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Skilled Production and Social Reproduction

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SOCIETAS ARCHAEOLOGICA UPSALIENSIS

Skilled Production and Social Reproduction

Aspects of Traditional Stone-Tool Technologies

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Some of the symposium participants outside SAU in Uppsala, Sweden. Top row: Nyree Finlay, Anthony Sinclair, Witold Migal. Second row from top: Kjel Knutsson, Leslie Harlacker, Greg Nunn, Marcin Wąs. Third row from top: Mika Tallavaara, Tuija Rankama, Hugo Nami, Dietz Stout. Front row: Jan Apel, Esa Hertell, Errett Callahan, Kim Akerman, Mikael Manninen.

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Introduction

Jan Apel and Kjel Knutsson

Skilled Production and Social Reproduction – an introduction to the subject

During a five-day symposium in late August 2003, a group of archaeologists, ethno-archaeologists and flintknappers met in Uppsala to discuss skill in relation to traditional stone-tool technologies and social reproduction. It soon became apparent that we, as the organizers of the symposium, should have steered the ship with more authority than we did, at least if our sole purpose was to cover the subject of the title of the present volume. As the reader no doubt will notice, not all of the papers in this volume strictly honour the chosen subject. Thus, the Jamie Reid-inspired cover of this book is intended to reflect "a situation" created when researchers from different epistemological positions gathered to discuss the study of traditional stone tools. We wanted to acknowledge our conviction that studies of material culture must involve outside as well as inside perspectives in order to produce both convincing and interesting archaeological interpretations. Unfortunately, or fortunately, depending on how you look at it, this was not achieved during the symposium. Participants disagreed severely over these issues and some of these conflicts are touched upon in Dobres' paper that follows this introduction. Even if our initial aims were not fulfilled, we are convinced that this book is a step in the direction of merging practice and theory in stone technological studies.

Inside and outside – realism and rationalism

Behind the choice of subject lies, among other things, a fundamental problem related to an epistemological project introduced to the philosophy of science by Gaston Bachelard in the 1930s (see for instance Bachelard 1984), which we believe is pertinent to archaeology. Bachelard was as critical towards orthodox empiricism as he was of logical positivism (Broady 1991). While orthodox empiricism aims to attain knowledge of the surroundings, and the primary mode of access to the surroundings is observation (Adams & Adams 1991:314 f), logical positivism adds to these propositions by demanding that the knowledge of the surroundings that science aspires to command is of a general character, and therefore permits us to explain phenomena not yet observed. This is achieved through a rigorous methodology and through the construction of general laws (for example the construction of middle-range theory à la Binford). While these research perspectives were traditionally regarded as two ends of a continuum between realism and rationalism, Bachelard suggested that they are equally important in "the scientist's everyday work". Similar ideas were later introduced to an English speaking audience by Thomas Kuhn and were established in the social sciences by leading post-structuralists such as Foucault and Bourdieu in the late 1960s. When we read Bachelard and Bourdieu it occurred to us that experimental archaeology, and flint knapping experiments in particular, followed very closely the way in which Bachelard suggested that scientific work proceeds: as a continuous motion between a sensually based description and theoretical analysis and reflection.

Closely connected to our view of skill is the notion that skill can be a means of making social distinctions. Valuable artefacts and social institutions that guarantee the reproduction of the technologies producing such artefacts will be used in social strategies. The main entry to this book is thus the acknowledgement that the knowledge and know-how, as well as the recipes for action involved in the production of stone tools, can be used as valuable assets in different kinds of cultural and social strategies. Knowledge of the reproduction of technologies is therefore essential for social interpretations. The symposium strived towards combining papers dealing on the one hand with theoretical issues such as the social aspects of craftsmanship and skill in traditional societies, and on the other with practical sessions on the actual making of stone tools. While research carried out in order to solve only practical, technological aspects often tends to be sterile, in the sense that researchers focus on technical procedures, research on the social aspects of stone tools often tends to be naïve and formally orientated if the researcher lacks a comprehensive knowledge of the technical aspects involved. We had hoped that by combining scholars with different backgrounds and focus, the symposium participants might be able to bridge the gap between practice and theory. This meant that participants from very different traditions were invited to present papers and make practical demonstrations and this, in turn, proved to be problematic. However, even if it was obvious that there were disagreements as to what is considered to be interesting or meaningful research, we hope that the content of this publication, or rather, the individual papers, will speak for themselves. The book contains 20 papers that have at least one thing in common: they revolve around different aspects of traditional stone-tool production. As we write this introduction, the fact that to some degree we experienced the symposium and its subject as a bit problematic will not discourage us from digging deeper into the theoretical problems that arose during the symposium. The epistemological problems involving cultural and social interpretations of past technological traditions are far too interesting not to investigate further.

Stone studies in Uppsala

It was not a coincidence that the "Skilled Production" symposium was held in Uppsala. During the early 1970s, the archaeological research process in Uppsala was enriched with knowledge produced during practical experiments, including flint knapping. The late Thomas Johansson, who formed the Institute for Prehistoric Technology in Östersund and the MNT teaching programme at the Bäckedal school in Härjedalen, was one of the originators. He wrote his BA thesis in Uppsala on experiments with bows and arrows, and thus introduced the investigation of theories of "the middle range". The experimental research tradition in tool technology and tool function was later expanded on by Noel Broadbent and Kjel Knutsson at the Department of Archaeology, Uppsala University (Broadbent & Knutsson 1975, 1980). This was an example of how archaeologists in that particular research climate recognised the behavioural interest of processual archaeologists and thus regarded the development of theories concerning the relationship between prehistoric activities and archaeological material patterns as important in a research strategy inspired by the natural sciences, that could be applied in Stone Age archaeology. During the 1980s, this tradition was further developed and several undergraduate and PhD theses were produced at the Department of Archaeology in Uppsala. Already during this period, researchers and lithic technologists were invited to participate in research projects and education. Harm Poulsen (Fig. 1) introduced the processual technological view of stone-tool production in different seminars in Uppsala between 1977 and 1980. Errett Callahan (Fig. 2) later became an important participant as he was involved in several experimental projects at the Department of Archaeology in Uppsala and the Historical Museum in Stockholm from 1981 onwards (see for instance Callahan 1987, Callahan et al. 1992) and Bo Madsen also visited the seminar in Uppsala (Fig. 3). Several undergraduate and PhD dissertations that based important aspects of their argumentation on experimental observations were thus produced during the 1980s and 1990s (K. Knutsson 1988, H. Knutsson 1995, Taffinder 1998, Apel 2001, Lekberg 2002 & Sundström 2003).

Fig. 1. Harm Poulsen in Schloss-Gottorf, Germany 1975.

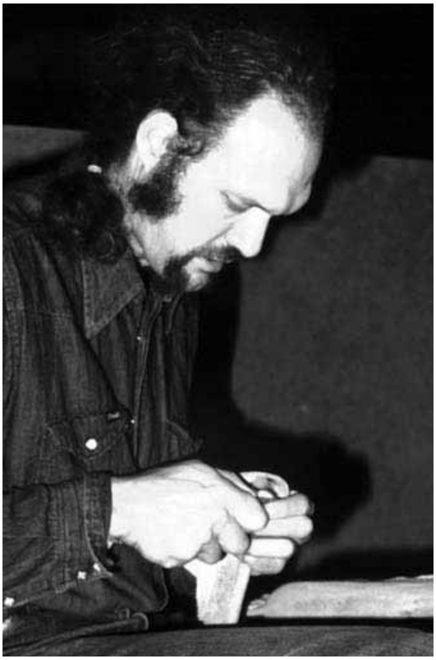


Fig. 2. Errett Callahan in Uppsala 1980.

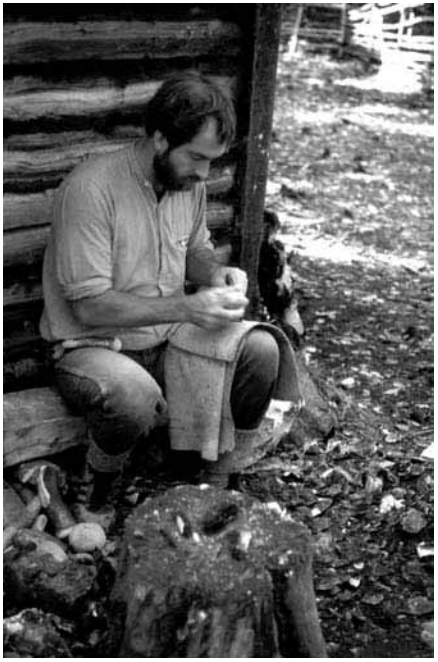


Fig. 3. Bo Madsen making a flint blade in Uppsala.

At the end of the 1980s, the experimental research tradition in Uppsala faded out. In part, this was explained by the fact that certain key persons, for instance Kjel Knutsson, finished their dissertations at this point and moved on to new adventures. However, it is also fair to say that the severe critique of scientific archaeology that was brought to bear by proponents of an archaeology that denied the value of experimental and ethnographic analogies in favour of historical and phenomenological approaches also was to be held responsible. These post-processual archaeologists rejected the notion of "the ideal generalisation" that, from a somewhat shallow point of view, lies at the heart of the experiment as an archaeological method. However, for wise, non-dogmatic experimentalists, this critique was aimed in the wrong direction. The technological reconstruction that is the result of carefully conducted experiments is an interpretative process that continuously moves from small to large issues and back. This is due to the fact that the experimentalists do not necessarily produce an understanding that makes objective knowledge of prehistoric events possible even if they base some of their classifications on natural laws. From an archaeological point of view, it might even be more appropriate to talk about experience rather than controlled experiments (in the scientific sense). Hands-on practice form one important way for archaeologists interested in technology to widen their perspective. Ideally, this is something that grows from an on-going dialogue between general knowledge and individual practical skill and thus mimics an hermeneutical circle. It is at the crossroads of practical mastering and understanding of the craft, on the one hand, and the distanced, scientific analysis and classification, on the other, that history, cultural conventions and the general way of life is negotiated. In fact, in one of the articles in this book, it is argued that prehistoric flint knappers themselves also took advantage of the inside versus the outside perspectives when actively trying to recapitulate older "forgotten" industries in cultural reproduction (see Knutsson in this volume).

Thus, we are of the opinion that it is important to maintain and develop the experimental tradition. Since the merging of the particular and the general is fundamental in cultural reproduction, it is only logical that it also is present in studies of stone-tool technologies. As Daniel Miller pointed out 20 years ago, it is striking that research on material culture, and the ways in which it affects us, diminished during the 20th century at the very same time that the amount of artefacts that we are surrounded by in our everyday life increased considerably. It is surprising that archaeology is one of the few subjects that actually study the complex relationship between material culture and people. As a consequence we consider it meaningful, from a general point of view, to investigate material culture, and traditional stone-tool technologies make up a significant part of the archaeological remains of craftsmanship.

Fig 4. Flint knapping session at the Skilled Production Symposium. Knappers l-r: Witold Migal, Errett Callahan and Hugo Nami. Photo: Per Falkenström, SAU.

It was important for us to bring people in from different research traditions, since we felt this might be one way of reaching a deeper understanding of the technologies and their role in society. Researchers, who had studied traditional stone-tool technologies from different aspects, were invited to Uppsala from all around the world. Thus, as participants we wanted stone smiths who had learned traditional technologies and who had knowledge of the complexity of the crafts. We also wanted archaeologists and ethno-archaeologists who studied societies where stone tools are still being made and used, because this would give important insights into the social framework in which the crafts were embedded. We also wanted theoretically orientated archaeologists who had worked with questions concerning technology and its role in society on a more general and theoretical perspective. We cannot do without any of these different perspectives in the discussion and investigation of cultural reproduction and change as it is represented in lithics and their context over the long time-span of human history. They must be used concurrently. Skill is not just a technological activity; skill is related to the understanding of the whole cultural setting and world view in which a technology is embedded. In this book "social reproduction" refers to the cultural knowledge of stone tool technologies, and the social use of this cultural knowledge, that is reproduced between generations. This information includes the recipies of action that can be described in a *châine opératoire* analysis as well as knowledge of raw material sources and qualities and the ability for each individual to learn the practical know-how that cannot be theoretically described.

The scientific world with its different epistemologies and institutionalized subjects thus create constructed borders in what is a constant interplay in cultural reproduction. Consequently, the conflict at this meeting has its historical reasons in science itself.

The papers in this book are divided into three sections that correspond to the three themes discussed at the conference. The first section "Experiments and experience" contains papers dealing with careful reconstruction and description of different stone tool technologies.

Experiments and experience

The papers in chapter one are mainly devoted to the description and discussions of results from practical experimentation and focussed on details of single artefact categories and stigmata related to variable method/technique concepts. The distinction between "method" and "technique" put forward in Pelegrin's paper is important, especially for non-French readers. The case study, Neolithic Macro-Blade production in Europe and the Near East, further illuminates the importance of experiments in the process of understanding technology through a dialectic and, as we see it, truly relational research process that takes its departure in a description of the method (realism) and then proceeds through careful production experiments (rationalism) towards the interpretation of the techniques used.

Papers by Nunn, Callahan and Nami contain detailed descriptions, recipes one might say, of production processes including details on flaking angles, holding positions, tools etc. This valuable information is interesting for many reasons, not least since the problem of cultural transmission is obvious. To know recipes and details about production processes of complex technologies, where you need nimble skills to accomplish a task, does not help much if you want to replicate them. However interesting the information may be, the reader will find it impossible to replicate any of the discussed production sequences since they require a large degree of practical know-how, i.e. skills that can only be acquired by practice. The papers in this section cover flint technologies in the South American Upper Palaeolithic (Nami's two papers), the Neolithic period in Europe and the Near East (Pelegrin, Nunn and Callahan). Callahan's paper on his experiments with the prestigious Type-IV Flint Daggers has an unconventional style and his purpose was to convey the visual aspects of the paper presented at the symposium. Originally, we intended to attach a DVD of the actual presentation with this book, but unfortunately the technical quality of the tape was not good enough. We are proud to be able to present preliminary results from his Dagger Project in this book.

In science, skill coupled with practical know-how is thus more related to how this knowledge can be transformed into the skill to read stones from prehistoric assemblages. This is a skill that to some degree can be learned and used in archaeological analysis by people not capable of actually making the artefacts. However, this would probably not have been a meaningful option in the past, unless the skills of reading the material environment included stones from variable cultural and time contexts were part of a necessary cultural knowledge. Examples of the need to or ability to read stones in the past as part of cultural reproduction are discussed by Knutsson and Högberg. We do not know whether this was only a cultural skill related to knowledge rather than know-how. In a prehistoric setting, the ability to discuss details of a reduction sequence by pointing to details in tools and flakes might have been a skill that was valued, for example in discussing relics related to ancestral events at sacred places or on a more mundane scale, related to the general ability to track friends and strangers in the cultural landscape covered with lithic debris from different times and places.

The cultural skill of using knowledge of technology and material culture to communicate important aspects of the world to members of your group must thus be understood as one aspect of skill that does not necessarily relate to the skill of practical know-how. The papers in this section illustrate this in relation to the present situation. The skill of the lithic craftsman *per se* is not valid for the reproduction of individuals in the culture of science. The lithic craftsmen are mainly reproducing themselves outside the academy. This practical knowledge has to be transformed into usable assets in a cultural value system, in this case the culture of science. This transformation may take different paths from sheer theft of symbolic capital to a more humble use of references.

Theoretical aspects

The seven papers in this section may represent another form of skill that is effective in a different setting. Here, the cultural skill of knowing how to transforme the know-how into knowledge appears with tha aim of using this in social reproduction within academia. Theoretical skills related to the scientific culture thus do not stand for a better or less valuable type of knowledge; it is just different and less concrete.

In his paper, Knutsson tries to show how a reflexive cultural practice of science and modernity in general, play an essential part in all human cultural reproduction. In an example from the Late Glacial-Early Holocene transition in Scandinavia, it is argued that an active re-reading of old lithic technologies was a decisive element in the implementation of cultural change in this period. The active copying of old technologies and designs thus indicates that reflexivity, so typical of the modern condition, was an important part of cultural reproduction in the Late Glacial period. The skill needed to cope with this is evidenced in the detailed reconstruction of blade-making strategies from Hamburg to Ahrensburg. Here, the ability of the prehistoric knappers to read ancient stone tools made it possible to produce similar items by implementing know-how into practical action, and this must be regarded as a sign of reflexivity. The cultural knowledge or cultural skill necessary, relating to what this return might have meant to these groups, can of only be speculated on.

Högberg's paper touches on the same subject as Knutsson, dealing with the dynamic relation between structure and agency in cultural reproduction. He uses the concept of "conspatiality" to describe the historicity of place, i.e. the repeated use of one and the same place over centuries. Repeated technological actions thus seem to create places of special significance. Focusing on the production of square sectioned axes from the Neolithic to the Bronze Age, Högberg can demonstrate how the places of procurement and initial reduction of axe preforms are characterized by a large number of fully usable axe preforms. The material manifestation of lithic production processes gives symbolic significance to the sites and they become essential in the collective memory of the community that are using and reusing them. The return to the place over and over again must have resulted in the re-reading of the material from earlier periods, Högberg continues. Since references to the past build a strong argument in the creation of legitimacy and constitute a future warrant for authorities, powers and rights, the skilled flint knapper who understood flint technology was thus a person who possessed knowledge of the past. The paper is important insofar as it shows that we have to take the impact of history seriously in the discussion of cultural reproduction, as well as that practical skills were important in the ritual sphere, being part of the conceptual skill necessary to interpret the world and thus constitute society.

Inspired by a French epistemological tradition, Apel points out that a conscious relational research strategy is imperative if we aim at social or cultural interpretations. In a case study consisting of an experimental and archaeological study of Late Neolithic Danish flint daggers, he suggests that a social role of skill connected to a technology can only be relationally defined through the use of personal experience, on the one hand, and objectifying techniques, on the other. Objectifying techniques, such as statistics or the use of scientific categories, as opposed to folk categories, develop a necessary resistance towards the subjective experience of the flint knapper or lithic analysts. On the other hand, a research strategy that denies the subjective experience of the experimental flint knapper can never understand the social dimension.

By means of experimental strategy, Leslie Harlacker wants to clarify the aspects of skill involved in the successful production of Oldowan lithic technology using both technological and biomechanical information. More specifically it relates to the investigation of Mode I technology and the question of the relative contribution of knowledge and know-how (skill) to Oldowan flaking. Based on a set of controlled experiments carried out by novice to skilled knappers and debitage analysis, a breakdown of performance into knowledge and know-how leads to the following hypothesis: It is the acquisition of know-how rather than knowledge that results in further gains in performance efficiency and consistency. This conclusion has implications for the study of hominid technological evolution in general and it implies that Oldowan hominids would have benefited from finding the time to practice tool making skills. Since notions of skill normally are intuitive and more related to the eye of the beholder (with variable experiences of knapping) than to explicit argumentation, Harlacker's contribution shows the importance of formalizing the definition of skill. Since in this version, skill is related foremost to technical skill, the amalgamation of technical and conceptual skills discussed for example by Högberg, is interesting. How was the Oldowan tradition reproduced as consciousness expanded and thus the past increasingly became the vehicle of the reproduction of the present and the future? Here technology as a durable and solid manifestation of practice, such as memory, has an important role in the study of early hominid cognitive development.

Rankama *et al.* discuss quartz technologies in Fennoscandia and the problem of relating them to the general discussion on gender, sociality and cultural reproduction that is currently ongoing within lithic studies in general. The fact that quartz does not so easily lend itself to the production of complicated tools, the use of quartz knapping in social strategies is less probable. Even if more elaborate technologies may be correlated to quartz, the degree of fragmentation is an obstacle to reading the material in terms of the necessary *chaîne opératoire* analyses. Recent work in Sweden (fracture analysis), however, has made it possible to partly overcome some of these obstacles. A few case studies in Finland thus give hope that more examples of different operational schemes can be detected in future analyses and interpreted as cultural or social markers, making *chaîne opératoire* analysis the long-awaited substitute for formal typologies in vein quartz studies, and thus aid in discussions of social and cultural significance. Perhaps a skilled quartz-user knew how to make the best use of the properties of that particular raw material in specific cultural, social and environmental circumstances. Perhaps the focus towards the skill needed to make quartz tools should be changed towards the skill to make use of this raw material. We know from recent lithic use wear analyses that both the tools made, and those used, show the same variation as flint assemblages and, as is stated in the paper by Rankama et al., the social and cultural context in which the quartz material was situated may have been important. Thus in a way we find it more obvious to break down the old dichotomy between the ritual and the mundane, the technical and the conceptual, in dealing with quartz assemblages. This is of course as true for flint or flint-like materials, but it is just too easy to forget that, since flint has an overt signal of technical complexity, this approach might be obstructive to the more important issue of its cultural meaning.

Andrews' and Sørensen's papers both deal with theoretical issues as well as culture-historical interpretations in connection with blade industries. Andrews discusses the scale and organization of the Classic period Teotihuacan obsidian blade production. By studying skill through surface collections from production sites, Andrews is able to infer that the obsidian craftsmen were probably not full-time specialists. In the paper, skill is defined through an estimation of the degree of know-how (Pelegrin 1990) and thereby Andrews considers "artisinal" versus "efficiency" skill as two ends of a know-how continuum. Sørensen contributes to the discussion of the differences between typologies based on formal or metrical attributes, and technological attributes on the other hand; the formal and metrical typologies are not suited to form a basis for answering the questions that archaeologists are interested in today. To illustrate his point, Sørensen introduces a technological blade definition that is used in a technological and experimental study of different blade traditions within the early Mesolithic Maglemosian tradition in Denmark.

From Experience to Interpretation

In this section of the book, archaeological case studies involving discussions on how lithic technology and skill is related to other social phenomena are presented.

Finlay's paper takes its departure in the fact that the production of microliths in the Mesolithic has been placed in the "functional" sphere of inquiry, and as such has not encouraged interest in the discussion of how cultures reproduce themselves through socialisation and the transmission of cultural knowledge. Having been seen as reflecting chronological change and "cultures" within the cultural historical tradition and a measure of environmental and functional change by processual archaeologists, Finlay discusses the role of microlithic production in the construction and negotiation of identities. Experiments show characteristic idiosyncrasies in microlith production. Based on the concept of performance, a term borrowed from Judith Butler's writings, a discussion is pursued where the tension between the secluded and the open, the expected and the un-expected, creates social dynamics. The focus on the social meaning of a reasonable simple production makes skill more of a conceptual ability (to know the social game) than a technical ability to produce insets in weapons. The similarity in form and design allows these microliths to be "socialized" in one and the same arrowhead. Similarly to the known *San* habit of exchanging hunting-arrows and thus to downplay individuality, the microliths act as a materialization of the social. Finlay's paper undoubtedly explores new grounds that are important for the topic of this workshop. Technologies are part of social communication and thus generative in societal reproduction. Skills are embodied understandings of how things are supposed to be done according to the rule book but, once learned and made explicit, they might as well become an arena for competition and tension and thus lead to social change.

Was initiates a discussion of exchange networks, cultural transmission and learning in the *Janislavice* culture in Poland based on an analysis of blade cores and debitage from two sites. The presence of blade pre-cores 200 km away from the flint source (chocolate flint) where it was produced, indicates functioning social networks in territories of this size. The fact that the skill to actually produce blades from such cores was found far away from the flint source must have something to say about cultural transmission in this time period. How was the skill of blade making transferred between the generations in an area with less flint? It seems reasonable that the network we see expressed in the spatial distribution of chocolate flint also meant the movement of people where at least becoming a flint knapper must have meant periods in the flint-rich areas for practice. It is interesting, compared to the Neolithic setting discussed by Migal, that ideas of exotics and value may have been related to the actual skill of making blades.

In his paper, Akerman describes the complex and varied use of lithics, their production and use in the social reproduction of Aboriginal groups in the recent past in the Kimberley region in NW Australia. It can be noted how similar technologies are used in more mundane functional settings as well as in decidedly reproductive rituals such as initiations. Such technologies are involved in a range of large-scale and far-reaching exchange networks where tools in one area used as ordinary spear heads and knives in another are related to more ceremonial situations. It is quite clear that in the case studies presented by Akerman, functional tools are always used in different cultural settings, transgressing the modernist border between the profane and the sacred. The technologies, tools, and social settings are intertwined, and there seems to be an always present relation to ancestral beings and cultural heroes, where lithics many times act as representations. This importance of lithics and lithic production in variable cultural settings may account for the cultural conservatism related to technologies that is observed by Akerman in this area of Australia. Cultural transmission is thus related to the construction of identities that despite, or perhaps because of the networks of exchanges in the area, are stable over time. Lithic technologics were embedded in and logic to local cosmologies in these societies, and thus generative of the experience of a local identity and the understanding of the world.

Falkenström looks at lithic raw materials and access to lithic raw materials as assets that can be invested in social strategies. A combination of ethnohistorical and ethnoarchaeological data together with experimentation is regarded as a fruitful avenue towards an understanding of social processes in the past. He discusses how different raw materials are related to myths and sacred rituals and thus form part of societal reproduction as representations of a meaningful history. Quarry sites are often related to, and guarded by, creatures and *dramatis personae* in culture bearing myths. To procure raw materials and to use them in the production and use of artefacts must thus be understood as deeply involved in the mythical sphere and therefore structured by cultural values and world view. Exotic raw materials in his own research area display a variability, in terms of quality and relation to source, that exemplify the complex wider cultural context that archaeologist has to grapple with to make sense of lithic technologies. The reproduction of social values and norms are seen as controlled not only by rituals but also by everyday behaviour.

Per Lekberg discusses the social implications of the production and consumption of Ground Stone Hammer Axes in Sweden during the Late Neolithic period. Traditionally, it has been difficult to discern distinct types within this large archaeological material, mainly because they display very little formal variation and to a large part are made up of stray finds without contextual information. By conducting a technological study of the axes, Lekberg is able to argue convincingly that the axes were originally manufactures in relatively large sizes and then consumed in sequences. A study of the axes that has been found in contexts shows that axes from different parts of this life-cycle were deposited in different contexts, large axes in hoards, small axes in graves and broken axes on settlements. Finally, a "social topography" of the Late Neolithic landscape emerges when distribution maps of the large material of stray found axes classified into these contextual categories display differences in wealth and social status between groups. Apart from the fact that Lekberg has shown that this large material of neglected, stray find axes, through an explicit technological approach, can produce social meaning, the paper also includes a valuable cultural historical interpretation of the social complexity of the Late Neolithic period in Scandinavia.

Migal's paper deals with the presence of regular pressure blades in the Polish Neolithic. Although this appears in the middle period of the Linear Pottery Culture, it is foremost connected to the development of the TRB tradition, a tradition that also enters Scandinavia at this time. Migal aims to show a connection between wine production and blade making by an anticipated use of a grape pressure device to make blades. The blade technology is interesting in this context because the blades, according to find contexts in depots and graves, seem to have been important not so much as a practical tool during this time but as part of societal ritual reproduction (Knutsson, H. 2003). The possible metaphorical connection between wine and blades are thus a topic that could be fruitful to investigate.

In Scandinavia, the blade-making tradition changes drastically in the TRB period. From being embedded in everyday activities on sites during the Mesolithic, it moves over to the sphere of the sacred where the sites of production are hidden. No doubt the special technical skills needed to produce regular pressure blades and punch blades must have been connected to and related to another skill, the conceptual skills and knowledge related to social and/or cultural reproduction. We see a continuation in this type of ritual technology in the Middle Neolithic Battle Axe Culture in Scandinavia (Knutsson, H. 1999).

Finally, Darmark's paper brings up one of the problems that Rankama *et al.* examine in their paper. i.e. the difficulty of discussing the importance of skill in relation to technologies that appear to have been carried out in an opportunistic and straight-forwards manner. This time, the object of study emanates from specific archaeological contexts: the rhyolite technology on two adjacent sites on a 5000 year old hunting/fishing site in the Ålandic archipelago. The technology consists of a rudimentary platform technique conducted with a hard hammer, but there are noticeable differences between the sites, and production experiments are conducted in order to explain these differences. Darmark's conclusion is that it is implausible to regard the choice of a simple technology as depending on a lack of skill. Rather, this choice must be understood in social terms.

The preservation of the remains of lithic technologies makes them especially appropriate for the study of the development of skill, crossing the border between the long sweep of evolution and history. In the book we meet research covering the history of choppers from the Acheulean to the Late Neolithic. This is an opening up for an exciting discussion of the evolutionary history of hominids and the equally interesting development of cognition and "the historical mind" in cultural reproduction.

Marcia-Anne Dobres

Skilled Production and Social Reproduction in prehistory *and* contemporary archaeology: a personal exegesis on dominant themes and their psychosocial influences

Introduction

For reasons worth investigating, archaeologists are loath to lay bare the hermeneutic relationship between their own interpersonal dynamics, such as those which run rampant at professional meetings, and intellectual trends shaping the discipline. By refusing to acknowledge the personal degree of investment we have in our research, and by denying just how much the personal is political and influences research on the past, we have come to believe that we are successful at keeping public discourse to impersonal issues of epistemology, methodology, and unbiased interpretation. While I am no champion of "big men" theories of cultural evolution, there is no doubt that dominant personalities (of variously gendered persuasions) have indeed shaped the discipline both theoretically and methodologically. In the next few pages I dare to reflect on the interpersonal psychosocial dynamics pervading the "Skilled Production and Social Reproduction" conference, on which this volume is based. I am specifically interested in considering whether or not (and how) they simultaneously reflect and influence dominant trends now popular in the study of ancient technology. I realize I tread on shaky ground, not only by breaking the taboo on keeping our dirty linen in the closet, but also by suggesting that there is a directional relationship between contentious interpersonal dynamics and how we ply our trade.

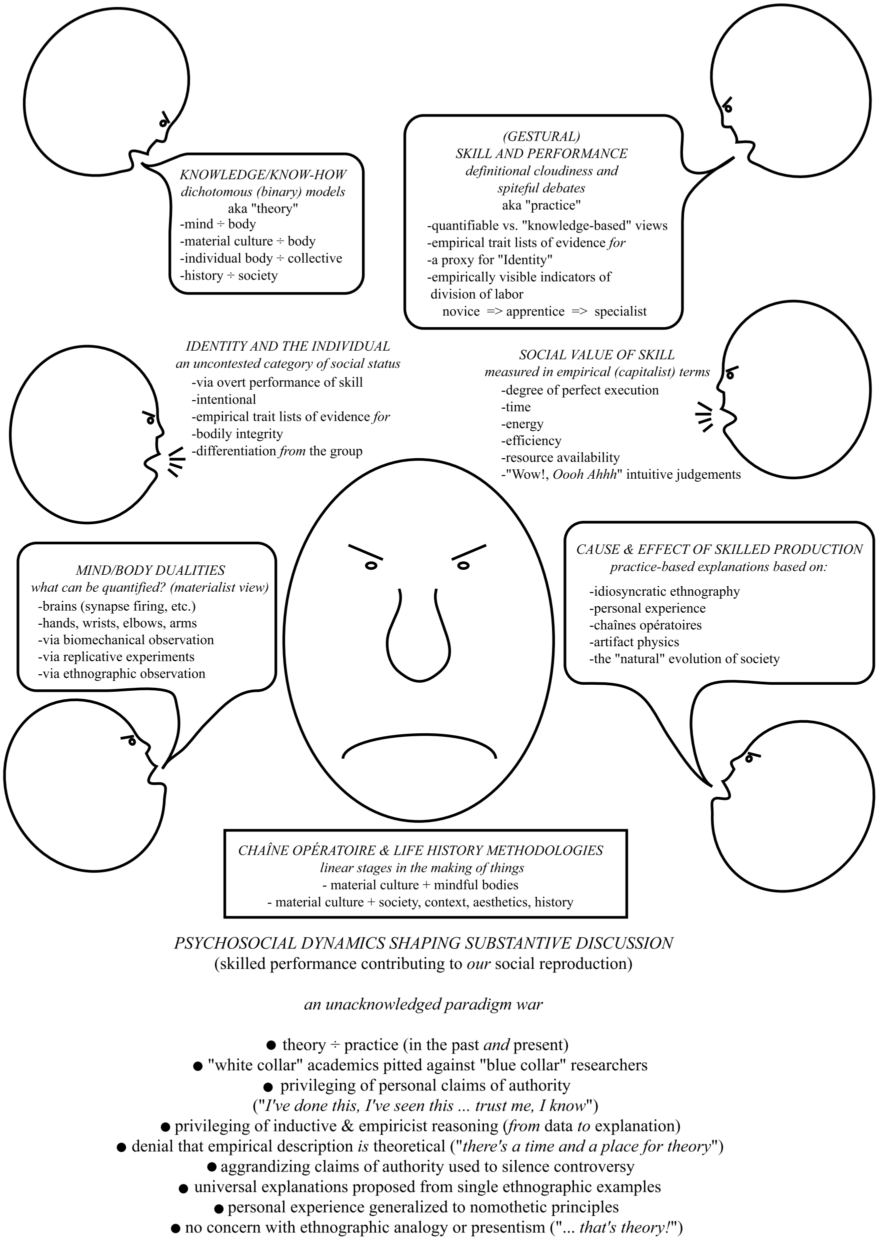


Fig. 1. Dominant themes discussed during the Skilled Production symposium. (Drawing by Kim Darmark).

The irony, of course, is that many archaeologists are similarly loath to entertain the possibility that psychosocial interactions and esoteric beliefs of prehistoric technicians directly shaped not only their material practices but also their social reproduction writ large. I no longer believe this parallel is a coincidence. As a participant-observer in Sweden, I learned a great deal from interacting with my colleagues – but mostly from those with whom I disagreed on substantive issues regarding prehistoric technology. What struck me at the time of the conference, and what I have been asked to reflect upon here, was the contentious nature of the aggregation *itself* and how our interpersonal interactions directly – and negatively – influenced substantive discussion. As with any aggregation of strong-willed and articulate individuals, we soon divided into two self-selected intellectual "camps." But what was most curious was how we interacted across this self-imposed border zone, not only during official discussions but even collective meals and libation breaks.

What this essay explores is the disturbing *resemblance* I sensed between the discursive strategies of the dominant few (in controlling the terms of debate) and how we talked about the role of skill and knowledge in ancient technical practice. Interestingly, while as a group we never quite got around to discussing the "social reproduction" theme of the conference, we nonetheless promoted our *own* social reproduction at every turn. And this is why I believe such critical reflections are necessary.

