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.

EXPERIMENTAL DETERMINATION OF THE FUNCTION OF ANTLER AND BONE 'BEVEL-ENDED TOOLS' FROM PREHISTORIC SHELL MIDDENS IN WESTERN SCOTLAND

Janet Griffitts and Clive Bonsall

Abstract: Bevel-ended antler and bone tools are among the most characteristic artefacts from prehistoric shell middens in western Scotland dated between 8350 and 3000 BP (7350–1250 cal BC). There has long been a debate about their function. They have been interpreted as hide-processing tools. However, experiments in their manufacture and use, coupled with a comparison of the wear patterns on archaeological and experimental pieces, indicate that bevel-ended tools were used primarily for processing and, possibly, collecting limpets, the dominant shellfish species represented in the middens.

Keywords: Antler, bone, bevel-ended tool, function, use-wear, shell midden, limpets, Mesolithic, Scotland

Résumé: Les outils biseautés en os et bois de cervidés sont parmi les objets les plus caractéristiques des amas coquilliers préhistoriques de l'Ouest de l'Ecosse datés entre 8300 et 3000 BP; 7350–1250 cal BC. Leur fonction a fait l'objet d'un long débat. Ils ont parfois été interprétés comme des outils pour le travail des peaux. Cependant, les expérimentations sur leur fabrication et leur utilisation associées à l'étude tracéologique des objets archéologiques et expérimentaux indiquent que ces outils biseautés ont été essentiellement utilisés pour traiter, et probablement collecter les patelles, principale espèce de coquillages présente dans les amas coquilliers.

Mots-clés: bois de cervidés, os, outils biseautés, étude fonctionnelle, étude tracéologique, amas coquilliers, patelles, Ecosse

Zusammenfassung: Geweih- und Knochengeräte mit abgeschrägten Kanten gehören im Fundgut aus prähistorischen Muschelhaufen im westlichen Schottland (datiert zwischen 8300 und 3000 BP; 7350–1250 cal BC) zu den charakteristischen Artefakten. Über ihre Funktion ist lange gerätselt worden. Manchmal hat man sie als Werkzeuge bei der Verarbeitung von Tierhäuten interpretiert. Wie dem auch sei, gemeinsam mit einem Vergleich der Abnutzungsspuren an archäologischen und experimentell hergestellten Stücken haben Experimente zu Herstellung und Gebrauch gezeigt, daß Geräte mit abgeschrägten Kanten vornehmlich für die Aufbereitung und das Einsammeln von Napfschnecken, der in den Muschelhaufen hauptsächlich vertretenen Art, zur Anwendung kamen.

Schlüsselworte: Geweih, Knochen, Geräte mit abgeschrägten Kanten, Funktion, Abnutzungsspuren, Muschelhaufen, Napfschnecken, Schottland

Introduction

Bevel-ended antler and bone tools are among the most numerous and distinctive artefacts found in Mesolithic shell middens in western Scotland. The sites containing these artefacts were at one time believed to represent a discrete Mesolithic culture confined to coastal areas of central-west Scotland, to which the label 'Obanian' was attached after discoveries made in caves in the town of Oban at the end of the nineteenth century (Anderson 1895, 1898; Movius 1942; Lacaille 1954).

It is now generally accepted, however, that the 'Obanian' sites are simply one aspect of the Mesolithic maritime adaptation of western Scotland. It is also recognized that a key element of the 'Obanian' toolkit — the bevel-ended tools — are not confined to the Mesolithic. They also occur in shell middens belonging to later periods of prehistory, direct AMS dates for bevel-ended tools ranging from *c.* 8350–3000 BP (7350–1250 cal BC: Bonsall & Smith 1990; Bonsall *et al*. 1994; Saville, in press). Nor are they exclusively of antler or bone. Elongated stone artefacts of similar form and size have been found in some of the west Scottish middens. Such stone forms may have a wider distribution along the Atlantic seaboard of Britain, since their occurrence would not be determined by the survival of shell midden deposits.

The uses of antler, bone and stone bevel-ended tools have been debated since the nineteenth century. Various functions have been suggested. They have been interpreted as 'chisels' for working wood, as 'punches' used in flint working, as 'grinding tools' for crushing seeds or nuts, and as 'multipurpose tools'. The most popular interpretations, however — and the only ones given credence today — are that they were tools used in the processing of animal hides (Anderson 1895; Finlayson 1995) or tools used in the collection or processing of limpets that are the dominant component of the middens (Bishop 1914; Bonsall 1996).

The functional interpretation of these artefacts is crucial to understanding the role of the shell midden sites in the Mesolithic economy of western Scotland. If bevel-ended tools were used for gouging limpets out of their shells and/or detaching limpets from rocks, then it would support the hypothesis proposed by Bonsall (1996) that the shell middens were rubbish dumps attached to special purpose camps where Mesolithic people came to collect shellfish from the intertidal zone (often combined with line fishing from the shore) and where the 'catch' was processed, prior to transporting the meat back to a residential base camp for consumption or storage. On this hypothesis, individual occupation events could have been of very short duration — often, perhaps, lasting less than one day. If, on the other hand, the bevel-ended tools were used for hide processing, then the midden sites must have been more than just shellfish processing camps. A greater range of activities would be indicated and it would be reasonable to infer that episodes of use were of longer duration, with people remaining at the sites for days, weeks or months.

This paper describes the preliminary results of an experimental study of antler and bone bevel-ended tools, which has been designed specifically to address the question of their function.

