CRAFTING BONE – SKELETAL TECHNOLOGIES THROUGH TIME AND SPACE

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

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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.

SKELETAL TECHNOLOGY IN CONTEXT: AN OPTIMISTIC OVERVIEW

Genevieve LeMoine

Abstract: Studies of skeletal technology have become increasingly important in the last few decades, after many years of neglect. This paper, based on a discussion of papers presented at the 1999 Society for American Archaeology meetings, looks at some recent research and identifies broad questions addressed by in-depth analyses of bone tool assemblages. Issues of preservation bias, both natural and cultural, as well as technological choices, style, and the integration of bone tools into other technological systems, are being examined by researchers in both Old and New World contexts. It is concluded that as research on skeletal technology continues, such studies can significantly enrich understanding of past societies.

Keywords: skeletal technology, prehistoric technology, bone tools

Résumé: Délaissées pendant de nombreuses années, les études de technologie osseuse ont pris de plus en plus d'importance au cours des dernieres décennies. Discutant des travaux présentés lors de la réunion de 1999 de la Society for American Archaeology, cet article prend en compte quelques recherches récentes et identifie les grandes questions posées par une analyse détaillée des assemblages osseux. Les chercheurs s'attachent a examiner, dans le double contexte de l'Ancien et du Nouveau Monde, les questions liées aux conditions de conservation, aussi bien naturelles que culturelles, mais également les choix techniques, les styles et l'intégration des outils en os dans d'autres systemes techniques. Au moment ou la recherche en technologie osseuse se poursuit, cet article conclut que ces études enrichissent de façon significative la compréhension des sociétés passées.

Mots-clés: technologie osseuse, technologie préhistorique, industrie osseuse

Zusammenfassung: Studien zur Verarbeitung von Knochenmaterial haben in den letzten Jahrzehnten mehr und mehr an Bedeutung gewonnen, nachdem dieses Forschungsgebiet lange vernachlässigt worden war. Der vorliegende Beitrag faßt Diskussionen zu Vorträgen zusammen, die 1999 während der Konferenz der Society of American Archaeology präsentiert wurden. Ferner beleuchtet er aktuelle Forschungsvorhaben sowie Fragen allgemeiner Art zu Detailanalysen von Artefaktassemblagen. Faktoren der Materialbeeinflussung, seien sie kulturell oder natürlich bedingt, der Materialauswahl, der Verarbeitung sowie der Integration von Knochenartefakten in andere Produktionssysteme werden in Fundkontexten sowohl aus der Neuen als auch aus der Alten Welt überprüft. Durch die Weiterführung solcher Studien wird unser Wissen um die Technologie bei prähistorischen Bevölkerungen entscheidend vorangebracht.

Schlüsselworte: Knochenverarbeitung, prähistorische Technologie, Artefakte

Introduction[1]

Bone[2] tools have always had a place in archaeological studies, but until recently they have served primarily as chronological, stylistic, and technological markers, most often relegated to descriptive appendices. With isolated exceptions researchers have described, categorized, illustrated, and forgotten them. Over the past three decades, and most particularly over the last five years or so, this has begun to change. Archaeologists working in many parts of the world have begun to realize that skeletal technologies have great potential for deepening our understanding of the people who made and used them. Analysts working with skeletal technologies must cope with greater problems of preservation than lithic or ceramic analysts, but are compensated by the fact that above and beyond the information that can be gleaned from the technological and stylistic aspects of the tools, skeletal materials as a raw material hold a wealth of information about issues from socio-economic patterns to technological and stylistic choices. By considering their data within a specific framework of raw material acquisition and consumption, analysts enrich our understanding of this technology and the people who produced it.

When I became interested in skeletal technology in the early 1980s, there was a lot happening, but it was mostly at the expedient end of the technological spectrum. The much publicized finds of Pleistocene-aged bone tools in point bars along the Old Crow River in Yukon, Canada, (Harrington, Bonnichsen et al. 1975; Morlan 1980; Jopling, Irving et al. 1981; Irving, Kritsch-Armstrong et al. 1989) sparked a flurry of interest in expedient bone tools, much as Dart's proposed Osteodontokeratic culture (Dart 1957) had earlier led to more in-depth studies of bone modification (e.g Sadek-Kooros 1972; Brain 1981). The Old Crow finds also led to studies of the taphonomic processes that impact bone, most particularly to studies of fracture mechanics and the mechanical properties of bone (Bonnichsen 1979; Morlan 1980). On a broader level Old Crow also was an important factor in a variety of studies and debates focused on expedient bone technologies, ranging from Frison to Binford and to a Chacmool symposium at the 40th Plains Conference (Binford 1981; Frison 1978; LeMoine and MacEachern 1983). Parallel to these developments in North America, European researchers, especially in France, were also showing a strong interest in expedient technologies (Camps-Fabrer 1974).

