CRAFTING BONE – SKELETAL TECHNOLOGIES THROUGH TIME AND SPACE

Proceedings of the 2nd meeting of the (ICAZ) Worked Bone Research Group

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Infrastructural support by

The staff of the Roman Department of the Aquincum Museum

Worked Bone Research Group 2nd Meeting
Budapest 31 August – 5 September 1999

BAR International Series
2001

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Special Assemblages

Participants in the WBRG 1999 Budapest conference (left to right): Ülle Tamla, Elisabeth Brynja, Tina Tuohy, Liina Maldre, Karlheinz Steppan, Heidi Luik, Gitte Jensen, John Chapman, Alice Choyke, Janet Griffitts, Andreas Northe, Noëlle Provenzano, Jörg Schibler, Nerissa Russell, Colleen Batey, Lyuba Smirnova, László Daróczi-Szabó, Daniella Ciugudean, Mária Bíró, Kordula Gostenčnik, Eszter Kovács, Christopher Morris, Sabine Deschler-Erb, Ans Nieuwenberg-Bron, Katalin Simán, Isabelle Sidéra, Mickle Zhilin

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Introduction

Archaeologists and Archeozoologists, both study worked osseous materials (bone, antler and tooth, including ivory, in short all referred to as "bone"). Such reports, however, are often buried at the very back of faunal analyses appended to site reports. Furthermore, the two groups of specialists have had little chance to interact, even within Europe since they tend to attend different conferences and write for different fora.

At the root of this problem lay the arbitrary, largely institutional division between pre- and proto-historians, often imposed on bone manufacturing experts by nothing but formalism in research tradition. The most exemplary series of studies n this field is entitled: "*Industrie de l'os neolithique et de l'age de metaux*" (Bone industry *from the Neolithic and Metal Ages*). Another classic, a book, is sub-titled "The Technology of Skeletal Materials *since the Roman Period*". In very early prehistoric assemblages, attention is often focused on the question of whether a particular piece of bone was worked or not. In later assemblages, it is the intensity of manufacturing that often renders objects zoologically non-identifiable, so that important aspects of raw material procurement, including long distance trade, remain intangible.

The history of raw material use, however, is continuous and many of the constraints and possibilities inherent in skeletal materials are the same whether one is dealing with Paleolithic or Medieval artifacts. Indubitably, the organization of manufacture, the function and value of bone artifacts (as well as some technological innovations such as the regular use of metal tools or lathes), differ substantially between simple and complex societies through time. On the other hand, fundamental questions of tensile characteristics, procurement strategies, style and certain technological requirements are not only similar diachronically, but also open up new vistas when apparently unrelated periods are compared. The function of these objects as social markers, for example, remains remarkably constant through time, even if details vary. The papers in this volume reflect these conceptual similarities and differences as did the papers delivered at the conference itself.

The first meeting of what was to become the Worked Bone Research Group (WBRG) was organized by Dr. Ian Riddler in the **British Museum, London, in January 1997**. The committment and enthusiasm of that first workshop has greatly inspired subsequent efforts in recruiting a wide range of bone specialists, capable of contributing to discussions concerning bone manufacturing.

In keeping with the aims of the Worked Bone Research Group, since 2000 an official working group of the International Council for Archaeozoology (ICAZ), an effort was made to present these papers on the basis of what *connects* them rather than segregating them by archaeological period or region. Contributions mostly include articles based on papers delivered in September 1999 at the second Worked Bone Research Group meeting in Budapest, organized by the editors with the unfailing support of the Aquincum Museum (Budapest) and its staff. Several people who were unable to be present at this conference were also asked to contribute papers. Finally, five of the studies in this volume, originally delivered at a symposium on bone tools organized by Dr. Kitty Emery and Dr. Tom Wake, entitled "*Technology of Skeletal Materials: Considerations of Production, Method and Scale*", at the 64th Annual Meeting of the Society for American Archaeology (Chicago 1999), were added thereby expanding the academic spectrum both in terms of research tradition and geographic scope.

There are a total of 36 papers in this volume. Research was carried out on materials from Central and North America to various regions of Europe and Southwest Asia. The authors represent scientific traditons from Estonia, Hungary, Romania, and Russia, European countries in which, until recently, ideas developed in relative isolation. Other European countries represented include Austria, Denmark, France, Germany, Great Britain, Greece, and Switzerland. Last but not least, the North American scholarly approach is also represented here.

Schools of thought may be said to be exemplified by what used to be Soviet research, well known for pioneering works on taphonomy, experimentation and traceology. Bone manufacturing was first brought to the attention of Western scholars by the publication in 1964 of the translation of S. A. Semenov's *Prehistoric Technology*, published originally in 1957. Scholars in France have also carried out decades of co-ordinated work on operational chains in the manufacturing process from the selection of raw materials to finished products, with special emphasis on prehistoric modified bone. An entire working group, "Unspecialized Bone Industries/Bone Modification", is directed by Marylene Patou-Mathis. This working group itself is part of a larger research program on bone industry "*La Commission de Nomenclature sure l'Indistrie de l'Os Prëhistorique*" headed my Mme. H. Camps-Fabrer. Several specialists such as Jörg Schibler in Switzerland, have created laboratories where ground laying work has been carried out for years on worked osseous materials, especially from Swiss Neolithic Lake Dwellings and Roman Period sites. Language barriers have often prevented these important bodies of work from being as widely disseminated as they deserve. Arthur MacGregor in England, writing in English, has had a decisive influence on specialists working on more recent Roman and Medieval worked bone assemblages in Europe.

The work of all of these groups as well as certain individual scholars is well known within limited circles. Otherwise, however, the overwhelming experience of most researchers on worked bone have been feelings of isolation and alienation from most archaeological or archaeozoological work related, most importantly, to the absence of an international forum where their often specialized work can be presented and problems discussed.