Characteristics of bevel-ended tools

The bevel-ended tools of antler and bone from Scottish shell middens share a number of characteristics (fig. 1). Typically, they are made from narrow splinters of red deer antler or bone. In the case of the bone specimens, the skeletal elements from which the splinters were obtained are frequently unidentifiable; those that can be identified are almost invariably metapodia of red deer (*Cervus elaphus*). One or, less commonly, both ends of the tool are bevelled and/or rounded, the bevelling often occurring on both faces of the tool. The bevelled end is usually convex in plan view. In some cases, the bevelling or rounding overlies chipping damage. Occasionally, bevel-ended tools are made from recycled fragments of other tools (Bonsall 1996).[1]

In this paper, the term 'bevelling' refers to macroscopically visible affects of removal of material from one or both ends creating an oblique facet. 'Rounding' refers to alteration and smoothing of the surface on a much smaller scale. If the ends of the tools are both bevelled and rounded, the rounding smoothes the sharp edges of striations formed through bevelling (see below). Rounding can be visible macroscopically, but is much clearer microscopically.

Metrical analyses of tools from shell middens in western Scotland have been undertaken by Finlayson (1993) and Farquhar & Bonsall (in preparation). However, since Finlayson did not distinguish between antler and bone specimens or publish details of how the measurements were taken, it is difficult to make detailed comparisons between the two datasets.

Farquhar & Bonsall (in preparation) examined the antler and bone bevel-ended tools from two sites — a Late Mesolithic site on the Isle of Risga dated to *c.* 6000–5850 BP (4900–4700 cal BC), and a site at Carding Mill Bay (Oban) dated between *c.* 5200–4750 BP (4000–3500 cal BC) around the time of the Mesolithic–Neolithic transition (Bonsall *et al*., in press). Table 1 records the values for overall length (L), bevel width (B) and maximum thickness (T) of the tools from those sites. The results are not dissimilar to those reported by Finlayson (1993) for other shell middens in western Scotland. They confirm the apparent uniformity that he noted in the overall dimensions of the artefacts from the various sites.

Typically, the width of the bevelled end is between 7 and 15mm; over 80% of the pieces from both Risga and Carding Mill Bay I fall into this range. Overall length is also variable, but the vast majority of antler and bone bevel-ended tools (over 90% at both Risga and Carding Mill Bay I) are between 30 and 75mm long.

Tool thickness corresponds to the thickness of the blank, which presumably varies according to the size of the antler or bone from which the splinter was obtained. There is no evidence of deliberate 'thinning' of the splinters prior to use.[2] On average, the tools from Carding Mill Bay I are shorter than those from Risga and mean/median thickness is also less. This is accounted for by the fact that many of the shorter tools (length less than or equal to 50mm) from the Carding Mill Bay site were made from relatively thin bones. This, in turn, suggests that tool length has some relationship to the size of the bone that was selected as raw material, and was not simply a function of the degree of use inflicted on a tool.

Experiments in the replication of bevel-ended tools

Production of 'blanks'

The first stage of the experimental programme was to produce 'raw' splinters of antler and bone that would serve as blanks. The experiments are described in detail by Farquhar & Bonsall (in preparation).

It was found that suitable blanks could be obtained from red deer metapodia simply by smashing the bones with a hammer-stone, but this gave very little control over the size and shape of the splinters produced. More regular splinters were obtained by splitting the bone longitudinally using a broad, flat wedge of cattle bone. The tip of the wedge was seated in the anterior groove of the metapodial, and the opposite end struck with an antler or stone hammer. Some of the fragments produced resemble the pieces illustrated on fig. 2, in retaining the epiphyseal end of the bone. These large fragments could be divided into smaller splinters by smashing or splitting. It is possible that thicker bones than those used in the experiments would need to be grooved with a stone tool prior to splitting.

Red deer antler could not be reduced to splinters by simple

Median values (mm):

Sample	n	L	B	T
Risga (bone)	53	51.0	11.2	8.4
Carding Mill Bay I (bone)	28	46.2	11.4	7.3
Risga (antler)	5	43.6	11.4	7.2
Carding Mill Bay I (antler)	9	45.0	13.6	8.2

Mean values (mm):

Sample	n	L	B	T
Risga (bone)	53	52.4	11.2	8.7
Carding Mill Bay I (bone)	28	44.8	11.7	7.6
Risga (antler)	5	47.7	12.6	7.1
Carding Mill Bay I (antler)	9	48.1	13.3	8.4

Standard deviation (mm):

Sample	n	L	B	T
Risga (bone)	53	12.7	2.8	2.1
Carding Mill Bay I (bone)	28	11.6	3.1	1.6
Risga (antler)	5	8.9	2.8	1.0
Carding Mill Bay I (antler)	9	9.1	2.7	2.0

Coefficient of variation:

Sample	n	L	B	T
Risga (bone)	53	24.2	25.2	23.7
Carding Mill Bay I (bone)	28	25.9	26.8	21.0
Risga (antler)	5	18.7	22.4	14.5
Carding Mill Bay I (antler)	9	18.8	20.4	23.4

Tab. 1 Statistical data relating to overall length (L), bevel width (B) and maximum thickness (T) of antler and bone bevel-ended tools from Risga and Carding Mill Bay I (after Farquhar & Bonsall, in preparation)

percussion using a hammer-stone or by splitting with a bone wedge. Blanks were obtained from pre-prepared sections of antler beams *c.* 10–15cm in length by the 'groove-and-splinter' technique. Two parallel grooves *c.* 15mm apart were cut in the antler beam with a flint tool. Once the grooves had reached the cancellous tissue forming the core of the antler, the intervening splinter was levered out by driving in wedges of bone and (willow) wood. Typically, the time taken to remove a single splinter *c.* 15cm long from a section of 'dry' antler was around 2½ hours. Presoaking an antler in water for up to 5 days had the effect of making the material much softer, and thereby reduced the time needed to cut the grooves by around 50%. Nevertheless, the process was quite laborious. Therefore, once the technique had been demonstrated, additional 'blanks' were manufactured by dividing up the antler beam sections longitudinally with a metal hacksaw or an electric bandsaw.