Studies of expedient bone technology relied heavily on taphonomy and an understanding of the fracture mechanics of skeletal materials. This research led to a vastly improved understanding of the mechanical properties bone and ivory particularly. Meanwhile, however, understanding of other sorts of skeletal technologies, more complex ones in particular, was lagging. The challenge of distinguishing expedient bone tools from bones modified by other, non-cultural, agencies distracted attention from formed tools, which had long been considered to be well understood. This is not to say that they were being ignored altogether. Some researchers developed typologies which are still in use today (Kidder 1932, for instance), while others examined aspects of manufacture and use of sophisticated bone and ivory tools (Semenov 1964). In the far north, where I ultimately began working precisely because of the complex and sophisticated bone technology, bone, antler and ivory tools had been classified and used as cultural and chronological markers for decades, but the technology associated with them had not been investigated. Archaeologists have always recognized well-formed bone tools, from the ever-present awls to harpoon heads and needles, as an important part of the archaeological record. Skeletal technology has served as *fossils directeurs* for the Upper Paleolithic, tools such as needles and bone and antler projectiles have been used as culture-specific markers, and even as evidence of other, missing, technologies such as tailored clothing, for example. But in contrast to stone tools and ceramics, bone tools have rarely been the subject of specialized analysis until recently.

It is not clear why study of skeletal technology has lagged behind analysis of more prominent technologies such as ceramics and lithics. Certainly tools made of bone, antler, or ivory are less ubiquitous than either stone tools or pottery. Possibly they seem to vary less from culture to culture, as anyone who has ever had to deal with a tray full of long, vaguely pointed objects can attest. More significantly perhaps, they are more susceptible to destruction by various post-depositional factors, making their presence or absence at a site a question with natural, as well as cultural implications. But are these drawbacks so serious that bone tools are not worth more detailed analysis? Current research clearly indicates that the answer to this question is no.

Recent research highlights a number of factors that distinguish the study of skeletal technology from other analyses, and amply demonstrates that an understanding of skeletal technologies adds to our understanding of the past on number of levels. In the discussion that follows, I will refer primarily to papers presented at the 1999 Society for American Archaeology Meetings. Other researchers in Europe especially, are also working on these issues and indeed, in many cases are at the forefront of this research.

Preservation

One of the biggest problems facing those studying skeletal technologies continues to be the question of preservation: how to deal with poorly preserved or even non-existent tools and debitage and how to tease out the cultural biases in preservation from the natural. Great strides have been made in understanding the differential physical preservation of skeletal materials. Taphonomy is, by now, a well-developed field with links to archaeology, biological anthropology, and paleontology (Behrensmeyer 1978; Behrensmeyer and Hill 1980; Brain 1981). Taphonomic factors operating in an archaeological context can be highly variable both within and between sites, but understanding them is a vital step in a comprehensive analysis of both faunal samples and bone tools.

Studying taphonomic changes in an assemblage is complicated by cultural actions which affect every aspect of preservation, from what species and elements are present to where they are ultimately deposited, and in what condition. Moholy-Nagy (1999) describes such a situation at Tikal, where early deposits of any kind are preserved only as building fill in later structures, while the distribution of debitage in more recent undisturbed deposits is skewed by refuse disposal patterns. In the case of Tikal this means that preservation of bone debitage is rare, even in undisturbed deposits, because the debris from bone tool manufacture was cleared away from workshops and dumped into contexts where preservation of bone is low due to natural factors such as acidic soils. Bone tools, on the other hand are found in a variety of contexts, but especially in burials and caches.

