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.

MACRO WEAR PATTERNS ON DANISH LATE MESOLITHIC ANTLER AXES

Gitte Jensen

Abstract: Though antler axes from Mesolithic settlements are numerous in Denmark their function has never been demonstrated. To create at comparative material for this purpose, experiments were carried out at the Historical Archaeological Centre at Lejre, Denmark. Experiments with wood working were carried out and all patterns of manufacture, resharpening and use were documented using silicone casts. The results of the experiments were analyzed against the Prehistoric material which showed patterns very similar suggesting that they may have functioned in almost the same way. Later, wood anatomical studies showed small fragments of wood splinters in the spongious part of a few Prehistoric axes making the similarity of use even more obvious.

Keywords: Denmark, Mesolithic, antler axes, macro use wear

Résumé: Bien que les haches en bois de cervidé provenant des gisements mésolithiques soient nombreuses au Danemark, leur fonction n'a jamais été établie. C'est dans le but de constituer un mobilier de comparaison en vue de régler cette question que des expérimentations ont été menées au sein du Centre Historique et Archéologique de Lejre, au Danemark. Les expérimentations ont concerné le travail du bois végétal et toutes les traces de fabrication, de réaffûtage et d'utilisation ont été enregistrées à l'aide de moulages en silicone. Les données des expérimentations ont été analysées et confrontées au mobilier préhistorique qui montrait des caractéristiques analogues, suggérant qu'il avait pu être utilisé d'une manière identique. Par la suite, les études ont montré la présence de minuscules éclats de bois dans la partie spongieuse de quelques haches préhistoriques, rendant encore plus évidente l'identité d'utilisation avec les répliques expérimentales.

Mots-clés : Danemark, Mésolithique, hache en bois de cerf, macro-traces d'utilisation

Zusammenfassung: Obwohl Geweihäxte in mesolithischen Fundplätzen Dänemarks häufig sind, konnte deren Funktion nie bewiesen werden. Um für diesen Zweck eine Vergleichsbasis zu schaffen, wurden am Historisch-Archäologischen Zentrum in Lejre/Dänemark Versuche durchgeführt, die das Arbeiten mit Holz sowie den gesamten Herstellungsprozess, das erneute Anschärfen und die Benutzung der Äxte beinhaltete und anhand von Silikonabgüssen dokumentierte. Die Ergebnisse dieser Experimente verglichen wir mit dem prähistorischen Material, welches sehr ähnliche Abnutzungsspuren aufweist und somit an eine gleichartige Verwendung denken läßt. Zudem sind in der Spongiosa einiger mesolithischer Äxte Holzsplitter entdeckt worden, die nach holzanatomischer Überprüfung eine solche Verwendung noch wahrscheinlich machen.

Schlüsselworte: Dänemark, Mesolithikum, Geweihäxte, makroskopisch analysierte Gebrauchsspuren

Axes made of red deer antler are often found in midden layers or wet deposits as waste material from Mesolithic settlements in Denmark. Two main types of antler axes are found: Base axes and T-shaped axes.

An analysis of 267 antler axes and adzes and waste products from the manufacturing of antler axes from settlements of Kongemose and Ertebølle Culture kept in the National Museum in Copenhagen yielded the following results.

The Material

Base axes are the oldest type, found in layers from younger Maglemose Culture till younger Ertebølle Culture. There are marked regional differences in the distribution of base axes. Base axes disappear in the Eastern part of Denmark (East of the Big Belt) in Late Kongemose Culture while they continue in Western part of Denmark until the younger Ertebølle Culture (4300 cal. BC; Andersen 1975:65; fig. 1).

The characteristics of the base axe are:

1. The axe is made from the proximal end of the beam. Nearly all beams were shed before use (over 90 %)

2. The shaft hole is placed at the proximal end of the beam near to the burr. The cross section of the shaft hole is mostly rounded oval and 2.2 – 2.5 cm in diameter

3. The shaft hole is mostly placed at the medio-lateral part of the beam (90.2 %). Only on 9.8 % the shaft holes were placed in the anterio-posterior part with shaft hole through the bez tine. The latter type is found in the younger zone (II) at Dyrholmen together with T-shaped axes. On Friesack in northeastern Germany these axes are only found in layers from the younger part of Ertebølle Culture (layer Va , 3750 – 3450 b.c. ^{14}C)

4. The edge could be both transversal (adze) and right-angled (axe). Adzes and axes with an edge which could be described as oblique-angled i.e. with an angle more than 50 degrees to the shaft, were the only types found in the Kongemose

Culture in the eastern part of Denmark. In Jutland this type of antler axes seems to disappear in the older part of Ertebølle Culture. From the middle part of the Ertebølle Culture antler axes with right angles - with an angle up to 50 degrees to the shaft – are the only type found

5. The axes could be ornamented: most commonly and in a most elaborate manner in the Kongemose Culture (35.3 %) and only occasionally and more schematically in the Ertebølle Culture (11.4 %).

