	
82	215	100.0	2	SAM 4937	
83	216	100.0	2	SAM 4938	
84	217	100.0	2	SAM 4939	
85	218	100.0	2	SAM 4940	
86	219	100.0	2	SAM 4941	
87	220	100.0	2	SAM 4942	
88	221	98.9	2	SAM 4943	
89	224	100.0	2	SAM 6080	
90	226	100.0	2	SAM 6643	
91	227	100.0	2	SAM 6644	
92	264	100.0	2	SAM23056	
93	265	100.0	2	O&W 6	
94	266	100.0	2	O&W 87	
95	270	100.0	2	O&W 155	
96	321	71.2	5	BAR 29	
97	36	100.0	3	SAM 2881	
98	197	100.0	3	SAM 4636	
99	198	100.0	3	SAM 4637	
100	205	100.0	3	SAM 4926	
101	255	100.0	3	SAM22235	1.3
102	314	100.0	3	BAR 15	
103	316	100.0	3	BAR 20	
104	338	100.0	3	BAR 64	
105	353	100.0	3	BAR 96	
106	359	100.0	3	BAR 102	
107	139	100.0	4	SAM 3046	
108	192	100.0	4	SAM 4348	
109	232	100.0	4	SAM 7280	1.4
110	257	100.0	4	SAM22240	
111	267	100.0	4	O&W 98	
112	268	100.0	4	O&W 99	
113	280	100.0	4	O&W 307	
114	1	100.0	5	SAM 8	
115	91	100.0	5	SAM 2988	
116	98	100.0	5	SAM 2995	
117	99	100.0	5	SAM 2996	
118	101	100.0	5	SAM 2998	
119	102	100.0	5	SAM 2999	
120	103	100.0	5	SAM 3000	
121	105	99.9	5	SAM 3002	
122	108	100.0	5	SAM 3005	
123	111	100.0	5	SAM 3008	
124	128	99.5	5	SAM 3025	1.5
125	172	93.5	5	SAM 3731	
126	185	100.0	5	SAM 4341	
127	186	100.0	5	SAM 4342	
128	189	100.0	5	SAM 4345	
129	190	100.0	5	SAM 4346	
130	203	98.7	5	SAM 4897	
131	235	99.9	5	SAM14465	
132	237	100.0	5	SAM14467	
133	238	100.0	5	SAM14469	
134	273	100.0	5	O&W 234	
135	275	99.0	5	O&W 253	
136	279	100.0	5	O&W 278	
			OPTIMAL GROUP		
137	6	58.7	2	SAM 2475	
138	7	56.4	2	SAM 2477	
139	15	49.8	2	SAM 2832	
140	28	65.0	2	SAM 2846	
141	29	65.0	2	SAM 2860	
142	76	60.1	2	SAM 2922	
143	80	60.7	2	SAM 2926	
144	85	55.7	2	SAM 2941	
145	86	59.2	2	SAM 2953	
146	90	64.2	2	SAM 2987	
147	92	63.7	2	SAM 2989	
148	95	63.4	2	SAM 2992	
149	97	54.2	2	SAM 2994	
150	100	51.1	2	SAM 2997	
151	107	63.0	2	SAM 3004	
152	109	62.4	2	SAM 3006	
153	110	53.5	2	SAM 3007	
154	112	59.6	2	SAM 3009	
155	113	59.6	2	SAM 3010	
156	114	60.4	2	SAM 3011	
157	115	59.6	2	SAM 3012	
158	116	60.4	2	SAM 3013	
159	117	58.7	2	SAM 3014	2
160	118	61.8	2	SAM 3015	
161	119	55.5	2	SAM 3016	
162	120	64.8	2	SAM 3017	
163	121	64.5	2	SAM 3018	
164	122	61.8	2	SAM 3019	
165	123	62.4	2	SAM 3020	
166	156	52.4	2	SAM 3612	

contd.