In spite of the fact that there have been many practical obstacles to information flow between specialists in this field, there are really remarkable similarities of approach which should ultimately lead to the development of more compatible paradigms in research. Agreement on methodologies will have a positive feedback on communications, helping the field to grow and develop properly.

It seems that, at last, archaeologists and archaeozoologists and other specialists are talking to each other and sharing methodologicial points of view. One striking example of this can be seen in the the emphasis on raw materials studied in parallel to types found in the majority of papers in this volume. Previously studies often concentrated on typo-chronological questions, ignoring the questions of raw material morphology and availability. The series published by the *Centre National de la Recherche Scientifique*, edited by Mme. Henriette Camps-Fabrer in France is largely to be credited for beginning this new trend. It contains many papers concentrating on understanding manufacturing sequences and, indeed, from Europe to North America there are papers which explicitly deal with manufacturing sequences in individual assemblages.

There is also a consistent emphasis on experiment and manufacturing techniques present in much of the work in this volume. The related but fraught question of function continues to tantalize and frustrate most specialists. A number of articles attempt to apply techniques of hard science, such as scanning electron microscopy or light microscopy, together with experiment to get objective, "processual" answers to this important group of questions. Other researchers rely deductively on analogy, archaeological context, gross morphology, and textual sources as they try understanding how these objects were used.

When editing the volume, we tried to concentate on the underlying main concepts represented by each paper rather than grouping them diachronically or by geographical region. As a result, contributions follow a line from the theoretical through the problems of raw material selection, manufacturing techniques, experimental work, technical function and socio-cultural interpretations. Obviously many of these papers deal with several of these aspects simultaneously. Finally, analyses of assemblages are grouped to show the current state of general application of these principles as illustrated in papers in the rest of the volume. Reports on bone tool types will ultimately benefit from more unified typologies and also provide researchers with comparitive databases from regions beyond their own.

Finally, a word on the organization of papers in this volume. Although the editors have tried to group these papers by what they see as the main theoretical and methodological thrust of the authors it should be understood that most papers, to a greater or lesser extent, overlap between these artificial sub-titles. Happily, almost all these works include considerations of raw material exploitation, manufacturing and functional analyses and all make some attempt to consider the social context from which these artifacts emerged. It is exactly this cross-cutting of boundaries which allows us to hope that the study of worked osseous materials is well on the way to developing into a discipline in its own right.

In addition to the generous support given by our sponsors and technical editors for this volume, organizing the conference would not have been possible without the active help of numerous colleagues. Special thanks are due to Paula Zsidy, Director of the Aquincum Museum, Katalin Simán, archaeologist and two students from the Institute of Archaeological Sciences (ELTE, Budapest): László Daróczi-Szabó and András Markó. The Hotel Wien, Budapest and its efficient manager provided a comfortable setting for our discussions at a reasonable price. Last but not least, help with abstract translations by Cornelia Becker, Noelle Provenzano as well as Marjan Mashkour and Turit Wilroy should also be acknowledged here.

METHODOLOGICAL SPECIFICS OF THE TECHNO-ECONOMIC ANALYSIS OF WORKED BONE AND ANTLER : MENTAL REFITTING AND METHODS OF APPLICATION

Aline Averbouh

Abstract: Using a technological approach to study prehistoric material culture can provide a way of understanding past technologies. It also provides an indirect way of getting at economic or social information, for example, by helping to reconstruct subsistence practices or identifying status differences. The idea is to analyze another basic prehistoric industry – the bone tool industry – in the same fashion. While there is no theoretical reason why this should not be possible, in practice it is very difficult because of the organic components in bone which make osseous materials very sensitive to taphonomic processes (differential preservation, deformation, and surface alterations). In addition, bone working and carving imply important modifications in the raw material, especially in the case of Paleolithic industries. As refitting is the methodological basis of the technological approach, it has to be re-considered in the case of bone artifacts. We have tried to apply the principal of 'mental refitting' (as used by lithic specialists) and to develop it within a framework adapted to particular aspects of bone industries. We present here methodological developments in this proposed adaptation.

Keywords: technology, bone tools, refitting by default as methodology, taphonomy, Paleolithic

Resumé: Par les études conduites depuis plus de trente ans sur l'industrie lithique, la démarche technologique a montré quel formidable potentiel d'informations elle renfermait sur les sociétés préhistoriques, tant sur les aspects techniques, économiques que sociaux. Son application à une autre industie majeure des groupes préhistoriques - l'industrie en matières osseuses - doit donc être en mesure d'enricher valablement nos connaissances. Si dans son principe la démarche technologique est parfaitement applicable à cette industrie, dans la pratique, elle se heurte aux contingences particulières de ces matières organiques qui interdisent pratiquement tout remontage direct. Cela est particulièrement le cas des séries du Paléolithique Supérieur où, à la conservation différentielle (qui peut aller de la conservation parfaite à la disparition totale des pièces, en passant par l'altération de surface rendant la lecture des stigmates difficile) et aux déformations parfois importantes de la matière dues à l'enfouissement ou aux diverse variations de température et d'hydrométrie, s'ajoute le façonnage souvent très poussé des objets finis qui ne permettent plus de les "remonter" sur leur bloc d'origine. Or, l'analyse technologique est méthodologiquement fondée sur le principe du remontage. Il était donc nécessaire de résoudre ce problème pour mener une analyse de ce type sur des matières osseuses. Après diverses tentatives peu fructueuses, nous avons choisi de reprendre le principe du remontage mental (crée par les lithiciens) pour l'adapter, dans un cadre méthodologique rigoureux, aux contingences particulières des matières osseuses. Ce sont les grands axes méthodologiques de cette adaptation que nous exposons.