Dominant topics – domineering themes

I sketched Figure 1 ("Dominant and Domineering Themes re: "Skilled Production and Social Reproduction") during the conference, as a sanity-saving strategy to keep me from jumping out a window during some of our more fractious discussions. As I began to perceive (and wince at) the formation of antagonistic intellectual camps and the crystallization of distinctly opposite viewpoints (which drew pleasure from misrepresenting each other), I was struck by the parallel I was witnessing to larger trends currently pervading the discipline. But the *speed* with which this happened (in the first hour on the first day), and the degree of willful entrenchment on all sides was striking and troubling to the degree that I felt the need to *chronicle* the key points of contention (while fully engaged in debating them). By day #2, I had identified six dominant themes regarding "skilled production" around which all subsequent discussion hovered:

- knowledge and know how
- (gestural) skill and performance
- identity (achieved through skillful performance) and the concept of the Individual
- the social value of skilled production
- mind/body dualities
- theoretical cause and effect of skilled production

Methodologically, linear and materialist approaches for chronicling technological life histories (or *chaînes opératoires*) dominated, and everyone, myself included, worried about or proposed concrete methodologies for studying the empirical remains of skilled practice in order to identify interpretable empirical patterns. The difference was that some of us latched on to such concerns on general anthropological ("theoretical") grounds, while others were led to such considerations based on their personal experiences replicating all sorts of prehistoric lithics. While I would suggest that, in fact, theory and practice *merged* into a single whole directing us to similar concerns with analytic methodologies, at every turn our explicit debates pitted theory *against* practice.

Descartes would have been pleased with the pervasive mind/body split dominating the conference. For practically every topic subject to heated discussion, those controlling the terms of debate formulated the question of technological skill (which quickly became a proxy for "skilled production") as *either* a matter of mind *or* a matter of physical bodies. In most instances, bodies were considered the physical "place" where skill and know-how resides and is performed, while minds are the locus of knowledge (until materially expressed by the hand). But because the gestural skill of bodies in motion ("practice") was distinguished from and privileged over mind, thought, and aesthetic considerations ("theory"), most of our conversations (about skill, knowledge, identity, the body, social values, or cause and effect) ended with a few individuals bickering about how to *see* and *measure* skilled production. It is not all that surprising that measurable and empirical aspects of ancient skill (*viz*. practice) were continually privileged "over" issues of knowledge (*viz*. theory), since practice (typically expressed of in terms of replication experience) was the dominant claim of authority employed by those controlling discussion (see below).

But it seemed to me that as *the* dominant concern of the weekend, materialism topped practice (explaining why "theory" was relegated to third banana). For example, whether talking about skilled production or its seemingly more intangible dimension, knowledge, the conversation always came round to the problem of identifying quantitative attributes. Over and over again we grappled with how to see and measure knowledge, the proper way to quantify (gestural) skill, and which specific material traits (in execution, form, or function) "signified" a particular level of skill or social status (be it "novice," "apprentice," or "specialist"). While no doubt important, these materialist debates effectively closed down fledgling discussions of less empirical considerations with which many of us were (also) interested. Often the majority of the participants (including the conference organizers) were left sitting on the sidelines while an intrepid two or three individuals became mired in endless but heated debates over some proposed trait list of physical attributes of skill.

To my recollection, our most contentious debates involved the social value likely attributed (in the past) to different levels of skilled production or the tools themselves. Too often, however, we uncritically projected into the past our own ("capitalist") value judgements (concerning time management or the most efficient use of resources). But in spite of this quantitative bent, the conversation always came back to a visceral "*Wow! Oooh ahhh*" appreciation of the more remarkable displays of gestural virtuosity found in the (lithic) archaeological record (and ably replicated by several participants). Such judgmental conversations about social value typically slid into untutored speculations about the identity and status of the most skilled technicians. But with the vocally dominant group's overarching concern with measuring such dynamics, we most often lapsed into discussion of the (empirical) "cut off" between novice, apprentice, and specialist – while presuming that perfect execution was always and everywhere the ancient technician's desired goal. Sadly, we never openly discussed the possibility that in at least some ancient contexts, overt (even gratuitous) displays of skilled performance might not have been culturally sanctioned or deemed socially acceptable. Without explicit discussion, the ontological premise which held sway over the weekend was that in all times and places technicians "naturally" aspire to grandiose displays of skill – while those who can't will necessarily marvel at (and hence highly value) those who can. Ironically, this is precisely the interpersonal dynamic that shaped our *own* interactions and value system throughout the weekend. Expert replications were marveled at and were given (or took) precedence in most discussions. No wonder we took it for granted that self-promoting displays of gestural skill are a universal means of social climbing.

Because materialist concerns with identity (trait lists) dominated most discussions, many of us readily (albeit tacitly) agreed that *chaîne opératoire* and life history methodologies are useful analytic tools. However, because we were fixated on distinguishing discrete stages of skilled (technological) performance and by extension identifying categories of social identity, in my view too many participants allowed their methodology to become the *goal* of analysis. It was as if a correct percentage or numeric degree of skill could adequately stand "for" the actual process of negotiating social identity.

Underlying psychosocial dynamics shaping substantive discussion

As a thoroughly "embedded" participant simultaneously engaging in these debates and observing body language, tone of voice, and style of personal interaction, I noticed a far more troubling dynamic lurking below the surface of every discussion, not only in the seminar room but even when we ate and relaxed before and after the day's planned activities. As the introduction to this volume mentions, it became clear to many of us that as a group of thoughtful and dedicated researchers we never directly addressed the conference's intended purpose: to understand *how* skilled (technological) production influenced or contributed to ancient social reproduction. As I suggest above and try to show in Figure 1, our inability to ever directly confront the question of social reproduction was because we were never able to get past materialist discussions of skilled production. Curiously, our *own* strategies of skilled production (performed in and outside the seminar room) were *all* about social reproduction – specifically about who could control the discussion and who would have the last word. These strategies varied from overt, self-aggrandizing displays of gestural skill by replicating extraordinary lithic artifacts to a gaggle of gaping onlookers, to the self-serving bandying about of three-, four-, and sometimes even five-syllable words and references to obscure (dead) philosophers.

That *we* employed a host of interpersonal strategies of skilled production in order to socially reproduce *ourselves* is, of course, not all that surprising. Admittedly, one can never aggregate a group of archaeologists without self-selected sub-groups trying to advance a myriad of competing sociopolitical agendas that have little to do with the explicit purpose of the aggregation! What's disturbing in all this, and which was particularly evident in Sweden, is the *parallel* I observed: between our unwillingness to recognize or admit the degree to which our own (physical and cerebral) skilled production during seemingly mundane and quotidian interactions shaped our social reproduction, and our general unwillingness to appreciate how such a dynamics may have operated in prehistory.

This exegesis is not intended to explicate or defend (through proper use of citations and the like) what I see as disturbing trends in archaeological research on technology (though many of the most common were in play at this conference and are summarized in Figure 1). Nonetheless, I could not help but sense yet another "duality" pervading the conference: something of a paradigm war pitting what I call "blue-collar" and "white-collar" archaeologists against each other – between those who "do" archaeology (in the case of technology researchers, these are typically replicators or ethnoarchaeologists) and those who (according to this first group) "merely" think and theorize (you know – academics). I neither defend nor critique such stereotypes. There is no doubt they exist in our folk consciousness, litter the pages of peer-reviewed journals – and put a damper on the conference in Sweden.

Like it or not, this pitting of the hands-on researchers against ivory tower academics pervades both anthropology and archaeology; that is, it is not unique to students of technology. Nor would I care, if it were not for how such intellectual squabbles and overt attempts at social climbing *directly influence* our research and our models of the past – and this is especially true in the study of prehistoric technology. What is important here is how the mind/body and knowledge/skill dualities which pervaded [del.] substantive discussions both replicated and were directly shaped by the self-imposed blue- and white-collar "camps" into which we readily placed ourselves and pigeon-holed others. As with the privileging of the measurable aspects of body, skill, identity, and social value which dominated our conversations about skilled production in prehistory, we similarly afforded different degrees of respect and value to each other, depending on which "collar" the speaker wore.

Curiously, but especially troubling to me, were the repeated claims of authority based on personal (hands-on) experience, which effectively silenced all controversies and dissenting viewpoints (based in theory). Claims of personal authority typically were expressed in statements such as, "I've done this myself, trust me ... I know what I'm talking about..." or "I've seen this with my own eyes in the field, how can you question my observations?!" Lest the reader think I am too sensitive about such tactics, I was not the only one who noticed the surprisingly visceral attempts to discredit and silence contrary opinions (expressed by the white-collar crowd) through such tactics [del.]. In many instances, [del.] references to personal experience were quickly followed by someone proposing a general principle or supposedly universal *theory* concerning technological skill, identity, or value for all of prehistory! I hope the irony here does not escape the reader's attention.

Disturbingly, not once during the entire conference were well-founded "theoretical" issues with epistemology *ever* mentioned. Most notably missing was any discussion of the many well-rehearsed dilemmas of ethnographic analogy, the inherent biases of presentism, or the manifold problems with empiricist-based induction as a means of generalization. This blatant disregard for topics which have been central to anthropological archaeology since the 60s attests to just how effectively personal claims of authority silenced controversy and directed discussion.

Just as we self-divided (and categorized each other) as either blue- or white-collar archaeologists, so too we divided the question of technological practice (skill) *from* theory (mindful and embodied knowledge). In each instance, we privileged the former (as more measurable, more empirically "knowable," and probably more deterministic). Those of us who (theoretically) questioned the premise that throughout the past overt displays of aggrandizing technological skill and experience were universal paths to social status, were discounted *out of hand*. If, in the present, such aggrandizing succeeds in achieving social status, value, and identity, why not through all of prehistory as well?!

Less overt attempts to gain social status in this conference were summarily drowned out by the flexing of hands and muscles, the passing around of exquisitely replicated blades ("just made it this morning ...") or photo albums of the same. Even when white-collar participants attempted to describe their *own* hands-on experiences making prehistoric tools, in order to make a more "theoretical" point (thereby legitimizing this strategy as the only acceptable means of being heard), it backfired. By virtue of *being* white-collar, their arguments were discounted even when supported by hands-on experience! On the other hand, most theoretical suggestions offered by blue-collar researchers were typically discounted (by the other side) as being impossibly naive.

Conclusions

Are there larger lessons to extract from this contextualized and ethnographic analysis, this untutored psychoanalysis, of the interpersonal dynamics played out in Sweden in late August 2003. Indeed I think there are, and they concern the disturbing relationship between our own skilled production (as blue- and white-collar archaeologists) and how we study and try to model skilled production in the past. But unlike the problematic split between mind and body and between esoteric knowledge and practical skill which prevailed in our discussions, this analysis explicitly integrates a somewhat detached intellectual analysis (informed by social theory and a few dead philosophers) with personal observation and embodied experience (what I observed, what I did, and how I felt at the conference). I have tried to intellectualize and reflect critically on both substance and style in the way the conference unfolded – but to allow my analysis to be informed by personal sensibilities as a participant who had her own agendas to promote that weekend. Admittedly, my observations [del.] are "merely" based on my sensing (rather than measuring and thus empirically verifying) a discernable pattern in our own means of social reproduction (ironically based on skilled production).

Importantly, I do not think what happened at the Skilled Production, Social Reproduction conference in Uppsala was in any way unique. I think it is the norm in how we currently study ancient technologies and interact with each other while doing so. Perhaps the dynamics were more striking than what similarly happens at larger conferences because there were so few people involved – we simply could not avoid each other and only interact with "our" kind. Nonetheless, to watch how our psychosocial interactions shaped (a lack of) tolerance for diverse ideas and analytic strategies, to see how strategies of careerism and aggrandizement impacted what we decided skilled production was all about in prehistory, and to see which particular aspects of skilled production were privileged – these struck me as a likely explanation for why, in the study of ancient technology, we cannot seem to agree on the fundamentals. While many of us talk about finding ways to *transcend* self-imposed and skillfully performed boundaries and intellectual borders, and conferences such as this are designed to further that worthy goal – *in practice* our habitus revels in maintaining such distinctions.

Again, it would not be so bad if all this play-acting was confined to the present. But the obvious impact our problematic discourse, our pet peeves, and our lack of tolerance for alternative views has on our understandings of skilled production and social reproduction in the past – that is something else altogether. If direct observation and hands-on know-how is to be epistemologically privileged over "mere intellectualizing" in our research and model building, then perhaps we should be more circumspect in the generalities we propose from such inductive reasoning.

Chapter 1

Experiments and Experience

Jacques Pelegrin

Long blade technology in the Old World: an experimental approach and some archaeological results

Abstract
With reference to an extensive body of production experiments, the author describes and discusses the long-blade production in seven areas from Portugal/France in the west to Bulgaria/Syria in the east. Two techniques for detaching the blades are defined: (1) indirect percussion, and (2) pressure reinforced by a lever. The author is able to identify five technological tradition and is thereby, among other things, able to suggest the movement of a few specialised craftsmen over large areas.

Introduction

Long and regular blades, excavated in Europe and in the Near East, and dating from the Late Neolithic or Chalcolithic (4th and 3rd millenniums BC) have long been discussed. Over this vast and diverse area, we are now aware that more than 20 regions rich in flakable and homogeneous stone (most of them flint but also metamorphic-contact-rock in southern Iberia) were exploited in an extensive blade production, many of them for several centuries, but not necessarily by a large number of craftsmen.

Some of these workshops have been known for more than a century, such as those of Le Grand-Pressigny (western central France) and Spiennes (Belgium), but are still little documented. Other workshops were discovered – or rediscovered – more recently, and/or are presently under study (e.g. the Forcalquier basin in south-eastern France, the "honey" flint workshops from northern Bulgaria). Others remain to be discovered, being suspected only from their blade-products found in settlements or grave contexts (blades in translucent flint in northern Greece, blades in tertiary flint in northern France and Belgium, blades in banded flint in northern Spain, etc.).

Very few studies were conducted on these blade productions from the Neolithic or Chalcolithic. A few years ago, nothing was known about their detachment technique, and the relevant criteria were even not documented (butt aspect, ripple-marks on the bulb, cracks, etc.). Regarding the reduction process (or "chaîne opératoire"), i.e. the core geometry, the position of crests, the platform preparation, the rhythm of the blade detachment, the only method described with some precision was that of the famous "livre-de-beurre" from Le Grand-Pressigny (Geslin *et al.* 1975, Kelterborn 1980, Mallet 1992, Pelegrin 1997, 2002, Millet-Richard 1997). Consequently, the only and insufficient argument for the specialized nature of such a production lay in its relative concentration and in the diffusion of the products over large areas. Likewise, our general ignorance of the knapping techniques and production methods prevented us from any attempt to group these different workshops or productions within well defined technical traditions.

In the hope of answering some of these questions, I conducted a long series of experiments on the matter from 1988 to 1995, most of them in the Archaeological Centre of Lejre (Denmark), while studying archaeological samples from a dozen of blade production workshops (this experimental program started in fact in 1986 and 1987 with the collaboration of Bo Madsen on a somewhat different topic). Presently, the experimental database includes more than 60 series (1 serie = the 15 to 40 blades from 1 blade core) produced by indirect percussion, and 25 series produced by lever pressure (the two technical modes identified in the relevant archaeological material). The most significant 40 series have been systematically documented (description, stigmata counts, photos).

Two techniques were used for the detachment of large blades: indirect percussion in a few of these workshops, and pressure reinforced by a lever in the most of them, using a copper point or an antler tool. The total characteristics that I could consider suggests that these different workshops can be regrouped in five groups or technical phylla. Moreover, the detailed analysis of the production features within similar but distant workshops allows the assumption that in some cases, it is the movement of one or a few craftsmen that resulted in the start of a new blade production workshop (for instance, from Le Grand-Pressigny towards the three known Pressignian spots in south-western France and towards the Vercors 440 km to the east).

In this article, I will briefly describe the diagnostic characters of the two techniques – indirect percussion and pressure – without developing the whole of my experimental documentation. I will then present a selection of different archaeological case studies.

Let us first recall some general principles about the identification of archaeological techniques.

Methodological principles of method and technique identification

We follow the basic distinction introduced by J. Tixier between method and technique (Tixier, 1967). The method, as an intentional process more or less systematized, refers to the organization in space and time of the removals (reduction process).

The technique refers to the execution modalities of these removals, including three parameters:

- the mode of force (Newcomer 1975), i.e. direct percussion, indirect percussion, pressure;
- the nature and morphology of the tools (stones, billets, punches, pressure sticks armed with wood, antler, or copper);
- the gesture and body position, the holding of the piece, etc.

Several techniques can thus be used within one single method of knapping, which explains why the main sequences of the process should be identified prior to the identification of the technique(s) used.

Such a distinction between method and technique is basically relevant, because the methods on the one hand and the techniques on the other must be deduced from the archaeological material through very different procedures.

The method from an archaeological production must be recognized primarily through a technological reading – inspection – of the whole of the collection, piece by piece, with special attention to the direction and organization of the negatives it bears on the dorsal surface, which provide information about the preceding sequence of the knapping. The synthesis of the whole of these observations, through a "mental refitting" (following J. Tixier), helps to reconstruct the method of knapping which can be expressed with diacritic schemes (Inizan *et al*. 1999). Only when a knapping method is precisely understood can it be reproduced employing the genuine techniques and raw material, with the aim of providing quantitative references (rate of products and waste, time, etc).

On the other hand, the identification of techniques strictly relies on an experimental reference base, as complete as possible, including at least the two first parameters (mode of force and tools) and the relevant raw material. Indeed, merely the observation of the archaeological material does not allow for a direct recognition of techniques. The diagnostic should be established from a comparative study of the morphological characteristics and technical stigmata from the reference collection and from the archaeological material. In this matter of techniques, one can only recognize what one already knows.

Thus, while the recognition of methods is a simple inductive approach, as it consists of a synthesis of the reading of the archaeological pieces, the identification of techniques requires an analogical-deductive procedure, similar to that of medical diagnosis. Our analogy can thus be extended to the nature of the procedure. The medical diagnosis does not only consist of refitting frequencies of symptoms (organized in syndromes) of a cause; it is primarily based on an understanding of physio-pathologic mechanisms (for instance, you can hardly diagnose and treat diabetes without understanding the function of insulin). The same goes, I believe, for the diagnosis of knapping techniques: a technical understanding of fracture based on systematic experiments is more effective than complex statistics. In this way we mechanically bind the morphological characters and technical stigmata to the initial technical parameters.

Presentation of the techniques

Ideally, we should here discuss the characteristics of all the techniques that can produce long blades, thus taking into consideration the direct soft percussion and soft stone percussion techniques, but this would be of little interest for the topic of large elegant blades from the Neolithic and Chalcolithic. We will therefore limit our discussion to the distinction between indirect percussion and lever pressure.

Indirect percussion

This technique appears rather late during Prehistory. A few scholars, after Bordes (1968, 1969), believed they had recognized it since the Early Upper Paleolithic in Europe, but recent experiments, and the re-examination of archaeological collections, do not support this assumption. At the moment, indirect percussion seems to appear and quickly spread around 7800 BP in western Europe (not identified as such but distinguished by Rozoy 1968, as "Montbani" style), as a specific feature of the recent Mesolithic for the production of regular bladelets for a part used as blanks for the fabrication of trapezes. It was then generally used during the Neolithic for the production of small to medium size blades, as well as to pre-shape the blade-core, most of the time with two or three crests. In the Middle Neolithic of Belgium, at Spiennes (Michelsberg culture), large blade cores and blades were found together with an antler punch (Cels & De Pauw 1886). During the Late Neolithic (3rd millennium), extra large blades were produced in Le Grand-Pressigny (western-central France) and spread over most of France and abroad (Switzerland, Belgium).

The indirect percussion technique consists in using an intermediary tool (punch; *chasse-lame* in French) to deliver the impact provoked by a mallet (a stone, wooden or antler billet) after placing the point of the punch near or at the edge of the core platform, itself flat or diversely prepared. A few archaeological punches (Poplin 1976, 1979, 1980) and numerous experiments helped define the most effective punches and their mechanical properties, as we will see later. Briefly, by varying the size and curvature of the punch and the mass of the mallet, indirect percussion – or punch technique – can detach a very wide range of products, from bladelets and minute flakes to large blades and flakes as large as a hand. It can imitate very well the direct soft percussion technique, and attains a regularity close to that achieved by pressure. Moreover, experiments proved that varying the holding positions of the core allows for a control over the profile of the blades (Pelegrin 1991).

Pressure

The pressure technique is known in the Old World since the Upper Paleolithic for the retouch of backed pieces from the Gravettian, for the finishing of small and medium size Solutrean laurel leaves, and for the production of micro-blades in large areas of North-Eastern Asia (Flenniken 1987, Inizan *et al.* 1992) and in Europe (Alix *et al.* 1995). During the Neolithic or a little before (Callahan 1985), pressure is used to produce bladelets and blades in flint up to 15-18 mm wide, which supposes a standing position, all over the Mediterranean basin (Tixier 1984) and the Middle-East (Pelegrin 1994).

From the 7th millennium on, and culminating during the 3rd millennium, the use of a lever to multiply human strength is demonstrated or suspected in a dozen different production areas, extending from the Near East to Portugal, and from Denmark to Algeria.

From my experiments, I could recognize that in some cases the pressure stick was probably made out of an antler tine, while in other cases it was armed with a copper point. I could also show that the blade core had to be completely immobilized, at best in a grooved tree trunk in which the lever was also fixed (Pelegrin 2003).

Morphological characteristics

Morphological characteristics provide essential information for the distinction of indirect percussion and lever pressure. The association of three characteristics is strongly indicative of pressure (Fig. 1):

- the extreme regularity of the edges and ridges,
- the almost straightness of the profile, except for a curved distal portion,
- the "lightness" of the section, meaning that the blades are (or can be, for some of them) relatively thin.

On the other hand, the punch technique can produce light and regular blades, but with some curve. It can also produce rather straight blades, but less regular and shorter. In any case, the most regular blades produced by indirect percussion present some undulations of the edges and ridges, as well as discrete to obvious "bellies" on the ventral side (Fig. 2). This is probably because the shock of the percussion generates vibrations in the core during the detachment, when pressure is transmitted on a strictly immobile core.

The distinction is more difficult for relatively shorter blades, from 15 to 20 cm long. A very accurate indirect percussion can produce almost straight blades in their first two thirds, with a clear curve in their distal third. A final characteristic can help to identify the punch technique in such a case: discrete undulations or a slight mesial belly, which can be found by running a fingertip along the ventral side.

Technical stigmata

Technical stigmata can also provide important information for a diagnosis. By these technical stigmata, I refer to the character of the butt determined by the platform preparation (dimensions, aspect, edge angle) and to the discrete details determined by the detachment itself (cracks, lip, ripple on the bulb, aspect of the bulb).

Using indirect percussion with an antler punch, the tests show that the appropriate edge angle (platform/flaking surface) should be very near to a right angle, that is from 80 to 95°, and that the contact area of the round tip of the punch should be rather large. Indeed, if the surface of the punch in contact with the platform is too small, the punch will become crushed in a few strokes. This contact surface, for blades 20 cm long, must reach a dozen square millimetres, whether flat or (slightly) convex-facetted. This means

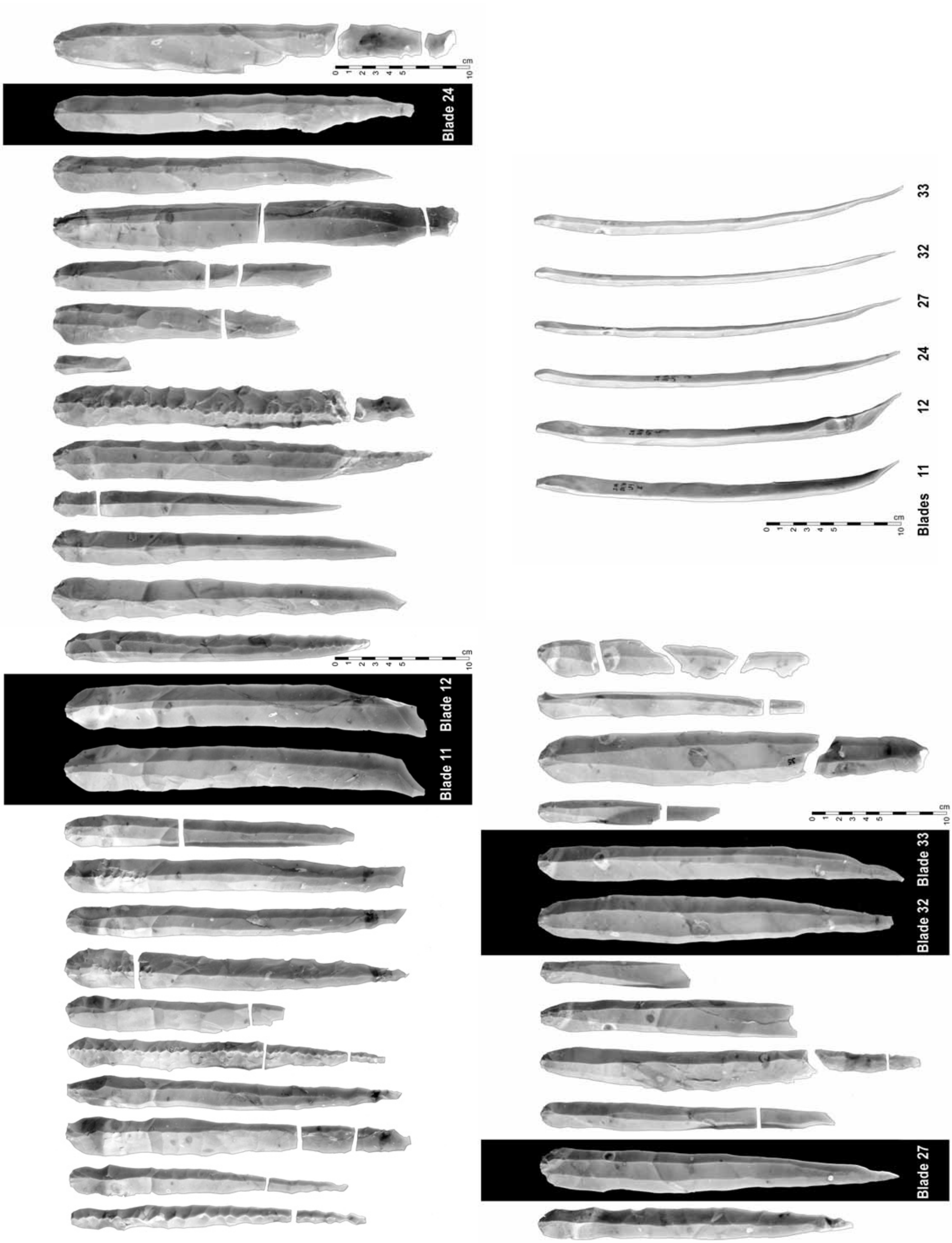


Fig. 1. The 37 blades (or attempts) from test LP9, detached by lever pressure in succession from a three-crested core, and profiles from six of them. Compared to indirect percussion, they are more regular with a less arched profile (see Fig. 2). Photos: Lejre Research Centre & J. Pelegrin.

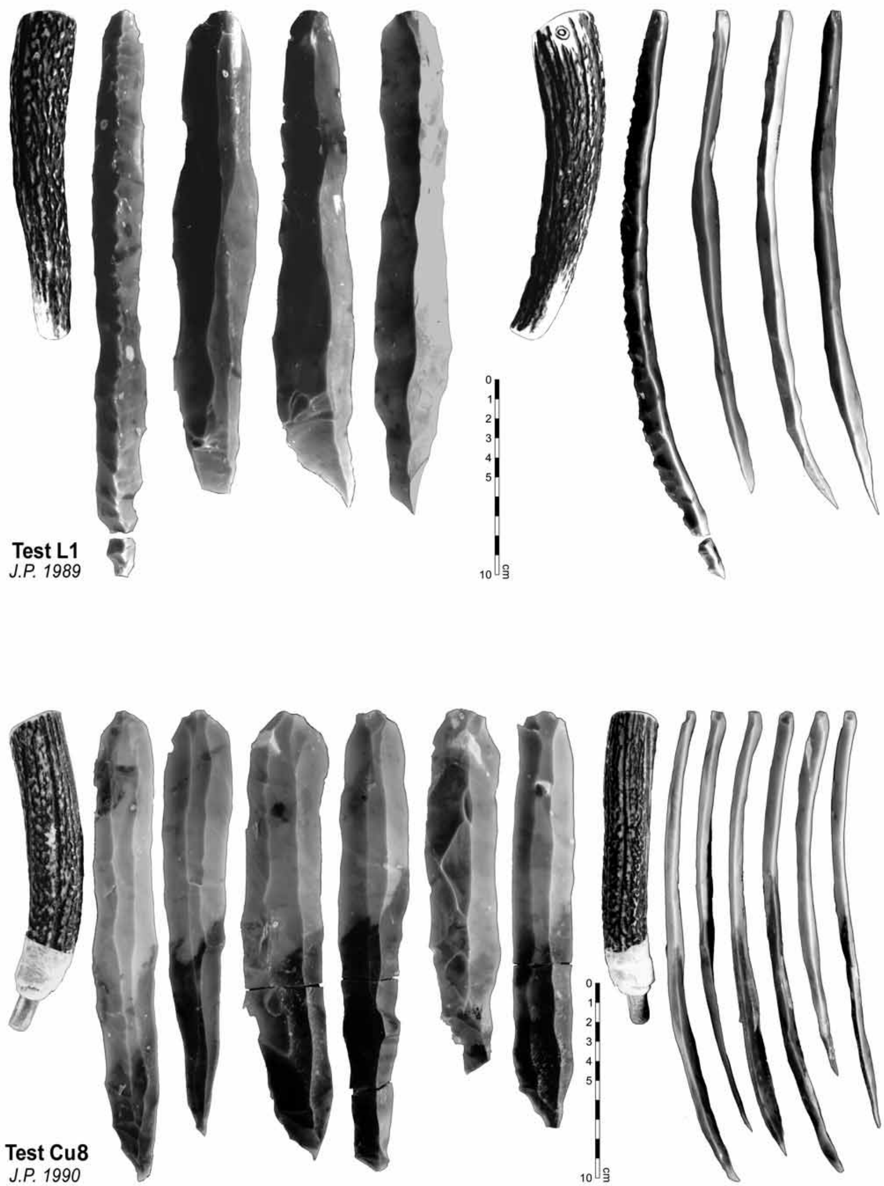


Fig. 2. Top: 4 representative blades from test L1, detached by indirect percussion with red-deer antler punch. Bottom; 6 representative blades from test Cu8, detached by indirect percussion with a copper-tipped punch. The use of copper-tipped punches did not prove more effective than antler punches. Photos: Lejre Research Centre & J. Pelegrin.

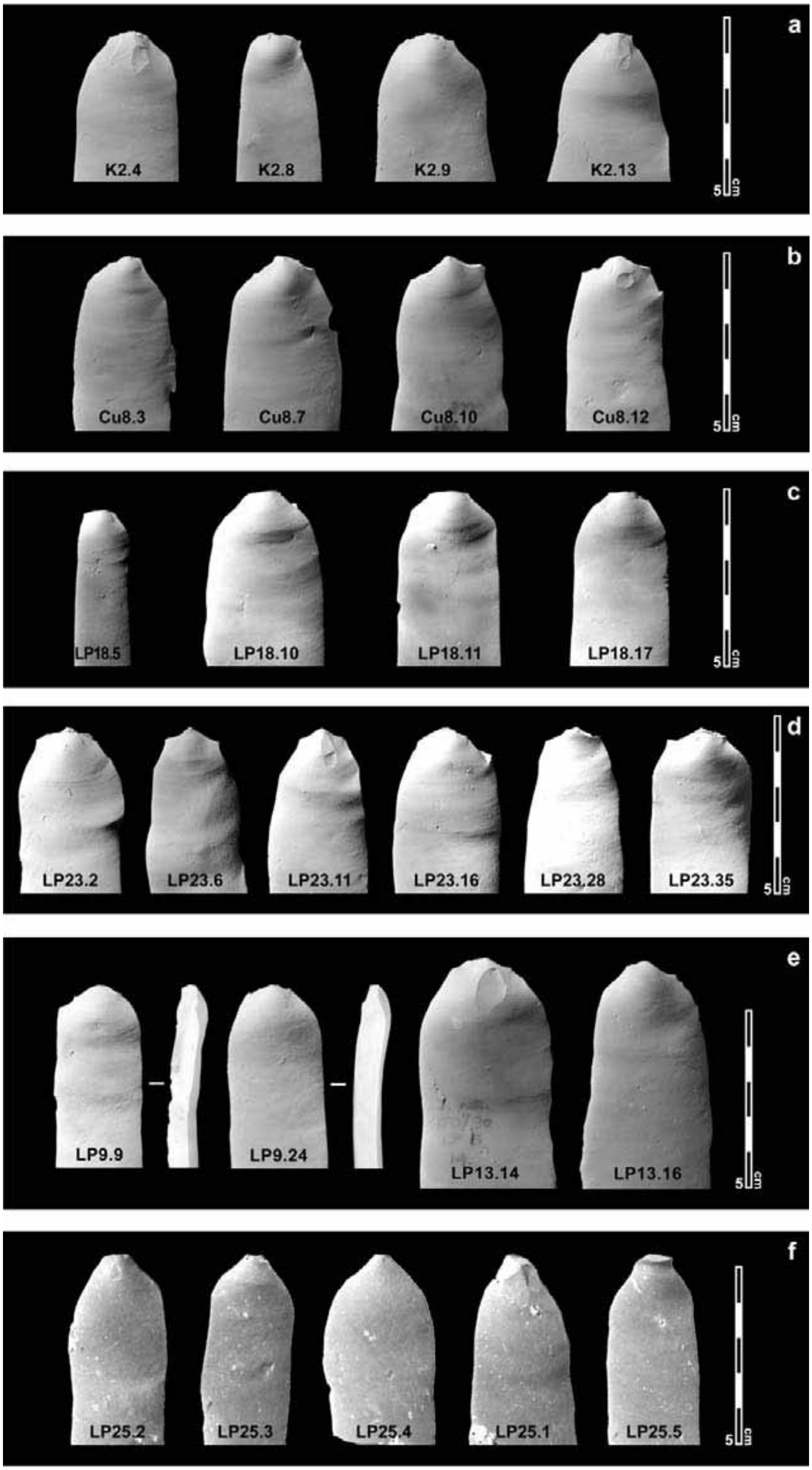
that the butt will be rather thick (minimum 3-4 mm) and wide (8 mm or more, according to the lateral isolation of the contact area). Meanwhile with antler material, being rather elastic and somehow "spreading" on the platform, the butt rarely presents a crack (if so, the crack remains incomplete, sketching the large diameter of the contact). For the same reason, as the fracture initiation starts a little behind the actual contact, the butt is lipped (Fig. 3a).

Using a copper-tipped punch leaves clear technical marks. Copper is hard enough to open the fracture right at the contact; thus, there is no lip at the contact point (Fig. 3b). Also, copper always provokes a circular or sub-circular crack with a small diameter (about 3 mm) on a plane orthogonal platform, or a regular crack across the most prominent arris of a facetted or dihedral butt on which the tool was set.

On large blades detached by lever pressure, the technical stigmata also help to recognize the nature of the pressure stick. With an antler pressure stick on a flat orthogonal platform (or facet), we can also expect a contact surface (butt) a dozen of square mm large, with an edge angle near 90°; such a butt will bear no crack but a little lip, indicating a rather diffuse (soft) contact (Fig. 3c). However, an antler pressure stick can also be used on a facetted or dihedral platform, with a more acute edge angle, giving a butt thick at least 3-4 mm. In this case, as antler is much less hard than copper, the butt bears no crack and a clear lip is visible at the back of it, even just behind the fracture initiation point (Fig. 3d).

