(1993)

CHAINE OPERATOIRE; THE CONCEPT AND ITS APPLICATIONS.

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In a recent paper, A. Jelinek described Geneste's technological study (Geneste 1985) of Middle Paleolithic *chaînes opératoires* as: "one of the most innovative and significant recent studies in Paleolithic Prehistory. It points the way toward an appreciation of new dimensions in the study of lithic industries and should serve as the point of departure for numerous explorations" (Jelinek 1991:27). What exactly is meant by "*chaînes opératoires*" and what makes it so innovative?

This concept has been widely used in French archaeology for the last ten years (Geneste 1985, 1989; Boëda 1986; Perlès 1987; Pelegrin et al. 1988; Boëda et al. 1990; Perlès and Binder 1990; Karlin et al. 1991 among others). Similar approaches have been developed in the United States by processual archaeologists and the *chaîne opératoire* remains ignored by the bulk of English speaking archaeologists. The goals of this paper are to provide a working definition of the *chaîne opératoire*, summarize its previous applications, explore its potential as an analytical or heuristic tool, and, define what makes this approach so different from a traditional typological study. This work will be divided into three parts. The first part will address the definition of the concept, the second will explain the methodology used to apply the concept, and the third will address more theoretical problems through a discussion of the applications of *chaînes opératoires*.

DEFINITION

The analysis of *chaînes opératoires* is a technological approach that seeks to reconstruct the organization of a technological system at a given archaeological site. A more precise definition is provided by Perlès: "the *chaîne opératoire* could be defined as follows: succession of mental operations and technical gestures, in order to satisfy a need (immediate or not), according to a preexisting project" (Perlès 1987:23).

Consequently, the *chaîne opératoire* aims to describe and understand all cultural transformations that a specific raw material had to go through. It is a chronological segmentation of the actions and mental processes required in the manufacture of an artifact and in its maintenance into the technical system of a prehistoric group. The initial stage of the chain is raw material procurement, and the final stage is the discard of the artifact.

SOME HISTORICAL CONSIDERATIONS

The concept of *chaîne opératoire*, as it is currently used by French archaeologists, was borrowed from other fields in social sciences, especially ethnology. Although the term appeared in the archaeological literature as early as 1968 in Brézillon's "*La dénomination des objets de pierre taillée*", he did not define the concept; he used it to describe a sequence of operations required in the context of lithic artifact manufacture -- describing, for instance, the different steps in the production of a Levallois flake (Brézillion 1968: 78). As a consequence, the idea remained largely neglected during the following decade. It is not until the late 1980's that it reappeared in some publications. Two names were then repeatedly cited by the principal proponents of such a technological approach in archaeology: Lemonnier and Leroi-Gourhan (see Lemonnier 1983; Pelegrin et al. 1988; Geneste 1989).

Leroi-Gourhan influenced the theories under-

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lying the notion of chaîne opératoire through his early comparative work of tool manufacture and raw material transformation processes (Leroi-Gourhan 1964). His work was amongst the first to systematize the analysis of technical activities with reference to the notion of a chain of operations. According to him: "technique is both motion and tool, which are organized to form a chain by a true syntax that gives to the operating series their rigidity and their adaptability" (Leroi-Gourhan 1964:323). For Lemonnier, whose work is based on ethnography, the *chaîne opératoire* also integrates a conceptual level and, thus, cannot be understood without reference to the technical knowledge of a group (in Pelegrin et al. 1988). It is around this last interpretation of the term that a definition adapted to archaeology was built. Subsequently, a *chaîne opératoire* study was seen as integrating three levels of analysis, which would reveal the technical decisions made in the process of tool manufacture. The most basic level is represented by the objects themselves (tools and by-products of the manufacture process); then comes a series of gestures or technical sequences (the methods by which the tools are produced); and finally, at the most abstract level, is the specific technical knowledge shared by all group members (Pelegrin et al. 1988:55).

A *chaîne opératoire* study reveals the dynamic of a specific technical system (the lithic system, for instance) and the role of this system within the broader technology of a prehistoric group. Indeed, the different chains constitute the whole technical system of a prehistoric group, at a given site (Pelegrin et al. 1988:55). Such an approach provides a dynamic view of the stone tools, because it takes into account the life trajectories of the tools. It permits a reconstruction of distinct technological strategies through an understanding of the relation between raw material procurement, tool manufacture, tool use, maintenance and discard.