Mots-Clés: Industrie en matières osseuses, technologie, méthode de remontage par défaut, taphonomie, Paléolithique

Zusammenfassung: Nähert man sich mit Hilfe eines technologischen Ansatzes den materiellen Hinterlassenschaften vorgeschichtlicher Menschen, so kann ein besseres Verständnis jahrtausendealter Arbeitsweisen erreicht werden. Daraus erschließen sich zusätzlich ökonomische und soziale Informationen, wie z. B. die Rekonstruktion der Wirtschaftsweise oder des sozialen Status. Auch die Knochenverarbeitung – ein wesentlicher Aspekt vorgeschichtlicher Technologien – kann auf diese Weise analysiert werden. Theoretisch gibt es diesbezüglich kaum Einwände, in der Praxis hingegen scheint es aufgrund der organischen Bestandteile des Knochen problematisch, da diese von taphonomischen Prozessen wie z.B. unterschiedliche Erhaltung, Zerstörung und Oberflächenveränderungen, in Mitleidenschaft gezogen werden. Zusätzlich trägt eine Verarbeitung des Knochens, insbesondere das Schnitzen zur Veränderung des Rohmaterials bei, vor allem im Fall paläolithischer Knochenverarbeitung. Die Methode des Zusammenpassens als methodischer Ansatz kann auch für Knochenartefakte in Betracht gezogen werden. Wir haben den Versuch gemacht, dieses von Silexspezialisten praktizierte Prinzip der optischen Anpassung *remontage mental* von Bruchstücken, auch auf spezielle Bereiche in der Knochenindustrie anzuwenden and methodisch weiterzuentwickeln.

Schlüsselworte: Technologie, Knochenartefakte, Anpassen von Bruchstücken als Methode, Taphonomie, Paläolithikum

Over the past several years, the technological analysis of bone and antler industries has developed alongside other kinds of studies such as typological and functional analyses.

Borrowed from ethnology (Mauss 1947, Haudricourt 1964), this approach consists of undertaking a "reasoned analysis of techniques" (Inizan *et al*, 1995); that is to say, to understand the factors involved in the fabrication of an object: how it was made and how this fabrication was organized in a succession of gestures and the final goal of these gestures. The former deals with static aspects of the procedure described in terms of large-scale operations. The latter deals with the dynamics of the process. Here one attempts to understand the succession of different actions organized into production phases. Together, these two aspects allow us to reconstruct operational chains by which materials are transformed. However, this kind of technological analysis provides us with knowledge that goes beyond this purely technical plane:

- First, we can reconstruct the entire chain of exploitation for a particular material at all points in the operational chain, taking into consideration at the beginning of the sequence, the selection, preparation and conservation of the raw material and, at the other end the use, re-working and, re-use in altered form and ultimate discard of the object thus produced (tab. 1).
- This approach then seeks to characterize the debitage and the general working of raw materials, not only technically but also in terms of production (kinds of products) and productivity (how much per unit of raw material).

In concrete terms, one obtains information on the economic system behind the acquisition, function and exploitation of the raw materials used (Pelegrin, Karlin, Bodu 1988).

Thanks to technological analyses of lithic industries, we have seen that in combining technical and economic data with spatial distributions of debitage, or more generally flaked remains, we can also get at information of a social nature (for instance, as N. Pigeot has shown with Unit 5 of the French Magdalenian camp of Etiolles (Pigeot 1987). The technological approach is thus a desirable means of getting at the economic, social and cultural reality of prehistoric societies for which, we should note that we have at our disposal only those items that were abandoned and which have been preserved.

But if technological analysis has been employed for many years to study lithic industries, its use for osseous materials remains underdeveloped. As other researchers have noted, there are two reasons for this underdevelopment. First, methods and terminology applied to lithics have to be adapted to osseous materials. This is a work in process, and it is not always easy to juggle with notions and identification criteria that are not yet on a solid footing. Then, problems of differential preservation of osseous materials do not usually allow us to perform one of the key procedures in technological analysis: that of refitting.

Refitting, as the lithics people say, involves "putting back together what is broken, in seeking to distinguish purposeful or accidental breakage from manufacturing reduction" (Tixier 1980). But for osseous materials it is impossible to obtain refits. We all know that they are subject to chance preservation (which can at best damage the surfaces, and at worst lead to the total disapperance of the objects) and that most techniques used (grooving, sawing, scraping) involve the repetition of the same gesture on the same surface, leading to the permanent modification of that surface. This also involves the detachment of micro-flakes and shavings that are likely to disappear and even if they are preserved, they tend to rapidly deform, not allowing their re-fitting. Finally, the transformation of finished objects is so complete, especially for objects from the Upper Paleolithic, that it is impossible to re-mount the object onto the block of material from which it came.