Hafting

The small size of the vast majority of antler and bone bevel-ended tools would have made them difficult to grip in the hand or between the fingers. So, unless they are the worn down stumps of originally much longer pieces, it seems highly likely that they would have been fitted into some form of handle during use.

Two pieces of circumstantial evidence support this interpretation. The first is the occurrence of a few archaeological examples of bevel-ended tools still 'attached' to the original metapodial (fig. 2) forming an implement that was long enough to be held securely in the hand, obviating the need for a separate handle. The second is the morphology of the tools themselves. In plan view, the splinters used almost invariably have a narrow wedge-shaped form (sometimes tapering to a point) that would have facilitated hafting (fig. 1). It is most often the broader end of the splinters that bears traces of bevelling/rounding. This would be a natural consequence of inserting the narrower end into a handle.

For the experiments described below, a handle was made from a short section cut from the beam of a small red deer antler, and the splinter was inserted into a hole *c.* 20mm deep made by drilling out the cancellous tissue from one end (fig. 3). A large antler tine would have served equally well. Splinters of differing breadth and thickness could be made to fit into the haft by using leaves or grass as packing material. The main benefit of the handle was to 'lengthen' the tool, allowing it to be gripped in the hand. It was found to be less important for the splinter to fit tightly within the haft.

No obvious examples of antler or bone handles have been recovered from Scottish shell middens. Therefore, if bevel-ended tools *were* hafted, then the handles must have been either heavily 'curated', or made from a material that does not survive in the midden deposits. Handles could have been made out of wood (cf. Anderson 1895: 222). They could also have been made from the thick, rounded stipes of the seaweed known as 'oarweed' or 'kelp' (*Laminaria digitata*) which abounds on rocky shores in western Scotland (fig. 4). A handle made from a kelp stipe would be very flexible when fresh, allowing a splinter to be inserted easily into the end. As it dried the handle would become more rigid and the shrinkage that occurs during drying, in theory, would result in the splinter being 'gripped' firmly by the haft.

This possibility has yet to be tested in the field, but a number of shell middens have produced indirect evidence for the collection/disposal of 'kelp' in the form of the tiny shells of molluscs that live on the fronds, stipes or in the holdfasts of *Laminaria digitata* (Bonsall *et al*. 1994; Russell *et al*. 1995; Pickard & Bonsall forthcoming).

Detaching limpets from rocks

Field trials were undertaken with experimental tools consisting of an antler splinter inserted into an antler haft, in order to determine whether the tools could be used effectively for harvesting limpets. The experiments were conducted on a rocky shore to the east of Edinburgh (Farquhar & Bonsall, in preparation).

Limpets (*Patella* spp.) inhabit rocks in the inter-tidal zone, and their behaviour is strongly influenced by the tide. When above the water, they attach strongly to rocks to reduce water loss. When covered by the tide they tend to loosen their grip on the rocks so that they can graze on attached algae. Thus, whether a limpet is emersed or immersed affects the ease with which it can be removed from a rock.

Several attempts were made to remove limpets that were above the water level (emersed). Considerable force was required. The tool tip was struck against the base of the shell, so that the tip contacted both shell and rock. Three out of six attempts were successful in removing limpets from rocks; the other three attempts succeeded only in breaking the shell without detaching the limpets. With practice, a higher rate of success might have been achieved.

Harvesting limpets was found to be very much easier when they were below the water (immersed), e.g. from the rock pools that are left during ebb tide. Very little force was needed to remove the limpets. They could be detached simply by pushing against the base of the shell with the tip of the splinter. The tool was held at an angle of 30–45º to the rock surface and moved a short distance across it in a unidirectional (longitudinal) 'grinding' motion until contact was made with the shell. In 12 attempts at removing limpets in this fashion, there were no failures (fig. 5).

To avoid killing large numbers of limpets, subsequent experiments attempted to simulate the action of removing 'live' limpets from rocks. These experiments were conducted both in the field and in the laboratory. They involved holding an empty limpet shell against a rock with one hand and attempting to 'dislodge' it by striking or pushing with the tip of a hafted antler splinter. Each experimental splinter was used for between 50 and 500 strokes on each face.

The splinters used in the limpet gathering experiments all developed bevelled ends. It was noted that the bevelling developed much more rapidly on those tools that were used to remove limpets from rock pools (or in simulating that activity) where the tip of tool was always immersed in water as it contacted rock or shell. Typically, in those cases it took only around 50 strokes on each face to produce the degree of bevelling observed on many archaeological examples of bevel-ended tools.

Gouging limpets out of their shells

One of the bevel-ended tools that had been created during the limpet gathering experiments was used in the field as a 'limpet scoop' in order to assess its effectiveness as an instrument for gouging limpets from their shells. Inserted into its antler haft, the experimental tool proved to be particularly well suited to that task. With a bevel width of *c.* 16mm it was easily narrow enough to fit right inside the shells of adult limpets. Using the tool with a 'scooping' motion on about a dozen limpets it proved possible to separate the flesh from the shell at either the first or the second attempt. An experienced prehistoric shellfish gatherer no doubt would have achieved a much higher strike rate.

A further important objective of the limpet 'scooping' experiments was to investigate the wear traces that are likely to result from using a bevel-ended tool repeatedly to remove limpets from their shells. Since it was neither practical nor desirable to destroy hundreds or thousands of shellfish, several experiments were designed to try to create comparable wear by replicating the motions used and materials contacted during limpet harvesting, without sacrificing the living animals.

The experiments were conducted under laboratory conditions with the help of undergraduate students of the Department of Archaeology at Edinburgh University. Three sets of experiments were undertaken. Experimental bevel-ended tools were used with a scooping motion inside, (i) dry limpet shells, (ii) 'wet' limpet shells (kept moist by being dipped in water at regular intervals), and (iii) shells filled with fish 'meat'. The tools were used for between 200 and 5000 strokes on *each* face. All the tools used for these experiments were on splinters of red deer antler.