Mobile hunter-gatherers can produce similar patterns, for different reasons. Large protohistoric Inuit winter villages in the Mackenzie Delta, Northwest Territories, Canada, contain many finely made caribou bone and antler tools, but very little in the way of debitage (LeMoine 1997). Preservation is not a problem, since the sites are permanently frozen, and faunal remains are abundant. The explanation is to be found in the seasonal nature of tool manufacture. Fall caribou hunting sites contain disproportionately high amounts of debitage (Morrison 1988), indicating that blanks, if not finished tools, were made predominantly at that time of year, away from the winter villages. This illustrates the importance of considering preservation and distribution patterns not only at the site level, but at the regional level.

Preservation is also significant at the level of the individual tool. As Griffitts (1999) pointed out, and as I have discussed elsewhere (LeMoine 1997), there is much information about both manufacture and use stored in microscopic details on the surface of well-preserved bone tools. Unfortunately, this level of preservation requires conditions of preservation found in few places of the world. Ultimately, the question of preservation is so important that it becomes a major factor in determining where analysts choose to work. It is not accident that early work on bone technology was done in locations such as the American Southwest, in European Paleolithic cave sites, and in the Arctic. Bone tools are both more numerous and better preserved in such locations. Elsewhere, it is often the uniquely well-preserved site which attracts attention. Many interesting and useful studies of skeletal technology have been prompted by exceptional preservation at sites blessed by ideal conditions (Emery, this volume; samples from Petexbatun for example).

Studies of Manufacture and Use: choices in social context

Understanding the choices craftspeople make when producing tools of any type is the key to putting such choices in social context. But in order to understand the choices made while making tools from skeletal materials, it is vital to consider the biological factors that constrain these choices. Of these, shape is the first that comes to mind. Many participants in the SAA session (Griffitts, Olsen, Russell) commented on the fact that long thin tools of various sorts typically dominate assemblages of bone tools. Variously identified as awls, pins (for hair or other uses), pegs, or projectile points, bone tools have an air of uniformity the world over. At one level, the reason for this is relatively simple. Bone, antler, and ivory, although slightly different in mechanical properties, are all tougher, and for long, thin tools, stronger, than the equivalent tools made of stone or wood, the most obvious alternatives. The task of the analyst is to go beyond this over-arching similarity to understand the various choices people made at different times and places. One way to do this is to move beyond the identification of formal categories (and an understanding of the preservation context) and begin to address questions about both how and why people chose to make tools and other objects from skeletal materials.

In this context, an important first step is to study assemblages using the *chaîne opératoire* approach (Lemonnier 1992). Understanding the sequence of steps taken by craftspeople when making objects of bone or any other material provides a context for studying a variety of questions of anthropological significance. Skeletal technologies are uniquely amenable to this sort of study, since although they are reductive, the debitage is frequently readily identifiable, and the techniques and even materials used in the process can often be understood from the marks left on both the debitage and the tools themselves (LeMoine 1997:4). Such research is by no means new. Experimental studies examining the techniques used to manufacture bone tools (although not always considering the whole sequence) go back at least a quarter of a century (see papers in Camps-Fabrer 1977), and discussions of the complete manufacturing sequence go back nearly as far [see for instance Choyke (1983) and MacGregor (1985)]. But describing the sequence is only an important first step. Such descriptions provide the data which make it possible to formulate questions and develop models of broader interest and significance.

Most of the papers delivered at the SAA session in Chicago and Budapest strove to put tool production in social context. In doing so the authors take advantage of a potentially rich source of information which can enrich and deepen our understanding of past societies.

Emery's work at Petexbatun (this volume) is a case in point. There, aided by excellent (and unique) preservation conditions combined with fortuitous disposal patterns, she has been able to recover virtually all of the reduction sequence for bone perforators produced in a household workshop at the site of Petexbatun in the Maya Lowlands. Emery uses these data to illustrate the variety of information that can be gleaned from bone technology. In particular, she uses information such as frequency of different species and elements used in tool production, and the variation/standardization of tip size to evaluate models for changing economic systems during the Terminal Classic.

Similarly Russell (this volume) using information such as the acquisition and selection of raw material, the degree of standardization in tool form, and reuse and conservation of tools, argues that there were significant differences in social organization in Neolithic societies in Turkey and Pakistan. Her arguments support models developed on the basis of other data, but rely on information particular to skeletal technology, such as differing relations of production between hunters and those making bone tools in different contexts.