next
page

166	156	52.4	2	SAM 3612	
167	162	63.3	2	SAM 3640	
168	167	63.2	2	SAM 3661	
169	169	53.9	2	SAM 3669	
170	184	60.7	2	SAM 4340	
171	187	64.9	2	SAM 4343	
172	191	51.4	2	SAM 4347	
173	230	59.8	2	SAM 7108	
174	239	56.7	2	SAM14470	
175	240	56.2	2	SAM14472	
176	241	64.6	2	SAM14473	
177	243	60.5	2	SAM14477	
178	247	62.8	2	SAM18029	
179	249	65.4	2	SAM22141	
180	342	65.3	2	BAR 68	
181	358	66.0	2	BAR 101	
182	18	95.6	3	SAM 2835	
183	20	94.5	3	SAM 2837	
184	22	83.7	3	SAM 2839	
185	87	39.2	1	SAM 2954	
186	200	86.5	3	SAM 4639	
187	234	95.6	3	SAM 7790	
188	251	91.8	3	SAM22228	3
189	262	93.3	3	SAM22249	
190	288	93.4	3	O&W 1183	
191	299	63.9	3	O&W 1300	
192	307	93.3	3	O&W 1321	
193	341	63.4	3	BAR 67	
194	17	98.3	3	SAM 2834	
195	21	100.0	4	SAM 2838	
196	25	100.0	4	SAM 2843	
197	83	100.0	4	SAM 2931	
198	84	100.0	4	SAM 2939	
199	89	100.0	4	SAM 2963	
200	130	95.1	3	SAM 3027	
201	141	94.7	4	SAM 3063	
202	145	100.0	4	SAM 3088	
203	294	99.8	4	O&W 1269	
204	295	90.2	3	O&W 1296	4
205	296	87.3	3	O&W 1297	
206	309	76.3	3	BAR 7	
207	310	92.4	3	BAR 8	
208	313	100.0	4	BAR 13	
209	326	75.5	10	BAR 36	
210	337	100.0	4	BAR 63	
211	344	93.6	3	BAR 70	
212	348	70.8	4	BAR 89	
213	350	100.0	4	BAR 91	
214	308	95.1	10	BAR 2	
215	311	99.8	7	BAR 9	
216	312	49.0	2	BAR 10	
217	315	100.0	5	BAR 17	
218	317	100.0	5	BAR 25	
219	318	61.3	1	BAR 26	
220	319	79.2	5	BAR 27	
221	325	63.3	1	BAR 34	
222	329	90.5	5	BAR 43	
223	330	100.0	5	BAR 44	
224	331	100.0	5	BAR 45	5
225	332	100.0	5	BAR 46	
226	333	100.0	5	BAR 47	
227	334	79.6	5	BAR 48	
228	336	100.0	5	BAR 62	
229	346	99.8	5	BAR 86	
230	347	44.2	1	BAR 88	
231	351	100.0	8	BAR 93	
232	355	62.5	2	BAR 98	
233	357	61.6	1	BAR 100	
234	361	65.3	1	BAR 104	
235	4	100.0	6	SAM 794	
236	30	100.0	6	SAM 2862	
237	134	100.0	6	SAM 3036	
238	135	39.6	1	SAM 3037	
239	136	100.0	6	SAM 3041	
240	137	100.0	6	SAM 3042	
241	155	100.0	6	SAM 3150	6
242	242	57.3	1	SAM14475	
243	245	63.4	1	SAM14479	
244	246	62.7	1	SAM16600	
245	290	99.4	6	O&W 1207	
246	335	100.0	6	BAR 53	
247	339	61.0	1	BAR 65	

contd.