Wear traces observed on the experimental tools

The tools used in the 'limpet gathering' and 'limpet scooping' experiments were then examined for traces of use, both *macroscopically* (with a 10X hand lens) and *microscopically* under a metallurgical microscope with incident light at magnifications of 33–400X.

Several kinds of wear were observed on the tools that had been used to simulate the removal of limpets from rocks. In all cases, the working end had become bevelled from contact with rock. The bevels exhibited coarse longitudinal striations parallel to the direction of tool movement. These were visible under a hand lens, and sometimes with the naked eye (fig. 6). The breadth of the striations varied, presumably according to the grain size of the rock. In addition small, localized patches of polish were noted on the extreme ends of the tools. In contrast to the clear traces of bevelling and associated striations, there were no signs of 'rounding' of the ends of the splinters. In general, the wear traces observed on the experimental 'limpet hammers' are very similar to those produced in manufacturing antler/bone tools by grinding against stone.

On the tools used to simulate 'scooping' of limpets out of their shells, it was found that very little (additional) bevelling had occurred. However, the bevelled ends had become rounded, resulting in smoothing of the sharp edges of striations formed through contact with rock. Under high magnification areas of polish could be seen to have developed. In places this took the form of a light non-diagnostic polish. In other places (especially on the end of the tool, but occasionally on the face of the bevel) it appeared as areas of very bright, 'smeared' polish. Features common to both types of polish were: (i) the polish had an uneven ('patchy') distribution, being concentrated on the high points of the bevel surface, and (ii) the surface of the polish appeared 'flattened'. Within the areas of very bright polish there were fine, parallel striations (usually only visible at 100X magnification and above) and some cracking (fig. 7a). Moreover, on some tools the *osteons* (circular microscopic structures in bone and antler) were exposed — these were most evident on tools used inside wet shells (cf. LeMoine 1994).

It was noted that rounding of the tips of the experimental tools occurred more rapidly when used on wet shells or shells filled with fish meat, compared to dry shells. But there was little difference in polish development between tools used on wet *versus* dry shell. Nor, after polish had begun to form, did there appear to be any direct correlation between polish development and duration of use. For example, polish development was no more extensive or intensive on tools used for 5000 strokes compared to those used for only 500 strokes.

A simple test was conducted to determine whether the polish seen on the experimental pieces was 'reductive' or 'additive'.[3] A flint flake was scraped against shell for 17,000 strokes. The resulting polish on the edge of the flake was very similar in appearance to that observed on the experimental antler tools. The flint was then placed in a weak (5%) solution of hydrochloric acid for one minute, and the polish disappeared. This process was repeated with 11,000 strokes of the flint flake against shell. The flint was again placed in dilute HCl, with the same result. The tool was used once more for 1500 strokes, again acquiring a bright polish that was photographed and allowed to remain (fig. 7b). The results of this experiment suggest that the shell polish observed on the experimental antler tools is additive.

Functional analysis of bevel-ended tools from archaeological sites

A set of 71 tools from seven shell midden sites in western Scotland were examined for wear and manufacturing traces.

Manufacturing traces

In general, few manufacturing traces remain on the bone and antler artefacts. The majority of antler tools were probably shaped using the groove-and-splinter technique, but on many tools most traces directly related to manufacture were worn or eroded away. The actual cut marks are preserved on only a few specimens, but many others have shapes suggesting that they were cut from antler beams.

All the bone tools examined appear to have been made from long bones of deer-sized mammals, most likely metapodia, although at least one fragment from a humerus was identified. Many of the bone tools have irregular broken edges, suggesting that they were made from splinters that had been obtained by smashing or splitting bones. Patterns of breakage indicate that the bones were probably broken in both fresh and 'dry' states. Some splinters show characteristic 'green' bone breakage (e.g. helical fracturing), while others have straight or angular fracture surfaces suggesting that they were broken from bones with reduced moisture content. Loss of moisture reduces elasticity making bone more brittle and this often results from cooking or weathering. However, some of the bone bevel-ended tools examined showed clear signs of longitudinal grooving on their edges. This observation contradicts Clark's (1956) deduction, based on the absence of burins from the middens, that bones were not worked by the groove-and-splinter technique.

Wear patterns

The wear patterns found on the archaeological tools were compared to those on tools used in the limpet collecting and processing experiments. The wear observed on both the archaeological and experimental bevel-ended tools was compared against a database of experimentally-produced wear patterns resulting from work on a variety of materials, including (1) processing silica-rich plants, (2) seed grinding, (3) wood-working, (4) pressure flaking, (5) hide- and leather processing, and (6) digging. The wear patterns resulting from these various activities are summarized in Table 2 and some are illustrated on fig. 7; the data relating to the non-shell materials are based on an earlier series of experiments conducted by the senior author as part of her PhD research at the University of Arizona.

The results of the functional analysis of 71 bevel-ended tools from shell midden sites in western Scotland are summarized in Table 3. The use-wear patterns are surprisingly uniform, suggesting that the tools were used consistently for the same kinds of activities. The bevelled ends of many tools show parallel deep V-shaped striations characteristic of grinding against stone. However, for obvious reasons it cannot be determined whether the bevelling and associated grinding marks were formed during manufacture or use. The most diagnostic wear trace is polish. The majority (63 = 89%) of the archaeological tools show wear traces on the working ends that are consistent with contact with shell. The ends of the tools exhibit an equivalent degree of rounding and similar polish characteristics to those seen on the experimental shellfish processing tools (fig. 8). It cannot be claimed that in all cases the polish observed on the archaeological tools is i*dentical* to that on the experimental limpet scoops, but it resembles much more wear formed though contact with shell than that produced by any other experimental activity undertaken. The slight differences in polish appearance noted between archaeological and experimental bevel-ended tools are probably due mainly to the fact that the 'limpet scooping' experiments did not replicate exactly prehistoric tool use.