The characteristics of the T-shaped axe are:

1. The axe is made of the distal/middle part of the beam – from the bez tine to the middle part of the upper beam

2. The shaft hole will always be placed through the trez tine. The diameter of the shaft hole will be 2.0 to 2.2 cm. The shaft hole will be rounded oval

3. The edge will always be right angled – i.e. with an angle up to 50 degrees to the shaft. Only one adze was found on the Ertebølle midden (A16692: EB 6660)

4. The first T-shaped axes are dated to 4300 B.C. (cal ^{14}C) and the period of use seems to be very short – about 200 years. (Andersen 1975:82)

5. Ornamentation is very rare. Only one axe had traces of what seems to be ornamentation: 3 long parallel striations probably made by burin with a distance of 0.3 to 0.5 cm between the lines running along the lower part of the shaft hole.

As many axes had well preserved edges with striations and polish which could not be explained without a comparative material there was only one solution to this problem: hands on!

Experiments

The experiments were financed by the Research Fund at the Historical-Archaeological Centre at Lejre, Denmark. Experiments were made at the same location.

Experiments of function were carried out with replicas of antler axes, mostly made using modern tools. Only few antler axes were made by flint tools to test methods of manufacture and to gain experience and knowledge of the material. (For further information: Studier i Teknologi og Kultur. Eksperimental arkæologi 1991 and Naturens Verden, temanummer "Forsøg med Fortiden", 1994).

A number of unsolved questions had to be answered during the experiments. The first question concerning function was the design of the shaft. Findings of shafted prehistoric axes have shown that the shaft would mostly have been a branch of hazel and about 60 cm long (Mathiassen 1938, Thomsen, & Jessen 1906). To decide whether the shafts had been dried before use they were tried both after drying and quite fresh. It quickly turned out that there was no reason for drying the shafts before use. The freshly cut hazel branches worked perfectly.

It was decided to work with different wood working processes and to try different types of antler axes. To preserve use wear patterns from the working process, a mould of silicone was made of all edges after each working session. Afterwards casts of coloured epoxy could be made from the moulds and used for further examination under microscope.

The working process included the following:

1. Tree felling
2. Cutting in dry wood
3. Debarking
4. Using the antler axe as a wedge
5. Splitting off wood between two notches
6. Using the antler axe as a mattock

Tree felling

After some initial difficulties the antler axe was working satisfactorily, however, the technique of cutting seemed quite different from the technique when using a flint axe. The antler axe was most efficient when hammered at a right angle into the wood. Because of the elasticity of the antler there was no damage to the axe even if the hammering was quite heavy. In this way the growth rings of the tree would "burst" and the cuts of the antler axe would be remarkably different from the cuts of a flint axe (fig. 2).

The properties of different tree types had a major impact on the time used for felling. Ash (*Fraxinus*) had a very compact wood without much turgor which made it hard to "burst". Elm (*Ulmus*) was a little easier to fell, while oak (*Quercus*), contrary to our expectations, "burst" without great efforts and could be felled in half the time needed for ash.

During work the edge of the antler axe would become blunted because the edge would be hammered flat and it had to be sharpened. The edge could be sharpened very quickly by using the upper edge of a flint blade or burin or maybe just the sharp edge of a flake as a plane. The axe had to be resharpened after about five minutes of efficient working.

The resharpenings would leave long rows of parallel striations on the sides of the edge while the edge being worked into the wood would be polished and striations would quickly disappear (after two minutes of efficient working).

Cutting in dry wood

This was tried primarily to study the difference between use wear from working in fresh and dry wood. Different types of wood were tried without any marked difference. The antler axes would work efficiently in dry wood without marked damages.

Traces of sharpening and polishing of the edge would occur in quite similar ways to the wear patterns from working in fresh wood. But as dry wood tended to be harder to work than fresh wood small "waves" could be located at the edge.

Debarking

Debarking with antler axes was tried, but worked very poorly. The axes did not seem suited for this process and actually debarking could be made much easier with the bare hands, drawing large strips off without difficulties.