As each of these studies demonstrates, understanding how skeletal materials were transformed into tools can increase our understanding of the social context of tool production, from raw material acquisition through use and disposal. The questions which arise through such an analysis, such as how craftspeople acquired the raw materials of their trade, which elements they selected and why, are not necessarily specific to skeletal technologies, but they involve separate trajectories from the production of other types of tools (stone, ceramics etc.) and so deepen and enrich our picture of past societies. In a different way from lithics or ceramics, skeletal materials are implicated in a variety of social and economic contexts. They can, then, speak to a variety of questions about these spheres.

Style: parallel concerns

The issues surrounding the manufacture of tools from skeletal materials cannot really be separated from issues of style, but in fact questions of decoration at least are often dealt with in isolation. Style is an ambiguous term of course, applied to variation along a continuum that ranges from purely decorative ("non functional decoration") to invisible style, or "isochrestic variation" (Sackett 1990). I lean towards the latter interpretation of style (MacEachern and LeMoine 1992) and would argue that most variation is at the same time nonfunctional from a technological standpoint, and functional from a social and symbolic standpoint. Craftspeople make choices at every stage of manufacture, but many of those have little to do with the intended function of the tool. Understanding the mechanical properties of different skeletal materials, and how these compare to other materials available to the craftspeople is an important step in understanding why a craftsperson chose to use a particular material. It is also important to consider which materials were readily available. In the past, as today, people do not always have access to their preferred raw materials. Similarly, the methods chosen to work skeletal materials have a strong 'stylistic' component, as craftspeople chose among available options. Campana (Campana 1980), for instance, showed that protoneolithic groups in the Levant and the Zagros shaped bone tools differently (whittling vs. grinding), although each was aware of the techniques used by the other. More often, though, variation in tool form and in decorative attributes are used to explore issues of style.

Participants in the SAA symposium (particularly Jefferies 1999) highlighted the fact that when it comes to decoration, skeletal materials are more like ceramics than they are like lithic tools, although the models used to interpret them are more often drawn from lithic technology. Like ceramics bone is easily incised, carved in relief, or in a fully three dimensional form. In fact, as was pointed out at that session, it is so easy to incise or otherwise decorate a bone tool that the fact that a tool is not decorated may be as telling as what sort of decoration is applied to similar tools. Jefferies' (1999) examination of Middle Archaic bone pins from the Ohio River Valley is a useful example of how variation in decorative elements (including absence of decoration) can be used to examine social interaction within and between neighboring groups.

Others have suggested that the very choice of raw material can be deeply symbolic, as McGhee does in his classic paper "Ivory for the Sea Woman" (McGhee 1977). Similarly Chris Darwent and I have recently postulated that the inclusion of secondary (marbled) ivory from the core of a walrus tusk in carvings during the Late Dorset period in the High Arctic may be symbolically charged (LeMoine and Darwent 1998). Elaborately carved bone objects from the Maya region provide another example. There the variety of options available to craftspeople working bone provides a rich palette of choices for conveying socially important messages. Ritual objects carved from the bones of important ancestors, such as the skull bracelet described by Schele and Matthews (Schele and Matthews 1998:307) are compelling evidence of the symbolic value that can be placed on raw material, even when the source of the material may not be evident to the observer.

From simple incised lines to elaborate bas relief, and from simple awls on bones with unmodified articular ends to elaborately carved and decorated pins, craftspeople make socially and symbolically charged choices depending on a wide variety of factors. They combine these with the symbolic potential of raw material, which may be made richer by complex associations with particular species, or even some characteristics of the material itself. Craftspeople manipulate these variables to convey a wide variety of messages. Only as we study tools made from skeletal materials in the social and economic context can we hope to decipher them.

Related to questions of ornamentation and symbolic communication, but on a less obvious level, is the question of "deep style" or "deep technology" (Jefferies 1999, Olsen 1999). There is ample evidence that craftspeople from different groups may make quite different choices about how to do the same thing, such as reduce an ungulate metapodial to usable blanks (e.g. LeBlanc 1984, LeMoine 1993, Morlan 1975, Morrison 1986, 1988) or sharpen an awl (Campana 1980, 1987). Elsewhere I (LeMoine 1997, in press) and others (Gosselin 1992; MacEachern and LeMoine 1992; Olsen 1999) have suggested that such differences, although not necessarily evident to the unaided or untrained eye, are important clues for differentiating between interacting groups of people in prehistory. Indeed, skeletal materials are particularly useful for this sort of study, since evidence of manufacturing techniques is often clearly present both as debitage and as microscopic and microscopic traces on tools and debitage alike. As many analysts have shown, bone debitage is frequently present in archaeological assemblages, making it possible to reconstruct detailed production sequences. Macro and microscopic traces make it possible to identify not only how the bones were cut and shaped, but what sorts of tools were used on them.