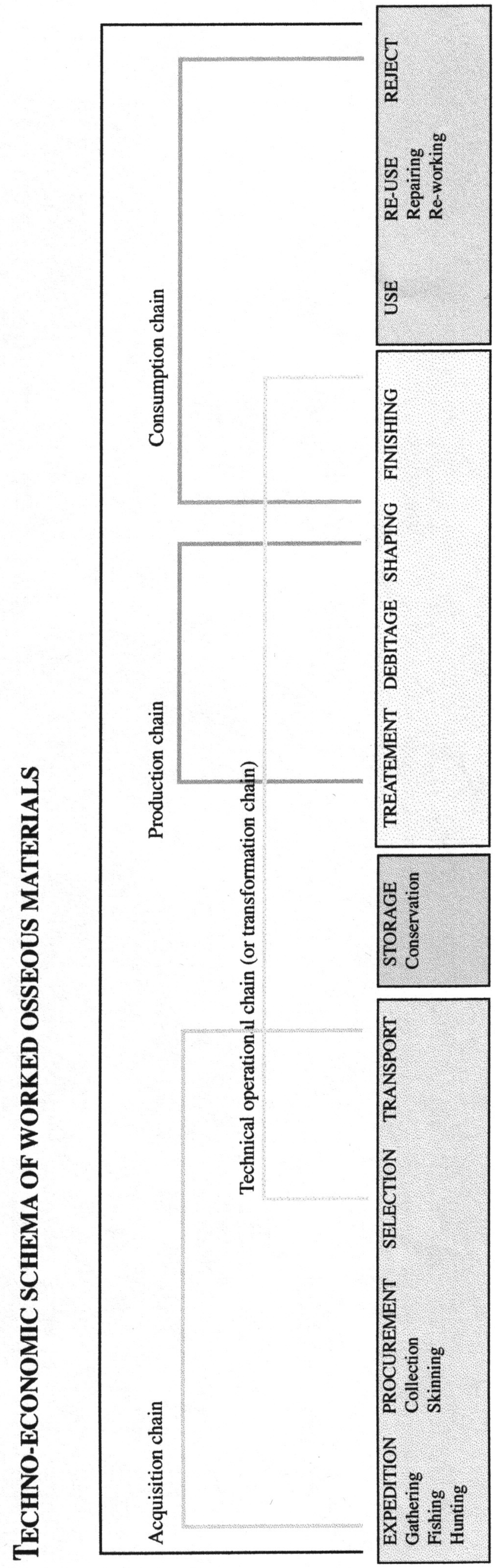
This lack of ability to refit results in a significant loss of information. For this reason we have tried to set up a practical method of re-fitting adapted specifically to osseous materials. We have gradually tested and established this method in recent years on materials from different sites, notably on French Pyrenean reindeer antler materials (in particular from the Magdalenian camps of Enlène and La Vache [Ariège], Averbouh 2000, Averbouh, Bégouën, Clottes 1999). It is this method that we present here.

A method of "refitting by default"

This method is based on the mental reconstruction of debitage and operational chains. It involves taking into consideration all products derived from the working of osseous materials (from by-products to the finished object as well as the support and rough-out); undertaking a reading of each of these products to recognize the techniques (via markings), how they were employed, the materials involved, etc., so as to ultimately take all pieces into account in trying to find out the organization between them; and thus, mentally reconstructing the procedures and processes of transformation (or of debitage where it exists) of one or more units of raw material.

This is not a new idea. At the end of the seventies, a French researcher, Jacques Tixier, specialized in lithic technology, first discussed it (Tixier 1978, Tixier 1980: 55). In 1995, another lithic technology specialist, Jacques Pelegrin, developed it and called it " mental refitting " (Pelegrin 1995: 23). And as early as 1977 and then in 1979, a bone industry specialist, A. Billamboz, used it on the red-deer antler industry from Holocene sites of central and western Europe, particularly from the Neolithic settlement of Auvernier-port (NE Switzerland; Billamboz 1977, 1979).

Thus, my purpose was mainly to develop mental refitting for osseous materials; systematize the methodological path by explaining in detail the different steps and; attempt to quantify the quality and the reliability of this refitting.



Tab. 1 Techno-economic scheme of worked osseous materials: extensions of the different chains (based on Pigeot 1991)

Because of the necessary adaptation to the particular contingencies of the sets of bone materials, this mental refitting is different from that carried out on lithic industries. This is the reason why we prefer to call it "refitting by default", which also encompasses the fact that it is impossible to work in any other way, contrary to what may be accomplished with lithic industries.

The components of refitting

The first goal of refitting was to identify the material and conceptual connections that structure the transformation of a block. At the same time, it is obvious that all the justifying elements should be taken into consideration.

The materials under study for this reconstitution should correspond to the complete industry, thought of here in its largest sense, that is to say (as was already stated by François Poplin, 1977) from the by-products of the used and then discarded object, and passing by the solid support up to the rough-out.

Whatever the transformation methods, every technical chain leads to the same four product categories:

- The by-products (coming from all phases of the tool manufacturing process and even from re-shaping whose production, derived from one of the supports as well as the objects themselves, was not sought after).
- The supports (untreated or unretouched products deriving from the debitage and later transformed into a finished object)
- The rough-outs that occupy an intermediate position between the support and the finished object which reflect various functional aspects of the accomplishment of different steps in the shaping (or *façonnage).*
- The finished objects (which can be composed of whole or broken elements, of new or in-use pieces, sometimes reshaped after a while or by elements that remain after exhaustive exploitation).

The presence of these four categories of technological materials and the conditions of identification are variable. Parallel to the problems of conservation of bone materials, these vestiges can take on in the same category, shapes and dimensions that are very distinct from one another, depending on the techniques and procedures used. In the by-product category, one can thus have pieces ranging in size from a micro-shaving to a large chunk of raw material. In all cases, the finished objects as well as the by-products constitute the principal pieces of mental refitting, because they are located at each extremity of the operational chain. If it is obviously more comfortable to work with four categories because they can thus rest on more solid ground, we can also explain the absence (relatively frequent) of the supports, the drafts, if we have two other product categories. The disappearance of these last categories, on the other hand, increases the difficulties of carrying out a "refitting by default" and the reconstruction of the operational chain.

Realization

There are three principal stages:

a - Composition of sub-sets

This first step begins with the recognition of the relationship between complementary sub-sets. Its aim is, thus, to separate materials by the way they function in the different levels they belong to: categories and types of products; schemes; techniques and transformation procedures and, to finally, categorize and type the raw materials.

With a technological reading, we can group the different components of the industry according to the material from which they are made, their location within the unit, the marks of their manufacture, the class of products they belong to (by-products, supports, finished objects).