Using the antler axe as a wedge

After cutting a notch into a newly felled trunk the antler axe (without shaft) was tried as a wedge. The axe was placed into the notch and hammered at the proximal end with a club of oak. Damage quickly disappeared at the proximal end where pieces of the burr were broken off and at the edge where a notch developed. The elasticity of the antler was very disturbing and prevented the axe from working its way through the wood. After some more attempts this working process was abandoned.

Splitting off wood between two notches

Two notches were cut with a flint core axe at a distance of about 0.5 m from each other. The wood between the notches was split off by antler axes. The long distance between the edge and the shaft makes it possible to split off wood with an antler axe while the haft of the flint core axe and the short distance to the edge prevents this type of axe from being used in such work. Adzes and antler axes with oblique-angled edges were particularly suited for this process which could have been employed for building dugout canoes.

During work the edge was polished and large splinters of wood would wedge in the spongious part of the edge (fig. 3).

Using the antler axe as a mattock

The axe was used for working in a sandy slightly clayey soil with roots and plants. Because of the elasticity of both materials the axe was unsuitable for cutting off roots. The edge would not be polished and small chips would burst off the edge.

Some few axes were made out of antler which had dried out too much. Consequently, axes would break immediately when used. The breakages would be identical to the ones of the prehistoric material: breaking off the whole edge or breaking at the shaft hole of the T-shaped axe (fig. 4). If the axes had been made out of fresh antler (shed the same year) there would be no breakages or greater damages to the axe even if cuts were heavy.

Use wear analyses

After each working process a copy of the edge would be made in silicone and afterwards casts were made in coloured epoxy for further analyses under microscope (WILD, 6.5 x magnification).

The overall picture of use wear patterns on antler axes was as follows:

Genuine use wear

When used in fresh wood, polishing would occur on the upper 1-2 cm of the edge at the part where the axe had been used for cutting into the wood. After few minutes of work the edge would be rounded and blunt. No traces of sharpening would be preserved after a few minutes of work.

If wood had been dry or very tough, "waves" could be seen at the edge (fig. 5).

When used as a mattock, the edge would be crushed without any polishing (fig. 6).

Traces of resharpening

When used for cutting in wood, traces of resharpening are still seen after use along the sides of the edge as long parallel striations usually at an oblique angle to the edge used for cutting. Striations are not preserved in the spongious part in the centre.

When used as a mattock, striations will be better preserved at the very edge as well as along the sides.

Preserved traces of manufacture

Traces of manufacture will be preserved at the lower part of the edge where there is no traces of polishing or sharpening. Cutting marks from flint axes or traces of planing with a flint blade or burin or grinding on sandstone could be preserved.

Again, the antler axe used in soil showed more preserved traces than the axes used for wood working.

The prehistoric material

Seventeen of the best preserved prehistoric antler axes were chosen for analysis of their use wear patterns. Ten of them were base axes – one with oblique-angled edge and nine with straight angled edges. Seven were T-shaped axes.

All axes were examined in the same manner as the experimental axes. One of the axes was too poorly preserved and had to be left out of the analysis.

Eleven specimens (7 base axes and 4 T-shaped axes) were polished at the edge in the same way as the experimental axes used for cutting in fresh wood indicating that they must have been used in some organic material.

One axe had not been finished or was maybe damaged during work and the edge remanufactured. Only heavy cuts from a flint axe could be registered at the edge.

Four axes showed marks of grinding probably without use after grinding, no polishing could be seen.

Ten out of 11 axes with polishing at the edge had also striations from re-sharpening at the sides of the edge. These had the same character as the striations from re-sharpening on the experimental axes. This indicates that they must have been sharpened by a flint tool. One axe had polishing without striations from resharpening. Probably this specimen had been ground on a stone to sharpen it before use.

Twelve axes had cutting marks from a flint axe at the base of the edge, probably marks from the initial manufacture of the edge.

Three axes had depressions in the spongiosa of the same kind as the experimental axes used for splitting off wood. In one of the axes fragments of wood were found in the depression. The fragments were analysed by a wood anatomist and pronounced to be fragments of ash (*Fraxinus*).

Because of this interesting discovery other axes were examined in the same way and 4 other fragments were found. One axe had fragments of hazel (*Corylus*) embedded in its edge, 1 had oak (*Quercus*) fragments in it while yet another axe had fragments of both hazel (*Corylus*) and oak (*Quercus*) in its edge.

In all axes the splinters of wood had been pressed into the spongiosa in a direction parallel to the length of the axe. During the experiments fragments were wedged into the spongiosa in exactly the same way when wood was split off between two notches along the log.