If the pressure stick is armed with a copper point, two cases can be seen. On a flat or convex facetted platform, the copper point being placed a little behind the front edge will provoke a crack on the butt (the crack is circular on a flat platform, corresponding to the conus head of the fracture initiation). There is no lip at the contact point (Fig. 3e). In the second case, the contact surface is prepared as an acute edge parallel to the front edge of the core, or as a triedric point. When the copper point is placed on this edge or point, the butt will be very small (Fig. 3f-1&3), and no crack is visible because the butt blends with the contact area. There is then usually no lip behind the pressure point (because copper is hard enough to initiate the fracture at the contact), but a lip can develop laterally (Fig. 3f–4), the more with the acuteness of the global edge angle. In some cases, the fracture starts well behind the contact point, and such a tear-out determines an obvious lip (Fig. 3f-5). It can also happen that the butt crushes or splits (Fig. 3f–2), seemingly after the detachment, since this accident does not impair the fracture propagation (when the blade is just detached and starts rotating in the air, the pressure stick is still compressing the butt and can damage it).

The aspect of the bulb can also help to distinguish pressure from indi-


a
K2.4
K2.8
K2.9
K2.13
5 cm
b
Cu8.3
Cu8.7
Cu8.10
Cu8.12
5 cm
c
LP18.5
LP18.10
LP18.11
LP18.17
5 cm
d
LP23.2
LP23.6
LP23.11
LP23.16
LP23.28
LP23.35
5 cm
e
LP9.9
LP9.24
LP13.14
LP13.16
5 cm
f
LP25.2
LP25.3
LP25.4
LP25.1
LP25.5
5 cm

rect percussion. A thick bulb, high and short, is more indicative of pressure (Fig. 3e). Bulbs by indirect percussion are often more extensive in length, or diffuse (Fig. 3a). For some of the lever pressure tests, the rate of bulb scar dropped to less than 50%, compared to the indirect percussion for which this rate is generally over 50%.

Looking very carefully at the tests, I could detect a few other discrete stigmata indicative of pressure, especially lever pressure: some of the blades have one or a few micro-ripples on the bulb. They might be due, I believe, to the effect of micro-crushing of the wooden support on which the core is resting during the build-up of pressure; micro-crushing which provokes axial micro-movements of the core. In a few cases, a strange ripple, positive on one side and negative on the other, indicates a sudden micro-rotation of the core during the course of the fracture pushed by the pressure. Such indices of micro-movements of the core during the detachment, axial or rotative, certainly indicate that it was placed or squeezed in a firm device. Finally, a rare and amazing accident can prove that the core was held using a firm frontal support. If a blade comes out wider than expected so that its edge reaches the contact of such a frontal support, the fracture front is highly disturbed; the edge of the blade looks as though it has been torn and a lateral crack might expand in a reverse direction, i.e. towards the butt. I will show below that one archaeological blade from Syria, certainly made by lever pressure, shows such an accident. On the other hand, on the numerous Grand-Pressigny blades I could examine, I could see several discrete lateral overpassings – taking off a little portion of the lateral crest – at a proximal, mesial or distal situation; this proves that the edges of the core were not squeezed in a firm device.

Fig. 3. Back views of blades detached by different techniques.
a) indirect percussion using an antler punch (same as test L1 Fig. 2 top)
b) indirect percussion using a copper-tipped punch (same test as Fig. 2 bottom)
c) lever pressure using an antler tine on a flat platform (test LP18)
d) lever pressure using an antler tine on a facetted or dihedral platform (test LP23)
e) lever pressure using a copper point on a facetted (test LP9; Fig. 1) and a dihedral platform (test LP13)
f) lever pressure using a copper point on an acute platform edge (test LP25).
Photos: Lejre Research Centre & J. Pelegrin.

Archaeological results

Given this experimental understanding of these techniques, several archaeological cases have been examined in the past few years, some of which have been published, others demanding further documentation.

In this section, we will consider a selection of cases that I could study and that have been published with at least a minimal iconographic documentation and discussion.

The early Neolithic blades made out of blond flint found in Greece

(C. Perlès 2004:29pp)

Thanks to C. Perlès, I could examine the Neolithic flint material from Franchthi, a very large cave open near the seashore in eastern Peloponnesian, with occupations from the late Pleistocene until the Bronze Age. In the Early Neolithic dated to the 7th millennium (from a coherent date 7700 +/- 80 BP, that is 6624 to 6378 BC cal. at 2 SD), were found a few fragments of very regular blades made out of a blond flint of exquisite quality. According to C. Perlès, such large blades are known even a little earlier from Argissa (Thessalia), in the Preceramic Neolithic, while the pressure production of small blades in different varieties of flint and obsidian is already common in the whole of Greece (Perlès 1990:131pp, Perlès 2001:89p; 202p).

These large blades found in Franchthi until the Late Neolithic are all fragmented, and quite often shined and reworked (Fig. 4). Fortunately, a few well preserved proximal fragments including one surely attributed to the Early Neolithic allow for a technical diagnosis (Fig. 4; top left).

The lever pressure was certainly used to produce most if not all of them, considering the striking regularity of most of the fragments, together with the very slight curvature and thinness of several pieces. The prominent bulbs, high and short, followed by clear ripples reinforce the diagnosis. The two well preserved butts are thick and safe of cracks: they indicate without doubt the use of a relatively tender material, obviously antler (copper was unknown in Greece at the time).

Considering the scarcity of such blades, Franchthi certainly lies at the margin of their distribution area. As they are lacking in the Neolithic sites of Macedonia, their origin should be expected in north-western Greece or abroad, in Albania or in the former Yugoslavia, without excluding Cephalonia and the south-eastern part of Italy.

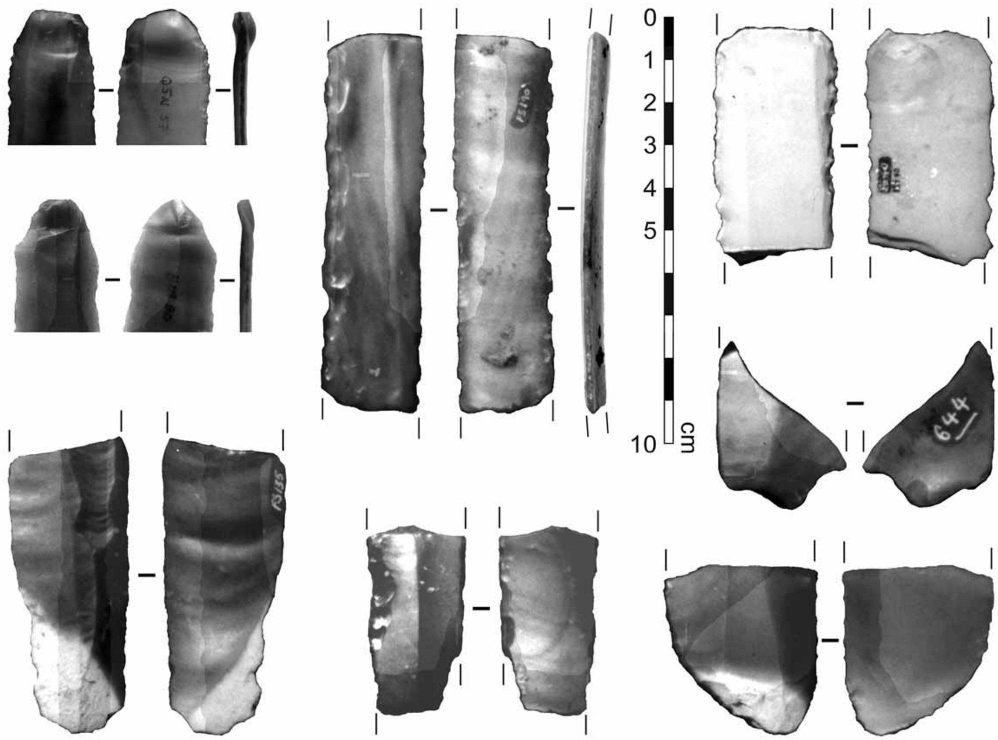


Fig. 4. Different fragments of blond flint blades from Franchthi (Greece). The top left proximal fragment, undoubtedly attributed to the Early Neolithic (I1), is very informative with its prominent and short bulb followed by ripples, and its flat and thick butt clear from any crack. Photos: J. Pelegrin.

The Varna large blades

(Bulgaria; L. Manolakakis 1994, 1996, 2004, in prep.)

The Chalcolithic Necropolis of Varna (4600-4300 BC cal.), the lithic material of which was studied by L. Manolakakis (1994), contains a remarkable series of large blades, most of them produced from a so-called "wax" prebalkanic flint (north-eastern Bulgaria). This production of large blades (Fig. 5-1&2) completed that of shorter and slender blades detached by standing pressure (Fig. 5-3) and a traditional domestic production of ordinary blades by indirect percussion (Fig. 5-4), which are also represented in some of the Varna graves. Conversely, large blades are found as retouched fragments in domestic settlements.

In one of the richest grave of the Varna Necropolis, that contained 225 gold objects, was also found the longest flint blade known so far, with a length of 43.3 cm (Fig. 5-1). On the whole, these large selected blades (neither cortex, nor crest-negatives) are 22 to 40 cm long, 14 to 40 mm wide and 3 to 8 mm thick only. They are very regular, with the exception of some that are regularly wavy in the profile. Their curvature is slight to moderate, increasing in the distal portion. The diagnosis of lever pressure stands without doubt, as well as the material of the pressure point: a small circular crack clearly visible on the flat and relatively large butts demonstrates the use of copper. Similar observations could be made on similar blades from early French excavations in Bulgaria.

Such a production can result from a local development, as standing pressure was already known in Bulgaria. However, it could also be rooted in the blond flint technological tradition, if we remember that the latest blond flint blades found in Greece extend until the Greek Recent Neolithic, which overlaps the Karanovo VI period of the Varna Necropolis. (princeps contextual and documental ref. from L. Manolokakis; 1996, 2005.)

The blades from Tell'Atij and Tell Gudeda

(Syria, Early Bronze Age; J. Chabot 2002)

Large flint blades or their fragments, called "Canaanean blades", have long been described from the Levant and Mesopotamia, although very little is known about their origin and production. Different varieties of flint seem to be represented in the whole, and there might have been several production centres of these "Canaaean blades" – and possibly different techniques – over time (4th millennium and early 3rd millennium) and within a large area (from south-east Turkey to Lebanon; Rosen 1997, Chabot 2002).

Our colleague J. Chabot has been in charge of the study of two settlement collections carefully excavated in northern Syria by M. Fortin from Laval University (Canada). Most of the lithic material consists of locally produced flakes, but both sites contain about 8% large flint blades, the raw material of which is not local. Indeed, these blades have been imported as long fragments from one or several workshops (ibid: 20). A study of their function indicates that they have been mainly used as elements of threshing sledges.

Using my experimental references, J. Chabot and I have conducted a careful examination of the two large blade collections which are extremely similar. Of the 296 blades in Tell'Atij, 69 can positively be attributed to lever pressure from their excellent regularity, almost straight profile, and relatively "light" section (most of them are 22 to 33 mm wide and 6 to 10 mm thick)

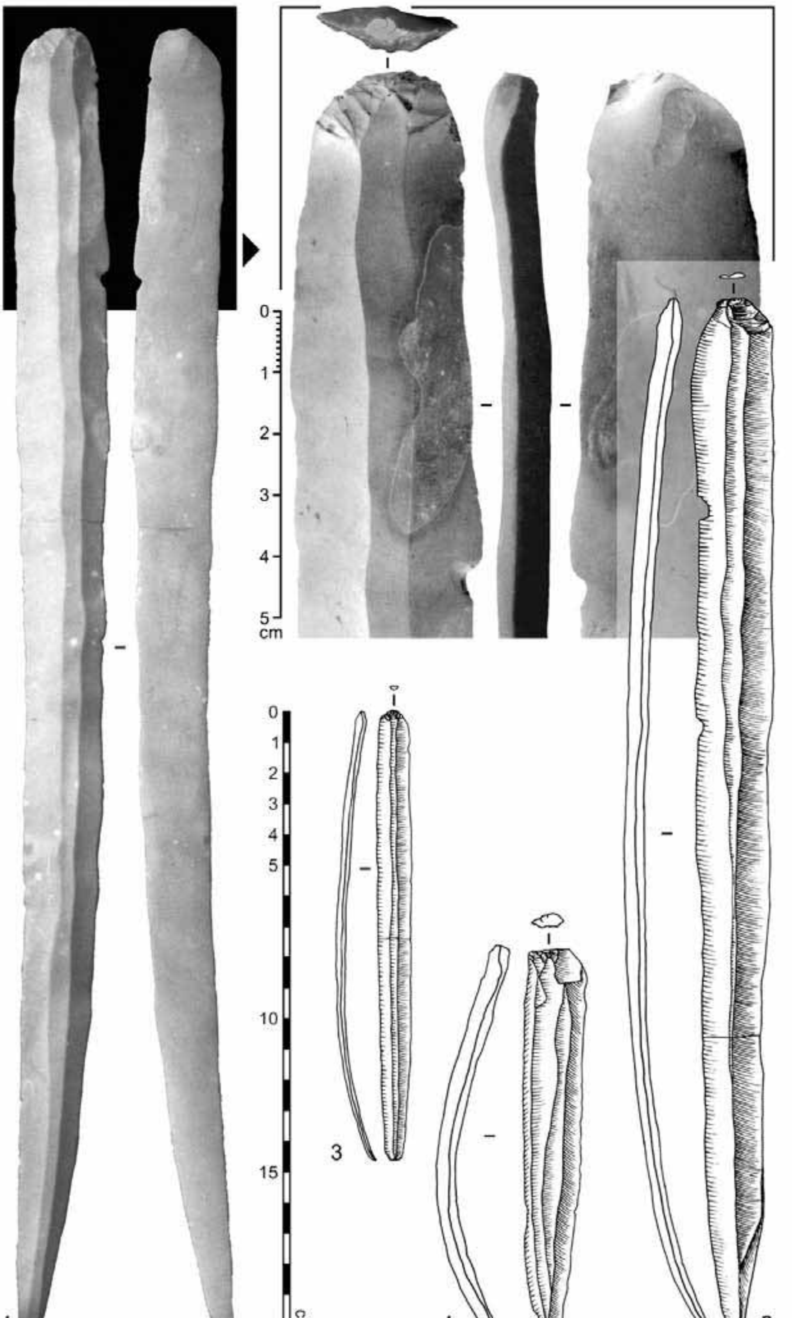


Fig. 5. Blades from different graves of the Varna Necropolis (Bulgaria); blades 1 and 4 from grave no.1, blade 3 from grave no. 26, blade 2 from grave no. 40. Drawings after L. Manolakakis 1994, photos: P. Kelterborn.

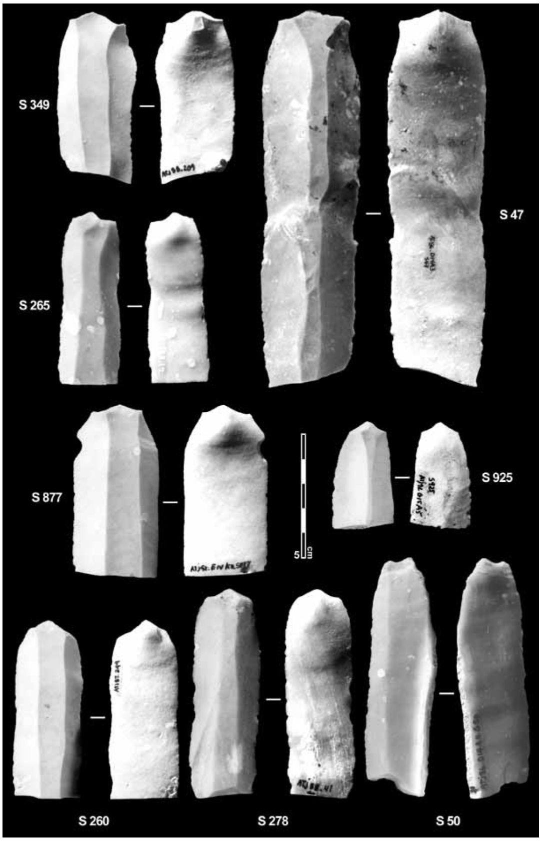


Fig. 6. Blades from Tell'Atij (Syria). Photos: H. Plisson (CNRS), J. Chabot & J. Pelegrin.

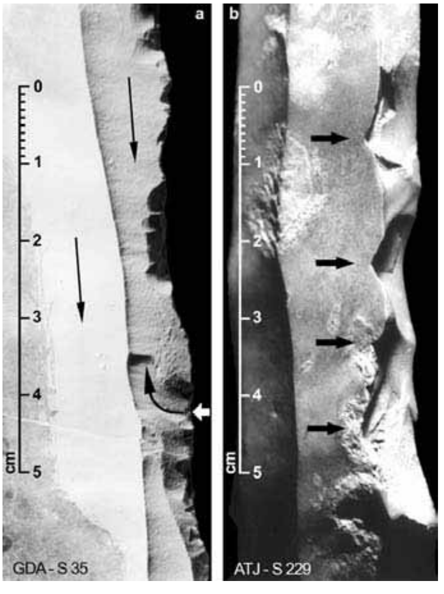


Fig. 7. a) Blade from Tell Gudeda (Syria), showing a "reverse" scratching of the edge; b) crested blade from Tell'Atij. Photos: H. Plisson (CNRS), J. Chabot & J. Pelegrin.

(Fig. 6). Indirect percussion was recognized for 15 other blades, most of them being obvious shaping blades saved during the preparation or opening of the blade-core, or shorter blades coming from the final reduction of cores. This diagnosis was rather conservative, as 202 blades remained undetermined, 44 of which were very regular but too short for an estimation of the overall regularity and profile, and 158 blades showing ambiguous or indiscriminate features (remembering that pressure can produce rather irregular blades, and that indirect percussion can give blades that are only slightly different from the best lever pressure). In Tell Gudeda, the total of 62 blades gave 35 lever pressure, 5 indirect percussion and 22 undetermined.

A very specific detail could be observed on a blade from Tell Gudeda (n° S35): one of its sides shows a strange "reverse" scratching (Fig. 7a). The same happened during our experiments, when the fracture front of a blade comes into contact with the device in which the blade-core is immobilized. This is one more argument, should one be needed, for the diagnosis of pressure, and a valuable indication that the device used by the original producers was similar to our experimental model.

The butt of the lever pressure blades is very typical, with a pronounced arris. The thickness of the butt is usually about 4 to 5 mm, and the bulb is generally high and short, many of them bearing ripples (Fig. 6). Indicative of the metallic nature of the pressure tool, the impact point is well marked, occasionally with a clear crack on the butt arris, and only a very few butts showing a lip (which is a minor variation, when the initiation of the fracture starts behind the effective contact). Indeed, the use of metallic knapping tools is also demonstrated in each of the collection by a lateral crested blade with very small and clear circular cracks from indirect percussion shaping flakes (Fig. 7b). On the other hand, several of the less regular blades identified as indirect percussion bear a thick and large butt, with no concentrated impact marks (showing that "soft" indirect percussion was also used for the shaping or reshaping of the cores).

The long blades from Pauilhac, produced in "banded" Oligocene flint from the south-east of France

In 1865, five blades were discovered together with other remarkable material such as human bones, axes and gold during the building of a railway 80 km WNW of Toulouse (Cantet 1991, Bischoff & Canéto 1865). At the time, the largest of them was the longest blade known in the south of France, with a length of 34.5 cm. This was exhibited during the "Exposition Universelle de Paris" in 1867 before being deposited in the *Musée des Antiquités Nationales* at Saint-Germain-en-Laye. Thanks to C. Louboutin from the MAN and A. Roussot from the Musée d'Aquitaine where the other blades are stored, I could study and draw these pieces (Fig. 8).

These five blades are extremely regular and relatively thin: they were obviously detached by lever pressure. The butt of them is very tiny: the pressure point was set on the very edge of the platform (angle 65° to 90°, with a lateral slope of 10° for blades 2 and 4) after the overhang from previous blades was removed. Note that the butts of blades 1 and 3 are discreetly split, as happened to the experimental blade LP25-3 detached with a copper point after a similar preparation of the platform (Fig. 3f). Indeed, an antler point would certainly spread on the platform and determine a thicker butt. Blades 2 and 4 also bear a discrete transversal crack, indicative of a metallic point. Blade 3, with its flat acute (65°) butt without crack and a slight lip, also resembles experimental blade LP25-4 (Fig. 3f).

These five blades are made of the same variety of flint: a banded brown beige flint that patinates into a creamy colour which preserves the bands, parallel to the long axis of the blades. A few fresh notches and breaks confirm the quality of the raw material, which is a little "dry" (dull). This is almost certainly a tertiary flint, occurring in very large flat rounded nodules. The only known source in the south of France of such raw material, regarding its quality and size, are the tertiary limestone (Oligocene, Aquitanian) outcrops of the Forcalquier area, in the southeast of France (Alpes-de-Haute-Provence, vallées du Largue, du Cavalon et du Lez), where large workshops of blade production have long been recognized (Courtin 1974). Very common in the Chalcolithic collective graves from southeast France (Sauzade 1983), these blades are still frequent in the Languedoc (Vaquer 1990) and are even expected in the Spanish Catalunya (pers. observation). In the north, they reached the Saône valley, the French Jura and Switzerland (Honegger 2001).

In a preliminary synthesis of his doctoral research, S. Renault (1998) presents such blades produced in the Forcalquier region during the Late Neolithic and Chalcolithic (about 3 500 to 2 500 BC cal.). He also describes shorter blades from a different regional flint that bear identical technical stigmata, on which traces of copper have been recently analyzed (Renault *et al*. in prep.). Apart from these particular blades, others in the same variety of Forcalquier flint are known which are thicker and less regular, usually with a thick facetted butt (cf. some blades from La Couronne in the Martigues museum, see also Renault 1998: Fig. 4). They seem to have been detached by indirect percussion.

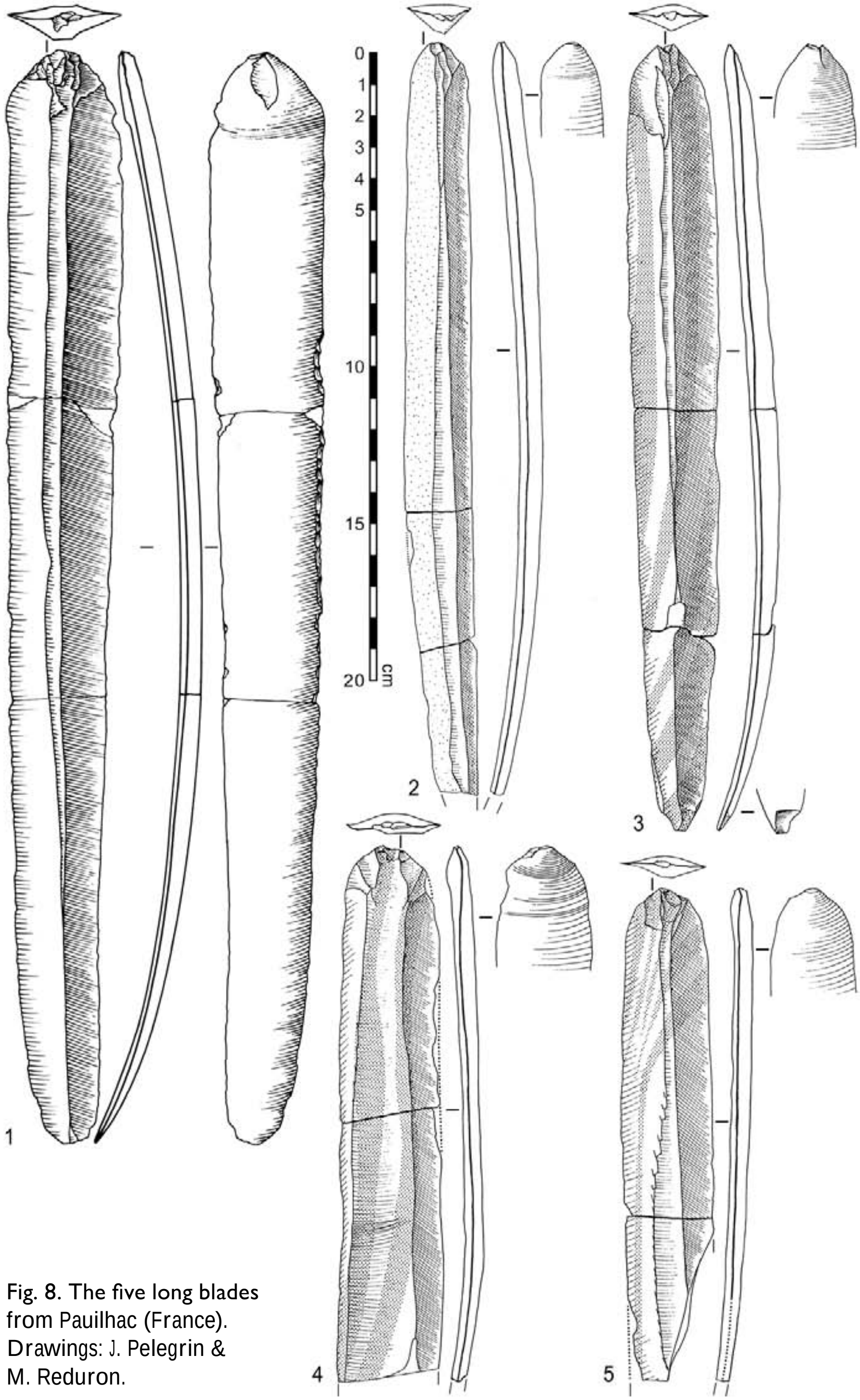


Fig. 8. The five long blades from Pauilhac (France). Drawings: J. Pelegrin & M. Reduron.

The large blades from Perfugas

(Sardinia; L.Costa et J. Pelegrin, 2004)

Ongoing excavations at Contraguda (Perfugas, northern Sardinia) revealed a large settlement including a workshop for the production of large flint blades, roughly dating to the Chalcolithic (end of the 4th millennium – early 3rd millennium BC cal.) (Boschian *et al.* 2001). A tabular bedded flint attributed to the Oligocene occurs in the vicinity. Slabs 4 to 5 cm thick with a light brown colour, including lighter or darker parallel bands that might come from a specific bed, were selected for the production of large blades. The core rough-outs were probably shaped on or near to the extraction spot, as large shaping flakes are extremely scarce in the workshop (most of the precores had to be shaped by transversal flakes to correct the profile of the blade detachment surface).

Two types of blades have been observed in the workshop:

- Fragments of rather thin and regular blades with a symmetrical trapezoidal section, most of them central blades (without cortex or transversal scars); the butt of these blades is very thin (Fig. 9-1 to 3).
- Complete blades or fragments with a thicker section and a less regular profile, with a cortical side (Fig. 9-4 to 6); the butt of these blades is thick, forming an edge angle about 90°, with a little lip.

The thin and regular blades are certainly detached by lever pressure and a copper-tipped pressure tool because of their very tiny butt. The striking similarity with the blades from Pauilhac should be noted (cf. Fig. 8). Again, such a minute contact point is not compatible with an antler tool, be it by lever pressure or by indirect percussion. The large butt of the thicker lateral blades indicates another technique, which is obviously indirect percussion.

At the moment, the distribution area of these blades from Sardinia remains to be investigated. Some of them which were collected in different sites of southern Sardinia are exhibited in and documented by the University of Cagliari (Atzeni 2000), where I could also examine them, thanks to our colleague Carlo Luglie.

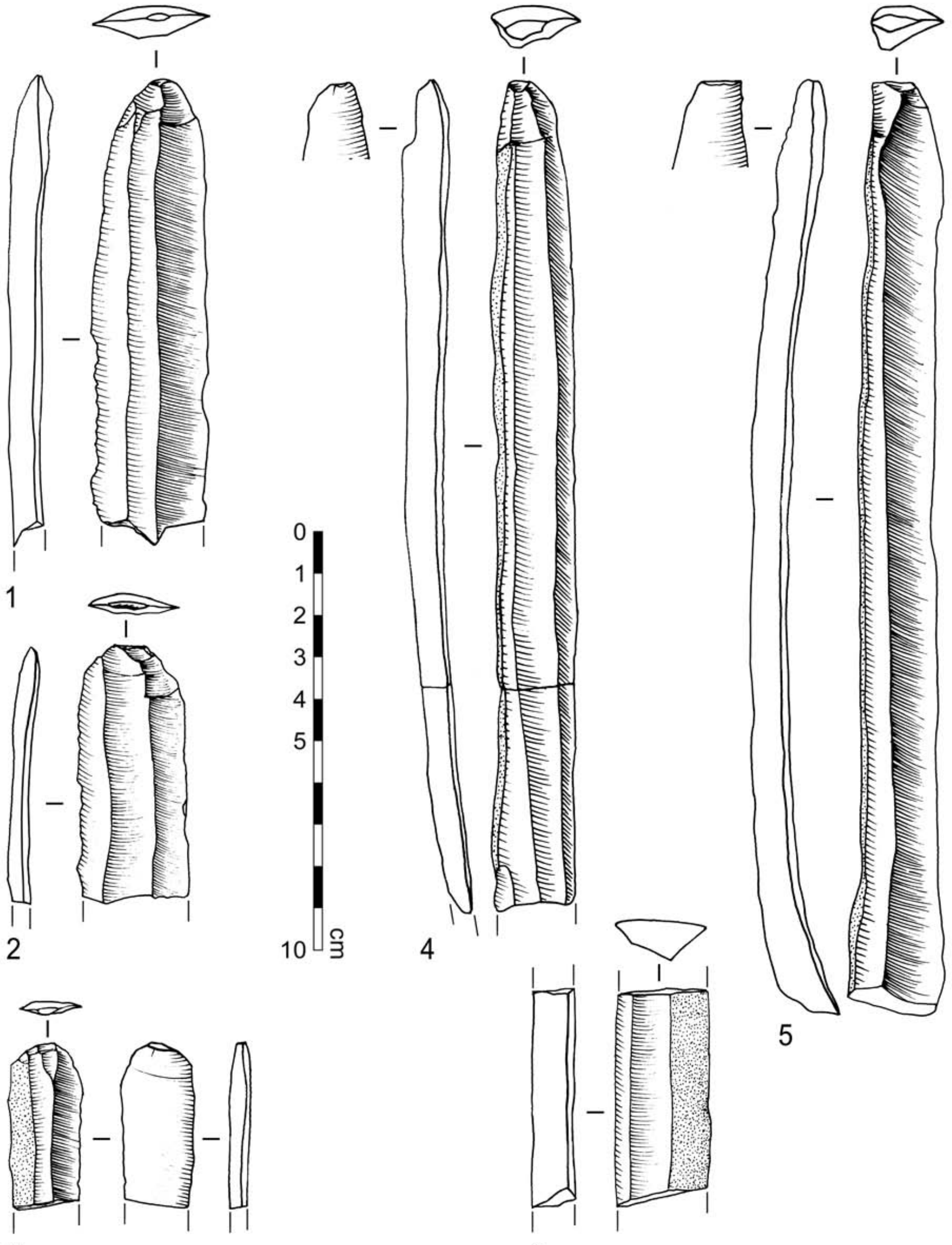


Fig. 9. Blades from Contraguda (Perfugas, Sardinia), after L. Costa & J. Pelegrin 2004 (redrawing: G. Monthel).

Large blades found in Portugal

In the collections of the National Museum of Portugal (*Museu Nacional de Arqueologia*, near Lisbon), I could document large blades made out of different types of flint, the origins of which remains to be confirmed or investigated.

Five blades or fragments, together with stone axes, flint blades and points, amber, copper, etc. come from the passage grave Alcalar III, one of seven megalithic monuments 40 km from south-western Portugal, published last century by Estàcio da Veiga (1889) and attributed to the Chalcolithic period (V.S. Gonçalves, 1989). According to the artistic drawings from A.J.N. da Gloria in the original publication, there were seven large blades in "chert", but two of them and other fragments are currently missing. What is traditionally called "chert" by our Portuguese colleagues is in fact a variety of light grey flint, that turns into a creamy colour when patinated, and that has a rather coarse grain. The surface of the cortex is rough, but the shape of the nodules can be very regular, with two parallel flat or slightly convex sides and a rounded peripheral edge. Indeed, discrete structural bedding appears on some blades, the material being coarser towards the centre of the nodule.

Most of these blades are massive. Judging from the original drawings, four of them are very long, from 27 cm up to almost 40 cm. They are also wide (30 to 45 mm) and thick (8 to 14 mm), with a slightly curved profile before a clear distal curvature. The regularity is rather good, considering that four of them are crested (Fig. 10-1) or "under-crest" (Fig. 10-2) blades. In particular, the last of the five (Fig. 10-3), with a trapezoidal section determined by the scars of three very regular preceding blade, is especially informative. After a pronounced proximal torsion, it follows a very straight profile and a thin section (8 mm), and reaches a length of 37 cm after a distal curvature.
Three of these blades have a preserved proximal end. The butt of a heavily crested blade that has been pre-shaped by indirect percussion (Fig. 10-1, no.10027) is slightly damaged by the removal of a minute splinter, during or after the detachment. However, the original shape of the butt can be evaluated as symmetrically dihedral and 2 mm thick, with a possible margin, 1 mm wide. The angle and the lip aspect cannot be evaluated.