In concrete terms, this means for each piece:

- Identification of marks of manufacture.
- Identification of the technical phases of the operational chain that they belong to including: debitage (all the operations concerned with the extraction of the support), shaping (all the operations which create the actual form of the object) and finishing (all those operations producing the final look).
- Precise identification of the raw material (at least, in terms of species and anatomical part).
- And, last but not least, determining the location within the block of raw material, which concretely means: mentally placing the piece back within its anatomic position (for instance, with a piece of antler, trying to discover whether it comes from the upper or lower beam, from the tine, eye tine, crown etc).

In concrete terms, series of selection procedures are realized by:

1). *A general distribution by category of each product*: this may seem obvious but experience has shown that it is far from being systematically done. Also, it is not so simple to carry through, notably when it concerns the distinction between a support and a first draft, or a first draft from a finished product.
2). *A general distribution by category of osseous materials*: in each of the four principal complementary sub-sets, we can distribute the functional products by their classification in one of the principal categories of raw materials: bone, antler or ivory.
3). *A general distribution by method of transformation*: in each of these new sub-sets, we can regroup the functional elements by the ways their *debitage* is produced (by slicing, by splitting, by extraction or by dual-partition. These *debitages* are recognized by the presence of products (of any category) on slices, splits, extracts (*baguette*) or semi-slices (Averbouh 2000).

This first phase of general distribution has the advantage of validating later similarities in the transformation and the exploitation of the different materials present. This method nevertheless distinguishes the composition of complementary sub-sets within the four categories of products. In order to establish new categories and to enlarge this four category organization, that is to say, to create new sub-sets that include by-products, supports, first drafts and finished objects that belong to the same transformational scheme – i.e., to produce a refitting – we must back track to a finer distribution by carrying out a more detailed study of each piece within one of the sub-sets predetermined at the end of the phase:

Within the groups thus obtained, the analysis is further refined by the identification of homogenous technical groups that consider equally in both finished objects and supports, their typo-functional aspects. This means:

4). *A precise distribution by type*: for the moment, this is applied in reality to finished objects of which the types are already recognized and which, in certain cases, bear witness to distinct variations in transformational methods within a pre-defined typo-functional group. From an analytical point of view, this has the advantage of helping to identify the production chain, not only of the different categories of finished objects, but also of the different types of objects themselves, which can be of real economic interest.

5). *A precise distribution by technical parameters*: amongst the obtained sub-sets, one should regroup the pieces by their classification within one of the principal operations of the technical chain (*debitage,* shaping, finishing*)* as well as by the function of their technical marks. Firstly, this consists of identifying the major marks of *debitage* when they are still visible (marks of the slice edges, marks on the by-products, etc.). In the second place, we consider the other marks, although this does not necessarily lead to new distributions, with the exception of major shaping marks on the supports, rough-outs and finished products.

6). *A precise distribution by raw materials*: amongst the sub-sets composing the preceding steps, we may regroup the elements by species and anatomical origins of the materials. In order to accomplish this, beyond the identification of species and the principal bone types (teeth or antlers), we must determine the precise location of the elements under consideration in the block of raw material: concretely, returning to reindeer antlers, this means knowing whether these elements come from the beam, the tines, the crown, etc. At this point, we can also calculate the dimensions and notably the thickness of the bone tissue, that not only varies by anatomical and species origins, but also by the age and sex of the animal.

By deducing the make-up of these precisely defined, technologically homogenous sub-sets, this second phase of distribution opens the path to recognition of a new relationship between pre-defined techno-economical sub-sets.

Thus, these first stages of the study have the advantage of making obvious the technical regroupings between the different elements of each category. In this way, the path towards "mental refitting" is created by looking toward the recognition and regrouping of the elements that reveal a similar type of assembly.

b - Complementary Identification

This permits one to find correlations that testify to their common origins within the same type of technical assemblage which leads to the theoretical identification of elements which can be recognized within the sub-sets.

In practical terms, this means making a combined deduction, primarily using finished objects and by-products:

- Starting with finished objects, determining different types of by-products theoretically produced during manufacture from their technical and anatomical characteristics.
- Secondly, to make similar deductions from by-products in order to identify the various types of supports – and beyond these different types of objects – the production they issued from.
- And finally, identifying the finished objects and by-products corresponding to particular supports and first drafts.

For example, let us take an assemblage that bears witness to production of a pierced staff from the base and upper beam of reindeer antler, carried out by a slicing method of abrupt bifacial technical grooving (fig. 2):

- From the finished object (fig. 2a), it may be determined that the slicing of the support has theoretically produced at least three types of by-products: one from the tine, another from the base part, and finally one from the upper beam. They each exhibit two opposing grooves on at least one end part (from the correct anatomical position), which are abrupt according to the *plan de debitage*. Even if their thickness and their width can be determined, by taking into account that the length of the tine and beam by-products cannot be identified at this stage from the pierced staff itself.
- From these by-products (fig. 2b), always supposing we are in possession of the three types, the same work is carried out on each sample in order to regroup them in the same scheme if they present the same morpho-metrical characteristics.

At this stage, we begin the procedure of mental refitting. In the present case, it seems relatively simple and, if the complementary analysis of the support or the first draft adds necessary information to the finer reconstitution of the technical chain, it permits us above all to definitively validate the association between the detritus and the finished object.

c - Final identification of refittings

The last phase permits us to collect all this data in order to make obvious the absence or presence of suitable fits between the elements that are actually present as well as the theoretically identified elements.

The perfect juxtaposition of these three principal criteria considered together – technique, anatomical location, dimensional parameters (species, age, sex, etc.) – for all the different groups of artifacts determine concretely a refitting by default as the pierced staff example testifies (fig. 2c).