This is quite similar to other analytical principles developed, in the seventies, in the United States. Schiffer's behavioral chain (Schiffer 1972, 1976), in particular, has strong affinities with the notion of *chaînes opératoires*. As Schiffer puts it: "the sequence of activities in the systemic context of any durable element can be grouped in a set of *basic processes* and represented by a flow model. These processes include *procurement, manufacture, use maintenance* and *discard*. A process consists of one or more stages .... A stage, in return, consists of one or more activities" (Schiffer 1976:46).

There is no doubt that a separate "invention" and "evolution" of the concepts in France and in America resulted in very similar outcomes. This is especially striking since one of the approaches evolved from ethnology, while the other was rooted in processual archaeology. The fact that these two views of technological systems were developed independently, however, led to slight differences in their expression, that is, in the theoretical elements involved in the definitions. One of the peculiarities of a study of *chaînes opératoires* for instance, is the analysis of the concepts and knowledge involved in tool manufacture. This aspect of *chaînes opératoires*, certainly one of the most controversial, is absent from an American behavioral chain approach, and will be discussed later in this paper.

Besides differences in the ingredients of the definitions, there are also differences in the way the analysis is implemented. The French proponents of a *chaîne opératoire* study have been more concerned in providing an analytical tool that helps describe the dynamics of the stone tools (Perlès 1987:23), than in making a theoretical statement. This has resulted in a more comprehensive methodology, as well as in a distinct characterization of analytical units. Schiffer (1976), for instance, considers a series of activities as the minimal analytical unit, while Pelegrin defines minimal analytical units through recognized changes in operations or techniques (Pelegrin et al. 1988:60). Consequently, the *chaîne opératoire* leads, ultimately, to a finer grained reading of technical activities.

In light of the similarities between *chaînes opératoires* and American *behavioral chains*, it is quite interesting to notice that their respective fates have been so divergent. *Chaîne opératoire* is currently the prevailing technological approach in France and is becoming increasingly popular in other countries, as well. In North America, on the contrary, few such studies post-date the 1970's. Jelinek attributes this failure partly to a lack of suitability of the New World data to such an analysis (Jelinek 1991:8). It seems more reasonable to credit the failure to two different research focuses. While French scholars have been

particularly interested in studying the conceptual level revealed by a *chaîne opératoire* analysis, American scholars have been more concerned with the organization of lithic systems in general (see Nelson 1991). However, a *chaîne opératoire* approach has the potential to increase our understanding of the structure of past lithic systems and, as I will stress later, it is possible to reconcile the applications of a *chaîne opératoire* study with the current American research agenda.

THE METHODOLOGY

Having defined the concept and its goals, it is necessary to describe more precisely how it can be operationalized. Although some of the following points can be generalized to other technological systems, the discussion will be restricted to stone tool assemblages.

On a larger scale, lithic materials have been divided into meaningful subsystems, namely raw material procurement, tool production, tool use, maintenance and discard (e.g.,Collins 1974; Schiffer 1976; Binford 1977, 1979; Tixier et al. 1980). Collins, for instance stated that: "any model claiming to cover comprehensively the production of chipped stone tools must account for all steps in manufacture from the acquisition of raw materials to the disposal of complete implements and must be able to account for the alternative procedures which might occur in any particular situation" (Collins 1974:3). Albeit probably too simple, this partitioning of stone tools into three or four categories will be retained for the sake of clarity. Let us now review the main subsystems and outline some of the analytical tools that could help extract relevant technological information.

RAW MATERIAL PROCUREMENT

An analysis of raw material procurement should serve to determine the type of raw material(s) brought and used on a site, their respective quantitative and qualitative importance in the system, the morphology under which they were introduced, and the process by which they were introduced (indirect vs. direct procurement). Distance to sources has been the prevailing criterion in studies of raw material procurement. Linear distances are traditionally used to infer the type of procurement: trade or direct procurement, for instance (e.g., Hayden 1982; Tankersley 1991). Such a measure, however, testifies only to the last quarries visited, and it does not express the extent of the territory that was exploited. Furthermore, different proportions of raw material are a direct consequence of organizational patterns (Ingbar 1992); thus, defining the role of different raw materials in the lithic system can be done only through an understanding of the strategies of production, use and discard.

REDUCTION SEQUENCES

The purpose of this analytical step is a recognition and description of all the reduction methods (choices which characterize different stages in a reduction sequence) associated with the different cultural groups, and an understanding of the role of these reduction methods within the lithic system of each group. For Geneste: "organizing a *chaîne opératoire* is done, on theoretical, archaeological or experimental basis, through a definition of the chronological steps of tool manufacture. Each logical step in a *chaîne opératoire* can then be characterized by one or a series of end-products, waste flakes or debris, bearing technical criteria and referring to a specific phase in the process" (Geneste 1989:443). Subsequently, three analytical approaches are available to the archaeologist for studying reduction methods: refitting, diacritical studies (studies of flaking sequences), and experimentation.