A small percentage of the archaeological specimens examined show wear traces suggesting contact with materials other than shell. In most of these cases the contact materials could not be identified, but two specimens examined appear to have contacted silica-rich plant material. The polish recorded on a small percentage of the tools suggests contact with some relatively soft substance(s) in addition to, or instead of, shell. The nature of that substance(s) could not be defined; it may have been animal hide/leather, meat, wood, other plant material, and/or seaweed.

Nevertheless, what is clear from this study is that the use-wear patterns on the vast majority of bevel-ended tools are very different from those on experimental hide- and leather-working tools. Rounding of the working ends is not as extreme as that produced by contact with rawhide or leather. Moreover, on the bevel-ended tools polish is confined to the high points, and does not extend into lower areas as is characteristic of skin-working tools (compare figs. 7c & 8). These observations match expectations based on tool morphology. Bevel-ended tools would not have been suitable for most stages of hide processing. The bevelled/rounded ends are too dull to be effective as scrapers and the tools generally are too small to have functioned efficiently for any method of hide processing. It could be argued, of course, that the archaeological tools have rounded ends because they are 'worn out'. However, a tool would cease to be functional as a skin-processing implement (or, for that matter, as a wood working chisel) long before it became as blunt as most of the tools from the shell middens.

Possible hafting traces

It was noted above that many of the bevel-ended tools from Scottish shell middens are too small to manipulate easily in the hand without a haft. This and the fact that very often they are broader at the bevelled end than at the unused end, argues

Contact Material/Activity	Polish appearance	Extent	Pitting	Cracking	Chipping/ battering	Distribution	Striation appearance	Remarks
LEATHER/HIDE	Bright, strong	Wear follows bone surface contour producing rounded wear	Common	Infrequent	Infrequent	Continuous. Wet hide tends to produce more widespread wear than dry hide or tanned leather	Smooth, rounded edges	
SILICA-RICH PLANTS	Usually bright but varies with different plants	Wear is limited to high points only	Infrequent	Common	Infrequent	Variable	Sharp edged, V-shaped	
DRY LIMPET SHELL	2 polish types: 1) bright 'smeared' looking 2) weak, light rough 'pebbly' looking	High points	Infrequent	Common with polish type #1	Infrequent	Patchy	Type 1 – fine, parallel striations. Type 2 – occasional faint striations	The polish is additive
WET LIMPET SHELL	Weak with occasional bright patches	High points	Infrequent	Common	Infrequent	Patchy	Infrequent	
LIMPET SHELL AND ROCK	Small patches of bright shell-like polish on end, otherwise little or no polish	High points	Infrequent	Found in bright polish patches	?	Patchy	Coarse, deep, longitudinal	Striations are similar to manufacturing marks. Tools used as limpet hammers are more likely to become chipped and battered than the experimental tools
WOOD	Medium, less bright than polishes from many silica-rich plants	High points and some lower areas, less rounded than leather/hide processing	Common	Common	Occasional	Variable	Smooth, narrow, grouped	Variable with different types of wood
PRESSURE FLAKING	Variable	High points	Common	Infrequent	Common	Patchy	Wide, deep or shallow irregularly spaced and oriented	
SEED GRINDING	Little to none	High points	Infrequent	Infrequent	Common	Patchy, restricted to edge	Wide, V-shaped, some macroscopically visible	Marks caused by seed grinding are often difficult to distinguish from manufacturing marks
DIGGING	Varying weak to strong, flat patches surrounded by bumpy areas	Strongest on high points	Common	Common	Common	Variable	Varied, isolated (not grouped) some macroscopically visible	

Tab. 2 Summary of use-wear patterns on experimental antler and bone tools (viewed at 33-400X magnification)

Site	Total	G	L	LS	S	M	MS	MP	U
Carding Mill Bay I	40	1	32	4	1	–	1	–	1
Carding Mill Bay II	1	–	1	–	–	–	–	–	–
Ulva Cave	1	–	1	–	–	–	–	–	–
Raschoille Cave	1	–	–	–	–	1	–	–	–
Risga (sample)	12	–	8	4	–	–	–	–	–
Cnoc Sligeach (sample)	13	–	9	2	–	1	–	1	–
Specimens of uncertain provenance, illustrated as from Risga by Lacaille (1954, fig. 102, no. 1 & 4) but labelled as from Cnoc Sligeach	2	–	2	–	–	–	–	–	–
'Viking Mound', Oronsay	1	–	–	–	–	1	–	–	–
TOTAL	71	1	53	10	1	3	1	1	1

Abbreviations for contact materials: G = grinding only; L = shell; LS = shell and soft material; S = soft material; M = multiple unknown uses; MS = multiple use including soft material(s); MP = multiple use including silica-rich plant; U = use unknown.

Tab. 3 Summary of wear patterns observed on antler and bone bevel-ended tools from shell middens in western Scotland strongly that they were hafted in use. The action of inserting an antler or bone splinter into a handle and slight movement of the tool within the haft during use could, in theory, leave wear traces. However, the form and extent of any wear traces are likely to vary according to the degree of movement within the haft and the material used for the haft.

Evidence of hafting was sought in the form of grouped striations, polish, or other surface modification on tool shafts. Use-wear patterns suggestive of hafting were found on a few tools. One bone tool from Risga, for example, showed heavy transverse and longitudinal striations (visible at 50X magnification) associated with flattened and rounded areas, at *c.* 25–30mm from the working end. Other tools frequently had a light, weak, non-diagnostic polish on the shafts, which could have formed either through hafting or handling. The polished areas sometimes contained longitudinal and/or transverse striations.