From the initial large set, comprised of all the elements in the series and within which the complementarity is organized initially by its classification within the four categories of products, we move on, using refitting by default, to the construction of new big sets, the sub-sets of which are complementary in terms of their technological affiliation. It is from this base that we can proceed to the reconstruction of operational chains of transformation from both a technical and economic point of view.

Results

Refitting should primarily allow the identification of the technical parameters of transformation, that is to say, the operations which have been carried out and their order. In short, this leads to the reconstruction of the operational chain, or more exactly for osseous materials, in the operational scheme. In fact, refitting by default generally does not allow reconstruction of the history of the precise block to which the term "chain" classically refers. Thus, it is not the individual history of each block that is understood but the collective history of all the blocks which is being considered. In other words we are not looking for the elements of the debitage, but rather the characteristics of a type of debitage.

This method does not permit the historical reconstruction of a precise block because it is impossible to make actual refittings. But, one can on the other hand, recreate the collective history of blocks. Thus, it is not the precise operational chain of each worked block that is considered, but rather the general group of all the blocks that come from a single raw material. In this manner, we obtain an operational scheme in a more direct way that can characterize the exploitation of a raw material on a particular site or, if it has been recognized at several sites, it can be characterized as specific to a chrono-cultural period.

The same applies to the economic chain of exploitation also established through refitting by the identification of economic parameters (raw material exploitation and the resulting production).

From the viewpoint of interpretation, the scope of refittings obtained varies by function of the context in which they occur. At site level, they enable not only recognition of the transformation methods followed by the group or groups using the site and their integration or not within a defined chrono-cultural scheme, but also help determine indigenous or foreign aspects of production. At the level of a chrono-cultural period or a given geographical zone, they contribute above all to isolating the characteristic elements of the techno-economic schemes of transformation of all osseous materials or of a particular material or form of finished object, turning the reconstuctions into models: chrono-cultural, regional etc. In both cases, the narrow link can easily be observed between refitting and reconstruction: the quality of the former governs the reliability of the latter, and as a consequence of the proposed interpretations of these phenomena. This is why we consider it necessary to specify the conditions which guarantee this reciprocity.

The different kinds of refitting and their reliability

Just because this method is based on mental reconstruction and hypothetical-deductive reasoning one should not assume that there is no need to base them on actual material evidence. On the contrary, one of the first ways to detect the reliability of a refitting by default is to obtain real evidence for its existence. Therefore, it is imperative to possess the key elements of a debitage, and these elements must be present either in the series under study if we intend to characterize the technology at a particular site, or between several groups if we are trying to characterize a region or time period.

Different degrees in the practice of refitting

If there are only two intermediate categories available (blanks/ supports and roughouts) or just one of these categories with one of the key elements, we could perhaps carry out refitting by default, but as this would necessarily contain shadowy zones, it would only permit reconstruction of the chain's sequences. The chain could only be envisaged in its entirety and its main lines retraced, if the evidence present can be compared by shape and type to reliable reconstructions established on material from other sites or from experimental copies. In that case then, we are not dealing with "reconstrution" but "estimation" of the operative chain and this requires providing more information on the comparative data (archaeological or experimental) on which it is based.

Obviously, one can object that the debitage products are not preserved. This is true of a certain number of products of microscopic size, and even then loss is not necessarily a result of this metric parameter, as has been shown with the working of ivory in the Aurignacian (Christensen 1999). But generally, bad preservation is universal within one site and either all the pieces disappear or they are all equally altered. In the case of good preservation (or – the least bad), it would be exceptional for most of the artifacts to be preserved except, precisely, those that permit a reconstruction. Thus, we begin with the premise that if a finished object is present on the site, and if it was manufactured there, we should be able to find certain by-products from its fabrication. It may be supposed that this was not the case in one single, unique debitage of the same type (or one unique block) but when it involves several debitages of a similar nature, it is simply inconceivable. Or, if the characteristic by-products are not found in the material studied, it must mean that the fabrication of the corresponding objects did not take place on the site. And, in this case, other parameters (such as the type of material, etc.) will generally lend support to this hypothesis.

Maintaining this cautious attitude, we also think that only the repetition of a refitting by default will enable us to identify the operative scheme or schemes and, at the same time, the transformation methods which followed. Also, at the current level of our knowledge, it is safer to guess that a mental refitting cannot serve as a basis for the reconstruction of an operational chain when it is not repetitive. This above all is the case when taken in a global manner, such as with osseous materials. The frequency of reconstructed assemblages varies considerably according to both the site's context and the general context of prehistoric working of osseous materials. Certain assemblages occur repeatedly, whilst others are less common but present, and the remaining few cases are very rare. Nevertheless, it is the regular repetition of the same juxtapositions in a given set which lends it a certain validity. However, if we are seeking to construct reliable models, unique cases of partial or complete juxtapositions must be treated with caution before being validated (or not), principally by analyses of other series. If the contrary proves to be the case, it is preferable to integrate a unique refitting within a broad exploitation model, rather than consider it special evidence for an insufficiently documented scheme or method. Repetitions can be sought afterwards within a single series (to characterize the operational scheme associated with a site) or in several series, if we aim to prove the more generalized existence of a transformation method or exploitation system.

Impending parameters

In addition to these different degrees in the practice of refitting by default, there are two further difficulties: the first concerns the quality of the refitted elements and the second stems from the different ways a block of raw material may be exploited.

The first depends on the possibilities for study offered by the elements in a series. These must be sufficient to provide answers to the main questions being asked: identification of the material and marks etc. This essentially depends on the state of preservation of the surface. Indeed, there are cases where surface damage is so bad that no clear indication can be obtained. In these cases, it would be better not to take account of any refitting, as the results would, of course, be uncertain.