The diacritical study is a count, orientation and chronological classification of all flake removals visible on an artifact (e.g., Storck 1983; Young and Bonnichsen 1984; Bradley 1991). This classification can be achieved with the help of all the different marks of a former removal (ridge or bulb, for instance). It allows reconstruction of the direction of removals and their chronology, and also the recognition of a shift in manufacture operations. The goal of such a study is the recognition of patterns in core reduction; thus, cores and bifaces are the primary source of data. They let us see a complete technological stage, unlike flakes, which show only a limited number of removals on their dorsal face.

The second approach for inferring reduction methods is refitting. This is the logical complement of a diacritical analysis. While both are

reconstructive, refitting represents a more secure procedure. There are two kinds of refitting (Tixier 1979): fracture refitting (refitting of broken pieces) and debitage refitting (sequential refitting). Although most of the breakage probably occurred during manufacture, refitting of the pieces broken during use or maintenance provides a dynamic view of the tool's life, and helps to infer the strategies of use. Refitting tools or non-retouched blanks to a core reveals the morphology of the raw material when introduced into the camp (blank, cores ready for reduction, or core in exploitation). It also shows, through the repetition of certain operations, some specific methods of reduction.

The reconstruction of reduction methods through a diacritical study and through refitting requires an analysis of the cores *and* the flakes (including waste flakes and resharpening chips). Once the reduction strategies are inferred from the cores, the reconstructed production methods are tested using the debitage. One of the goals of an operating chain analysis is to assign to all flakes a stage in the reduction process. This can be done in modeling the morphological and technological criteria associated with the different stages of production The role of experimentation provides a better definition of relevant technological criteria for use in making inferences.

USE, MAINTENANCE AND DISCARD

Defining strategies of use and discard are the ultimate steps of a technological analysis, without which a reconstruction of the *chaîne opératoire* is incomplete. One of the goals of technological analyses is a determination of the relation between unifacial tool types and tool blanks. This can be done only if there is a good understanding of the successive transformations of a tool (Frison 1968). Fracture reassembling of tools, as outlined by Tixier (1979), helps to reconstruct the tool life and, thus, evaluate the validity of traditional typologies. Fracture reassembling and refitting unifacial tools to cores are the most secure way to reconstruct the life of a tool, but a study of the type of blanks and an analysis of the resharpening chips should also provide relevant information. The goal here is not to reconstruct the function of each tool (this goal should be the focus of a specialized study of use-wear), but rather to refine the data provided by traditional typological analyses. Unlike typological studies, technological analyses yield a dynamic view of tool life, and therefore allow a description of the strategies of use and discard.

To summarize the methodology associated with a *chaîne opératoire* analysis, one can make several points: 1) This process relies on an inferential procedure which is experimentally or archaeologically based. Reproduction of the artifacts and techniques that were used in their manufacture allows a determination of relevant technological criteria. These criteria are later used to classify the archaeological remains into meaningful units; 2) The analysis requires all artifacts present at a site -- the end-products of flint-knapping, as well as the by-products of such activities; 3) As it is necessary to take into account all the products of stone tool-related activities, it is also crucial to consider all the sequences of such activities and to evaluate their interactions. To do so, all the data provided by the study of reduction methods, utilization and discard should be linked to raw material type.

The methodology outlined above is the one traditionally associated with a study of *chaînes opératoires*; however, I argue that other analytical tools also have the potential to disclose the dynamic relationships among lithic subsystems . Among those, a minimal nodule analysis (Kelly 1985) is probably the most promising, and could become a powerful heuristic device when combined with a refitting study or a diacritical analysis (Sellet, in press). A minimal nodule analysis can be summarized as being a classification of all cores and flakes into multiple units (nodules), based on raw material type, color or grain. Each group thus represents the products of the reduction of at least one (and ideally only one) chunk of raw material. A qualitative and quantitative study of the different groups (analysis of the tools and of the segments of the *chaîne opératoire* represented in each group, of the weight and quantity of respective raw materials, for instance) provides a unique insight on precisely what has been produced and discarded at the site, and what was brought there or taken away. It also shows the role of each raw material, reduction strategy, or tool type in the whole technological system of a given prehistoric group. In short, a *chaîne opératoire* study associated with a minimal nodule analysis can help reconstruct the complete prehistoric tool-kit, and subsequently, provide a window on the needs of Paleolithic

hunter-gatherers. Such a technological approach should allow a better understanding of the strategies surrounding the stone tools, and thus enhance the interpretation of technological organization.