Conclusions

This paper has sought to address several aspects of the debate surrounding the function of the bevel-ended tools that characterize the antler/bone artefact assemblages from prehistoric shell middens in western Scotland. Three main questions were considered: (1) How were they made? (2) Were they hafted for use? (3) How were they used — were they skin-working tools as suggested by Finlayson (1995) or were they used in the collection and/or processing of shellfish as suggested by Bonsall (1996)?

From experiments in the collection and processing of limpets using replicate antler tools, and from a comparison of wear patterns on archaeological bevel-ended tools with those on experimental tools used on a variety of materials (soft plant material, wood, stone, hide/leather, soil and shell) the following observations may be made:

1. Typically, bevel-ended tools were made on splinters detached from red deer antlers or bones by means of the groove-and-splinter technique or (in the case of bones) by splitting with a wedge or smashing with a hammer-stone. Bones were worked in both fresh ('green') and dry states.

2. Most bevel-ended tools were probably hafted for use, although this could not be demonstrated by use-wear analysis.

3. Contrary to suggestions made by some authors, there is no evidence that bevel-ended tools were intended for hide- or leather working.

4. Use-wear analysis suggests that bevel-ended tools were used primarily in the harvesting of shellfish.

5. The vast majority of bevel-ended tools appear to have been used for gouging limpets out of their shells.

6. Prior to their use as 'limpet scoops' the ends of the splinters usually were bevelled, either incidentally in the process of detaching limpets from rocks, or deliberately by grinding against a stone.

These should be regarded as preliminary conclusions. Further research is planned that will attempt to address some of the limitations of the present study. It will focus particularly on the question of hafting, including the effectiveness of wood and stipes of laminarian seaweeds as hafting materials.

Notes

1 Lacaille describes one example from Druimvargie Rockshelter (Oban) as made from boar tusk (Lacaille 1954: fig. 82), but the present authors have not examined this piece.

2 Stone bevel-ended tools from the shell middens sometimes show flaking damage on the non-bevelled end, which could represent deliberate attempts at reducing the breadth or thickness of the tool shafts to facilitate hafting (cf. Breuil 1922, fig. 4). Stone and bone examples also occasionally exhibit flaking on the working end. This is more likely to be impact damage caused during use. Stone and (especially dry) bone, being more brittle than antler, would be more susceptible to this form of use-wear.

3 Reductive polishes occur when material is removed from a tool, removing high points and producing a smooth, reflective surface. An additive polish produces a reflective surface through deposition of additional material on the surface of a tool. An additive polish can fill in low points of the tool surface.

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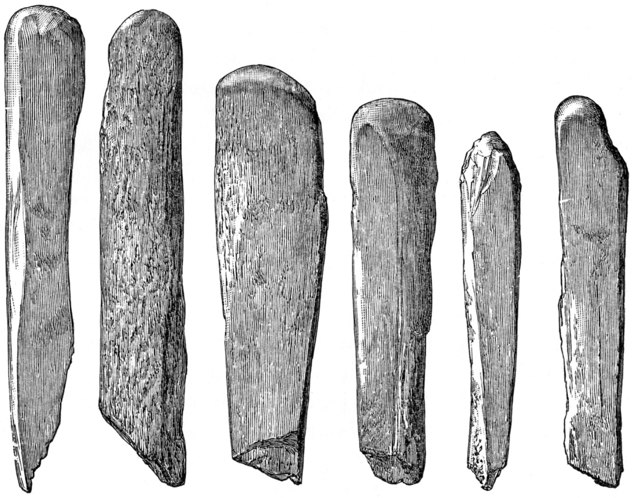

Fig. 1 Antler and bone bevel-ended tools from Druimvargie Rockshelter, Oban. Note the narrow, tapering form of most pieces with traces of bevelling/rounding on the broader end. Reproduced from Anderson 1898, figs 10-15. Scale 9:10

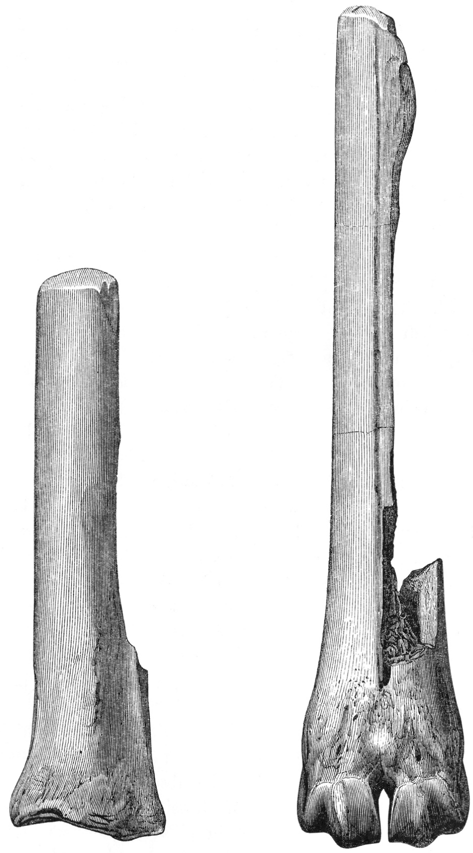

Fig. 2 Bevel-ended tools made on the fractured ends of red deer metapodials, with the opposite ends of the bones intact providing a 'handle' - from MacArthur's Cave, Oban. Reproduced from Anderson, 1895, figs 9-10. Scale 2:3

Fig. 3 Experimental bevel-ended tool and antler haft (Photograph: J. Farquhar)

Fig. 4 'Kelp' (Laminaria digitata). The thick, rounded stipes (stalks) of this seaweed could have been used to make handles for bevel-ended tools