The second depends on how the block was exploited. Most blocks of raw material were exploited chiefly in one manner – longitudinally or transversally – associated with a single method of transformation. Their complete refitting can thus be envisaged if debitage waste is present. But certain blocks, which offer several distinct parts for debitage, are not necessarily exploited in the same manner. Even if this is the case, the transformation methods employed can vary as a function of these parts. The exploitation of reindeer antler during the later periods of the upper Palaeolithic illustrates this well. Although certain parts can be refitted, the complete refitting of the block is much more difficult to achieve. In addition to mixed modes of exploitation, there is also differentiated production, which makes all the more delicate the simple grouping together of the material studied for the reconstruction.

The types of refitting

Following these considerations, refittings can be divided into four main types:

- *Complete refittings* are those which enable the entire debitage of a block to be refitted. They are rarely exhaustive but include sufficient representative and well preserved evidence to establish a reliable reconstruction of the operative scheme.
- *Partial refittings* refer to complete refittings made with one or several parts of the block but not its totality. Thus, one can reliably reconstruct the debitage schemes for these parts, but much less easily the scheme for the complete block. Following the size of the parts for which the transformation mode has been identified, the general mode of exploitation of the block can be considered. Partial refittings often concern ivory (mammoth tusk) and cervid antler.
- *Incomplete refittings* correspond to refittings for which only a few operations can be identified because of the absence of a certain amount of evidence or because of their poor state of preservation. The possible reconstructions essentially concern sequences in the operative scheme. They can later serve as a basis for more general considerations but these will always be quite hypothetical, even if other sources of information are used.
- *Impossible refittings* are those which cannot be carried out, either because the material is poorly preserved or because only one category of product is present. This rules out any reconstruction of the operative scheme which, as we have already seen, can nonetheless be estimated, provided that there are supporting experimental or archaeological data.

What information can be obtained from refittings by default?

Firstly, information of a technical nature can be gained that permits the identification of the components of the technical transformation chain, and more largely, of the operational scheme. This could already have been done solely by studying the objects, and what is more, certain sequences of the operational schemes have already been reconstructed by several researchers e.g. Cattelain (1988), Choï (1999), Christensen (1999), Hahn (1999), Julien (1982), Knecht (1993), Murray (1982), Newcomer (1974), Peltier (1992), Provenzano (1999), Stordeur (1979), Vincent (1993), White (1995). The mental refittings will thus permit a richer and more profound knowledge of prehistoric bone working.

Above all however, refittings by default can be measured by their economic aspects, by permitting a better understanding of the method of exploitation of a particular raw material (represented, for example, by the ribs of small ruminants, or yet again for the adult male reindeer antlers, etc.), whether it be from a diachronic or synchronic point of view. They also permit a parallel observation of real and theoretical objects and allow us to determine if the finished objects present on a site were really and manufactured there or not. If the by-products correspond to the finished objects (technically, metrically or are made from the same materials) we can suppose that both belong to the same blocks exploited (although, one must verify afterwards that all other evidence concurs with this, either in terms of other osseous materials, or other materials). Either, they have only a partial correspondence to the finished objects: in this case, we can deduce which is on-site production, and which is delocalized production. Or, the by-products do not correspond to the finished objects (on one or several points): in this case, we can simplify things and suppose that the objects that are present on the site were brought there after fabrication and that the by-products which are present testify to the existence of other finished objects that were taken away from the site. Thus, it is both the production and the consumption economy of the osseous materials that can be understood by way of refitting by default.

For instance, refittings undertaken on antler industry from a French Magdalenian cave (Enlène, Ariège, Pyrénées) allowed us to understand that the majority of the by-products corresponded to the production of objects such as pierced staffs or spear-throwers. The few by-products that suggest an extraction of "baguettes" only corresponded to a tiny part of the equipment present which could have been made from them (such as projectile points or half circle baguettes). In fact, the vast majority of these objects seem to have been produced in other places from much larger, adult male reindeer antlers (Averbouh, Bégouën, Clottes 1999). It is not my intention here to describe these aspects, but it is thanks to these results that it was possible to evoke the idea of a seasonal cycle in the production of equipment made from reindeer antlers by Magdalenian groups in the Pyrenees.

Conclusions

In conclusion, if we find this method to be generally reliable when applied to osseous materials, we think that it should nevertheless be further refined, which will invariably be the case if several other researchers from different schools of thought make regular use of it. In this manner, we can all contribute to the establishment of an analytical methodology that would also be beneficial to the study of technical and economic systems relevant to the osseous industry, just as actual refitting contributed to the understanding of flint knapping.

Acknowledgments

I am very grateful to Holly Warner and Michael Ilett for kindly translating this paper so well.