The two other butts are also dihedral but very asymmetrical. However, the tool was not identically placed for these two blades. On no. 10028 (Fig. 10-3), the contact area (3 mm thick) was the protruding dihedral (120°) arris of the butt, slightly smoothed prior to the detachment and forming an edge angle of 80°. The contact area was thus very small and potentially aggressive. On no. 10026 (Fig. 10-2), the contact area was actually just beside the protruding dihedral arris of the butt. The effective contact was produced on

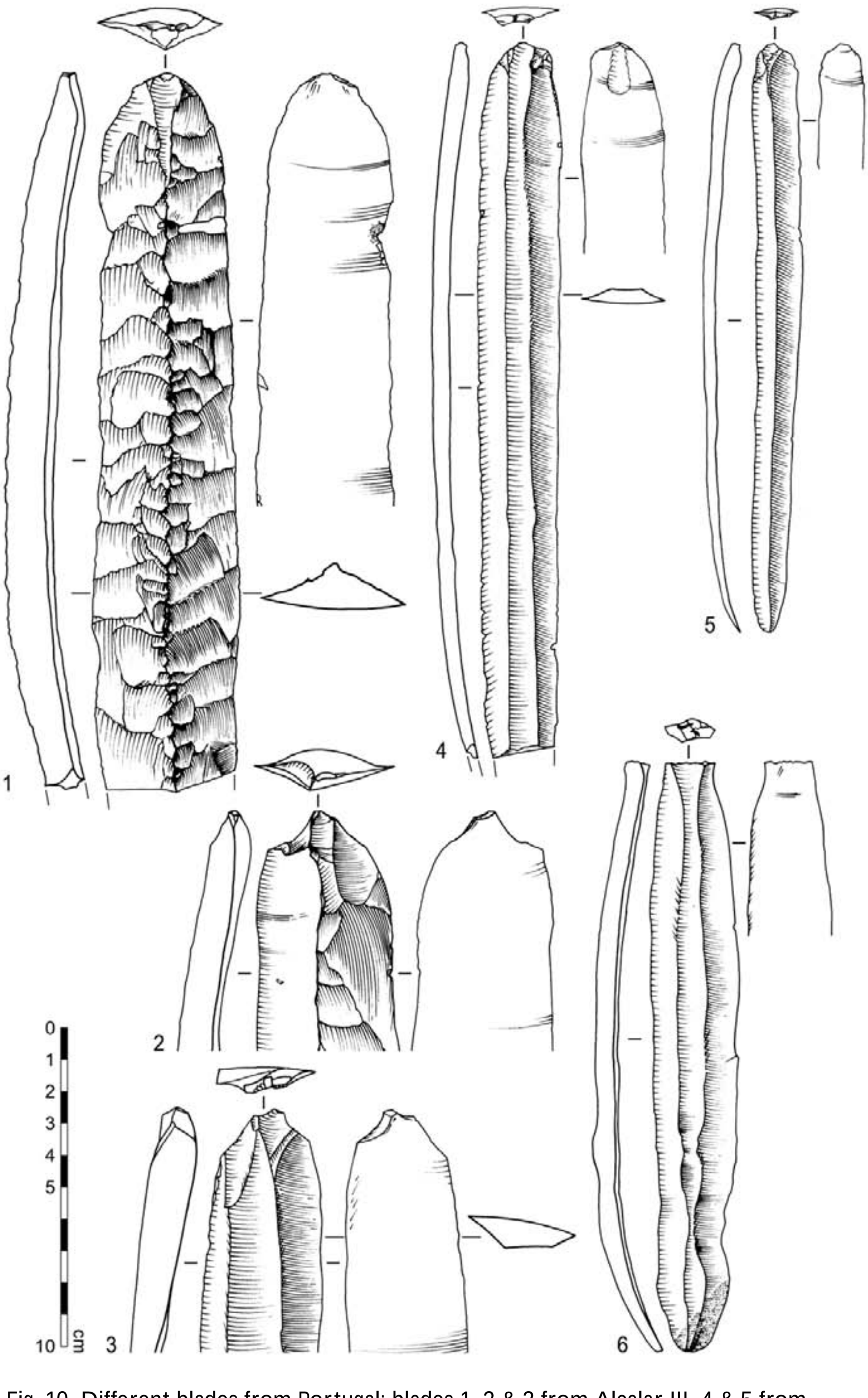


Fig. 10. Different blades from Portugal; blades 1, 2 & 3 from Alcalar III, 4 & 5 from Aljezur, 6 from Vila Cha. Drawings: J. Pelegrin & G. Monthel.

a slightly concave facet, discretely smoothed towards the platform, forming a 65° edge angle and laterally 20° inclined. On both blades, there is no lip behind the contact area, but a lip appears laterally behind the butt's facets which form an acute edge angle (for instance on the left of the contact area of blade no. 10026).

Note that blade 10027 bears a very clear positive ripple at the lower part of its bulb, as well as the previous blade detachment visible on 10026.

At first sight, one could think that such massive blades were produced by powerful indirect percussion, but not necessarily. Lever pressure can also detach very heavy blades, up to 6 cm wide in some of my experiments. The morphology of blade no. 10028, 37 cm long combined with a very moderate curvature, a very good regularity of its edges and arrises and a rather thin section (8 mm) indicate that it was not detached by indirect percussion. Indeed, the technical stigmata provide several arguments in favour of lever pressure: the very small contact area, the two clear ripples visible on these three blades, as well as the torsion of blade no. 10028.

Moreover, the tiny dimensions of the contact area and the absence of lip behind the contact area certainly implied a rather hard material, that is to say copper. With an edge angle of respectively 65° and 80° (blades nos 10026 and 10028), one would expect a clear lip behind the contact area, if antler had been used.

I now turn to a few blades from Aljezur, a collective grave 25 km from south-western Portugal, excavated very early during the 19th century. V. Gonçalvès considers Aljezur a Chalcolithic "*fosse funéraire*" (1992:172).

The elegant blade no. 8984 (Fig. 10-4) is made from a discretely banded light grey flint, very homogeneous. The very good regularity, reduced curvature, light section (25 mm wide, 5 mm thick in the mesial portion) together with a length that would reach 24 or 25 cm but for a fresh distal break clearly indicate lever pressure. The bulb is rather diffuse, with its lower limit marked by a soft ripple (non-diagnostic), and is followed by two other soft ripples 3 cm from the butt. The butt is dihedral symmetric and a little smoothed, forming a 70° edge angle. Its thinness (2 mm) indicates a copper tipped pressure tool, even though there is a little lip (due to the rather acute edge angle).

The raw material of blade no. 8991 (Fig. 10-5) is a very homogeneous fine grain flint, in a light grey colour. The blade is remarkably slender (14 to 12 mm) and thin (4 to less than 3 mm) compared to its length (186 mm long) and reduced curvature. The medium regularity and the triangular section suggest that it comes from an early stage of the blade core reduction. Despite the medium regularity, the morphological features are enough to strongly suggest a pressure technique, and possibly "standing pressure" in regard to its narrow section. The butt and bulb features further support the diagnostic of pressure. The bulb is well rounded, short and high, with a clear ripple a few millimetres just below the butt, which probably indicates that the blade was finally detached after a second push. The butt is very thin (2 mm), dihedral symmetric, with a 90° edge angle and a little lip. This is not enough to determine the material of the pressure stick, but we are inclined to think that it was copper.

Attributed to the same collection of Aljezur, blade no. 8986 is retouched by pressure as a double end-scraper. Although the butt is missing, the morphological characters (length 17 + 3 cm, width 27 mm, thickness 4 mm, slight curvature, excellent regularity) indicate a lever pressure detachment. The flint is very finely grained, with a marbled light brown colour. Another blade no. 9003 is very retouched and broken, but can be estimated to have originally been 20 to 25 cm long, about 3 cm wide and 9 mm thick. The small dihedral butt and the regularity of the ventral face suggest a lever pressure detachment. The greenish and slightly grainy material is unusual; a preliminary investigation of T. Aubry in the University of Coïmbra indicates a "contact silexite", i.e. a local metamorphic formation due to the contact of extrusive melted rhyolite (provisional name "green rhyolite", or "green silexite").

Still in Portugal, but about 135 km north of Lisbon and 10 km south of Pombal, the Vila Cha grave-shelter (called "Abrigo de Souto") gave a large collection of archaeological objects to the "Grupo de Arqueologia e Espeleologia de Pombal". Together with numerous human bones, the collection includes 117 flint blades, 15 arrow points which can be attributed to the Late Neolithic or Chalcolithic, 2 fragments of ground axes and a few potsherds. Thanks to the president of the group Mario Sacramento, I could study this collection deposited at the town-hall of Pousadas Vedras.

A great majority (114) of the blades is made of "Caxarias flint", which T. Aubry and I could sample on a vast area north of Caxarias (16 km south from Vila Cha); also known for its numerous knapping scatters (Zilhao 1994). Their variety of colour and grain indicate that these 114 blades come from many different blade cores, and it was not possible to refit any of the blades. They seem to represent the result of occasional selection from a living stock of fresh tools: many of them bear a limited retouch or macro-use wear (bulb removed by a thin inverse retouch, direct truncation at one end or at both ends, awkward inverse retouch at the end in an attempt to reduce the distal curvature).

The general calibre of these 114 blades ranges from 18 to 12 cm in length, 30 to 17 mm in width, and 8 to 4 mm in thickness. The profile of the blades is moderately curved in the proximal and mesial portions, the curvature expanding in the distal third. Their regularity is generally good but not extremely so; waves are noticeable on the arrises and edges, especially for the longest specimen, more discrete or even absent on the medium long and lighter blades, some of which are also slightly straighter than the longest blades. Figure 10-6 illustrates a typical specimen of these blades.

From the 75 blades from which the proximal end is preserved, the butts are very repeatedly thick and wide, prepared by a flat or slightly convex facetting of the platform, without removing the overhang from the previous blade detachment. Indeed, the preservation of the concavity of the previous bulb-negative helped to detach thin flakes towards the platform in order to facet the contact zone for the detachment of the coming blade. The global edge angle formed by the facetting regularly averages 90°. Only a few partial cracks can be observed on the butts, in various positions, indicating a rather large contact area. The back-line of the butts is rather regular, with a discrete but clear lip. The bulb of these blades is variable in prominence and size. No really clear ripple could be observed in the proximal portion of the blades, but discrete and soft waves.

The morphological and technical features contribute to the same diagnostic: indirect percussion. The limited length is an argument in itself, to which could be added that that the longest blades are more curved and less regular. The ideal range for the best systematic control stays within the limit of 16-17 cm, a limit that we could clearly observe from our experiments with indirect percussion, using well-adapted punches and preferably a short elastic support.

The technical stigmata correspond very well with such an interpretation (a direct soft percussion can be immediately eliminated because of the butt aspect and edge angle, as well as soft or hard stone percussion). Such thick butts could by themselves be compatible with a copper point acted by lever pressure, but this would leave many more and sub-circular cracks on the butts, and no lip at the contact point. Lever pressure with an antler tine would provoke much more prominent bulbs on such thick butts.

Finally, and logically, it is difficult to understand why the prehistoric knappers would have used the lever pressure to produce blades that would be as easy to produce with a well-adapted indirect percussion.

Other similar blades, detached by indirect percussion on a thick facetted butt, could be observed in different collections from the central and southern regions of Portugal. Most of them are seemingly made of Caxarias flint, confirming the importance of the original work-shop. However, there are also some of them in different varieties of flint, the origin of which is presently unknown (according to T. Aubry).

Conversely, I could not recognize (lever) pressure blades from Caxarias flint. Similarly, the lever pressure blades made out of "chert", green silexite, fine grey flint and marbled light brown flint seem to come from specific workshops, the location of which remains unknown. A survey done together with T. Aubry in the South of Portugal combined with further information suggest that the "chert" and the green silexite may well correspond to the "volcanic-sedimentary" formation found north of Huelva (south-western Spain), where large blade cores are documented (Linares *et al.* 1998). The varieties of grey and brown flint resemble samples from Andalusia, where several large outcrops and workshops have been identified, including the production of regular blades with a clear dihedral butt (Martinez-Fernandez 1997, Morgado 2002).

The Grand-Pressigny long blades detached from the "livre-de-beurre" cores

(western France; J. Pelegrin 2002)

The Grand-Pressigny workshops, about 50 to 60 km south of Tours, have been identified since the 19th century as a large production centre of long blades, further diffused as "daggers" in the whole of France and even up to Switzerland and the Netherlands (Mallet 1992, Delcourt-Vlaeminck 1999, Honegger 2001, Ihuel 2004). In 1970, a cache of 134 to 138 fresh blades was discovered at "La Creusette" and carefully excavated (Geslin *et al.* 1975). I could later document that they represent a non-selected fraction of an original production of 500 to 800 blades, detached from about 50 to 80 cores (Pelegrin 1997). They can thus be considered an excellent sample of the Grand-Pressigny production.

These blades are massive: 25 to 38 cm long, 4 to 6 cm wide and about 1 to 1.5 cm thick (Geslin *et al.* 1975, Kelterborn 1980, Pelegrin 1997). They show two types of profile: the early blades have a regular and pronounced curvature, and the later blades are typically more curved in their proximal half (Fig. 11-1 to 3) and less curved if not purely straight in their distal half (Fig. 11-4 to 7). They are not very regular, always bearing moderate to obvious undulations of their edges and arrises (together with corresponding waves or inflexions of their ventral side). Thus, the morphological characters of Grand-Pressigny blades are much more indicative of indirect percussion than pressure.

The technical stigmata are very repetitive. The platform preparation consists of shaping a clear arris in the line of the blade to be detached, and gently pecking this arris (with the edge of a specific flint tool which has lately been identified, called "*piqueteur*"; Geslin *et al.* 1982). This pecking progressively crushes the arris into a rectangular or trapezoidal surface, about 7mm long and 2 mm wide, which will serve as the contact surface to the knapping tool and become the butt of the blade (Fig. 11-photo). It has long been said that this systematic preparation helps to adjust the geometry of the contact area (regularly inclined with a 80-85° angle to the flaking surface) and that it can provide a helpful grip for the knapping tool. However, more importantly, it also facilitates the initiation of the fracture. The bulb of the blades is reduced or diffused, and never bears any ripple or ridge (this has been checked systematically). Also, different blades with a side overpassing in proximal, mesial or distal position prove that the core was not held or squeezed in a wooden vice or device, which also speaks against lever pressure. The Grand-Pressigny blades had to be detached by indirect percussion.

Reproducing the blades proved to be a great challenge. All the early tests failed with undulating detachments and/or a final hinge at 18-20 cm from the platform, until I understood that the problem was the recoil and shaking of the core under the percussion (or very shortly after, in the way of a gun). Assuming that fracture speed is constant, detaching a 30 cm long blade would take twice the time than a 15 cm blade. The solution of resting the core standing on an elastic support (a piece of wood acting like a spring) proved effective, together with a subtle adaptation of the punch and hammer, so that regular blades up to 35 cm long could be obtained. In addition, the specific preparation of the platform should be seen as a very clever way of shortening the delay between the impact and the fracture initiation. In this complicated mechanical problem. that can only be approached intuitively, the Grand-Pressigny blade makers certainly proved a remarkable empirical intelligence. Indeed, to our knowledge, the Grand-Pressigny blade production constitutes the best performance ever produced by indirect percussion.

Since the 19th century, several scatters of typical livre-de-beurre cores have been identified in south-west France, up to 240 km south from Le Grand-Pressigny (Pelegrin 2002). With about a hundred cores or less in each, they seem to correspond to a season of activity by one individual. The "Pressignian" work-shop from Vassieux-en-Vercors (Malenfant *et al.* 1971), about 440 km east of Le Grand-Pressigny, is much more consistent, with an estimated 5 to 10 thousands of cores (more than 1160 are already recovered). Another spot of livre-de-beurre cores is also known in northern Vercors, and such a workshop is also assumed in north-east France near Reims. Curiously, the Pressignian way of shaping the core was not the best method for working the Vercors thick fragments of nodular flint. It was thus introduced there at some time between about 2800 and 2400 BC (cal.), which is the period of mature typical production at Le Grand-Pressigny, where precursory

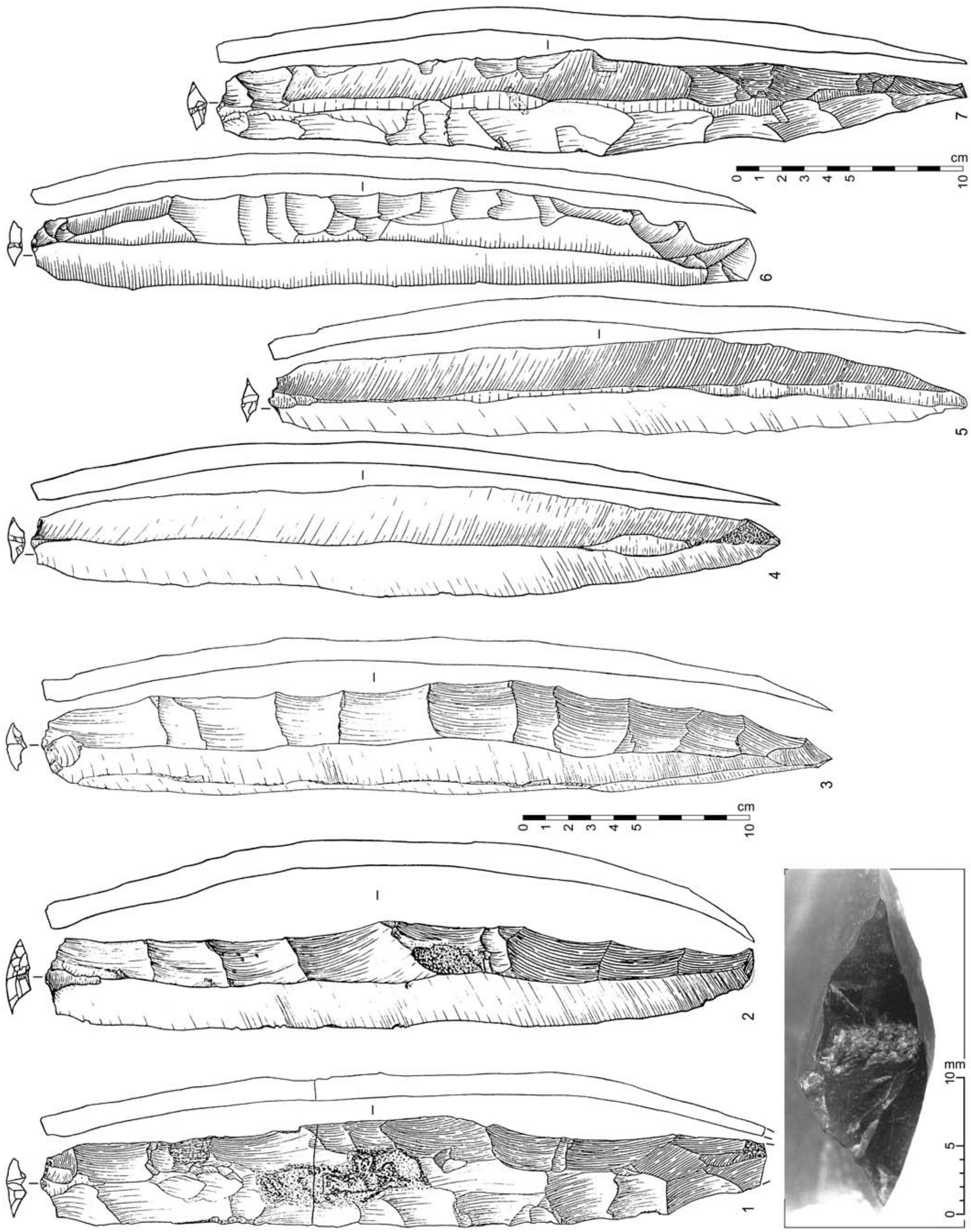


Fig. 11. Seven blades from the “La Creusette” cache (Barrou near Le Grand-Pressigny, France), selected according to their respective order in the core reduction, and upper view of the typical butt of such blades. Drawings from G. Bastien after Geslin et al. 1972 & 1975, photo: M. Geslin (et al. 1975).

shaping methods dated to about 3000 BC are now identified (Pelegrin 2002, in prep.).

It is unrealistic to imagine that the Pressignian method and technique, which are so particular and precise down to their details, may have travelled over hundreds of km by mouth to ear. Such distribution implies that some of the craftsmen ordinarily working at Le Grand-Pressigny happened to travel very far away from it, and were probably informed on their way about the availability of large flint nodules. Considering that short and medium distance distribution obviously follows other mechanisms (Mallet 1992), this evidence of travelling craftsmen may account for a direct transportation of a portion of the production by the producers themselves (whether ordered or not, and/or further controlled by other individuals).

Conclusion

At a methodological level, I would like to stress that the experimental references should not be considered complete. At different steps of the research, it appeared that complementary tests had to be made when facing new types of platform preparation or particular varieties of archaeological raw material that could influence the diagnostic stigmata aspect or occurrence. Diagnostic guesses based on allusive or preliminary knowledge can be uncertain to the point of being later contradicted by further more reliable experiments consisting of minute details of platform preparation and knapping tool adaptation.

Another difficulty comes from the fact that indirect percussion was frequently associated with lever pressure, as can be seen in several cases such as in Bulgaria, south-eastern France, Sardinia and Syria (and probably in other productions under study such as Spiennes in Belgium and northern Spain). A short-cut reasoning such as assuming the technique from the raw material identification would be scientifically incorrect and practically uncertain. Moreover, it would compromise possibly interesting interpretations if punch blades were not accorded the same value as pressure blades, whether primarily (in the workshop) or secondarily (during distribution or use). It may also be possible in some cases that the detachment technique retains a chronological significance in the evolution of production through time.

In this line, the recognition of techniques on archaeological material remains as much a delicate matter as an interesting one.

At an archaeological level, the few cases presented here allow for some brief considerations.

1. The blond translucent flint blades found in Greece indicate a surprisingly early production (mid 7^{th} millennium BC cal.) using the lever pressure technique and an antler point. It is certainly a genuine innovation rooted in the practice of standing pressure blades, and seems to last over the Middle and Late Neolithic without being imitated elsewhere.

2. The next production appears in north-east Bulgaria in the middle of the 5^{th} millennium (BC cal.), also using lever pressure but a copper point. The platform conception is "classic", i.e. orthogonal to the flaking surface, with the pressure point placed "inside" the platform. Experiments prove the difficult control of this method, which demands a very accurate setting of the point and pressure incidence in order to avoid a short detachment or an excessive bulb and blade width. In Bulgaria, standing pressure (and indirect percussion) was practiced before lever pressure, but I do not know whether it was with or without copper points.

3. The Early Bronze Age north Syrian production is a late stage in this framework, and large blades were certainly produced earlier in the Near East, possibly without copper and with different platform preparations or techniques (a long mesial fragment of an obsidian blade with perfect regularity, a trapezoidal section and a width of 3.1 cm, probably detached by lever pressure was found at Cayönü in the Late PPNB, dated to about 7200 BC; examined at the Istanbul University). Experiments have proven that preparing the platform, thus giving a dihedral or convex facetted butt to the blades, eases the fracture initiation and the control of the blade width.

4. The blades produced in south-eastern France and in northern Sardinia engaged a similar technique and method (lever pressure, copper and platform treatment). These two production centres, at least partly synchronic according to their current estimated dates, might have generic relations. In both workshops, the placement of the pressure tool on a small portion of the acute platform edge is also a clever way to improve the control of the detachment. Both workshops also used indirect percussion to produce blades with a thick orthogonal butt.

5. At least two different traditions coexisted for some time in southern Iberia, so that their respective productions ended sometimes in the same Chalcolithic graves. An extensive investigation about the distribution of the central Portugal punch blades (which might be rooted in an older regional tradition) would be relevant, as well as studies about the identification and distribution of the at least three different types of raw material used for lever

pressure blades prepared with the same dihedral butt, which probably belong to the same "south Iberic" technical tradition or group.

6. Apart from these Mediterranean workshops, the Grand-Pressigny tradition in western central France remains original and rather continental, with a distribution much more turned to the west (Brittany cf. Ihuel 2004), east (Mallet 1992) and north (Delcourt-Vlaeminck 1999) than to the south, where it rarely overlaps with the lever pressure blades produced in the southeast of France.

By the way, the remarkable inventiveness of knapping craftsmen, to whom this research is dedicated, opens a little window both in the history of techniques – that reaches one of its highlights with the production of large blades – and in the socio-economy of Neolithic and Proto-historic societies, a field of research where so much remains to be done.

Note : figure computerizing and layout by G. Monthel UMR 7055 CNRS France

Hugo Nami

Experiments to explore the Paleoindian flake-core technology in southern Patagonia

Abstract

With exception of the famous “fishtail” or Fell projectile points, Paleoindian lithic assemblages from southern Patagonia on the southern tip of South America have been little known. However, during the last few years, archaeological research has provided many new insights into this topic. It has been acknowledged that unifacial stone tools were made on diverse flake-blanks, many of them with very delicate morphologies. This fact suggests some kind of preparation of the cores not yet found in the archaeological record.

Based on detailed experiments and documentation, this paper shows examples of morphology and variability that exist during the flaking of similar Paleoindian flakes. Thus, experiments are useful for exploring newly discovered technologies and in this case for suggesting that apart from non-patterned flaking, some kind of core preparation was used to obtain flake-blanks by the Paleoindians in Patagonia.

Introduction

Patagonia in the southern part of South America is a region of about 1000 000 km² shared by the Republics of Argentina and Chile. At its southern tip, near the Magellan Strait on the Chilean side of the border, Junius Bird excavated the Fell and the Pali Aike cave in the volcanic region of Pali Aike in the 1930s. Both sites became world-famous because of the association of Pleistocene fauna with the commonly called “fishtail” or Fell projectile points and other stone and bone tools (Bird & Bird 1937, Bird 1988). However, until the new discoveries and studies were made during the 1980s, the Late Pleistocene hunter-gatherers were a little known and controversial research topic (e.g. Borrero 1986, Borrero et al. 1988, etc.). Fortunately, the archaeological finds made in newly discovered archaeological deposits and the subsequent detailed studies made of them today allow us to understand the diverse technological issues related to the earliest human populations living in southern South America during the time span lasting between 13,200 and 11,900 BP (Rubinos Perez 2003:24).

From a technological perspective, based on detailed experiments and documentation, this paper describes examples of morphological variability existing as the result of flake detachment of Paleoindian flake-blanks. Thus, the experiments suggest that besides non-patterned flaking, some kind of core preparation was used by the Paleoindians in Patagonia.

General archaeological considerations

Apart from the ground discoid stones, for a long time the only know Paleoindian flaked artifact was the Fell projectile point, which was widespread in South America (Bird 1969; 1970; Mayer-Oakes 1986; Politis 1991). However, during the past few decades, a number of archaeological excavations have been carried out in Patagonia and nearby regions that have expanded the knowledge of early human occupation in the southern zone (Massone 1987, Nami 1987; 1996; Miotti 1992; Nuñez et al. 1994, Paunero 1993-1994; Mazzanti 1997; Flegenheimer et al. in press). Moreover, recent technological studies on the Fell and Pali Aike´s collections curated at the American Museum of Natural History (New York) have produced new insights in the Fell lithic assemblages (Nami 1998). For example, it was observed that there are lateral scrapers and knives made on flake-blanks that obviously were obtained from non-patterned flaking. However, some showed a very delicate morphology, striking platforms carefully isolated and abraded, suggesting some kind of core preparation. There are also larger flake-blanks resembling those resulting from bifacial thinning (pers. obs. 1999; Cattaneo 2002; Paunero 2000). These suggest that the flakes were obtained from bifacial and/or dicoid cores with a convex surface preparation for flake detachment. However, the cores have not yet been found in the archaeological record.

Experiments

General remarks

Experimentation in science has different objectives; on one hand, it is beneficial to test a hypothesis; on the other, it is useful to make discoveries and in these cases it plays a heuristic role as a guide in hypothesis formulation (Hempel 1989). Experimental archaeology and lithic technology are both part of such investigations. These inquiries are framed in the contemporary flow of archaeological thinking that is aimed at the prediction, retrodiction and explanation of a number of aspects related to archaeological remains (Nami 2003a; n.d.a, n.d.b).

During the last decade, I have been carrying out experimental and archaeological research on different core preparation technologies from North and South America (i.e. Nami 1992; 1995; etc.). To understand the diverse aspects of those technologies, I have made over a hundred experimental specimens (i.e. Nami 1996 Fig. 3-4; 1997: Fig. 18A; 1999a: Fig. 1A-C; 1999b; 2003a; 2003b, Nami et al. 1996; etc.).

In the previous section, I pointed out that in the lithic assemblages from southern Patagonia there are delicate flake-blanks that, in my opinion, were detached from prepared cores. Thus, to explore this technological hypothesis I made several experimental, partially and totally prepared cores to obtain similar flake-blanks; some of them are shown in figures 3 and 5. However, to illustrate my ideas and observations in detail, I recorded the entire reduction process, from the initial nodule to the exhausted core and including the detached flakes. I also carefully documented the typological and metrical attributes of the resulting core as well as the resulting flakes after each series of flake detachment.

Materials, techniques and results

The raw materials employed were different kinds of rocks with diverse lithic grade, varying from 1 to 5 on the Callahan scale (Callahan 1979:16). Bifacially prepared cores were made out of obsidian from Mono Lake (California, U.S.A.), Glass Buttes from Idaho (U.S.A.), industrial glass from Buenos Aires (Argentina) and chert from the Río Negro area (Republic of Uruguay). In the experimental piece described here I used an obsidian nodule from Glass Buttes. Concerning flaking implements, I employed an antler billet of 1 kg from Alaska (U.S.A.), a small soft calcareous hammerstone of 125 g from the loessid deposit existing in the subsoil of Del Viso in the Buenos Aires province and a larger one of sandstone (790 g) from the Vinchina River, La Rioja province, Republic of Argentina (Fig. 1). Finally, I employed a neoprene piece as a pad and a soft granitic stone as an abrasive.

During the flaking activity I sat on a chair, wrapping the core with the neoprene pad (Fig. 2b). I did this to prevent damage to the flake if it fell down on the floor and to avoid injury from the sharp rock. For the flake detachment I used direct percussion flaking with soft hammerstone and antler billet with the core pressed against the outside of the thigh (cf. Waldorf 1993:41, Fig. 45-46; Whittaker 1994:184, Fig. 8.6). I changed positions according to the size of the core and the best position for the flake detachment (Fig. 3c, 4b). During the core and platform preparation, I employed anvil percussion flaking with the small soft-hammerstone while resting the core on the leg (Fig. 3a, 4a) or holding it in the left hand and left wrist steadied on the padded upper leg (cf. Whittaker 1994:183, Fig. 8.5).

Figure 1. Flaking implements used in this experiment. a) Antler billet, b-c) soft stone hammerstones, d) hard hammerstone (photo by the author).

Figure 2. Holding positions mostly used during the flake detachments (photo by María de las Mercedes Cuadrado Woroszylo).

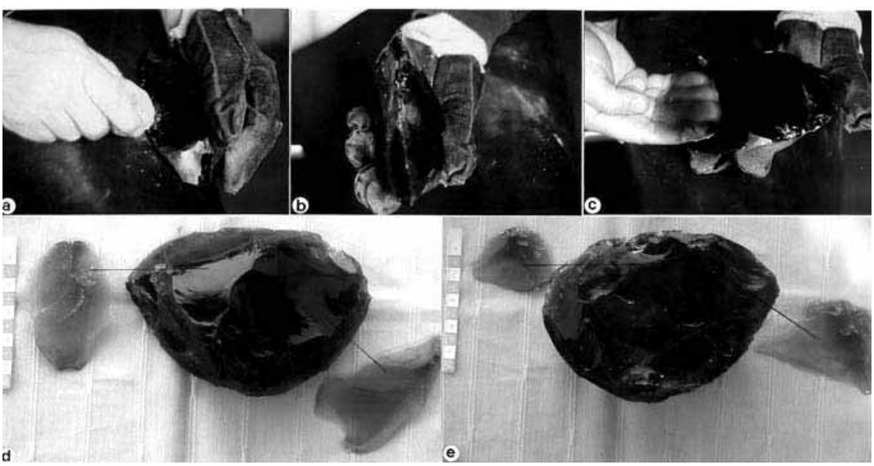


Figure 3. Flake detachment from a partially prepare core. a) Surface and platform preparation with soft hammerstone, b) lateral view of both preparations, c) flake detachment with the antler billet, d-e) anverse and reverse of the resulting core with the flakes detached on both surfaces.

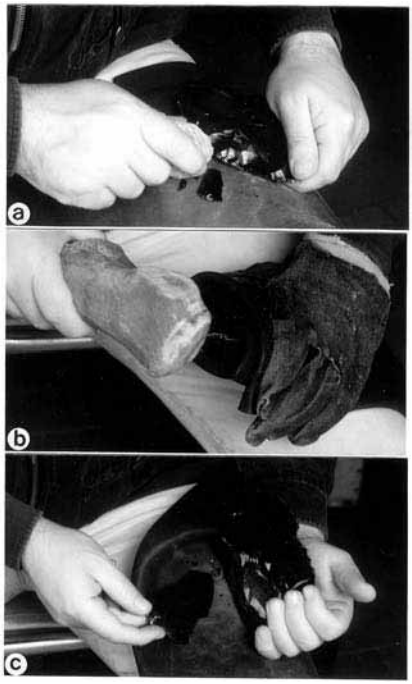


Figure 4. Bifacial preparation of the core and flake detachment. a) Core preparation with the small soft hammerstone, b-c) detachment and the resulting flake by anvil direct percussion flaking (photo by María de las Mercedes Cuadrado Woroszylo).

I removed the flakes following different patterns. They were regularly detached around the margin on one face or irregularly, by alternate detachment on both faces (see Figs. 4 to 9). However, in the experiment described in detail in this paper, all the series of flake detachment (SFD hereafter) -- referring to a series of flakes removed on one face around the margin of the core -- were made following the same pattern, respectively performed on one surface and then the opposite. Sometimes, due to the natural form of the nodule, for the first and second SFD the initial preparation was not necessary. Furthermore, by isolating selected points of impact and following an adequate and carefully prepared platform with an angle of 80°, I abraded the material with the granite soft stone and afterwards, in order to detach the blades, I mostly used anvil percussion flaking in the way described above. When the platform angle was a little higher (~ 85°) I had to use the heavy soft hammerstone to detach flake number 3. By using this kind of prepared core, with an adequate platform preparation and a controlled blow -- precise but not strong -- I can detach the predetermined flakes. This observation is also valid for high graded lithic raw materials, such as quartzite and rhyolites (Nami 1999a:25, Fig. 1A-C).

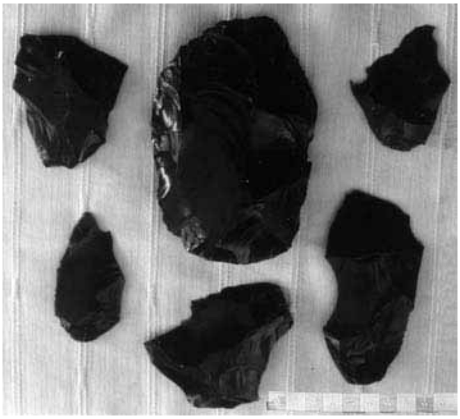


Figure 5. Bifacial core and flakes resulting from the flaking activity showed in previous figure (photo by the author).

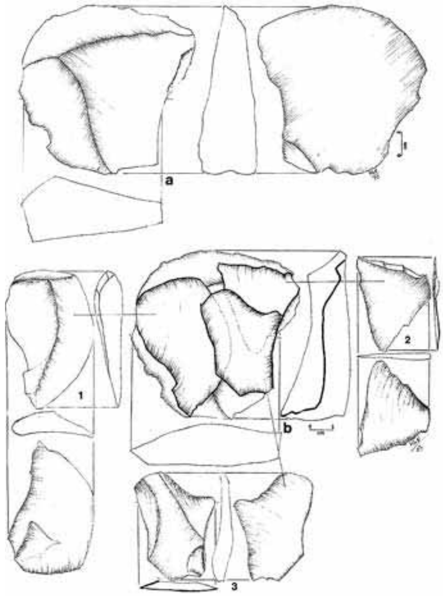
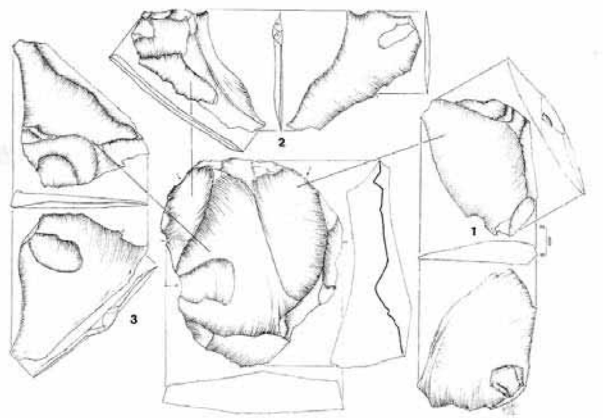


Figure 6. a) Tabular nodule, b) Core and flakes resulting in the First SFD. The numbers show the order of the removals in clockwise sense (drawings by the author).