Conclusions

The results from experiments combined with analyses of prehistoric material have shown that the use wear patterns of wood working were in good accordance with the patterns found on the prehistoric axes. The most indicative pattern: polishing of the edge was found on 11 of the 16 axes that could be examined. Though other organic material may produce polishing too, this makes wood working a very probable function for antler axes in the Late Mesolithic.

The findings of wood splinters in prehistoric axes makes this even more probable. Combining this with the good results of experiments of tree felling and splitting off wood makes it hard not to believe that these axes were not used in wood working.

However, more analyses on a larger, well preserved material would be desirable and as antler axes are found in a wide range of periods and locations all over Europe other functions should also be considered.

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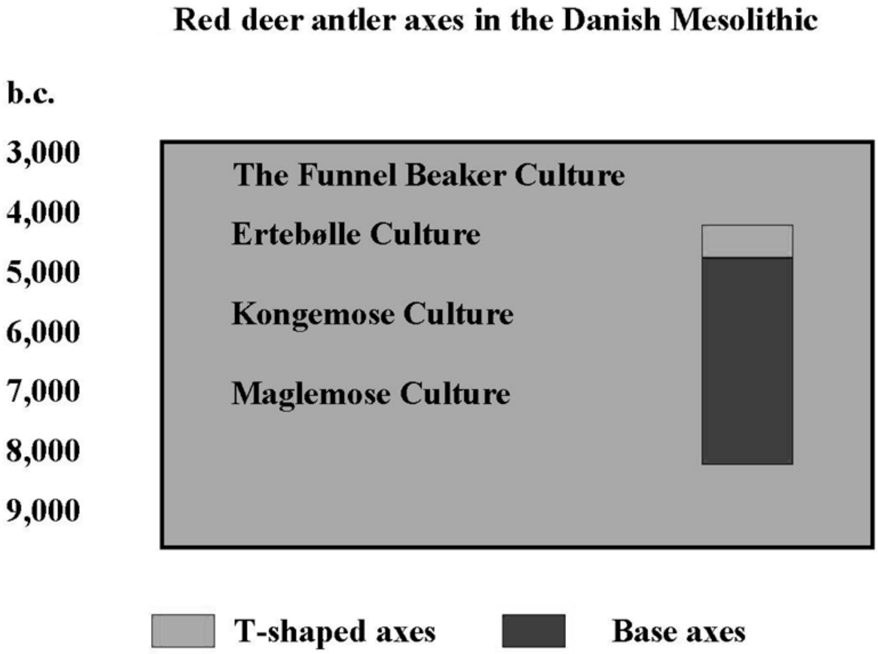

Fig. 1 The dates are based on calibrated ^{14}C samples. All dates were taken from cultural materials in the layer where the axes were found. No dating samples were taken on the axe itself

Fig. 2 When "bursting" through the wood the antler axe leaves very characheristic marks

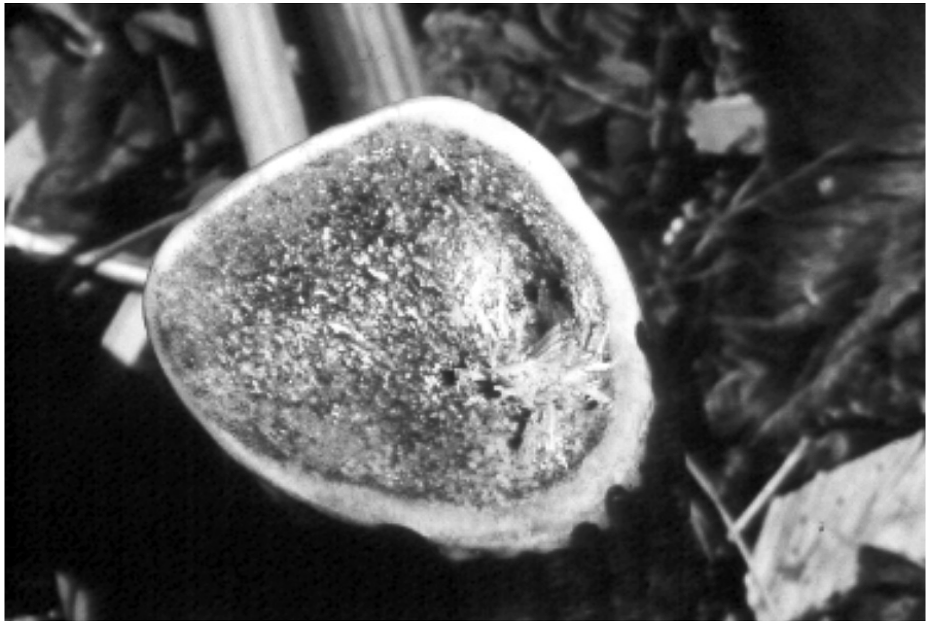

Fig. 3 The edge of the antler axe after splitting of wood between two nothces. Please note the wooden splinter wedged into the spongiosa