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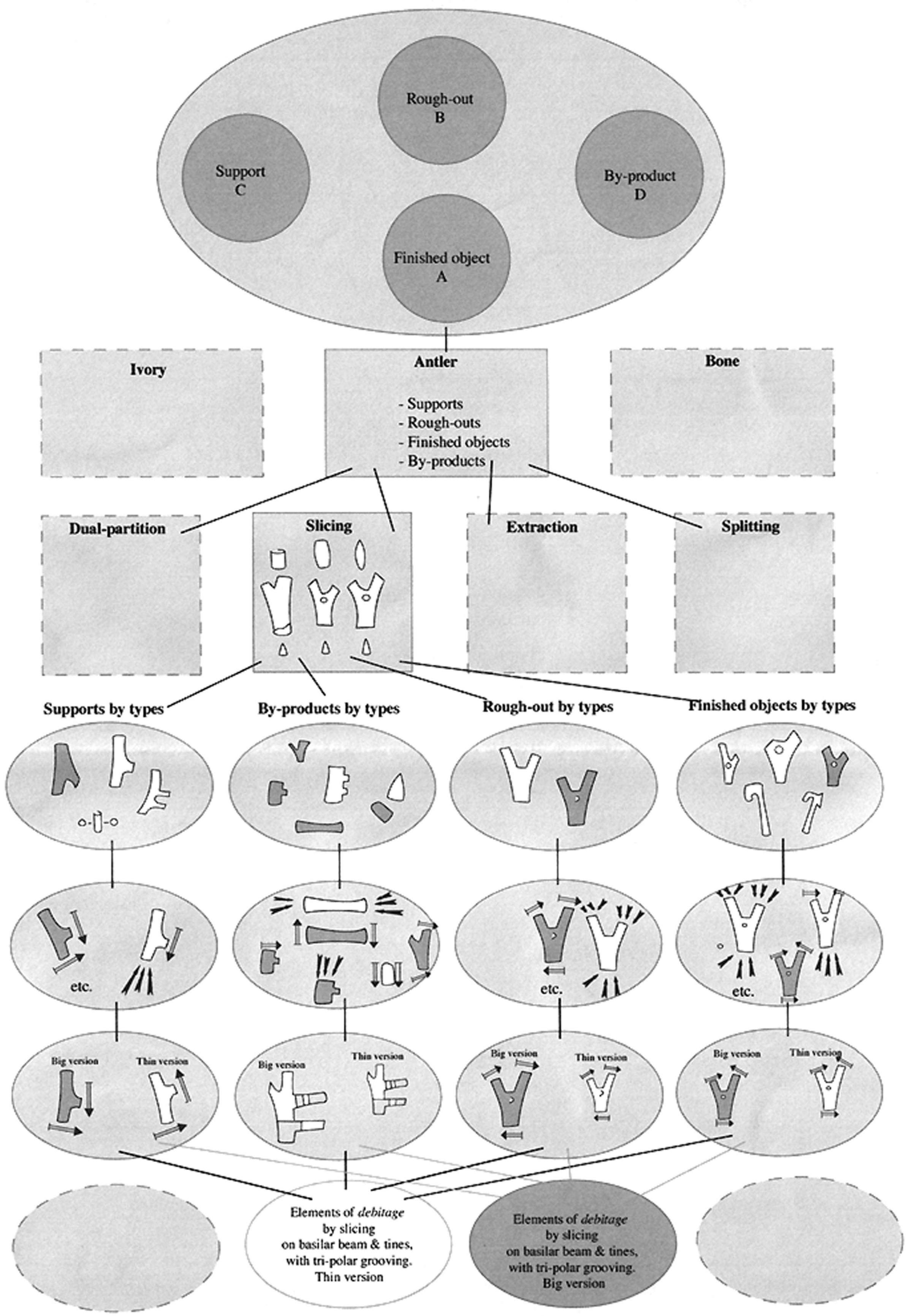

Fig. 1 First stage refitting: schematic illustration of the composition of sub-sets (Averbouh 2000)

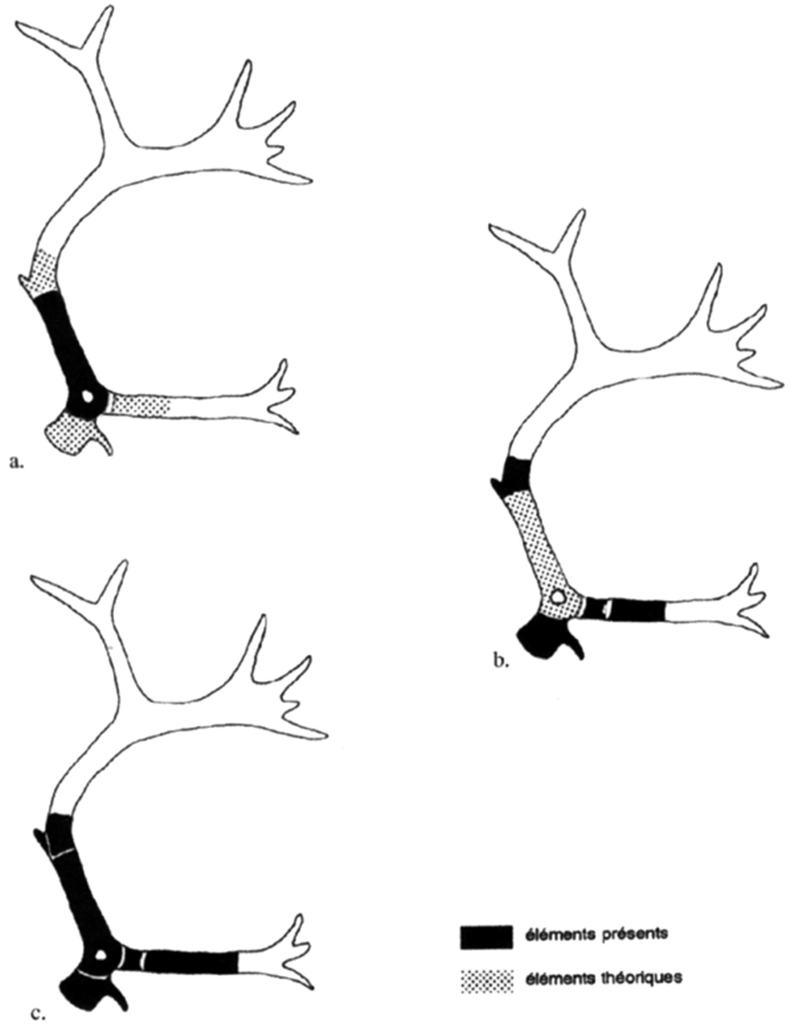

Fig. 2 Second and third stage refitting : schematic illustration of combined-deduction (a.: from finished object, b.: from by-products and, c. final refitting) with the example of the production of a pierced staff.