DISCUSSION

In 1979, Binford called for a *rethinking* of current approaches to the study of assemblage variability, and argued that: "such rethinking especially is needed with regard to the 'cost/benefit' analysis of lithic source locations and differential relationships between reduction strategies, raw materials, tool design, recycling, reuse, and the relative contributions of each to 'assemblage variability' " (Binford 1979:271). I would assert, in light of the above discussion, that the *chaîne opératoire* concept is perfectly suited to such an approach. Jelinek was correct to stress its innovative nature. Furthermore, when associated with the proper methodology, this concept is an adequate analytical tool for addressing problems such as curation and the diversity or efficiency of a technological system, which are central to the technological debates in North America.

A good understanding of the process of curation cannot be achieved without a dynamic view of the lithic system. To do so it is crucial to assess the timing of the technical operations involved in the manufacture of stone tools and their maintenance in the system (e.g., manufacture, use, resharpening, recycling, discard). A study of the complexity of the *chaînes opératoires*, in terms of their degree of fragmentation or the type of sequences represented (is the complete chain represented at a site and how complex is it?), provides important information concerning the segmentation of these operations in time and space. Being able to answer the problem of curation in the archaeological record should give us a framework for interpreting the effects of mobility in shaping the structure of the lithic system of a prehistoric group. This issue is central to the definition of archaeological variability. This is why a technological approach through the notion of *chaîne opératoire* has heuristic capabilities, where the traditional typological approach has only descriptive value.

Consequently, a *chaîne opératoire* and a typological approach are opposed as much by their goals as by their means. The *chaîne opératoire* study provides us with a dynamic perspective of a technological system. Unlike typological studies that have failed to consider stone tools as responsive to specific needs, it lets us see technological trajectories through the relationships of lithic subsystems, and thus outlines the choices made by the prehistoric people. Though a *chaîne opératoire* study requires a taxonomy, this taxonomy does not have universal explanatory value. The type of classification needed in a *chaîne opératoire* analysis is peculiar to each situation and answers specific analytical needs. In light of this discussion, it is hard to agree with Bar-Yosef when he states that: "the analysis of *chaînes opératoires* does not differ from the traditional one, which seeks to discover 'prehistoric cultures'. Only we believe that this kind of analytical procedure better reflects the individuality of the prehistoric group and, in some cases, the individual artisans themselves" (Bar-Yosef 1991:322).

It is true that some recent works have attempted to look for an individual signature in the archaeological record (e.g. Ploux 1991), but these studies have shown the limits of a *chaîne opératoire* approach. The study of the concepts and technical knowledge used in the manufacture of stone tools remains the most abstract and the most difficult application of *chaînes opératoires*. The extraction of technological information from the archaeological data by the *chaîne opératoire* concept relies, as we have demonstrated, on an inferential procedure; and, while most of the technological observations can be secured by refitting or experimentation, for instance, the interpretation of the technical behavior itself needs to be supported by an evaluation of alternative hypotheses. This process is unfortunately too often overlooked in an evaluation of technical knowledge or technical skills, the notions used in the identification of individualistic behavior.

The above overview of the history, theory and implications of the *chaîne opératoire* approach is a necessary simplification: the applications have gone in many directions since the concept was first applied to the study of stone tool assemblages. Such a divergence of opinion reflects the analytical potential of the concept and, what is more important, the good health of technological research. The analytical capacity of a *chaîne opératoire* approach is, however, far from having been exhausted. The concept associated with the

proper methodology could, for instance, play a central role in the interpretation of the organization and the dynamics of lithic systems. Subsequently, this unexplored potential calls for a readjustment of the goals and applications of *chaînes opératoires*, as well as for their (re)integration into the North-American research agendas.

SPANISH SUMMARY

El concepto de cadena operativa en los estudios tecnológicos tiene su raíz en Francia hacia fines de la década del '70. Se discute su utilización previa, explorando su potencial desde el punto de vista heurístico y analítico. El estudio de las cadenas operativas ayudará a la completa reconstrucción de los conjuntos líticos prehistóricos. Esto permitiría una mejor comprehensión de la dinámica de los diferentes procesos técnicos relacionados con la manufactura de los instrumentos líticos, así como de distintas estrategias adaptativas relacionadas con los mismos.

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