As a result of the first and second SFD, the flakes were mostly primary and secondary and did not show evidence of previous flaking (Fig. 6 and 7). They were detached both after weak and more thorough isolation of platforms. Afterwards, keeping in mind some of the archaeological flakes and my hypothesis about their origin, I began a true core preparation with the small soft hammerstone. In this way, by carefully eliminating the bulbar scars resulting from the previous flake removals, I made a uniform convex surface and also an adequate angle to the striking platform for detachment of the next series of flakes. This resulted in a sort of discoid biface core that allowed further SFD. I made this type of preparation twice, after the second and fourth SFD (Fig. 8a and 9a). After this first core preparation, the detached products resembled bifacial thinning flakes (Fig. 8b1-4, 9b1, 3). On the other hand, the anvil percussion flaking for platform preparation produced small and short flakes.

Figure 7. Core and flakes resulting in the second SFD made in the reverse face of the core illustrated in figure 1. The numbers show the order of the removals counterclockwise.



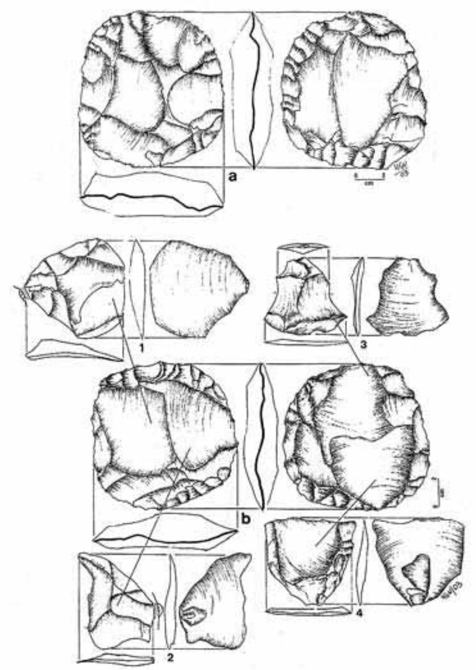


Figure 8. a) Bifacial prepared core arranged to continue with the next SFD, b) Bifacial core and flakes resulting from the second and third SFD.

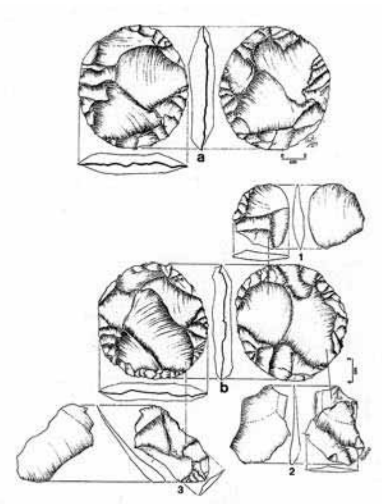


Figure 9. a) Bifacial prepared core ready to continue with the next SFD, b) Exhausted core and flakes resulting from fifth and sixth SFD. Note that this biface core might continue its development as an early stage of manufacture for a bifacial stone tool.

During the entire core reduction process I made six SFD and obtained twelve flakes with much variability, resembling those found in the earliest archaeological lithic assemblages from southern South America. Most flakes were obtained with the antler billet. However, when the platform had a little higher angle (~85°) than the optimum value, I used the heavier soft hammerstone weighing 790 g. In my opinion, the discoid morphology of the core is optimal, because it allows platform preparation around the entire perimeter and also provides a uniform surface for flake detachments. The core's morphological variations and dimensions resulting from SFD 1, 2, 3-4 and 5-6 are illustrated in figures 6 to 9 respectively and depicted in tables 1 and 2.

After the sixth SFD, the problem is that the core is very thin. Hence, the flakes become thinner and tend to resemble those from bifacial thinning producing many fractures (see Fig. 9b2); however, it is still possible to detach usable flake-blanks. In this case, the exhausted core might be discarded, recycled for another tool, used as a blank or as an early stage of manufacture for a bifacial tool (cf. Nami 1997, Fig. 18A).

SFD	*Flake's form*	*Length*	*Width*	*Thickness*	*Figure*
1	Primary	80	115	20	6b1
1	Primary	58	43	6	6b2
1	Secondary	96	70	13	6b3
2	Primary	80	112	17	7.1
2	Angular	79	124	10	7.2
2	Angular	112	58	7	7.3
3	Angular	70	55	13	8
3	Angular	62	63	9	8
4	Angular	58	67	8	8
4	Angular	54	57	9	8
6	Angular	46	54	8	9b1
5	Angular	80	40	8	9b3

Table 1. Description of the useful flakes obtained in the experimental specimen discussed in this paper according to the SFD. Measurements are given in mm.

Morphological transformation of the nodule/core	*Length*	*Width*	*Thickness*	*Observation*	*Figure*
Natural nodule	147	152	55	--	6a
Unifacial discoidal core	145	142	54	First SFD	6b
Bifacial discoidal core	145	140	32	Second SFD	7a
Prepared bifacial core	112	105	32	--	8a
Bifacial core	112	105	25	Third and fourth SFD	8b
Prepared bifacial core	105	92	18	--	9a
Exhausted bifacial core	102	91	15	Fifth and sixth SFD	9b

Table 2. Description of morphological change in the experimental cores resulting after each preparation and SFD. Measurements are given in mm.

Final and archaeological considerations

The experiments performed with these cores, particularly the piece described in this paper, was useful to understand diverse aspects of bifacial prepared flake-core technology, but also to discuss several topics related to Paleoindian technology from both regional and continental perspectives. They are as follows:

From a regional perspective

Experimental

According to this experiment, the Paleoindian flakes might be obtained from diverse kinds of cores, some of them by using some sort of partial or total preparation. It also showed the morphological modification of the core after each SFD. In this sense, its reduction emerges as a dynamic process with much morphological variability in the cores and the flakes as well, rather than as inflexible, prescribed actions that inevitably lead to the same result (cf. Kuhn 1995).

To create these types of cores some knowledge of bifacial flaking and core preparation strategies is required, especially how to prepare the surface and striking platforms. By knowing the method and from a simple tabular nodule, with the appropriate flaking tools, techniques and holding positions, it is easy to maximize the raw material by extracting a good number of useful flake-blanks potentially used in the manufacture of unifacial and/or bifacial stone tools. The goal is to obtain a tool of predetermined shape with very little retouch.

Regarding core preparations, there is a broad range of possibilities. However, in the Patagonian case, one of the probabilities might be a core similar to the piece presented here and other variations in outline, which might be ovoid, circular, semicircular, quadrangular and other varieties (cf. Anderson 1970; Leroi-Gourhan 1978: Fig. 37:7-8; Locht & Swinnen 1994).

Concerning techniques, I suggest that Paleoindian hunter-gatherers used some variety of soft or semi-soft direct anvil percussion flaking by using hammerstones and/or osseous tissues (i.e. bone, antler, etc.) with high-density values ranging between 0.6-1 (Nami & Elkin 1994).

Archaeological

In the archaeological remarks, I pointed out that some archaeological flake-blanks resemble bifacial thinning flakes (cf. Whittaker 1994:185 pp). For this reason, some archaeologists suggest that Paleoindians used "bifaces as cores" (Cattaneo 2002). In the Americas, a biface is a knapped stone with two flaked faces and a single continuous edge. Although this term may refer to any artifact, it is normally used in reference to those that are interpreted as unfinished tools in early stages of manufacture (Frison and Bradley 1999:109). Despite that its debitage may be used as flake-blanks, this does not mean that they are "biface as cores". The flakes detached from bifacial cores, differs in sizes from the bifacial thinning waste observed in several Patagonian sites (Nami 1991, 1993-94a) and other places in the world (i.e. Bradley 1982: 203 pp; etc.). As demonstrated in this and previous experiments, flakes obtained from prepared bifacial cores and detached with soft or semi-soft flaking implements show some attributes existing in the bifacial thinning, but with larger dimensions than those small Patagonian size bifaces (Nami 1986; 1991; 2003a). Furthermore, based on previous studies of thousands of experimental and archaeological bifaces and their debitage along the Americas (e.g. Nami 1988; 1993/94b, 1999c; 2003a, etc.), in my opinion this type of flakes might be part of the flakes´ variability detached from some kind of partially or totally prepared core, particularly from unifacial or bifacial discoid cores and by using soft percussion flaking. Despite the fact that some waste flakes from bifacial thinning might be used as blanks for making tools, bifacial thinning produces a particular kind of debitage according to their different stages (i.e. Callahan 1979: Figs. 20, 26, 31-35, 52, 54, etc.; Nami 2003b). Consequently, it is important to differentiate between flakes obtained from true cores, and those that are waste from bifacial thinning, since, from a technological perspective, these are different strategies. Flakes with similar dimensions of those detached from bifaces and/or discoidal flakes taken from larger, early stage bifaces were used as blanks for manufacturing many projectile points, particularly in Patagonia (cf. Callahan 1979; Nami 1991; 1993-94a; 2003b).

As a method, core preparation technology involves a particular and different concept from other techniques (Pelegrin in Callahan 1981: 65 p). The main goal in the flake production is to obtain the largest usable flake possible from a bifacial core. The aim of bifacial thinning is to thin the bifaces. Despite what might be some morphological similarities in the bifacial thinning flakes and those obtained from bifacial cores, they are the result of different recipes for action, technical decisions and process (cf. Schiffer & Skibo 1987; Nami 1994; Apel 2001a). If so, from a technological perspective "the biface as cores" concept in this case might be fallacious. Incidentally, the transportation of bifaces to detach usable flakes might be a risky situation. In fact, diverse kind of failures might occur during the flake detachment, in the flakes and/or the bifaces (cf. Callahan 1979).

From a continental perspective

Flake-blanks found in the Paleoindian assemblages from southern South America might be compared with the highest standards of flake detachment in the Old World Upper Paleolithic and North American Paleoindian lithic assemblages. Thus, in technological evolution, the technology existing in southern South America is comparable to the highly developed flaked technologies existing during the terminal Pleistocene in the world, with very well developed bifacial reduction and prepared core strategies.

Particularly in the New World, several authors reported the presence of Levallois-like, discoid bifacial cores and flakes detached from them in the early lithic assemblages along the Americas, from Alaska (Anderson 1970:18 pp, Figs. 13-16, Plate 1) to southern South America (Cardich et al. 1981-82:197, Fig. 8).

In North America, Paleoindian hunter-gatherers also used similar delicate flake-blanks for making unifacial flaked stone tools. They suggest that they were detached from prepared Levallois-like and bifacial cores. In fact, Levallois-like flakes and cores were reported in several Clovis assemblages (Nami et al. 1996; Collins 1999). Despite the fact that not all Clovis large-sized bifaces are cores, some of them might be (i.e. Parson & Pearson 2001:51, Fig. 1 a & c). Following Clovis hunter-gatherers, Levallois-like flakes and those probably detached from bifacial cores were identified in Plainview lithic assemblages (Knudson 1983:80 pp, Fig. 24-29 and 33-34); also in the Folsom collections from the Hansom site (Frison & Bradley 1999 Fig. 6), Lindenmeier (Wilmsen & Roberts 1978; Nami 1999c), Lake Ilo (Root 1993: Fig. 52a & c) and Rio Grande valley area (Judge 1973:89). Although not all Folsom bifaces are cores (LeTourneau 2001), Stanford and Broilo (1981) reported a large biface from Texas that in fact might be a core.

During the latest Pleistocene across South America, prepared cores and flakes detached from them were identified in the middle valley of the Magdalena river in Colombia (López Castaño 1999), at the Cubilán site in Ecuador (Temme 1982) and Cerro Los Burros archaeological locality in the Republic of Uruguay (Nami 2001).

Summary and final statements

In summary, as a result of this experiment, my technological hypothesis on the possible origin of the Paleoindian flake-blanks was tested. Thus, it is possible to suggest a derived archaeological hypothesis: the latest Pleistocene hunter-gatherers from Patagonia might have used some sort of core preparation. Based on both archaeological and experimental observations I suggest that apart from non-patterned flaking, some kind of partial or total core preparation was used for flake-blanks detachment according to the nodule morphology, material of the cortex and other circumstances. The preparation might vary from "turtle-back", unifacial and/or bifacial discoid cores and/or other variations of Levallois technology (cf. Böeda 1993; Dibble & Bar-Yosef 1995). It seems likely that some sort of totally or partially prepared bifacial core with symmetrical and/or asymmetrical cross-sections might also be considered a part of the Levallois-core technology (Truffrow 1995:413; Yalçinkaya 1995:319; Wengler 1995:315).

I am aware that the South American Paleoindians might have used different kinds of prepared cores. However, one of the alternatives to consider is the bifacial one, such as it has been discussed here, which might be part of the variations occurring during the core preparation strategies. Therefore, neither the bifacial prepared cores with asymmetrical or symmetrical cross-sections nor the presence of flakes resembling bifacial thinning flakes prove that in their technological organization Paleoindian hunter-gatherers used "bifaces as cores". Like some Paleoindian groups of North America, in the early lithic assemblages from the far South, not all bifacial flaking might have resulted in projectile point production (cf. Collins 1999). Beyond adaptive and social differences, this fact suggests that certain technical similarities that existed among Paleoindians from North and South America hint of shared technical knowledge (Nami 1997; n.d.a). Additionally, the use of prepared cores strategies also implies that during the early times in the New World archaeology, by diverse historical and social mechanism, human populations would have shared some kind of technological information.

Acknowledgements

My special thanks to: Jan Apel and Kjel Knutsson for the invitation to participate in the symposium; the Societas Archaeologica Upsaliensis (SAU) that supported my participation in the event; Maria Louise Sidoroff for her invaluable collaboration during the edition of this paper; Britta Wallsten for her help; E. Callahan for his discussion about this subject; María de las Mercedes Cuadrado Woroszylo for her continuous help and support; finally, to Jan Apel for his invaluable help and kindness during my stay in Uppsala.

Greg R. Nunn

Using the Jutland Type IC Neolithic Danish Dagger as a model to replicate parallel, edge-to-edge pressure flaking

Abstract
The Jutland Type 1C Neolithic Danish Dagger is one of the first of a long series of Late Neolithic Scandinavian Flint Dagger manufacturing traditions dating from approximately 2350 BC to 1750 BC. The Danish Dagger sequence included six main types and numerous subtypes. The Jutland Type 1C is recognized for its elegant, well-controlled parallel, edge-to-edge final pressure flaking series. Neolithic Danish flintknappers were the only craftsmen to create and perfect the type of flaking required for the Type 1C Dagger. This style of pressure flaking is considered one of the most difficult and least understood techniques by modern flintknappers. Using the Type 1C Dagger as a model, the author will describe the manufacturing stages and techniques required to replicate this unique style of pressure flaking.

History

Type 1C Danish Daggers (Fig. 1) were made in the early part of the late Neolithic 1; LN 1 2350-1950 cal BC (Vandkilde 1996; as per Apel 2001*a*:10). According to Lomborg (1973; as per Apel 2001*a*:10) "…Late Neolithic was set in the period when flint daggers replaced battle axes as the male prestige gifts in the upper graves of the Single-Grave Culture in Jutland." Further, "Daggers of type 1 A-C are assigned to a delimited period in Northern Jutland when this part of Scandinavia was influenced by the Western European, Bell-Beaker and Beaker traditions." "The area around the Limfjord was…the centre of the dagger production during the early phase" (Rasmussen 1990; as per Apel 2001*a*:268).

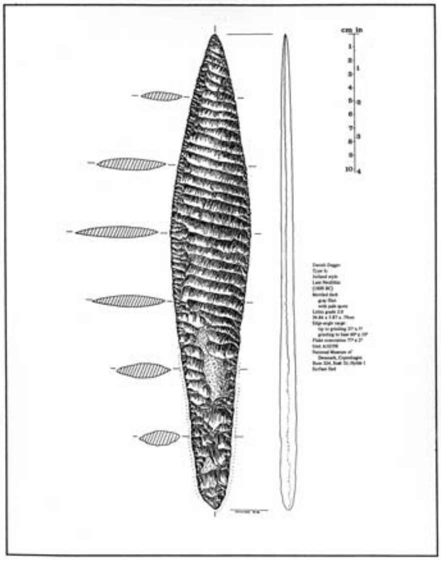


Figure 1.Original Jutland style Type 1C dagger. (National Museum of Denmark, Copenhagen, Museum number A 10198, illustrated by E. Callahan).

Archaeological evidence

Archaeological evidence of beginning and ending points are essential when replicating an artifact. With the Type 1C Danish Dagger, evidence of earlier stage preforms is limited, while completed daggers are abundant. However, archaeologists and flintknappers are fortunate to have enough verified archaeological evidence to assemble the primary, secondary, final preform, and ground preform typology (Figs. 2, 3 and 4). In addition, Arnold's (1990) skillful refitting of debitage from a lancet dagger recovered from a late Neolithic settlement provides valuable information. With this archaeological evidence one can understand the morphology and accurately replicate the Type 1C Danish Dagger.

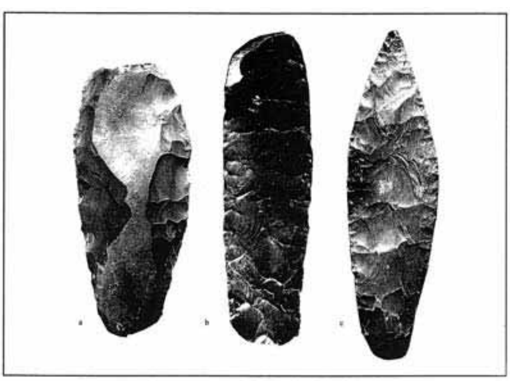


Figure 2. (a) Original stage 2 – initial edging, length 32 cm, width 13.5 cm (National Museum of Antiquities, Stockholm, Museum number 2549 SKJEGRIE 37A; 2(b) Original stage three primary preform – stray find, length 31.5 cm, width 9cm (Danish National Museum, Copenhagen); 2(c) Original stage four secondary preform, length 32 cm, width 9 cm (Danish National Museum, Copenhagen); photographed by E. Callahan.

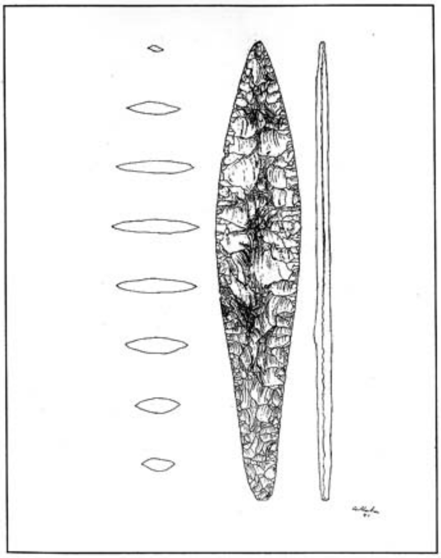


Figure 3. Original stage five - final preform with traces of early grinding, from unprovenienced grave site, length 38.7 cm, width 2.31 cm, thickness 1.7 cm (Moesgaard Museum, Arhauss, Denmark); illustrated by E. Callahan.

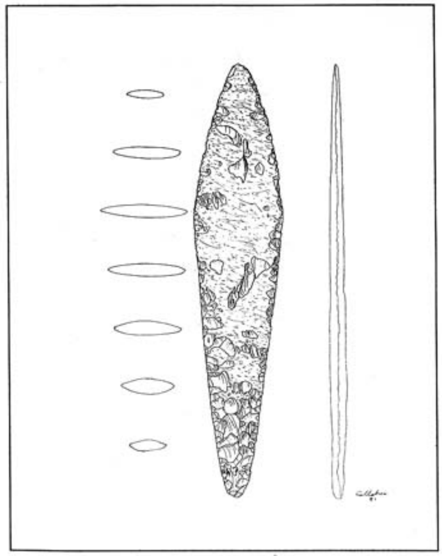


Figure 4. Original stage six - ground preform; length 37.1 cm, width 7.53 cm, thickness 1.1cm; (Moesgaard Museum, Arhauss, Denmark, Museum number A 27691); illustrated by E. Callahan.

Morphology

There are six main dagger types with numerous subtypes (Lomborg 1973; as per Apel 2001*a*:234). There are five subtypes for the Type 1 series. Type 1 is defined by "[l]ancet shaped daggers without handles or with marginally marked handles that display a lenticular cross section." Further, "The type is distinguished from other oblong and thin, bifacial objects, such as lance- and spearheads by the fact that the edges of the handle taper towards the base and that the base tends to be convex or sometimes even pointed" (Lomborg 1973; as per Apel 2001*a*:235).

Definition

Definition of Type 1C Danish Dagger is parallel pressure flaked "…type-1 daggers with symmetrically curved and concaved shaped handle edges." "In Denmark this subtype is almost exclusively concentrated to the Limfjord area in Northern Jutland" (Lomborg 1973; as per Apel 2001*a*:236). All other subtypes are percussion finished.

Prior research

Prior research on manufacturing Type 1C Daggers is contained in Errett Callahan's unpublished manuscript *A Successful Test Model of the Type 1 Dagger* (Callahan 1985). Also, see "Danish Dagger A- 10198" (*Flintknappers Exchange* Callahan 4(2):1981). Errett Callahan made numerous Type 1C daggers, flaked edge-to-edge over seven plus years, and worked out the system seen here. He has displayed hafted knives, so flaked in his Piltdown Productions catalog since 1993 (p. 18-21) and has passed on this knowledge to the author.

In terms of grinding flint daggers, the author hand ground numerous flint daggers over a twelve-year span. Unrecorded grinding experience verifies that a similar approximation of labor was required for each flint dagger.

Preface

Data in this paper was recorded from the manufacturing process of ten Type 1C daggers. Four completed daggers are made of Glass Buttes obsidian from Oregon (Tabs. 1-4), and four completed daggers are made of heat-treated Texas flint from the Edwards Plateau (Tabs. 5-8). Obsidian was used first to refresh and practice techniques. Data was collected for comparison analysis. Of the remaining two flint daggers, both were completed through stage three to collect preliminary data (Tabs. 9-10).

Danish flint daggers were not heat treated in Neolithic times (Errett Callahan, personal communication 1991; Larsson & Olausson 1982:281-284). Unheated Danish flint measures 3.0 on the lithic scale (Callahan 1979 & 2000:16), which is considerably easier to work when compared to raw Texas flint. The Texas flint from the Edwards Plateau is medium quality flint, which measures 3.5 to 4.0 on the lithic scale (Callahan 1979 & 2000:16). Texas flint was heated to 163 Celsius, which approximates 3.0 on the lithic scale. At 163 Celsius, the flint is barley altered. When heated to 205-232 Celsius the flint is very glassy and measures 2.5 on the lithic scale (Callahan 1979 & 2000:16). The later is too glassy for dagger work. After heat treatment of 163 Celsius, Edwards Plateau flint is comparable to unheated Danish flint. The author does not have enough physical strength to complete edge-to-edge pressure flaking on large flint daggers with Edwards Plateau flint, without first heat-treating to 163 Celsius.

Type 1C Attribute Table

Table 1. Dagger Number 1
Material: Dacite Obsidian Spall

	Stage							
Attributes	1	2	3	4	5	6	7	8
Length - cm	34,5	27,5	25,5	24,5	23,3	23,3	23	23
Width at widest span - cm	22	19	11,5	8,3	4,8	4,5	4,3	3,8
Thickness at widest span - cm	4	4	2,5	1,8	1	0,7	0,55	0,55
Width to thickness ratio			1: 4.5	1: 4.5	1: 4.5	1: 6	1: 7	1: 7
Weight (g)								64,3
Total grinding strokes						4600		
Width lost from grinding - cm						0,3		
Thickness lost from grinding - cm						0,15		
Weight (g) lost from grinding								
Width lost from pressure flaking - cm							0,2	
Thickness lost from pressure flaking - cm							0,15	
Weight (g) lost from pressure flaking								
Width lost from final retouch - cm								0,5
Weight lost (g) from final retouch								
Time per stage - min.	5 min.	15 min.	80 min.	120 min.	180 min.	162 min.	35 min.	25 min.
Total Time								10 HRS. 21 MIN.

Remarks: Between stages 2-4; 3.0 cm was lost in length from constant breakage of distal end.
Blank boxes reflects data not collected.

Type 1C Attribute Table

Table 2. Dagger Number 2.
Material: Dacite Obsidian Spall; core blank

	Stage							
Attributes	1	2	3	4	5	6	7	8
Length - cm	37,5	31	28	26,7	22,9	22,9	22,7	22,3
Width at widest span - cm	28,5	26	17	9	5	4,5	4,2	4,1
Thickness at widest span - cm	6	6	3,2	1,8	1	0,82	0,63	0,63
Width to thickness ratio			1: 5	1: 5	1: 5	1:5	1: 6.6	1: 6.5
Weight (g)								83,9
Total grinding strokes						4800		
Width lost from grinding - cm						0,5		
Thickness lost from grinding - cm						0,18		
Weight (g) lost from grinding								
Width lost from pressure flaking - cm							0,3	
Thickness lost from pressure flaking - cm							0,19	
Weight (g) lost from pressure flaking								
Width lost from final retouch - cm								0,1
Weight lost (g) from final retouch								
Time per stage - min.	5 min.	20 min.	130 min.	150 min.	180 min.	172 min.	40 min.	35 min.
Total Time								12 HRS. 12 MIN.

Remarks: Spall had a long crack beginning at distal end upper left lateral margin running inwards 6 cm at 80 degrees. Spall should have been rejected. Lost 10 cm in length because of crack.
Blank boxes reflects data not collected.

Type 1C Attribute Table

Table 3. Dagger Number 3.
Material: Gray Banded Obsidian from Glass Buttes Oregon; core blank

	Stage							
Attributes	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Length - cm	41	33,5	33,5	33,2	31,7	31,5	31,4	31,4
Width at widest span - cm	22,3	17,5	13,2	9,2	5,3	4,8	4,65	4,5
Thickness at widest span - cm	7,7	2,8	2,4	1,9	1,15	0,95	0,79	0,79
Width to thickness ratio			1: 5.5	1: 4.8	1: 4.8	1:5	1: 5.8	1: 5.7
Weight (g)								134,2
Total grinding strokes						7300		
Width lost from grinding - cm						0,5		
Thickness lost from grinding - cm						0,2		
Weight (g) lost from grinding								
Width lost from pressure flaking - cm							0,15	
Thickness lost from pressure flaking - cm							0,16	
Weight (g) lost from pressure flaking								
Width lost from final retouch - cm								0,15
Weight lost (g) from final retouch								
Time per stage - min.	0 min.	25 min.	75 min.	170 min.	205 min.	270 min.	35 min.	15 min.
Total Time								13 HRS. 15 MIN.

Remarks: The latter part of stage 2 resulted in a massive overshot which created a major disadvantage. The biface instantly advanced to the middle of stage 3. Blank boxes reflects data not collected.

Type 1C Attribute Table

Table 4. Dagger Number 4.
Material: Gray Banded Obsidian from Glass Buttes Oregon; Spall

	Stage							
Attributes	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Length - cm								35,3
Width at widest span - cm								5,7
Thickness at widest span - cm								0,85
Width to thickness ratio								1: 6.7
Weight (g)								227,5
Total grinding strokes						8600		
Width lost from grinding - cm								
Thickness lost from grinding - cm								
Weight (g) lost from grinding								
Width lost from pressure flaking - cm								
Thickness lost from pressure flaking - cm								
Weight (g) lost from pressure flaking								
Width lost from final retouch - cm								
Weight lost (g) from final retouch								
Time per stage - min.						303 min.		
Total Time								

Blank boxes reflects no data collected.

Type 1C Attribute Table

Table 5. Dagger Number 5.
Material: Texas Flint Edwards Plateau; Tabular Nodule

	Stage							
Attributes	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Length - cm	33,8	32,5	32,5	31,5	31,2	31,2	31	31
Width at widest span - cm	19,5	16,5	11,5	7,6	4,5	4,3	4,1	4
Thickness at widest span - cm	2,8	2,8	2,6	1,8	0,9	0,85	0,75	0,75
Width to thickness ratio			1: 4	1: 4	1: 5	1: 5	1: 5	1: 5
Weight (g)								131
Total grinding strokes						28000		
Width lost from grinding - cm						0,2		
Thickness lost from grinding - cm						0,1		
Weight (g) lost from grinding								
Width lost from pressure flaking - cm							0,2	
Thickness lost from pressure flaking - cm							0,1	
Weight (g) lost from pressure flaking								
Width lost from final retouch - cm								0,1
Weight lost (g) from final retouch								
Time per stage - min.	0 min.	17 min.	85 min.	300 min.	315 min.	988 min.	28 min.	8
Total Time								29 HRS. 1 MIN.

Total grinding time more closely reflects authentic replication because no mechanical process was used.Blank boxes reflects no data collected.

Type 1C Attribute Table

Table 6. Dagger Number 6.
Material: Texas Flint Edwards Plauteau; Tabular Nodule

	Stage							
Attributes	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Length - cm	35,5	35,5	33	31,8	31,7	31,5	31,5	31,3
Width at widest span - cm	19	17	11,5	7,7	4,9	4,6	4,45	4,3
Thickness at widest span - cm	3	3	2,7	1,8	1	0,9	0,75	0,75
Width to thickness ratio			1: 4	1: 4	1: 5	1: 5	1: 6	1: 5.7
Weight (g)					201	180,2	153,8	144,8
Total grinding strokes						*28,000		
Width lost from grinding - cm						0,3		
Thickness lost from grinding - cm						0,1		
Weight (g) lost from grinding						20,8		
Width lost from pressure flaking - cm							0,15	
Thickness lost from pressure flaking - cm							0,15	
Weight (g) lost from pressure flaking							26,4	
Width lost from final retouch - cm								0,15
Weight lost (g) from final retouch								9
Time per stage - min.	0 min.	20 min.	140 min.	265 min.	285 min.	360/120	35 min.	30 min.
Total Time								20 HRS. 15 MIN.

Remarks: *Regarding grinding, each hour of mechanical grinding approximates 8,000 hand strokes. Dagger 6 was ground 12,000 strokes by hand, the rest was completed machanically (2 hrs.), adding an equivelant to 16,000 hand strokes.& Regarding time per stage, 360 minutes by hand plus an additional 120 mechanicalminutes, totals 480 minutes. Blank boxes reflects no data collected.

Type 1C Attribute Table

Table 7. Dagger Number 7

Material: Texas Flint Edwards Plateau; Tabular Nodule

	Stage							
Attributes	*1*	*2*	*3*	*4*	*5*	**6*	*7*	*8*
Length - cm	40,5	38	34	33,5	32,8	32,8	32,5	32,5
Width at widest span - cm	19,5	17,6	14	9,2	5,1	4,8	4,5	4,4
Thickness at widest span - cm	2,7	2,7	2,5	1,7	1	0,9	0,8	0,8
Width to thickness ratio			1: 5	1: 5	1: 5	1 :5	1 :5.5	1 :5.5
Weight (g)					212,6	180,3	153,8	146,7
Total grinding strokes		*22,466 .						
Width lost from grinding - cm						0,3		
Thickness lost from grinding - cm						0,1		
Weight (g) lost from grinding						32		
Width lost from pressure flaking - cm							0,3	
Thickness lost from pressure flaking - cm							0,1	
Weight (g) lost from pressure flaking							26,5	
Width lost from final retouch - cm								0,1
Weight lost (g) from final retouch								7,1
Time per stage - min.	0 min.	30 min.	115 min.	287 min.	300 min.	263 min.	55 min.	30 min
Total Time								18 hrs.

Remarks: * Regarding grinding, each hour of mechanical grinding approximates 8,000 hand strokes. Dagger 7 was ground 3,400 strokes by hand, the rest was completed machanically (143 min.), adding an equivalent to 19,066 hand strokes. **Regarding time per stage, 120 minutes by hand plus an additional 143 mechanical. Blank boxes reflects no data collected.

Type 1C Attribute Table

Table 8. Dagger Number 8.

Material: Texas Flint Edwards Plateau; Tabular Nodule

	Stage							
Attributes	*1*	*2*	*3*	*4*	*5*	**6*	*7*	*8*
Length - cm	32,5	31,1	29,5	27,7	27,3	27,3	27,3	27,2
Width at widest span - cm	16,5	15,6	11,5	8,2	5,3	5,1	4,7	4,6
Thickness at widest span - cm	2,5	2,5	2,2	1,6	0,9	0,8	0,7	0,7
Width to thickness ratio			1 :5	1 :5	1 :6	1: 6	1: 6.5	1: 6.5
Weight (g)	2412	1958	1087	466	180	155,3	126,6	121
Total grinding strokes						*18,105.		
Width lost from grinding - cm						0,2		
Thickness lost from grinding - cm						0,1		
Weight (g) lost from grinding						24,7		
Width lost from pressure flaking - cm							0,4	
Thickness lost from pressure flaking - cm							0,1	
Weight (g) lost from pressure flaking							28,7	
Width lost from final retouch - cm								0,1
Weight lost (g) from final retouch								5,6
Time per stage - min.	0 min.	25 min.	90 min.	270 min.	310 min.	325 min.	34 min.	5 min.
Total Time								17 HRS. 39 MIN.

Remarks: * Regarding grinding, each hour of mechanical grinding approximates 8,000 hand strokes. Dagger 8 was ground 6,800 strokes by hand, the rest was completed machanically (85 min.), adding an equivalent to 11,305 hand strokes.**Regarding time per stage, 240 minutes by hand plus an additional 85 mechanical.Dagger broke during final retouch.Blank boxes reflects no data collected.

Type 1C Attribute Table

Table 9. Dagger Number 9.
Material: Texas Flint Edwards Plateau; Tabular Nodule

	Stage							
Attributes	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Length - cm	26	26	26					
Width at widest span - cm	22	17,5	11,5					
Thickness at widest span - cm	4	4	3					
Width to thickness ratio	2298	2071	1: 3.8					
Weight (g)	2298	2071	1164					
Total grinding strokes								
Width lost from grinding - cm								
Thickness lost from grinding - cm								
Weight (g) lost from grinding								
Width lost from pressure flaking - cm								
Thickness lost from pressure flaking - cm								
Weight (g) lost from pressure flaking								
Width lost from final retouch - cm								
Weight lost (g) from final retouch								
Time per stage - min.	0 min.	15 min.	85 min.					
Total Time								

Remarks: Dagger incomplete. Blank boxes reflects no data collected.