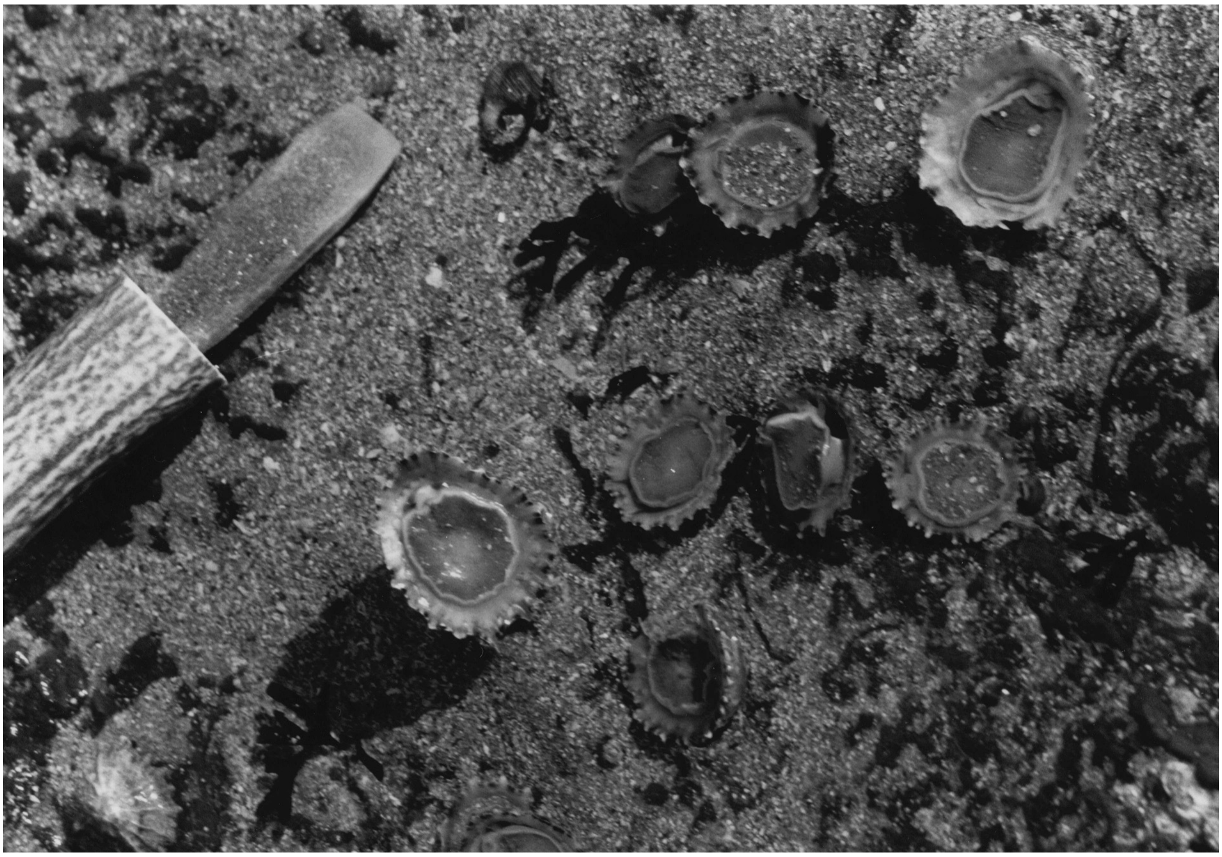

Fig. 5 Limpets removed from a rock pool using a hafted antler splinter (Photograph: J. Farquhar)

Fig. 6 Antler splinter used to remove limpets from a rock pool. Note the bevelling at the tip and the longitudinal striations on the bevel. Width of bevel = 16mm (Photograph: Joe Rock).