next
page

248	11	62.9	1	SAM 2777	
249	12	100.0	7	SAM 2778	
250	81	100.0	7	SAM 2927	
251	131	58.2	1	SAM 3028	
252	142	100.0	7	SAM 3066	
253	291	61.1	1	O&W 1242	
254	292	97.3	7	O&W 1248	
255	293	86.6	7	O&W 1249	
256	297	100.0	7	O&W 1298	
257	300	99.4	7	O&W 1311	7
258	301	49.0	1	O&W 1312	
259	302	62.6	1	O&W 1313	
260	303	94.4	7	O&W 1314	
261	304	100.0	7	O&W 1315	
262	305	93.4	7	O&W 1316	
263	306	99.8	7	O&W 1319	
264	349	62.2	7	BAR 90	
265	352	44.6	7	BAR 95	
266	26	100.0	8	SAM 2844	
267	160	66.8	1	SAM 3633	
268	178	100.0	8	SAM 3772	
269	179	100.0	8	SAM 3773	
270	180	100.0	8	SAM 3774	
271	181	100.0	8	SAM 3775	
272	182	100.0	8	SAM 3776	8
273	196	100.0	8	SAM 4439	
274	222	100.0	8	SAM 5190	
275	223	100.0	8	SAM 5191	
276	225	70.2	1	SAM 6373	
277	285	100.0	8	O&W 446	
278	13	100.0	9	SAM 2785	
279	14	40.9	1	SAM 2787	
280	132	63.6	1	SAM 3032	
281	176	100.0	9	SAM 3770	
282	177	100.0	9	SAM 3771	
283	244	51.6	1	SAM14478	
284	250	43.6	1	SAM22223	
285	252	100.0	9	SAM22229	
286	253	100.0	9	SAM22233	
287	254	100.0	9	SAM22234	
288	263	100.0	9	SAM22264	9
289	269	63.0	1	O&W 120	
290	286	64.5	9	O&W 465	
291	287	100.0	9	O&W 634	
292	322	100.0	9	BAR 30	
293	323	100.0	9	BAR 31	
294	324	100.0	9	BAR 32	
295	340	85.2	9	BAR 66	
296	345	90.2	9	BAR 77	
297	362	97.9	9	AXX 1	
298	2	51.0	10	SAM 9	
299	3	98.1	10	SAM 10	
300	8	61.0	2	SAM 2478	
301	9	56.9	10	SAM 2481	
302	24	100.0	10	SAM 2842	
303	77	52.4	10	SAM 2923	
304	79	99.8	10	SAM 2925	
305	82	100.0	10	SAM 2929	
306	93	64.5	2	SAM 2990	
307	94	64.8	2	SAM 2991	
308	96	62.9	2	SAM 2993	
309	104	61.4	2	SAM 3001	
310	106	63.9	2	SAM 3003	
311	124	63.8	2	SAM 3021	
312	125	47.3	2	SAM 3022	
313	126	62.5	2	SAM 3023	
314	127	47.0	2	SAM 3024	
315	129	52.3	10	SAM 3026	
316	138	66.1	10	SAM 3044	
317	147	99.9	10	SAM 3090	
318	148	80.3	10	SAM 3092	
319	149	59.3	10	SAM 3093	
320	150	80.4	10	SAM 3094	
321	151	93.6	10	SAM 3095	
322	152	50.8	2	SAM 3096	
323	153	84.5	10	SAM 3100	
324	154	99.8	10	SAM 3115	
325	157	64.2	2	SAM 3613	
326	158	98.4	10	SAM 3615	
327	159	52.0	10	SAM 3617	
328	174	99.9	10	SAM 3754	
329	175	99.4	10	SAM 3757	
330	188	77.0	10	SAM 4344	10
331	193	50.8	2	SAM 4349	
332	194	48.8	10	SAM 4350	
333	195	99.9	10	SAM 4351	
334	201	63.4	2	SAM 4895	
335	228	87.8	10	SAM 7046	
336	229	61.5	2	SAM 7073	
337	231	70.5	10	SAM 7279	
338	233	99.3	10	SAM 7293	
339	236	99.5	10	SAM14466	
340	248	65.4	10	SAM21674	
341	258	99.7	10	SAM22241	
342	259	58.8	2	SAM22242	
343	260	95.0	10	SAM22243	
344	261	100.0	10	SAM22244	
345	271	57.8	10	O&W 232	
346	272	61.8	2	O&W 233	
347	274	54.9	2	O&W 235	
348	276	99.7	10	O&W 254	
349	277	69.7	10	O&W 255	
350	278	100.0	10	O&W 256	
351	281	100.0	10	O&W 315	
352	282	92.6	10	O&W 334	
353	283	55.2	2	O&W 335	
354	284	49.6	2	O&W 352	
355	298	75.9	10	O&W 1299	
356	320	100.0	10	BAR 28	
357	327	99.9	10	BAR 37	
358	328	100.0	10	BAR 42	
359	343	100.0	10	BAR 69	
360	354	53.8	2	BAR 97	
361	356	99.9	10	BAR 99	
362	360	91.1	7	BAR 103	