Type 1C Attribute Table

Table 10. Dagger Number 10.
Material: Texas Flint Edwards Plateau; Tabular Nodule

	Stage							
Attributes	1	2	3	4	5	6	7	8
Length - cm	29,5	29,5	29,5					
Width at widest span - cm	21,5	17	11,2					
Thickness at widest span - cm	3,1	3,1	2,9					
Width to thickness ratio			1: 3.8					
Weight (g)	2951	2262	1299					
Total grinding strokes								
Width lost from grinding - cm								
Thickness lost from grinding - cm								
Weight (g) lost from grinding								
Width lost from pressure flaking - cm								
Thickness lost from pressure flaking - cm								
Weight (g) lost from pressure flaking								
Width lost from final retouch - cm								
Weight lost (g) from final retouch								
Time per stage - min.		20 min.	92 min.					
Total Time								

Remarks: Dagger terminated after encountering pre-existing crack at the proximalend, extending longitudinally for 9 cm towards distal end and stopping in the middlezone.Blank boxes reflects no data collected.

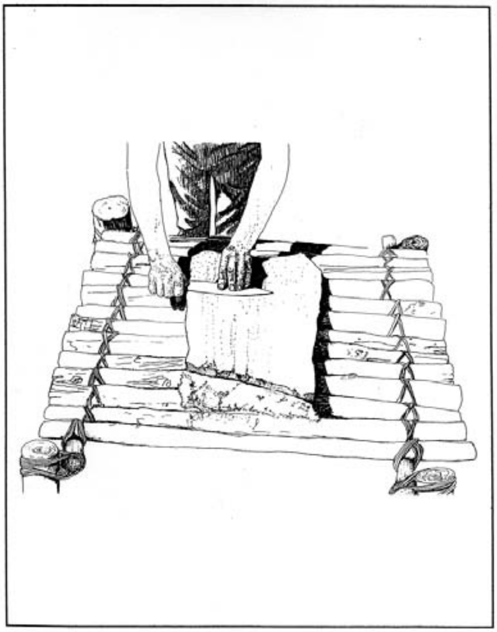


Figure 5. Author grinding a flint dagger on sandstone slab and Douglas Fir pole table.

Figure 6. Holding position used to make edge-to-edge pressure flakes.

The focus of information is on the later stages of manufacture; grinding and pressure flaking techniques (Figs. 5 & 6). Grinding and pressure flaking techniques are required to execute edge-to-edge parallel pressure flaking. The application of direct and indirect percussion thinning strategies on earlier stages one through three will for the most part be omitted. However, empirical data regarding weights and morphology is included to provide the reader with a continuum of the process (see Tables 1-10). In addition, for a complete range of tools used in all stages refer to figures 7, 8, and 9. For information on replicating stages one through four, see Callahan's *The Basics of Biface Knapping in the Eastern Fluted Point Tradition* (1979 & 2000). For an example of early reduction sequence stages one and two, see figures 10 and 11. It is critical one have a thorough understanding of the morphology of stages three through five (Figs. 12-14). The proper execution of precise direct percussion biface thinning in stages four and five will determine if the biface can be taken to stage six (grinding stage) (Fig. 15).

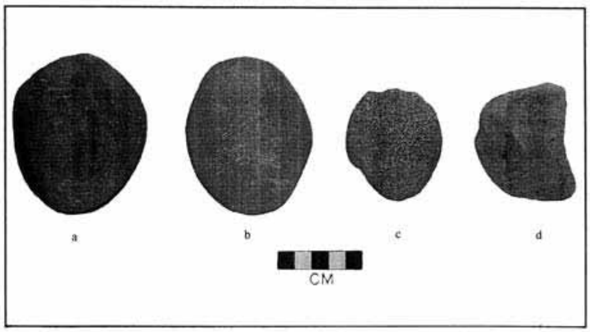


Figure 7. (a) Medium hard heavy sandstone hammerstone, 450 grams; (b) Soft sandstone hammerstone, 409 grams; (c) Soft sandstone hammerstone, 134 grams; (d) Sandstone abrader, 90 grams.

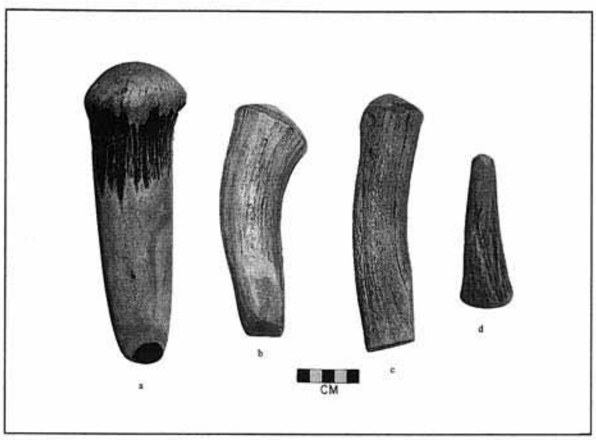


Figure 8. (a) Heavy moose antler billet, 810 grams; (b) Heavy moose antler billet, 545 grams; (c) Medium heavy moose antler billet, 410 grams; (d) Moose antler punch for indirect percussion, 96 grams.

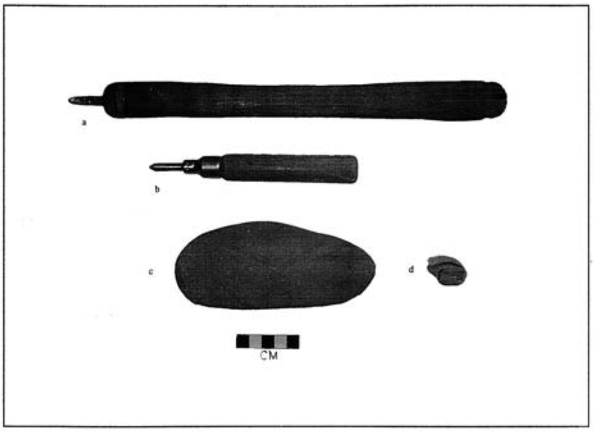


Figure 9. (a) Ishi stick pressure flaker with copper tip used for edge to edge pressure flaking; (b) Small pressure flaker with copper tip used for retouch; (c) Sandstone baton used with punch for indirect percussion, 383 grams; (d) Leather thimble worn on index finger.

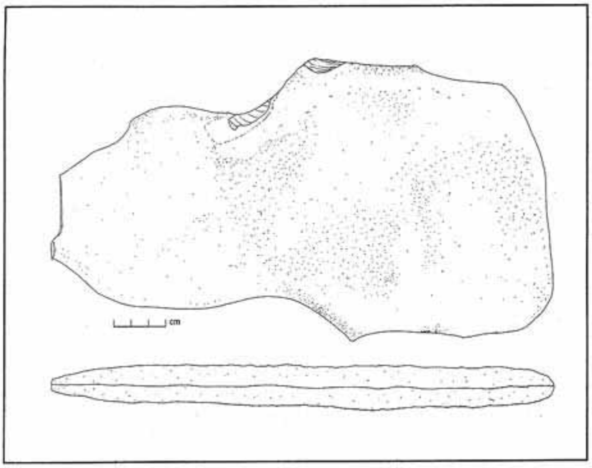


Figure 10. Stage one – unmodified Texas flint nodule; illustrated by Greg Nunn and Joe Pachak.

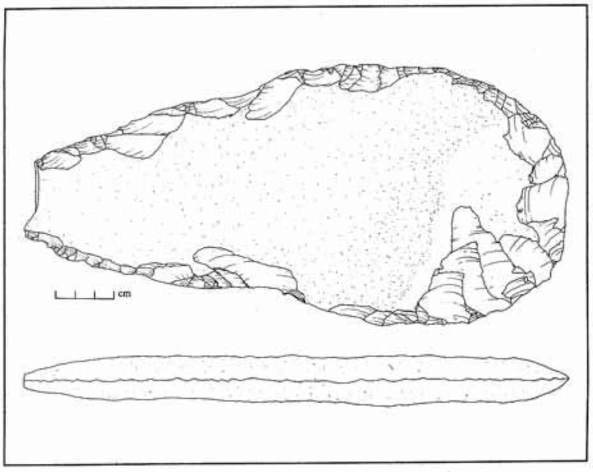


Figure 11. Stage two – initial edging, Texas flint; illustrated by Greg Nunn and Joe Pachak.

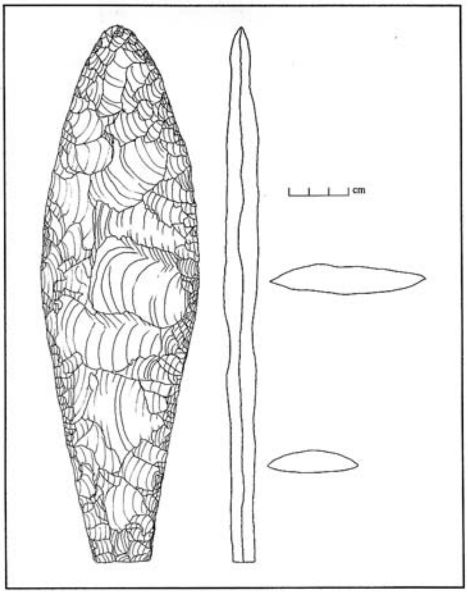


Figure 12. Stage three – primary preform, Texas flint; illustrated by Joe Pachak.

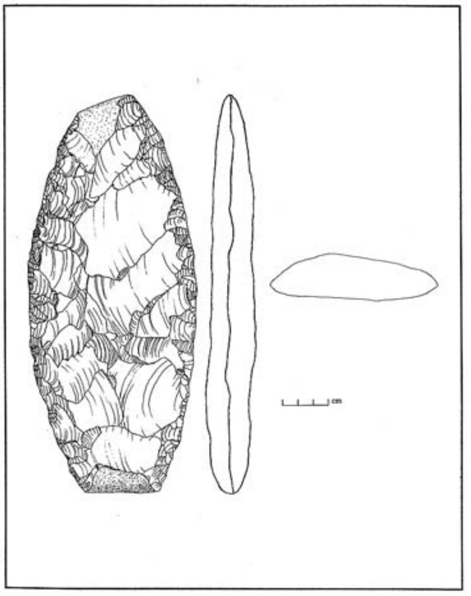


Figure 13. Stage four - secondary preform, dagger number eight, Texas flint; illustrated by Joe Pachak.

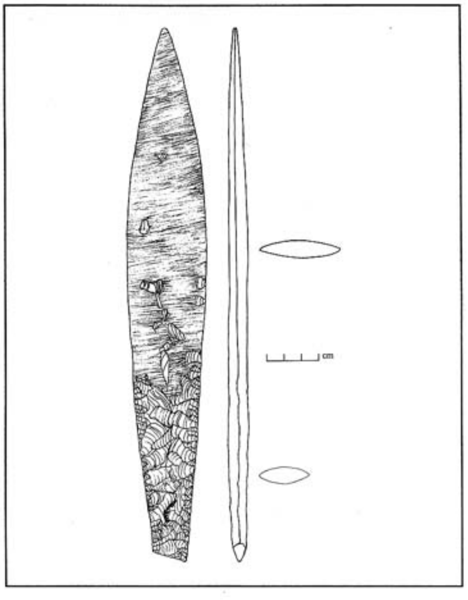


Figure 14. Stage five – final preform, dagger number seven, Texas flint; illustrated by Joe Pachak.

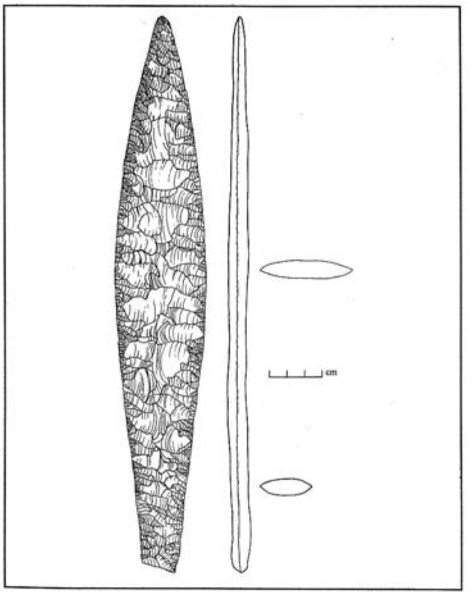


Figure 15. Stage six – ground preform, dagger number six, Texas flint; illustrated by Greg Nunn and Joe Pachak.

Overview

The knapper must take absolute command of thinning strategies in stages four and five. For example, if diving flakes are created into the middle zone (Callahan, Cliffside Workshop, 1999: Fig. 16) one has produced a concavity (negative flake scar) that will create a laborious hand grinding process. For more information on zones, see Callahan, Apel and Olausson's upcoming book *Neolithic Danish Daggers: An Experimental and Analytical Study.* The biface must be ground to the lowest plane of the deepest negative flake scar. If the biface is not properly thinned and left too thick, it will cause excessive grinding which will take many hours and several thousand extra grinding strokes. In cases such as these, the biface may lead to rejection before grinding is initiated. It is easier to grind out high spots than to grind out low spots. What is ultimately desirable is to create a stage five final preform with a lenticular cross section and an average width to thickness ratio of 1:5 to 1:6 (Fig. 14).

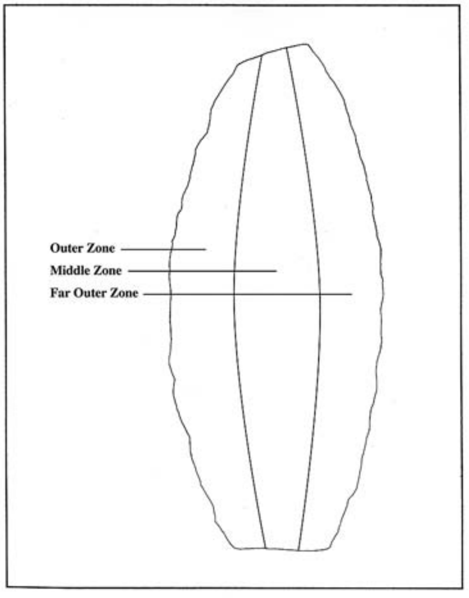


Figure 16. Outline of biface illustrating zones as indicated by E. Callahan:1999; illustrated by Greg Nunn.

Methodology – stage four

A valuable strategy from Errett Callahan in gauging biface contours and proper percussion flake removal is a technique that utilizes a straight wooden dowel (Callahan, Cliffside Workshop, 1991). The author prefers the dowel to be at least as long as the biface. The dowel is placed flat on the biface surface, tip to base, which reveals high spots and low spot problems for further flake removal. During this stage of direct percussion flake removal, using a large to medium large moose antler billet (Fig. 8a and c), flake removal should be well controlled, widely spaced and systematic. To achieve proper contours, the principal percussion thinning flakes to be removed should travel from margin to margin with feathered terminations (Fig. 17). The result prepares the biface for an ideal cross-section. Edge angle should range from 25 to 45 degrees (Callahan 1979 & 2000:30). Stage four widths to thickness ratios range from 1:4 to 1:5.

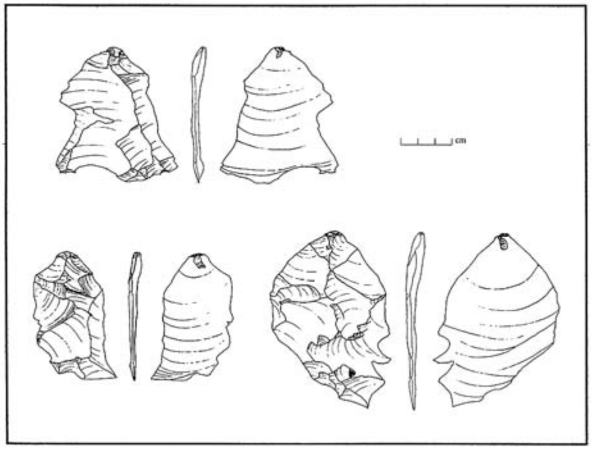


Figure 17. Stage four - three complete direct percussion biface thinning flakes from dagger number five; illustrated by Greg Nunn.

Methodology – stage five

The beginning of stage five will utilize the same flake removal technique as explained in stage four. There will be high spots on the surface of the biface in the middle of stage five. Using the wooden dowel as a contour gauge and direct percussion using a small soft hammerstone or medium moose antler billet (Figs. 7c & 8c), high spots will be systematically removed. In addition, these flakes will be smaller than the previous thinning flakes.

At this time, the knapper must be extremely cautious to prevent flakes from diving into the middle zone (Fig. 16) of the biface. Ultimately, feathered flake terminations are required.

After final direct percussion thinning has been completed it will be time for the final alignment of the lateral margin. Some pressure flaking will be required for the removal of deltas, ridges, overhangs, and concavities that have occurred in the outer zone. The outer zone is the surface area from the lateral margin inward one-third the width (Fig. 16). Assuming proper execution of percussion thinning has taken place, there will be very little pressure flaking for final clean up of the final preform.

Next, one creates opposing bevels on both lateral margins (Callahan 2001: Fig. 18) by removing small pressure retouched flakes up to 8 mm in length in succession along the entire margin. Place the pressure flaking tool .05 mm – 1 mm above the lateral margin and push downwards at a steep angle into the palm of the padded hand (Fig. 6). Creating opposing bevels will bring the margin line slightly below the centerline of the biface (Callahan Basics 1979 & 2000:34).

Final width to thickness ratios range from 1:4 to 1:6 and the final edge angle before grinding should be 25 - 45 degrees. The handle and blade should be the same thickness at the end of stage five (Fig. 14).

Methodology – stage six: grinding

Only in the Neolithic period did the technique of deliberate flake over grinding take place. Evidence is found in Neolithic Egypt with the Gerzean knives (Kelterborn 1984) and in Denmark with various types of Danish Daggers (Callahan, unpublished paper *A Successful Test Model of the Type 1 Danish Dagger* 1985 and personal communication 1991). Flake over grinding gives a clean and precise appearance, which has an aesthetic appeal. The grinding stage is time consuming and laborious. One must hand grind both faces of the dagger, excluding the handle. The author used sandstone in order to prepare the surface of the preform for pressure flaking.

It is notable that the use of sandstone slabs for grinding daggers has not been found in Denmark, or if so, has not been recorded as such (Apel, personal communication 2002). That verified dagger grindstone slabs have not been located is a missing link in the Dagger making process. However, archaeological evidence confirms that Type 1C Danish Daggers were ground (Fig. 4).

A high-quality grinding stone is difficult to obtain. One wants to get the most out of the implement, especially if it has been transported or traded over long distances. The author traveled 187 miles (300 kilometers) to acquire the ultimate grindstone from the Chinle formation (from the Upper Triassic) in Garfield County, southeastern Utah. The sandstone should be moderately bonded with silicate and composed mainly of quartz granules. During grinding, quartz granules should be continually released over the surface area to enhance cutting ability. The continual release of quartz granules will rejuvenate the surface and prevent it from glazing over. If harder sandstone is used, it will glaze over and require pecking to expose new cutting surfaces. Glazing over forms when high silicate content bonds the quartz granules together within the sandstone. The proper sandstone has a lower percentage of bonding silicate. The Chinle sandstone used by the author is approximately 50 grit, as compared to modern sandpaper.

By adding quartz sand to the grindstone, grinding time is reduced. Quartz sand acts as an extra cutting agent and rejuvenates fresh granules from the grindstone. In addition, it is necessary to continually add water to the grindstone while grinding the preform. If the additional quartz granules are too big they will cut the sandstone rapidly, reducing the life of the grindstone (Dagger Research Project 2002). Contrarily, if the grindstone is too hard, the quartz will shatter into smaller particles and not cut effectively. One needs to experiment in order to realize optimum grinding results.

Quartz sand was collected at the base of the Cretaceous Dakota sandstone horizontal cap that is a conglomerate composed mainly of quartz sand. The quartz sand particles are rounded from ancient geologic activities, which is a disadvantage in this application. Angular quartz granules cut the best. In addition, commercially crushed quartz masonry sand was used which is angular in structure and is available in 10 to 20 grit. Both Cretaceous quartz sand, and commercially crushed quartz masonry sand was used for all daggers. Errett Callahan used crushed burned quartz chunks and screened to size by hand (Dagger Research Workshop 2002).

Two sandstone slabs were used for this project. One slab measured 40 cm long, 23 cm wide and 6.5 cm thick. The slab was used solely for grinding four obsidian Type 1C Danish Daggers. A larger slab measured 50 cm long, 36 cm wide, and 6 cm thick, with a beginning weight of 19 kilograms and was used solely for flint daggers.

Sandstone slabs were placed horizontally on a table made of Douglas Fir poles (Fig. 5). Table legs were set in postholes 46 cm deep. The height of the table measured 75 cm, 80 cm long and 97 cm wide, and was assembled without the use of nails. The tabletop was lashed together with jute cordage. All initial cuts and tree felling were done with an eight-pound metal splitting mall. The final squaring of the tabletop was cut with a handheld bow saw to save time. A similar table could have been constructed in Neolithic times except for the use of metal cutting tools that could have been converted to flint axes and adzes. A rudimentary table such as a tree stump could also have been used (Madsen 1984).

Now that the final preform has been properly prepared it is time to grind the previously prepared 25 - 45 degree beveled lateral margin to a 90-degree margin using a handheld sandstone abrader (Fig. 7d). One can also grind the margin directly on the grinding slab, but there are disadvantages. Groves will be cut below the surface, which causes irregularities with long and deep striations (Dagger Research Project 2002). In addition, the preform cuts quickly into the slab and exhausts the sandstone faster, especially with flint.

Phases of grinding

Four phases of grinding will be described. A summary of each phase is provided, followed by detailed descriptions of each phase.

- Phase 1: Grind or abrade lateral margin.
- Phase 2: Moderately grind predominantly high spots.
- Phase 3: Grind from the margin edge to the outer zone (approximately 1 cm) removing deltas, ridges, and concavities.
- Phase 4: Major and final grinding of entire face except handle; final control of contours, cross section irregularities (high spots and negative flake scares), and grinding facets that may have been created.

Phase 1

Using a handheld abrader (Fig. 7d) the lateral margin is at first ground to 90 degrees and 1 mm thick. The purpose of grinding the lateral margin is to strengthen it so that when grinding in the outer zone and along the margin of the dagger, one will not chip the margin. If the margin is too thin, it becomes fragile and when the edge makes contact with the grindstone it will chip away and cause undesirable concavities along the lateral margin.

During phases 3 and 4 there will be considerable grinding from the outer zone and up to the edge of the margin. Because of this grinding, the margin will become thinner. It will again be necessary to regrind the margin to 90 degrees. Grinding the 90-degree margin will occur several times during the grinding process of each face.

Phase 2

Begin by grinding predominate high spots in the middle zone to a lower plane. This will take some effort. Initial grinding of high spots will range from 400 to 3,000 strokes depending on the material (obsidian or flint respectively).

Phase 3

Grind the outer zone approximately 1 cm from the margin edge and up to the margin edge. Grinding will focus on minute deltas, ridges, and concavities left over from earlier pressure retouch in stage five. As grinding continues in this area the lateral margin will become thinner. Once again, it will be time to thicken the lateral margin by regrinding it with a handheld abrader. As previously mentioned, thickening the lateral margin prevents chipping of the margin in future grinding. By this time one has easily accumulated an additional 3,000 – 4,000 strokes (using flint). In addition, grinding time will vary depending on problem areas and material used (obsidian verses flint). Grinding will continue up to the margin edge and to the outer zone for the finishing touches later.

Phase 4

The major grinding will now take place. Grinding may be ¼ completed. Phase 4 will take final control of the contours and cross section irregularities. Grind the remaining high spots and negative concavities.

When grinding the preform, it is important not to focus on one locale for a long period of time. If grinding continues for an excessive amount of time in one area a flat facet will result. A flat facet is undesirable and will take considerable labor to recontour (Madsen 1984). Any ridge remaining from the facet may cause the final series of edge-to-edge flake removal extremely difficult. The ridge can act as a wall and stop the flake short. Some areas of the preform will need more grinding attention than others. As with creating facets, it's important not to create low spots or shallow concavities. If one grinds too much of a concavity, this may also stop the final pressure flake short.

Grinding the handle of the preform is not necessary, nor was it elaborately pressure flaked. However the original Type 1C Danish Dagger's handle (Fig. 1) has occasional grinding striations, due to haphazard contact during the grinding process (Callahan's Type 1C Dagger Replication Class 1992). Grinding contact on the handle did not pose a problem for the Neolithic knappers because the completed daggers were sometimes covered with a wooden handle or other coverings (Jorgensen 1992; as per Apel 2001:254).

Detail of grinding process

When grinding, one takes long strokes in a back and forth motion along the longest axis of the grindstone (Madsen 1984:29). A stroke is defined by beginning at the lower end closest to the person grinding, pushing forward to the opposite end of the grindstone then pulling backwards to the person grinding. Grinding in this manner will result in contours comprised of consistent lenticular cross sections. In addition, facets and concavities will be prevented.

Hold the dagger handle in one hand and the distal portion of the blade in the other hand (Fig. 5). Begin the first stroke in the outer zone underneath the lateral margin edge farthest from you (Fig. 5). Apply pressure and push the preform away toward the opposite end of the grindstone. When pushing away, gradually rotate the biface in an arching manner so that when the biface reaches the opposite end of the grindstone, the margin closest to you will be making contact with the grindstone. Next reverse the stroke by pulling the biface backward toward yourself. Once again, rotate the biface gradually in an arching manner, so that when the biface returns to the starting position, the lateral margin farthest away will be making grinding contact with the grindstone. Most all the surfaces will be making contact during each stoke.

As previously stated, the grindstone the author used for flint daggers is 50 cm long. A stroke is the total of 100 cm. In addition, it will take a considerable amount of time to complete the first face. As grinding continues, the lateral margin will again become thinner. Toward the completion of grinding the first face and as the margin becomes increasingly thinner, it is advisable to decrease grinding pressure when grinding around the margin. One can stop using quartz sand and grind in a gentler fashion so as not to chip the margin. After all the high spots and most of the negative flake scars are removed, the first face is done. Ideally one should end up with both margins relatively sharp at the end of grinding the first face.

It is important to realize that eliminating all negative flake scars may be unattainable, especially with flint on the finished ground preform. It is likely remnants of negative flake scars will be visible. Visible negative flake scars are to a certain extent allowable (Fig. 4). If negative scars are shallow, the final series of pressure flakes may undercut beyond minor low spots. If negative scars are too deep the flake will not travel beyond concavities. Knowing the tolerance allowed will come with experience. There is a great deal of hard labor involved with grinding, therefore it is worth going the extra distance for the ultimate result.

The opposing face will begin the same as the first face, by grinding the lateral margin to 90 degrees. Once the opposite face is near completion, one must not regrind the lateral margin to 90 degrees. The final grinding should terminate with both lateral margins ground relatively sharp. The grinding stage is now complete. Width to thickness ratios should be an average of 1:5 to 1:6.

Stage seven: final pressure flaking

Stage seven begins by hand abrading opposing beveled margins to approximately 70 degrees and approximately 1 - 2 mm thick, so an accurate platform can be created for removing the final series of pressure flakes. Opposing beveled margins reduces the risk of overshot (Callahan 2001: Fig. 18).

With the knapper sitting down (Fig. 6), the preform is placed on a leather pad held in the left hand. The area of flake removal should rest firmly on the leather protected thumb muscle (Thenar Eminence). Contact with the Thenar Eminence and biface help extend flake travel. The back of the left hand is placed firmly against the inside of the left thigh and the back of the right hand is placed firmly against the inside of the right thigh.

The right hand contains a handheld Ishi stick pressure flaking tool with a copper tipped insert or antler insert (Fig. 9a). For this project, a copper tip was used. With the preform held in the left hand against the left thigh, begin at the right hand margin. Place the tip of the pressure flaking tool against the ground lateral margin and begin the pressure flaking sequence at the distal end of the preform. Flakes will be removed from tip to base. Apply pressure and remove the first pressure flake. Repeat the procedure for two more flakes, spacing them approximately 6.5 mm from the last flake removed from the margin. The first three flakes will generally not reach the opposite margin, but they should come close (within 2 mm). During early flake removal, if one pushes too hard it is entirely possible to shear the tip away.

Before removing the fourth flake, one must place the tip of the padded left index finger firmly against the opposite left hand lateral margin from where the pressure tool is placed to remove flakes. The author uses an industrial leather thimble, which straps over the finger (Figs. 6 and 9). The thimble has a protective strap encased with a flexible, non-visible lead shield that protects the fingertip (Cliffside Workshop 1991). The left index finger acts as an anvil for guiding flakes to travel in the proper direction. It is essential that the left index finger be padded. Padding prevents the pressure flake from penetrating the finger and helps absorb the pressure that is being applied to the finger from the pressure flaking tool.

To remove the fourth flake, (wearing the finger guard) place the left index finger against the opposite lateral margin at the very tip of the distal end (Fig. 6). Apply the tip of the pressure flaking tool to the lateral margin opposite the index finger at approximately a 77-degree angle (Callahan personal communication 1991; Fig. 1). Start by applying pressure from the pressure flaking tool and directing this pressure precisely towards the tip of the padded index finger. Slowly increase the pressure by leaning slightly into the flaking tool and adding upper torso weight. One approaches the upper pressure load limit by pushing downwards from the torso and squeezing thighs together, Crabtree style (1973:24), directing outward force, which detaches the flake. Most often the pressure flake shatters into two or three segments during detachment. On occasion they will stay complete (Fig. 18).

Remove the next flake by placing the tip of the pressure flaking tool approximately 6.5 mm from the last flake. Continue this process to the blade and handle junction. For the most part the handle is complete, except for final retouch and minimal shaping, which will be accomplished in stage eight.

After the first series of pressure flakes have been completed the right hand lateral margin is somewhat irregular with sharp edges and deltas (Fig. 19). It is important to slightly retouch and straighten the right hand lateral margin. By using a small pressure flaking tool (Fig. 9b) remove the remaining protruding deltas and margin irregularities. Remove short retouch flakes at a steep angle as not to intrude into the outer zone more than 1 mm. After minimal retouch and edge straightening is complete, the margin should be somewhat sharp with minimal opposing bevels that will still help reduce the chance of overshot. If the margin is left irregular, it can lead to unsuccessful edge-to-edge flaking for the second face. Similarly, margin irregularities can lead to improper placement of the padded left index finger, giving the pressure flake being detached the wrong message. The padded index finger acts as an anvil and flake direction guide. Improper placement can lead to massive overshot and premature flake detachment. In addition, improper placement can change the angle of flake travel and/or collapse the sharp edge where pressure is being applied with the index finger.

The second face is a repetition of the first. After the second face is complete, remove deltas and straighten lateral margin (same as above). Next create slightly opposing bevels on both right hand lateral margins for preparation of final retouch (stage 8). Width to thickness ratios can vary from 1:5 to 1:7.

Stage eight: final retouch

If proper execution of edge-to-edge pressure flakes were accomplished there will be very little final retouch. If edge-to-edge flakes were not accomplished it will take a little more work and time to remove any left over grinding striations in the outer and middle zones that were not removed during stage seven. Abrade both opposing bevels along the left hand lateral margins to about .5 mm thick. Holding the dagger flat on the padded left hand, final retouch will begin by removing small to medium pressure flakes. To remove small pressure flakes, begin at the blade to handle transition area along the left hand margin and proceed left to right to the distal end. Using an Ishi Stick or small pressure flaking tool with a sharp tip, remove any grinding striations that weren't successfully removed during stage seven. This will initiate the sharpening process. After the retouch flakes have been removed from both left hand margins there will be some remaining deltas. Remove the deltas using a small and sharp pressure flaking tool at a steep angle. When deltas are removed, the dagger will be nearly finished and relatively sharp. Lastly comes some minimal final shaping of the handle, along with dulling the handle margins by abrasion for hafting or use. The handle will be slightly thicker than the blade (Figs. 1, 20-22). Final width to thickness ratios can vary from 1:5 to 1:7. Note: Fig. 21 (dagger 8) broke during final retouch. The dagger broke because the margin was slightly above center and the pressure flaking tool was blunt. Breakage occurred during flake detachment. Fig. 22a and b are completed daggers (numbers 3 and 5).

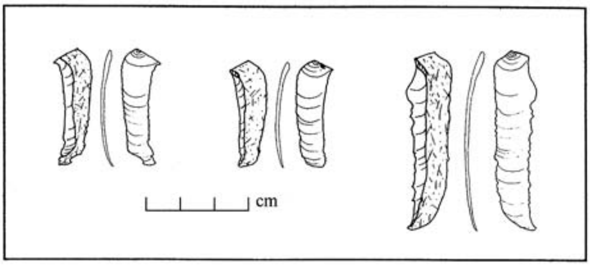


Figure 18. Stage seven - three complete edge-to-edge pressure flakes from dagger number eight; illustrated by Greg Nunn.

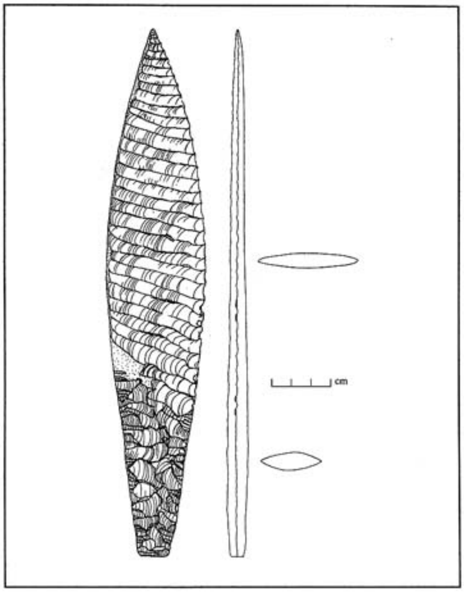


Figure 19. Stage seven – after first series of pressure flakes, dagger number eight; illustrated by Greg Nunn and Joe Pachak.

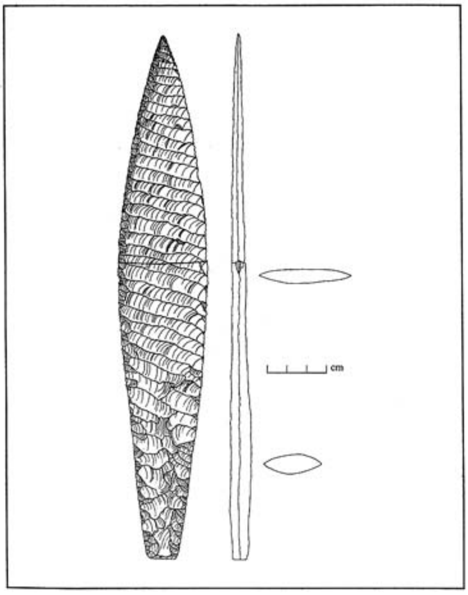


Figure 20. Stage eight – dagger number eight; an excellent example of edge-to-edge flaking which broke during final retouch; illustrated by Greg Nunn.

Figure 21. Photograph of dagger number eight.