Fig. 4 Large splinters of wood could be split off during the work along the log

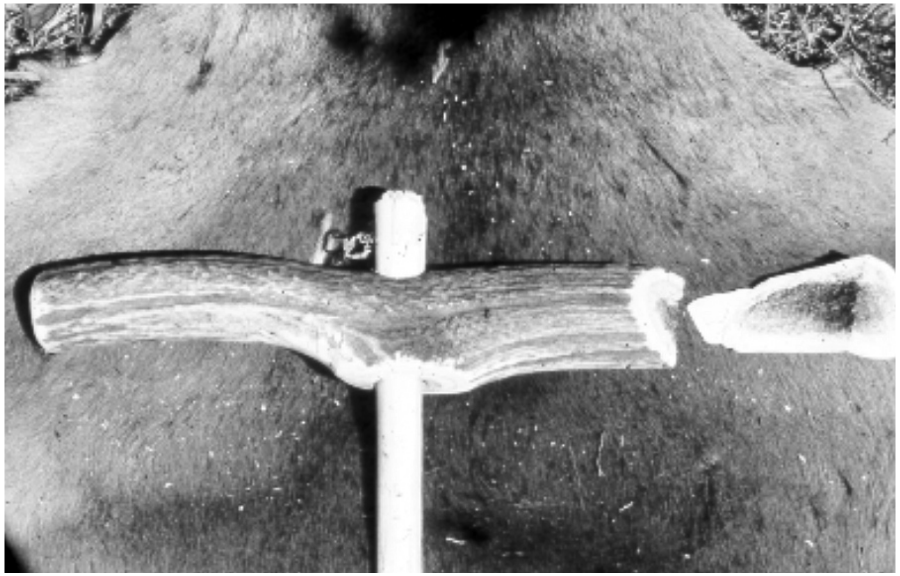

Fig. 5 The most usual breakage pattern for antler axes during work - the edge is broken. This form of breakage will only occur when the antler has dried out too much

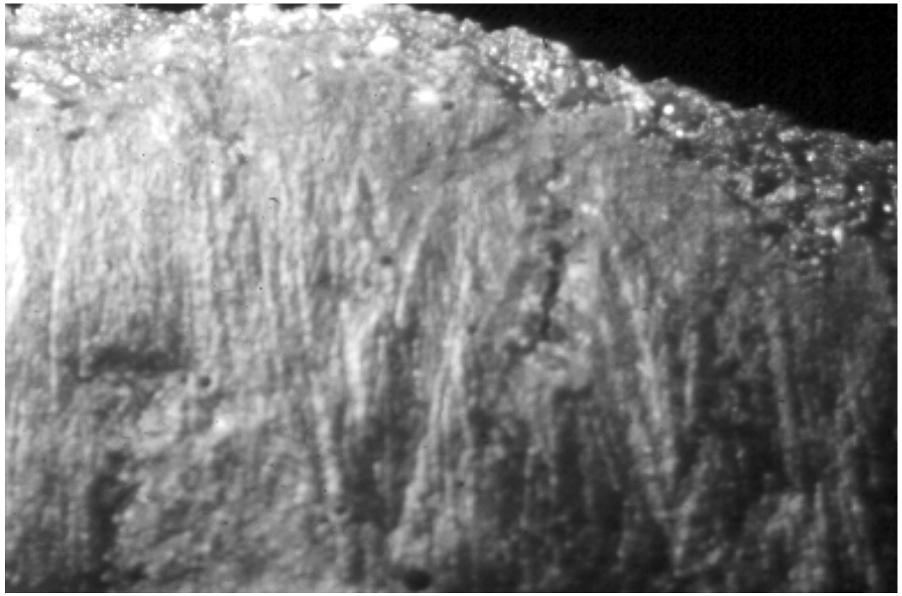

Fig. 6 Epoxy cast of antler axe used as mattock. The edge has been crushed and bears little resemblance to the polished and smoothed edge of axes used for woodworking