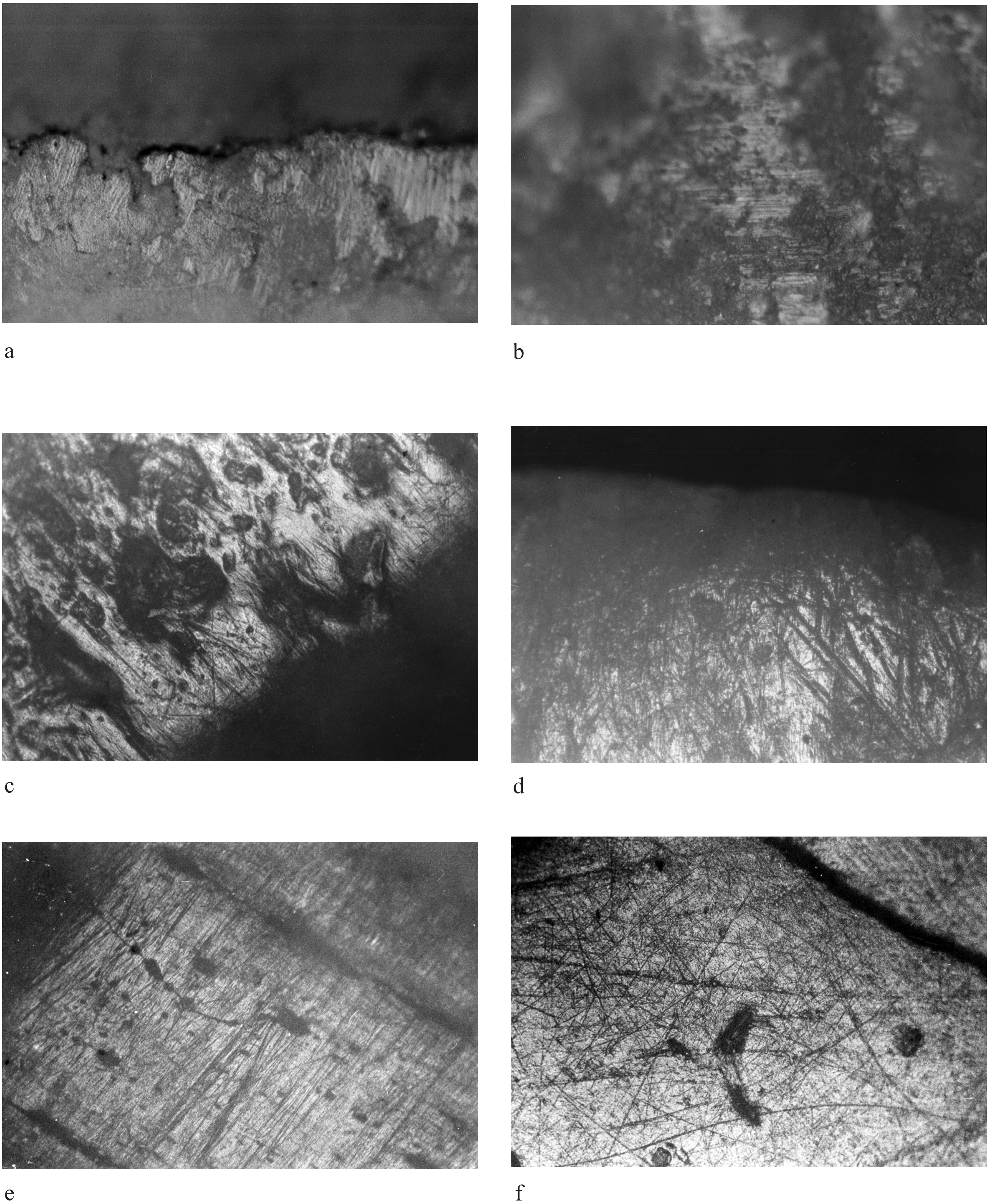

Fig. 7 Examples of polish on experimental tools used to work various materials: a - dry shell polish on the working end of an experimental antler bevel-ended tool (33X magnification); b - dry shell polish on the edge of a flint flake (66X magnification); c - hide-processing (100X magnification); d - wood-working (50X magnification); e - silica-rich plant (agave splitting, 100X magnification); f - silica-rich plant (grass cutting, 100X magnification). (Photographs: J. Griffitts)

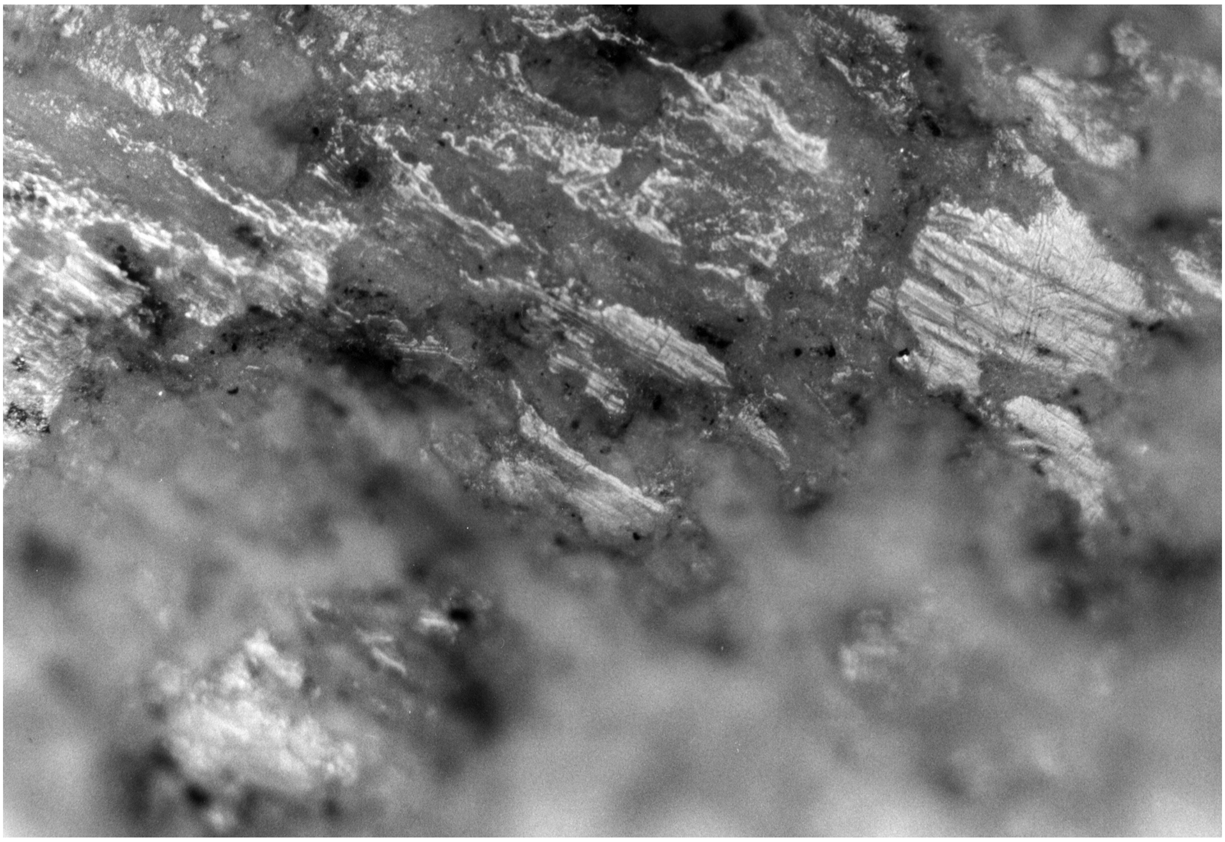

Fig. 8 Shell polish on a bone bevel-ended tool from the shell midden at Carding Mill Bay I, Oban. The polish is confined to the 'high points' of the bone surface. Note the fine striations and cracking within the polished areas (33X magnification; Photograph: J. Griffitts)