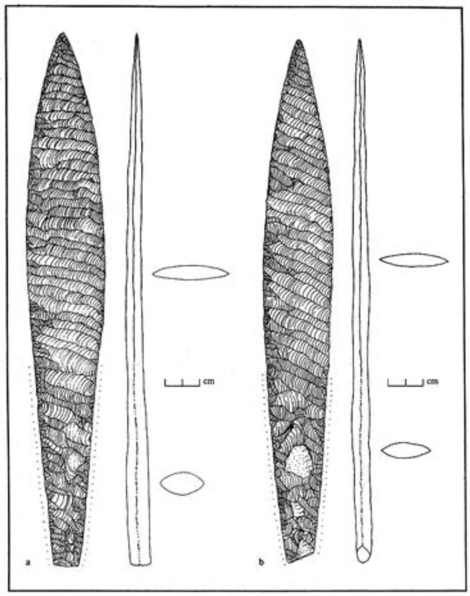


Figure 22(a) Completed obsidian dagger number three; (b) completed flint dagger number five; illustrated by Greg Nunn and Joe Pachak.

Presentation of data

Grinding

The number of grinding strokes to complete each dagger was recorded. An average of 1,700 strokes per hour was accomplished. It is possible to complete more strokes per hour, but one is continuously evaluating and recording the progress. Evaluating the progress reduces grinding time.

All obsidian daggers were ground on Chinle sandstone enhanced with approximately 20 grit equivalent quartz sand. Before grinding, the grindstone's greatest length was 40 cm, greatest width 23 cm, and greatest thickness 6.5 cm. Upon completion of grinding four obsidian daggers, a total of 4 cm in thickness was lost from the grindstone. Weight data was not retrieved.

A small obsidian final preform (dagger 2) 23 cm in length, the greatest width of 5 cm, and the greatest thickness of 1.1 cm was ground. This dagger required a total of 4,800 grinding strokes, equaling the distance of 3,840 meters or 3.84 kilometers. An average of 1.6 mm in thickness was lost from grinding (Tab. 2).

A moderately sized obsidian final preform (Fig. 22a; dagger 3) the length of 31.5 cm, greatest width of 5.3 cm, greatest thickness of 1.1 cm, required 7,300 strokes, equaling the distance of 5,840 meters or 5.84 kilometers over the grindstone (Tab. 3). An average of 2.0 mm in thickness was lost from grinding.

A large obsidian final preform (dagger 4) the length of 35.5 cm, greatest width of 6.5 cm, and greatest thickness of 1.3 cm, required 8,700 stokes, equaling the distance of 6,960 meters or 6.96 kilometers over the grindstone (Tab. 4).

The flint daggers were ground on Chinle sandstone (from the Upper Triassic) enhanced with approximately 20 grit equivalent quartz sand. Before grinding, the grindstone's greatest length was 50 cm, greatest width 36 cm, and greatest thickness 6 cm. Weight before use was approximately 19 kilograms. Upon completion of grinding one flint dagger, a total of 3.5 cm in thickness was lost from the grindstone. The final weight of the grindstone is approximately 8 kilograms.

A moderately sized final preform (Fig. 22b; dagger 5) was made of heat-treated Texas flint. Texas flint was heat treated to a lithic grade of 3.0 (Callahan 1979 & 2000:16). The length of the preform was 31.2 cm, greatest width of 4.5 cm, and greatest thickness of 1cm. The preform required a total of 28,000 grinding strokes, equaling the distance of 28,000 meters or 28.0 kilometers over the grindstone. An average of 1.4 mm in thickness was lost from grinding (Tab. 5). Note: Tables 1 and 6-10 are provided for comparative analysis.

Summary

Data provided in this paper indicate grinding flint is labor intensive compared to obsidian. The obsidian dagger preforms ground with quartz sand developed deep striations in the dagger. Additionally, the biface was pitted and very course in appearance. Grinding the face to a smooth surface on bare sandstone (i.e., no quartz sand added) alleviates major striations and pitting that may default extended flake travel. Extra grinding of approximately 500 strokes without sand gave the obsidian a semi-polished appearance.

The flint dagger preforms that were ground with quartz sand had some pitting and crushing, but striations did not cut as deep, and took on a more polished appearance. However the final grinding cleanup of the deep striations on the flint preform was not necessary and it flaked quite well without extra grinding.

Using the quartz sand particles definitely decreases the longevity of the grindstone. Two flint daggers could be ground on the large grindstone without using the quartz sand. However, sandstones are abundant in the southeastern Utah region, so quartz sand was used to expedite the grinding process.

If the archaeologist assumes grinding occurred in one location over a continuous period throughout Neolithic manufacturing sites, it may be possible to isolate horizontal stratigraphy of grinding episodes. An indication will be debris that was created from slurry with sand particles from disintegrating grindstones. A broader stratigraphy will be present if an extra grinding agent (such as quartz sand) was added. The author's debris pile (under the table) from grinding five daggers was 100 cm long, 70 cm wide, and 11 cm in the deepest portion of the debris pile.

Although flint is labor intensive to work with, it provides a better medium for accurate replication. The author has found the Texas flint used in this study most closely resembles Danish flint. Dagger quality Danish flint is not readily available to this author; however, a spall of Danish flint from Falster, Denmark was acquired (complements of Errett Callahan) for a comparison analysis with the heat-treated Texas flint. A miniature Type 1C dagger replica was made using the Danish flint. Although data was not collected, the Danish flint is a superior knapping stone.

Physical disadvantages to grinding

After hand grinding five daggers over a three-week period, the accumulating effects essentially left the author's left hand useless for six weeks. Loss of dexterity, severe pain, and weakness in the metacarpophalangeal joints, (MP joints) associated with the middle and index finger of the left hand resulted in barely being able to lift a glass of water. Four months later the author was still far from healing. Damage was mainly caused from grasping daggers with the fingertips while grinding. As a result daggers six through eight were ground 2/3 complete mechanically and 1/3 by hand for finishing touches.

Current thought suggests dagger production was configured as an apprentice system (Apel 2001*a*:45). Therefore it is possible to speculate that master knappers did not grind daggers, and that grinding was assigned to apprentices. In addition, the number of apprentices and rates of dagger production are not known.

Flint dagger number five took 16.5 hours to grind. If the author were to grind two large flint daggers per week, over a brief time he would likely become seriously or permanently disabled. It is natural to speculate whether another method of grinding was used. Rather than on a slab by hand, could there have been another apparatus or semi – mechanical process? Could there have been a wheel involved? By observing grinding striations on the original Type 1C Danish Daggers, quantitative data may lead one in an appropriate direction for further research on this subject.

Physical disadvantages of pressure flaking

Although the left index finger is highly padded, intense pressure from the flaking process results in severe nerve damage to the distal portion of the index finger. After making several daggers, the knapper will experience a complete loss of feeling in the tip of the index finger for several weeks. Experimentation in knapping holding positions is indicated in order to alleviate this side effect.

Conclusion

The author explained in detail the replication process of parallel edge-to-edge pressure flaking using the Jutland Type 1C Neolithic Danish Dagger as a model. Included is detailed information on stages four through eight, ending with the completion of the replication process. Empirical data is the basis for the interpretation of the replication process (Fig. 23).

Although replication is possible given current knowledge, further research is indicated to consider other possible techniques. For example, did they have a wheel for grinding? What other holding techniques could have been used for parallel edge-to-edge flaking? Continued studies and experimentation will answer these and other questions, bringing professional knappers and archaeologists closer to a complete understanding of the manufacturing mysteries contained in these exquisite daggers.

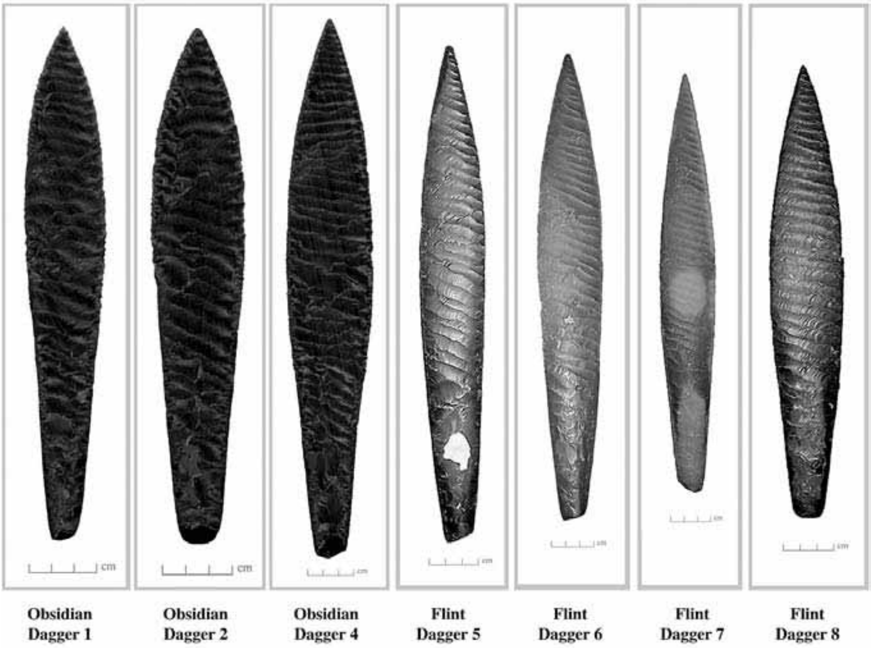


Figure 23. Group photo of all completed daggers excluding dagger number three; photographed by Jody Bierschied.

Addendum

After completing this research project, the author had the opportunity to analyze the original Type 1C Daggers at the Danish National Museum in Copenhagen, Denmark. The analysis revealed significant insights into the grinding aspects of the grinding stage. The grinding stage is basic to technological aspects of dagger production, and vital for completing a prestigious Type 1C dagger.

The original ground preforms show dominate vertical grinding striations (fig. 24) that are perpendicular with north and south poles of the ground preform. The angles of the striations vary from 70 to 90 degrees (fig. 25). In addition, the lateral margins display considerable grinding damage due to this technique (fig. 26), more so than the horizontal grinding technique (Fig. 5).

Figure 24. Original Type 1C ground preform. (National Museum of Denmark, Copenhagen, Museum number A 27691); photographed by John Lee.

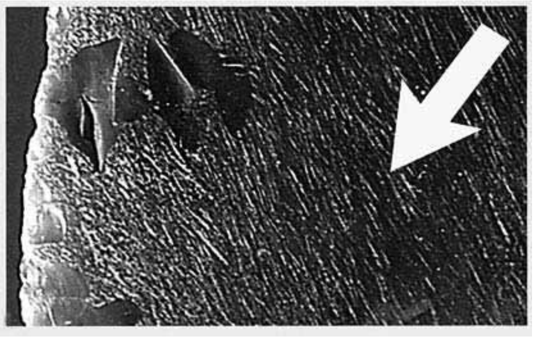


Figure 25. Close-up of original Type 1C ground preform showing grinding striations. (National Museum of Denmark, Copenhagen, Museum number A 27691); photographed by John Lee.

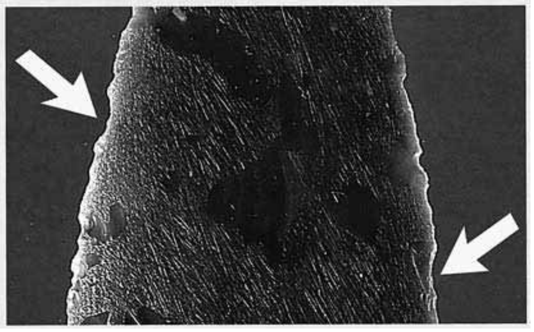


Figure 26. Close-up of original Type 1C ground preform showing grinding damage along the lateral margin. (National Museum of Denmark, Copenhagen, Museum number A 27691); photographed by John Lee.

To begin accurate replication of original grinding evidence, one must address how to hold the dagger during this stage. As previously indicated, grasping the thin preform with the finger tips causes damage to the hands. A holding devise that will fit within the Neolithic time period was created (Fig. 27a and b). This device encompasses a two part system (Fig. 28a and b). Part A consists of a handle which is comprised of a straight pine branch, 25 cm long by 6 cm in diameter. One quarter of the branch is split down the entire length which creates a continuous semi-flat surface. The surface is then sanded flat to receive part B (receiver). The receiver is comprised of a length of the heart section of a straight pine branch, 29 cm long by 1.5 cm thick and approximately 3 cm wide, which has been sanded smooth on both faces.

The receiver must be narrower than the width of the preform and somewhat resembles the preform in outline.

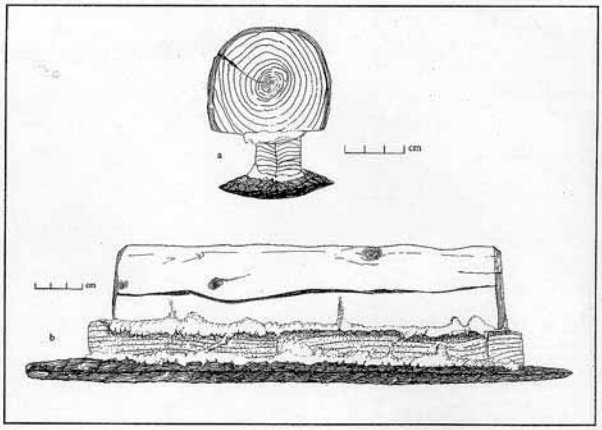


Figure 27(a). Front view of holding devise, (b) side view of holding device; illustrated by Joe Pachak.

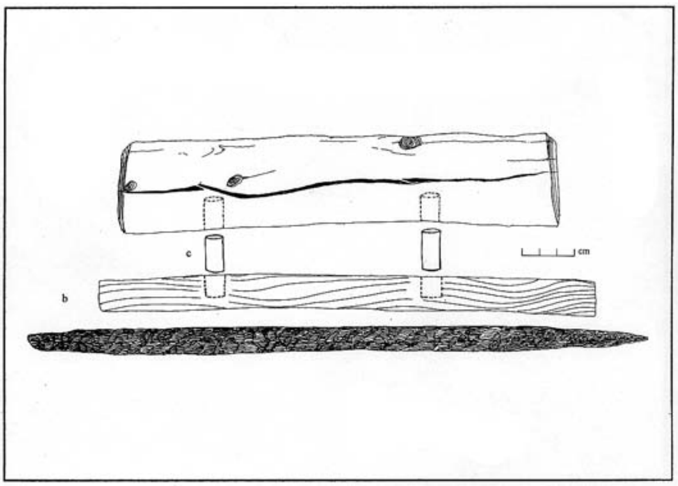


Figure 28(a) and (b). Side view of two part handle system; illustrated by Joe Pachak.

Two holes are drilled and matched into both the handle and receiver (Fig. 28a and b) .75 cm in depth. Next, two wooden posts (Fig. 28c) 1.5 cm long are inserted with a tight fit into the drill holes of the handle.

Hot bees wax or pine pitch is applied to the face of the handle and one face of the receiver. While the glue is still hot, both the handle and the receiver are joined together with the handle post inserted into the receiver holes. Using the post and organic glue is insurance for a secure fit and eliminates any movement.

After the handle and receiver are secure, the organic glue is applied to the second face of the receiver. In the meantime, the final preform has been pre warmed (approximately 66 degrees centigrade) next to a camp fire or in an oven. While the preform is still warm, it is applied to the second face of the receiver with the coating of organic glue. The face of the warm preform will then melt into the glue coating. At this time there will be voids between the preform and the receiver. All voids will then be filled with a final application of the organic glue and then set aside to cool and harden. The cooling takes about 10 minutes. After cooling, the preform is ready to grind.

The holding device (Fig. 29) works well and alleviates physical disadvantages to the hands. In addition, grinding time is slightly decreased. The author's stage six ground preforms mimic the original stage six ground preforms in all attributes.

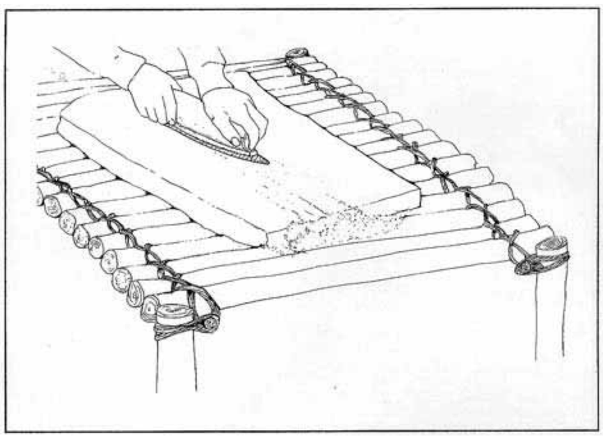


Figure 29. Holding devise in use; illustrated by Joe Pachak.

It is probable, most if not all original Neolithic Type 1C ground preforms developed grinding damage along both lateral margins (Fig. 26). This damage was to be expected, and therefore would destroy the time consuming opposing beveled lateral margins that the author prepared earlier in stage five (Fig. 14). Therefore it is not necessary to prepare the opposing beveled platforms along both lateral margins in stage five. Rather, it is at the beginning of stage seven when the edge damage is eliminated by the removal of small pressure flakes (approximately two to three mm long) from both left hand lateral margins. Concurrently, two continuous opposing beveled platforms are created using pressure retouch (Fig. 30).

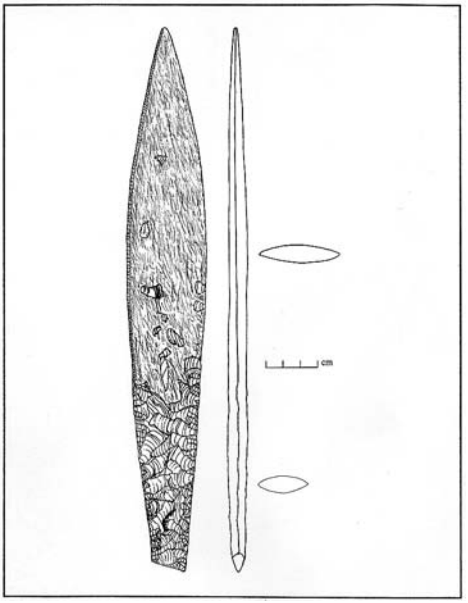


Figure 30. Stage seven ground preform with opposing beveled platforms created with pressure flaking: illustrated by Greg Nunn and Joe Pachak.

The insights regarding grinding discrepancies and opposing beveled platforms gained from analyzing the original daggers brought important new information into the production processes in stages six and seven.

Acknowledgements

I'd like to thank Keith and Jackie Montgomery of Montgomery Archaeological Consultants (MOAC), for their lab equipment and initial proof reading of the manuscript. In addition, Jan Apel, Errett Callahan, Jackie Montgomery, Jody Patterson (MOAC), and Dan Stueber provided technical assistance. Thanks to Joe Pachak and Errett Callahan for illustrating many of the figures. Jody Bierschied supplied digital photos. Theresa Breznau and Jenny Carlson provided computer imaging and scanning assistance regarding the figures. Special thanks go to Peter Vang Petersen of the National Museum of Denmark, Copenhagen for access to the museum's dagger collection. Furthermore, I would like to acknowledge Errett Callahan for providing illustrations and photos of original artifacts, providing a good deal of information which formed the basis of the manuscript, and proof reading the manuscript near its completion. Most of all, a heart felt thanks goes to my beloved wife, Karen Clark for her editing and typing skills, and her absolute support throughout the project.

Errett Callahan

Neolithic Danish Daggers: an experimental peek

Introduction

This report is a visual summary of 25 years of experimental research into the production of prestigious, Type IV Neolithic Danish daggers. Though only 66 figures are shown here, the ongoing research has entailed the examination of many hundreds of original daggers, the detailed analysis of 49 originals, the production, to date, of 242 replicas, and the detailed analysis of 88 of these examples. This experimental approach was done so as to devise a hypothetical "Production Model" which could yield accurate replicas and so explore some means by which the originals may have been produced.

In conjunction with the present report, a broader study has been implemented which entails examination of the full technology hypothesized to have been involved in dagger production in the past and a detailed analysis of the resultant debitage, executed by Jan Apel. This research is intended to lead the way to a prediction of the archaeological evidence that should be found at a Type IV production site, none of which has yet been located. It is our contention that unless the replica performs and finished daggers match the original data and qualitynof the originals, and so reflect the archaeological reality, then the experimental production debitage has little meaning. Thus this study required decades of skill improvement before the present conclusion could be presented (Apel 2001*a*).

This report visually depicts the appearance of some finished originals, some known archaeological performs, and some replica performs and finished daggers, stage by stage. Emphasis is given to several procedural models for realizing the complex transition between Stages 4 and 5 (Secondary Preform to Final Preform). The final stages of precision pressure flaking and edge treatment of blade and handle are also presented.

Originals and practice pieces

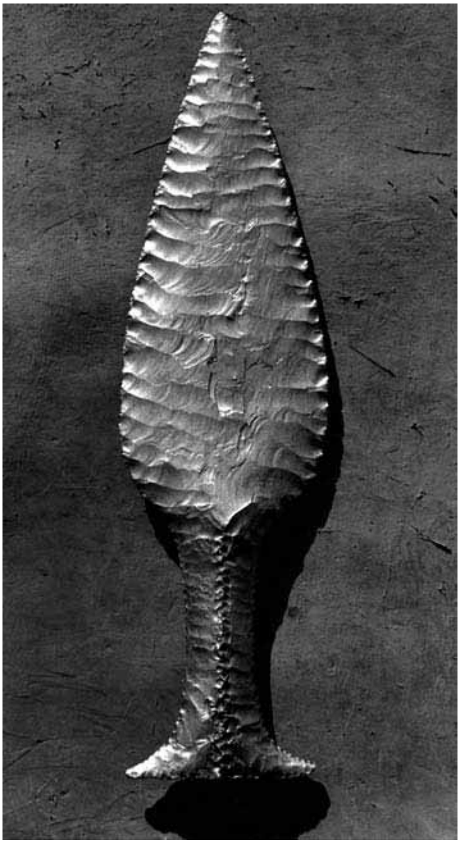


Figure 1. Photo of dagger replica #120, by author, 1992. The author´s best, full-sized, Hindsgavl replication. Obsidian. 29,3 cm. Also see figure 64. Peter Kelterborn collection (study #31).

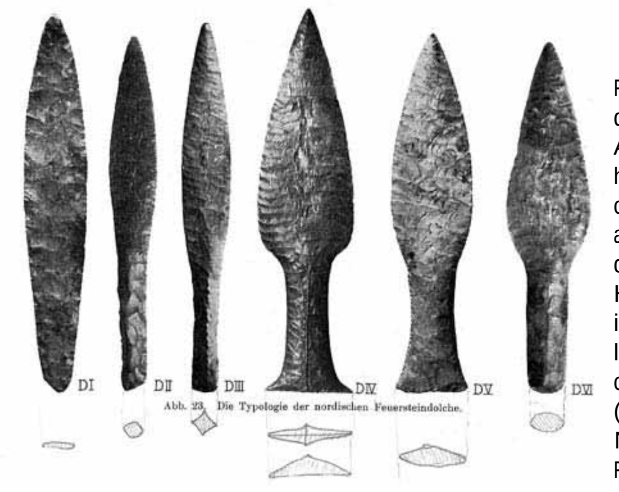


Figure 2. The Basic Six dagger types. D IV, from Alnarp, Sweden, dubbed here as “elegance”, is considered by the author as the third best Type IV dagger known, after the Hindsgavl and Skatelöv. It is with Type IV that Neolithic knappers sterted copying bronze daggers (from Forssander 1936). Note orientation. (see Figure 60)

Figure 3. Replica of Type I-C dagger mande by author in 1994, featuring edge to edge pressure flaking from right sides and characteristic retouch from left sides, as needed. Such replication of other dagger types provided critical practice for the author for Type IV work (See Nunn this volume & Callahan 2001). (Dagger #103; 32,1 cm).

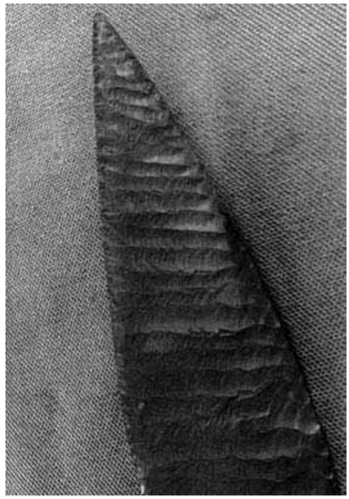


Figure 4. Close up of another Type I-C replica made by the author, showing detail of uni-directional, edge to edge flaking. Not until this technique was under firm control did author feel he was ready for the much more difficult Type IV flaking. Naturally, such was not the case in the past due to the time gap between the types. (Dagger #122).

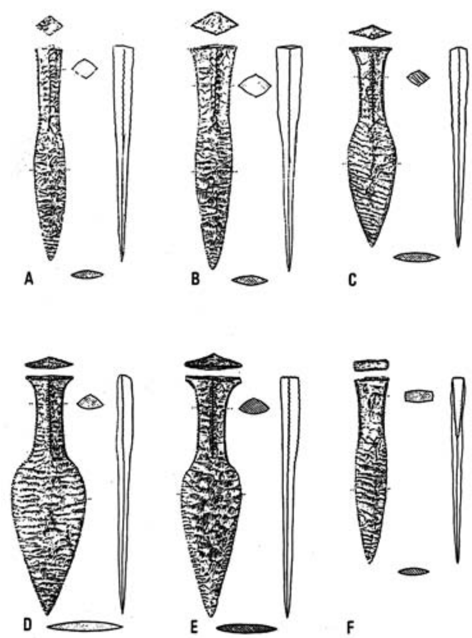


Figure 5. Sketch of the six Type IV Sub-Types. Our concern was with Types C, D, and E. (From Lomborg 1973).

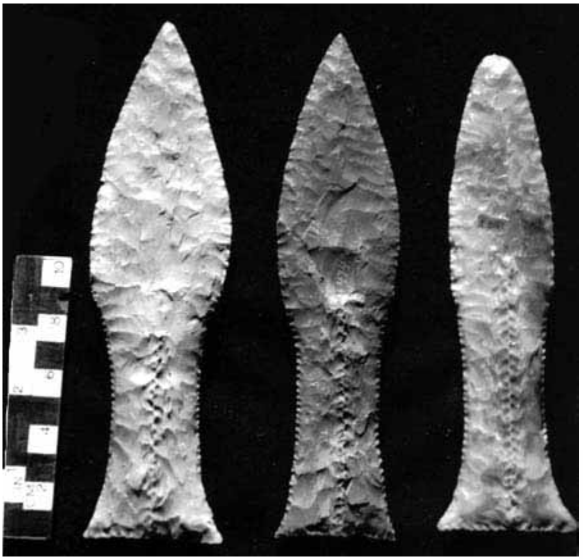


Figure 6. Three examples of what the author considers are “ordinary”, as opposed to “prestigious”, Type IV daggers. Most type IV daggers are under 20 cm in length (see Apel 2001) and of limited surface control, while virtually all prestigious daggers are over 20 cm and with well-controlled surfaces. These daggers are, from left to right: 19,3; 18,9 and 18 cm. (DNM #A272, Z474, and A10169).

Figure 7. A bronze dagger of the type imitated by the Type IV and V fishtails. The modern stitched leather handle wrap shown here is one hypothetical explanation of stitching on flint originals. This is a modern casting in bronze of an original, found in England, made by Simon Fearnham of England, in the collection of the author (28,0 cm).

Figure 8. The famous Hindsgavl dagger in the Danish National Museum, Copenhagen. Designated as a National Treasure. (DNM#A33093). Photo: The Danish National Museum, Copenhagen.

Figure 9. The infamous Skatelöv dagger in the State Historic Museum, Stockholm, Sweden. It exceeds the Hindsgavl (at 29,6 cm) by 6,5 cm, totalling 36,1 cm and is the longest Type IV known. It is also wider and thinner. Both were probably made by the same knapper. For undetermined reasons, this national Swedish treasure has been removed from public display since 1989. The author strongly urges that it be put back in the limelight so that Swedes may enjoy their National Treasure, which is no less elegant than Denmark's Hindsgavl dagger. (SHM #12750) (S-1). Photo: The State Historic Museum, Stockholm.

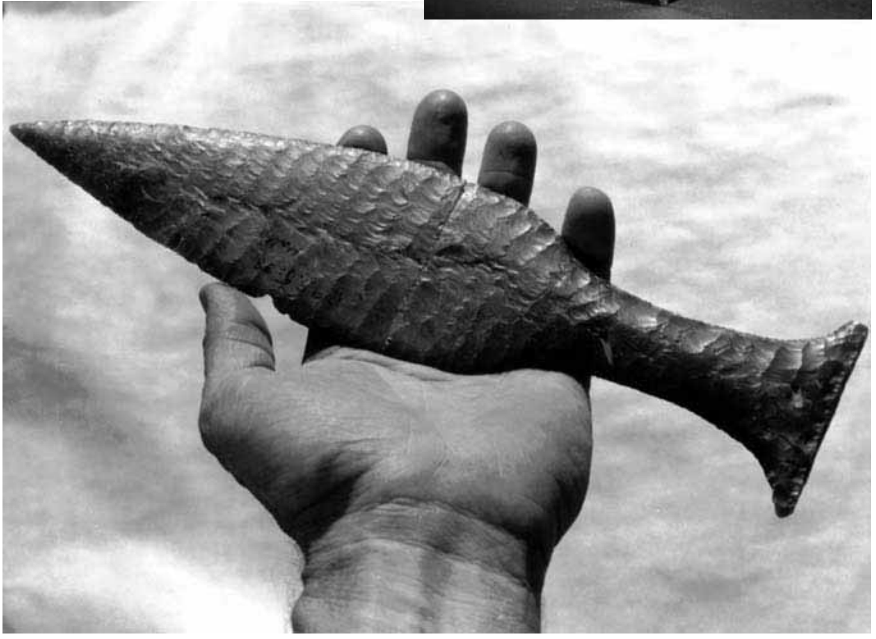


Figure 10. The Köinge dagger from halland, Sweden. In outline and in length-width ratios of blade and handle, this dagger is almost exactly the shape of the "average" prestigious dagger, as analysed in this study. It is thus more typical than the Hindsgavl in outline. It seems identical to the Skatelöv in style of surface treatment. (SHM #8325:38). (S-1) 31,2 cm.

Original Stages

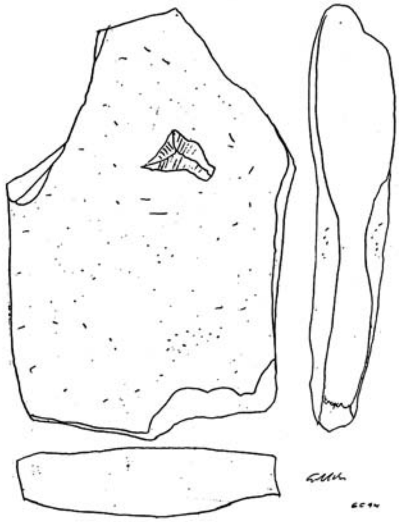


Figure 11. Geological example of an unmodified Stage I Blank. This is a nodular piece of flint ideal for dagger production, 30,6 cm.

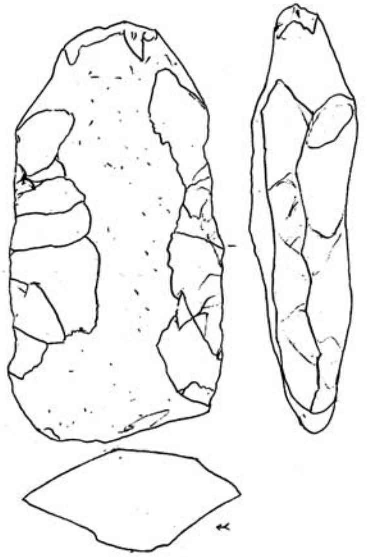


Figure 12. Original Stage 2 Rough Out preform such as might be used for any type of dagger. This piece is knapped on outer zones and incompletely worked. The wide base here is especially suitable for fishtail types. (Malmö Museum MM 16), 18,5 cm.

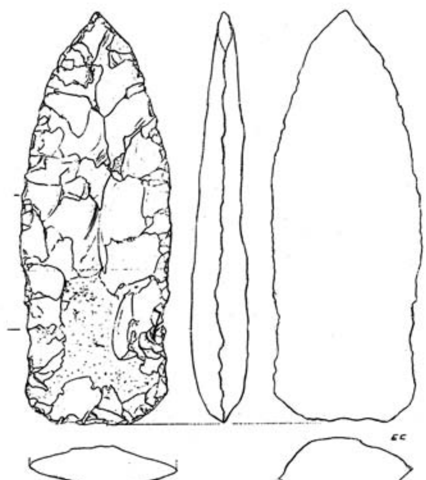


Figure 13. Original Stage 3 Primary Preform such as would be ideal for Type IV or V daggers. Note handaxe-like configuration, parallel handle outline, fliking to middle zone on blade, and lack of notable thickness distinction between blade and handle. This preform has been on display as a preform at the Danish National Museum opposite the Hindsgavl for years. (DNM #A12294) 25,9 cm.

Figure 14. Original Stage 4 Secondary Preform such as would be ideal for Type IV or V daggers. Note that, Whereas the outline may be little changed from Stage 3, the thinness of the blade and thickness of handle distinguishes it from that stage. (See Figs 28 & 30 for examples of this. LHM #25582).

Figure 15. Original, nearly finished Stage 5 Final Preform of modest size and width. Suitable for Type IV or V. (It is the author's contention that both types were probably made at the same workshops, the Vs being the "economy" model.) (LHM #24583).

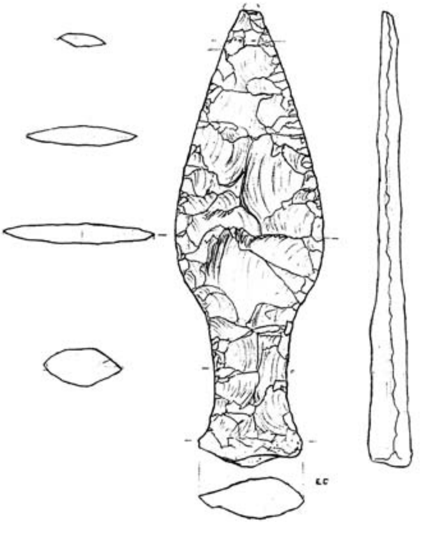


Figure 16. Original Stage 5 Final Preform ideal for a prestigious Type IV D or E dagger. (DNM #27966) 23,3 cm.

Experimental setup, debitage, and tools

Figure 17. View of flintknapping arena by the Old Historic Smithy at the Lejre Experimental Center, Denmark 2004. Forge has now been converted into a storage/office space for visiting flintknapping scholars. Fenced in area is where the author, shown here with legendary Danish knapper Søren Moses and family, knapped in recent years. The author has conducted dagger knapping tests at Lejre numerous times since 1978. Ljre funded the author's recent visit there in 1993 and 2003–2005, as public observed. The Pottery beyond houses researchers, as well as exhibits and pottery demonstration areas.

Figure 18. Layout of daggers and preforms produced by the author and the Dagger Research Team during the work-shop at the author's home, 2002.

Figure 19. Layout of dagger pro-duction debitage, organized by stage, as produced and analysed by the Dagger Research Team, as directed by jan Apel, at the author's home, 2002.