This work also highlights another important issue, the question of the social scale of variation in both technological and stylistic attributes. At what social level do the differences we identify in assemblages operate? This question applies to all sorts of assemblages of course (see MacEachern 1998 for example), but it is one which deserves closer attention. Interpretation of decorative attributes seems to be fairly well suited to study of local or regional interaction spheres, in much the same way that ceramic decoration is used, but in some cases, such as the Late Dorset period in the High Arctic, stylistic uniformity spans such a vast area that it hardly seems possible that it represents a single interaction sphere. Study of less obvious attributes, such as the methods used to reduce and shape skeletal materials, also reveals difference at least at a broad scale (on the level of language groups for instance, in the case of Athapaskan versus Inuit reduction techniques described by LeBlanc [1984], Morlan [1973] and Morrison [1986, 1988]). There is limited evidence to suggest that such differences may be significant at smaller scales, (such as between Thule or Inuit and earlier Dorset populations in the North American Arctic, or possibly within Dorset groups, (see LeMoine in press) but in North America at least, the limited number of studies done in any one region restricts our ability to accurately identify such cases. These questions are not unique to skeletal technologies of course, but as I have argued elsewhere for manufacturing techniques (LeMoine 1997:4), and as Jefferies (1999) and many others have shown for decorative attributes, given adequate preservation bone, antler, and ivory are well suited to studying them.

One final issue related to the complex skeletal technologies discussed both in Chicago and Budapest, is what Olsen (1999) refers to as 'reciprocal illumination.' Bone tools are embedded in larger technological systems, ranging from simple, such as a blade and handle, to complex, such as a whaling harpoon. They are also often part of tools to make other tools, and in some cases may have been made with specialized tools themselves. By thinking of bone tools in this large context, it is possible to infer the presence of materials and activities which might not otherwise be evident, and to understand aspects of the manufacture and use of linked systems. The classic example of this is the claim that the appearance of eyed needles in the Upper Paleolithic implies the development of tailored clothing, widely disseminated in introductory texts (e.g. Sherratt 1980:90). Other examples abound. Olsen (1999) describes bone stamps used to decorate pottery as one example, where study of both the impressions on the pottery and the edges of the combs revealed both how the combs were used and how the pottery was made. Conkey (1991:76-77) discusses how the presence of both complete and incomplete harpoons and needles at the Magdalenian site Cueto de la Mina implies extensive manufacture and use of cordage at the site. Similarly, antler handles with thin blade slots are used to infer the use of metal bladed knives at prehistoric sites in the High Arctic (McCartney and Mack 1973) and Semenov (1964) suggested that elaborate ivory carving in the Bering Strait region could only have been accomplished with metal tools.

Conclusion

Skeletal technology has been, and continues to be neglected when compared to other technologies, especially lithics and ceramics. The papers delivered in Chicago and Budapest, however, demonstrate that interest in and understanding of this significant part of material culture is growing. There remain many important questions to be resolved, but we have reached the point where studies of skeletal technologies can significantly enrich our understanding of past cultures.

Bone tools are no more or no less integrated into larger technological, economic, social, and symbolic systems that other types of material culture. The research discussed here, however, demonstrates that considering them in such larger contexts is vital. Whether we are dealing with basic issues of physical preservation or the ideological or symbolic importance of using a specific type of bone, the benefits of considering these larger arenas are evident in the papers presented here.

Notes

1 These comments are based on papers delivered in a Society for American Archaeology Symposium entitled Technology of Skeletal Materials: Considerations of Production Methods and Scale, organized by Kitty Emery and Tom Wake, in Chicago in April 1999 for which I served as discussant.
2 I use the term "bone tools" as shorthand for tools made out of any skeletal material, bone, antler, ivory, and to a lesser extent, horn as I find it less cumbersome than "tools made from skeletal materials". In general my remarks are applicable to all and any of these materials, unless noted otherwise.

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