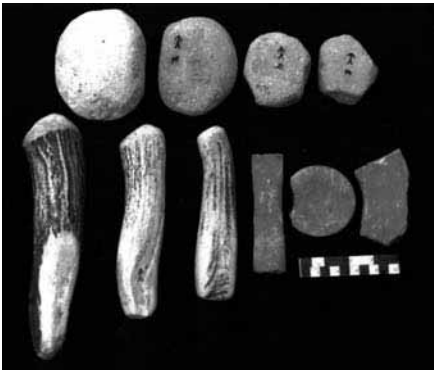


Figure 20. Hammerstones, antler billets, and abraders used by the author for dagger production in this study.

Figure 21. Pressure tools used by the author for dagger production in this study. Ishi stick to left has antler tip insert. Others have copper tips, which the author feels simplifies the work tenfold. Copper was available during the Late Neolithic period in Scandinavia.

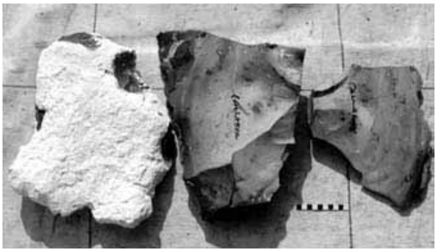


Figure 22. The three forms of Danish Senonian flint blanks (Stage 1) suitable for dagger production. From left to right: nodule, block core, and spall.

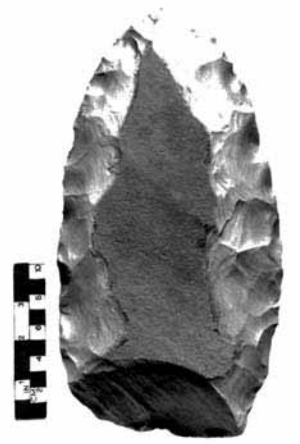


Figure 23. Ideal Stage 2 Rough Out replica as produced from a thin blank. Emphasis here is upon creation of outer zone flakes with a relatively centered edge. Shape is irrelevant at this stage. (Dagger 228, #82).

Figure 24. Core Blank produced from large block of irregularly-shaped material. This is now ready for Stage 2 reduction. (w/o #).

Figure 25. Ideal, extra-wide, Stage 3 Primary Preform replica, as produced by author in 2005 of Lolland flint donated by Master Danish knapper, Thorbjørn Petersen. (#05EC36) 28,8 cm.

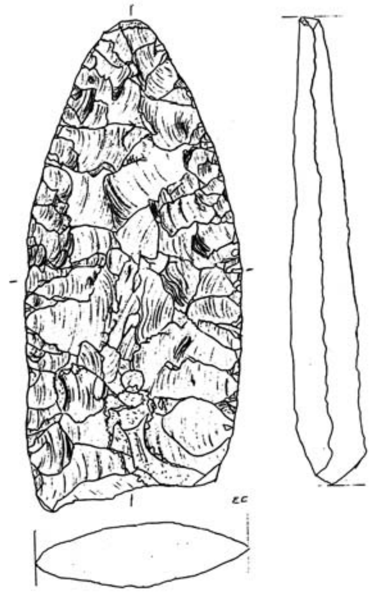


Figure 26. Sketch of typical Stage 3 Primary Preform replica in flint showing cross-sections. Note handaxe-like profile and thickness, but with parallel-sided handle area. This is the first stage in which a certain shape is required. Up to this stage, the preforms for Types IV and V are identical. Differences become evident in the forthcoming stages (though last-minute switching from IV to V is possible). 27,2 cm. (Compare with Fig. 13) Dagger 154 (#50), 99% soft hammer percussion.

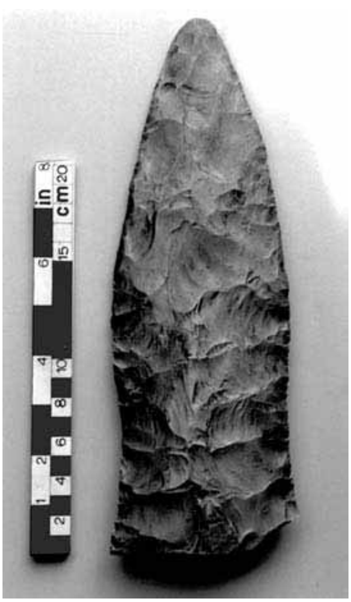


Figure 27. Near-ideal Stege 4 Secondary Preform replica produced in coarse Danish flint (Stevns). This is the stage where direct percussion is pushed to the limit, prior to the onset of punching of handle margins. On some pieces of thick material, punching may enter earlier. Dagger 129. (#35).

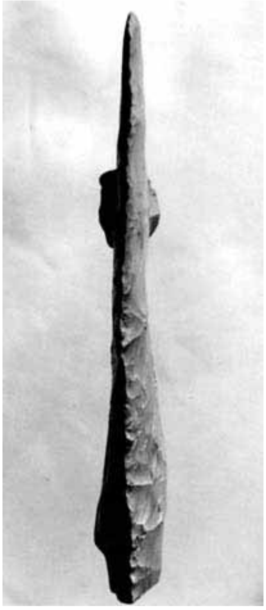


Figure 28. Side view of same preform showing how blade is knapped thin while handle is left thick. Also see #60 (#35). Ignore clay lunp on base.

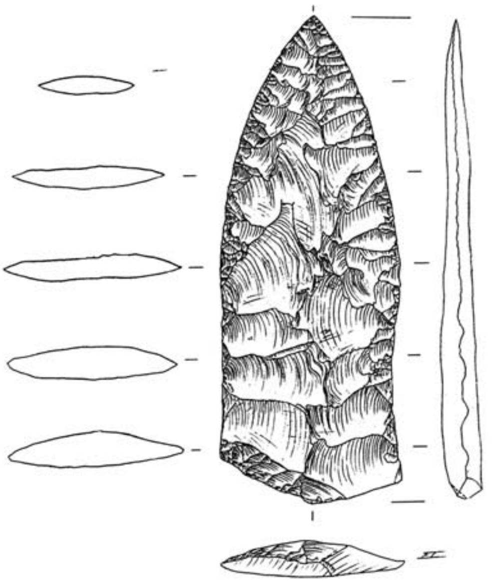


Figure 29. Sketch of ideal Stage 4 Secondary Preform replica, showing cross-sections and appearance of last direct percussion flakes on handle (handle is a bit thin). Compare with Figure 14, dagger 178. (#58) 26,4 cm.

Figure 30. Photo at oblique angle of ideal Stage 4 Secondary Preform, of Lolland flint, vividly depicting contrast between thinness of blade and thickness of handle. Note that opposite things are happening with blade and handle. The blade is made to lose thickness while keeping width, while the handle is made to keep thickness while losing width, with a characteristic abrupt transition between the two. See Figures 34, 60 and 61. Dagger 240. (#88) 28,2 cm.

Replication Stages 4-5

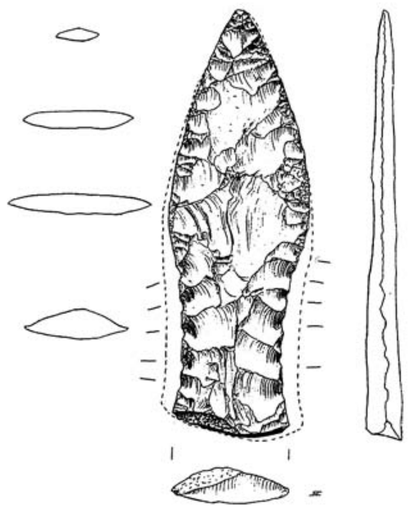


Figure 31. First of series of four sketches showing transition of Stages 4 to 5 by repeated punching of lateral margins (as suggested by knapper Thorbjørn Petersen). Note changing outlines and cross-sections as well as characteristic debitage. This is presented here as a likely reduction model for the past. Shown here: after first set of 10 flake removals. 25,3 cm. Compare with Fig. 15. dagger 182 (#62).

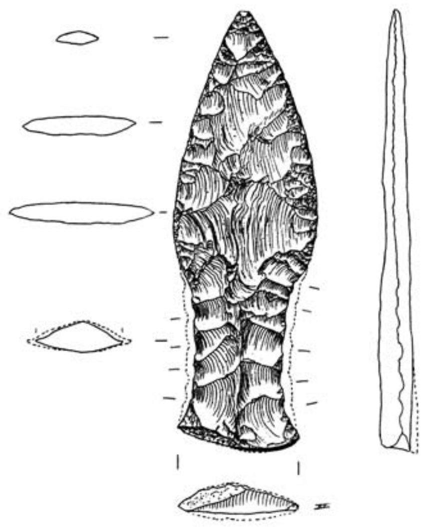


Figure 32. Same dagger showing second set of nine punched flake removals. (#62) 25,3 cm.

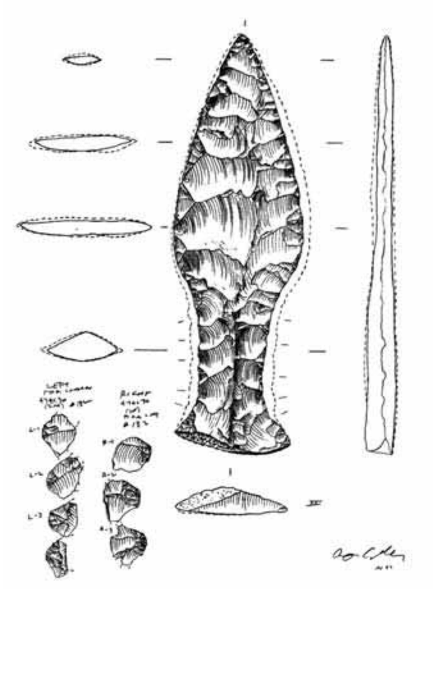


Figure 33. Same dagger showing third set of 10 punched flake removal scars and seven characteristic punched flakes. Blade has also been extensively reworked by direct percussion. Compare with Fig. 16. (#62) 25,2 cm.

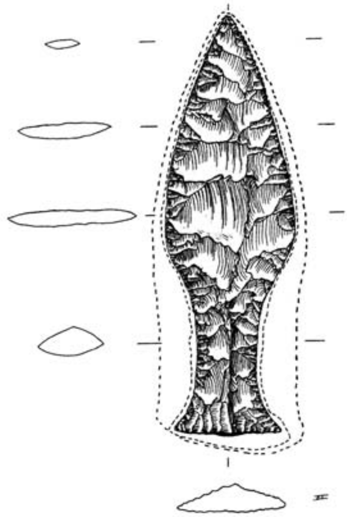


Figure 34. Finished Stage 5 Final Preform replica after final delicate percussion and pressure trimming of outer zones. Note characteristic loss of outline width and thickness in cross-sections (compare with Fig. 33). This model is predicted to be the most typical path of action for Stage 5 development when no preliminary seam is punched. In general, Stage 5 is the most difficult stage to reproduce, calling for a near Master level of skill. Previous stages could probably be executed by knappers of Journeymen level of skill – if under the watchful eye of a Master. (#62) 24,2 cm.

Figure 35. Four original daggers. Two at left illustrate preliminary seam punching. Two at right are Type III daggers such as might result from preforms at left. Such might also result in Type IV-A or B daggers. One at left is a reject. (SHM #2549; 8970:54SK; 2548; 33:97, 1393:33).

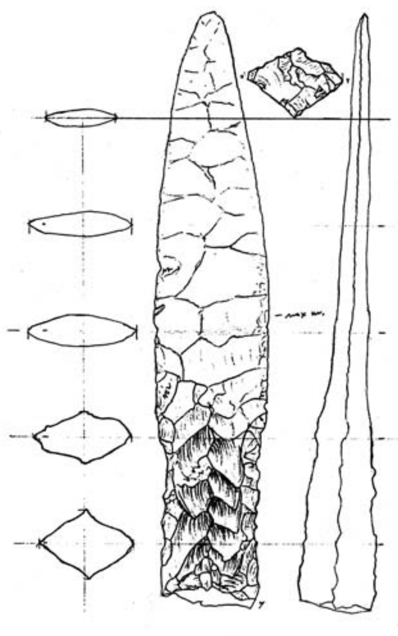


Figure 36. Rough sketch of original preform shown in last figure. This clearly shows that the handle was punched with a preliminary seam. Though possibly a Type III perform, it shows a path of action that would have been known to Type IV knappers. The author has observed that the vast majority of finished Type IV daggers bear evidence of such preliminary seam treatment (other modern dagger knappers don't seem to realize this and so directly press the seam without prior punch work). (SHM #8970:54SK) 23,0 cm.

Figure 37. Two aberrant, finished Type IV daggers showing well-controlled punching of all four handle seams. Though probably local, "inexpensive" variants imitating the classic model, they illustrate the appearance of preliminary punched seams. The author doubts if the classic daggers were so puched on final series of lateral margins, where pressure finishing predominates. Note that these punched flakes, which were removed from left to right, are backwards oriented, as are the pressure seams. (DNM w/o #s).

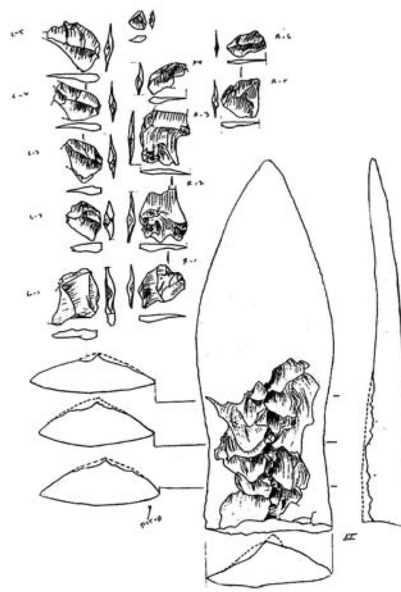


Figure 38. First of a series of three sketches showing repeated punching of preliminary top seam during Stage 4-5 transition. Note characteristic debitage and cross-section evolution. Also note how bulbar dips below the ridge serve to catch laterial punched flakes in the next sketch and to allow forthcoming pressure seam flakes to dig into prior bulbar concavities. The author thinks this is a likely reduction model for explaining the archaeological evidence seen on the original daggers and preforms. Daggers 170. (#56) 25,8 cm.

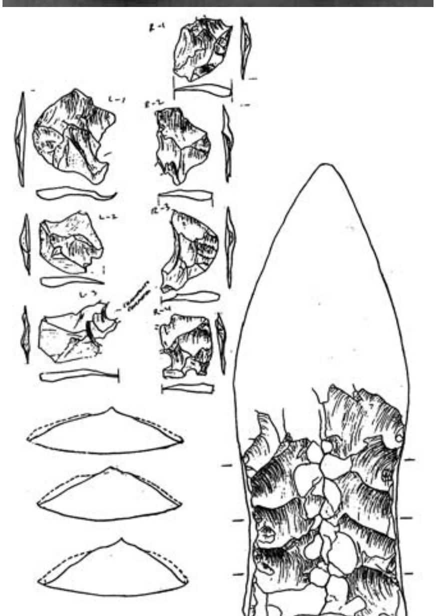


Figure 39. Same dagger showing first set of lateral punch flake removals and characteristic debitage. Such alternating between top seam and laterial sides is the predicted path of action. (#56) 25,8 cm.

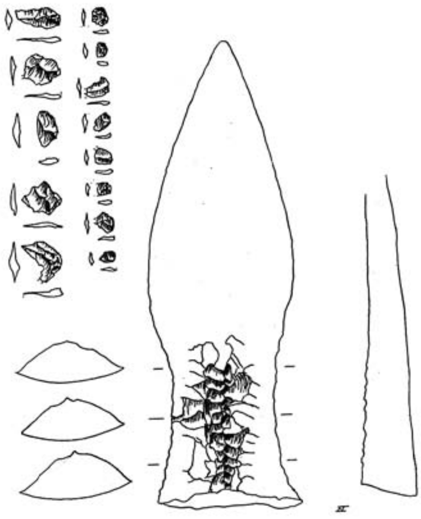


Figure 40. Same dagger showing how both punching and pressure may be used to regulate the preliminary seam. The author hypothesizes that the preliminary seam will later be exactly straightened before the final pressed seam is applied. (#56) 25,2 cm.

Figure 41. First series of three photos showing how the author punched the seam of dagger replica made in 1989. Preform was cushioned with a bed of clay as dumbhead of shaving horse, pressed downward with foot, held preform in place. The author later developed a much simpler press using two boards and a rope. View from front. (#23).

Figure 42. Same perform viewed from left. Puch is copper-tipped antler. (#23).

Figure 43. Same preform finished. This is the Final Preform Stage, Stage 5. Preliminary seam punching met the author's expectations of the original model. (#23).

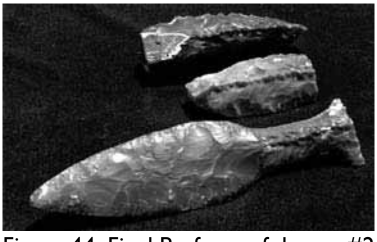


Figure 44. Final Preform of dagger #240, made in 2004, of Lolland flint, with preliminary puched seam successfully executed. Note the two stitching practice pieces predicted to be found at a Type IV dagger production site. One doesn't let beginners practice on nearly-finished daggers made by the Master. They must have practiced on scraps. (#88) 27,9 cm.

Replication Stages 6-8, replicas and originals

Figure 45. Plastic cast (by Bostrom) of original Type IV-D/E dagger, reversed face, showing clear evidence of grinding on blade. A resharpened, ordinary dagger. Handles of daggers were never ground (but handle edges were always ground quite smooth). Author has observed that about 50% of the Type IV prestigious daggers were ground on the blade. Grinding would allow more time to be expended and thus, perhaps, creater a higher value. Grinding also facilitates a higher quality surface beauty.

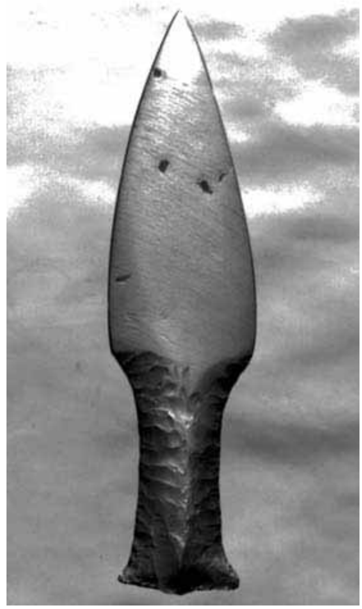


Figure 46. Replica of a Stage 6 Ground Preform after 3000 strokes of hand grinding on sandstone slab. Note direction of grinding striations, which match originals. See Figs. 48 and 49 for holding positions (see Fig. 49 caption for number of strokes required of flint). Dacite obsidian is shown here. Dagger 206. (#66) 25,3 cm.

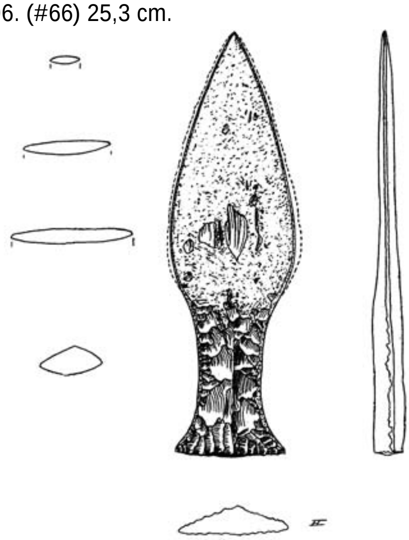


Figure 47. Sketch of Ground Preform #182. See earlier stage of this dagger in Fig. 34. Note that two stages are evident on the blade. Such evidence on the originals allowed the author to reconstruct the missing stages years before he discovered archaeological samples (i.e. Figs. 12-16). (#62) 24,2 cm.

Figure 48. Author grinding dagger replica #240 at Lejre Experimental Center, Denmark 2004.

Figure 49. Close-up of the author grinding dagger #240 on the side of an old farmer's sharpening stone. It took 10 000 strokes on each side to grind the blade about 80%. By comparing this with the data in Fig. 46, it is evident that flint is *much* harder than obsidian. This underscores the importance of finalizing one's test using original materials, though non-original materials may be useful for pocedural practices. Note the use of flint sand in grinding this dagger. This saved no time whatsoever with grinding flint, though it helped noticeably with obsidian. (#88).

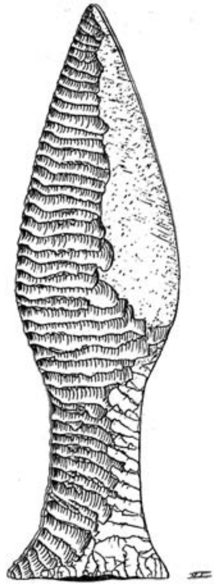


Figure 50. Dagger replica #170 during stage 7 Flaked Implement reduction. Note the nature of straight-in parallel pressure flakes ("flat flaking") on reversed left side. Such procedures, moving from left to right along either edge, is characteristic of Type IV daggers. Three stages are now evident – Stage 5 on right side of handle, Stage 6 on right side of blade, and Stage 7 on left sides of blade an handle. (#56) 24,3 cm.

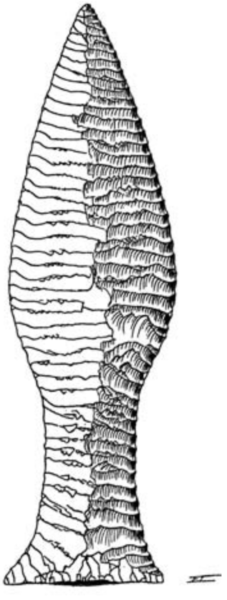


Figure 51. Same dagger as flaked on right side. The Flake Removal Sequence (Callahan in this volume) shown in these two figures was practiced quite consitently by Neolithic knappers, and hints at strict regimentation of production practices by some superior authority. (The above procedure is missed by most modern would-be dagger knappers). (#56) 24,3 cm.

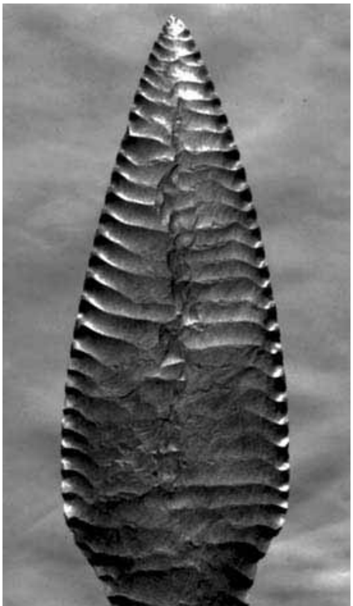


Figure 52. Blade of dacite obsidian dagger #206 after parallel pressure flaking of blade using an *antler-tipped* Ishi stick (see this tool in Fig. 21, far left). Correct "C" flaking resulted, especially on right margin (Kelterborn 1984, which illustrates *reverse* "C" flaking). Edge retouch has yet to be done. Stage 7 Flaked Implement. (#66).

Figure 53. Blade of dagger replica #181, showing retouched margin (Stage 8) with delta flaking on left side and unretouched margin (Stage 7) on right side. Clearly, "retouching" (as used in the Western sense of fine edge-alignment flaking on the outer zone cutting edge rather than in the Continental sense of referring to the long parallel flakes into the middle zone) is an important production stage needed before the edge becomes "functional" (note also the remnant of ground surface at the bottom center of the blade. Such grinding facets did not prevent the circulation of the Neolithic daggers for such evidence is common archaeologically.) (#61).

Figure 54. Blade of dagger repica #182, showing characteristic flake terminations in the center of the blade (shaded) caused by last series of parallel flake removals from the right side. As the last removed flakes, they undercut their prior flakes from left side, as with most originals. Stage 8 Retouched/Finished Implement. (#62).

Figure 55. Sketch of dagger replica #181, showing Stage 8 retouch flaking of blade and handle (shaded areas). Blade features delta retouch (Kelterborn 1984) while handle features distinctive stitched zig-zag pressure seam flaking of ridge, lateral margins, and base. Handle edges will next be heavily abraded. See Fig. 7 (#61), 26,7 cm.

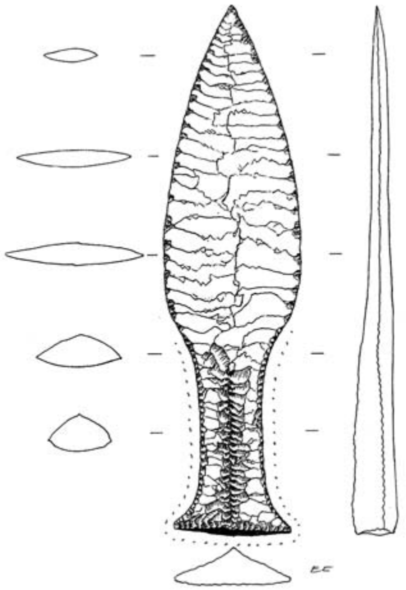


Figure 56. Dagger replica #178 showing initiation of seam flaking at bulbar dip, approached from base. Note sharp median ridge and flat planes of lateral sides. (#58).

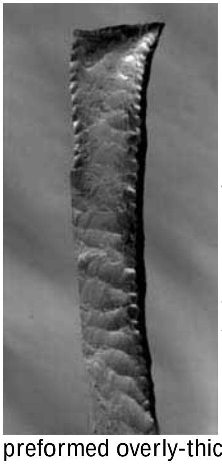


Figure 58. Same dagger replica with top seam, to right, half –stitched, side view. Note backward-oriented flake scars, which are more difficult to obtain than the zig-zag zipper effect of the plan view. Also note thickness loss caused by stitching. Handles must be preformed overly-thick to allow for this loss. (The same may be said for the preceeding stages and steps). (#61).

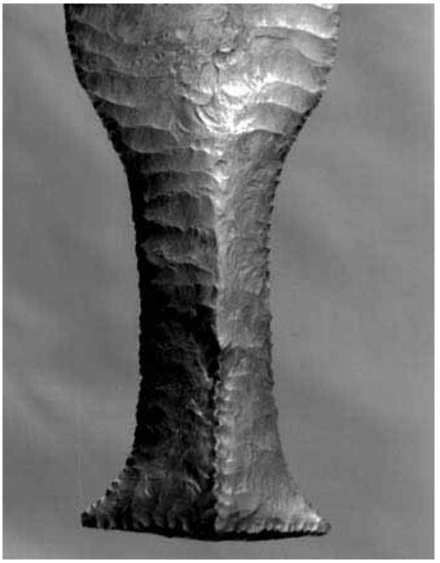


Figure 57. Dagger replica #181 with handle seam half stitched by pressure. Note absence of an earlier, punched seam and presence of sharp ridge forward of the "pinched" seam. Unlike most originals the path of action shown here shows no evidence of an earlier punched seam, as in Figs. 35-42 (most modern knappers work as shown here). (#61).

Figure 59. Dagger replica #178 showing reverse, right lateral seam, half stitched. Note backward-oriented flake scars and loss of handle width. It is the author's conclusion that fine seams of this nature may not be done without copper, though preliminary seams might be. (#58).

Figure 61. Handle detail of dagger replica #120, showing finished seam stitching on handle and base and blade-handle transition (2,64 seam flakes/cm). Compare this, the author's best, with the work of a far superior Neolithic knapper in Fig. 62 (#31) (Notice that transition from blade to handle is abrupt, not gradual, as with most originals).

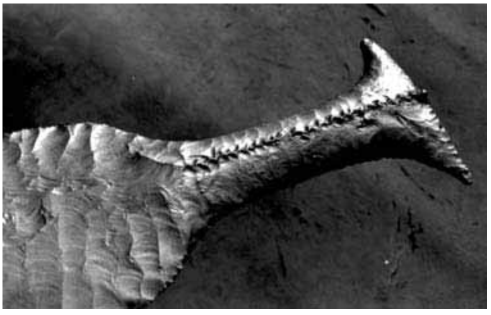
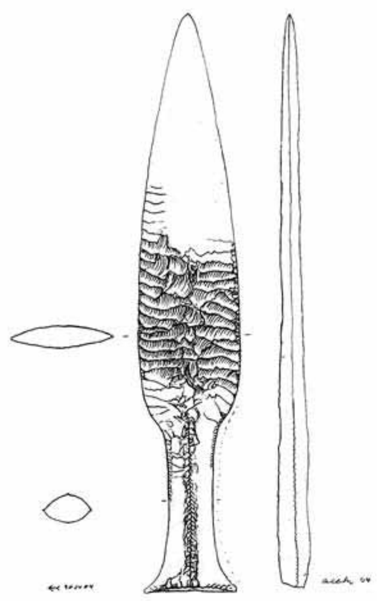


Figure 60. Same dagger half-stitched on left lateral side. Also note the finished top seam, to right, and abrupt, rather than gradual, dip where handle joins blade. (#58).

Figure 62. Handle detail of an original masterpiece, showing finest seam stitching author has ever seen (4,63 seam flakes/cm. The average is 3,4, Hindsgavl is 2,28). This is the Alnarp dagger, aka "Elegance", at LHM, #11874. See it in our Figure 2, (L-1).

Figure 63. Partial sketch of the Møn dagger. At 33,4 cm, it is the longest Type IV dagger in Denmark (it is second only to the Skateløv in Sweden). Detail of some key blade and fine stitching scars (DNM #4871), (D-11).



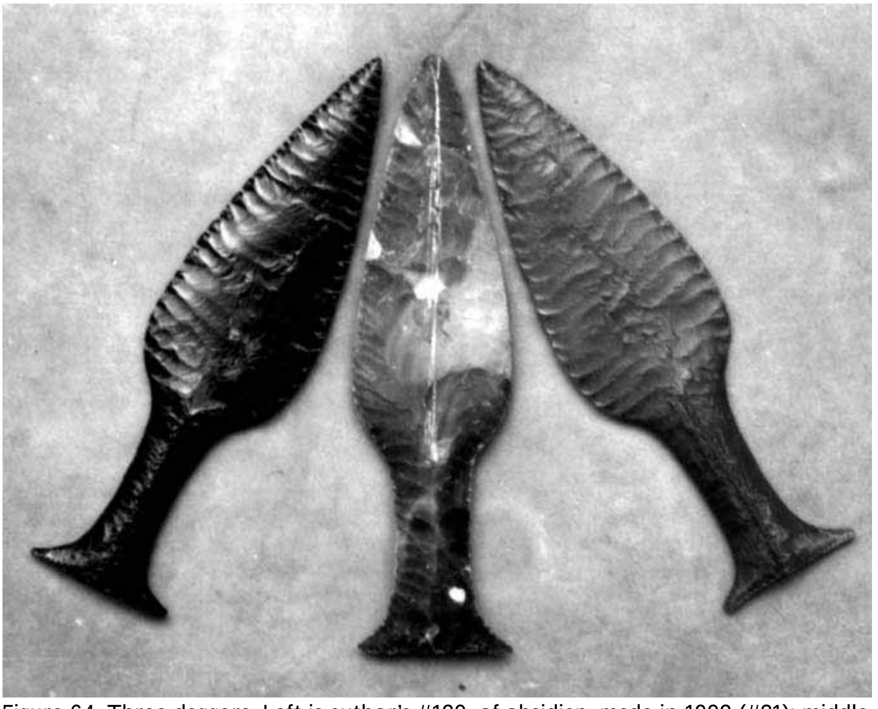


Figure 64. Three daggers. Left is author's #120, of obsidian, made in 1992 (#31); middle is author's #142, Final Preform, of Falster flint, made in 1993 (#43); right is plastic cast of Hindsgavl, donated to author bt Søren Moses.

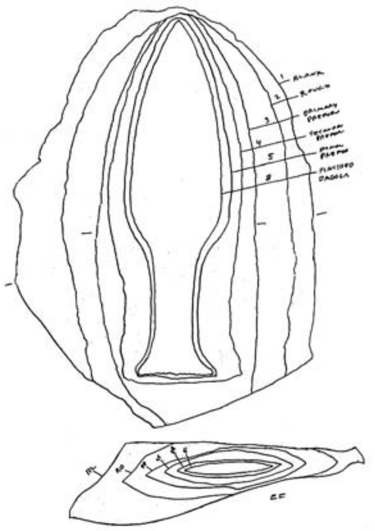


Figure 65. Outlines of Stages 1-8 of dagger replica #180. Notice dramatic loss of width and thickness in early stages and minimum loss in later stages. The nature of this loss should be evident in the debitage. (#60).

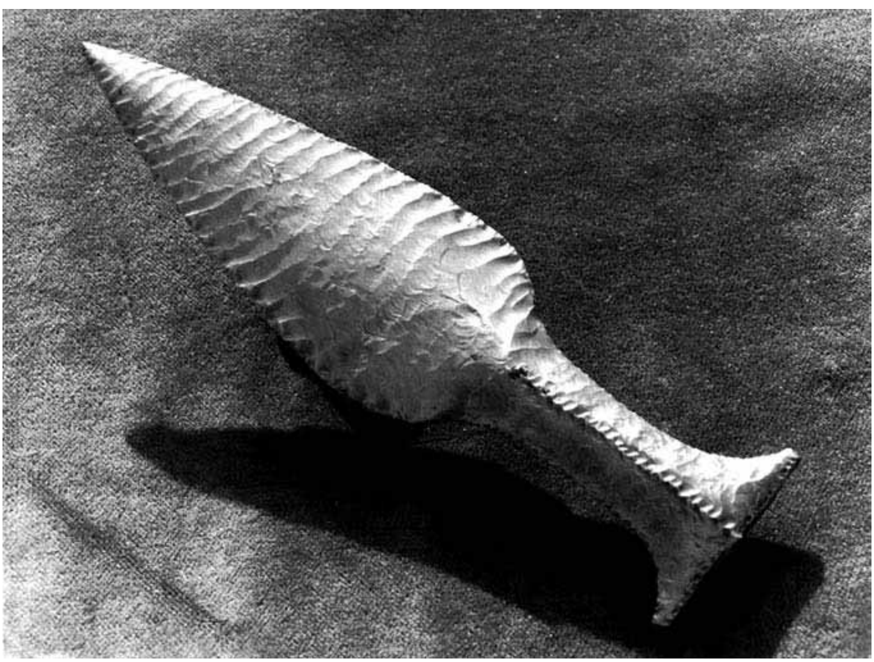


Figure 66. Replica dagger #123, made in 1993, as depicted for knife show exhibitions and web site. Such sales of replicas to customers/patrons were, as in the past (?) the author's principal means of financial support for this research project over the decades. All are indelibly signed and numbered. In the collection of Bob Verrey. (#32).

Notes

1. All sketches and photos are by Errett Callahan unless otherwise noted.
2. Replicas are of obsidian unless noted otherwise.
3. Daggers are depicted point upwards, as originally shown in Müller 1902, Montelius 1917, and Forssander 1936, and in keeping with current professional conventions. This is noteworthy because of designations of left and right sides, etc.
4. Original daggers have been given names according to where found. This is usually the Parrish.
5. Replica daggers are usually named after the patron who supported its creation, but daggers in the author's collection are named otherwise (i.e. #88 was dubbed the Mustang, as it gave me such a fight (Figs. 30 & 44).
6. Most of the original daggers were stray finds from the 1800s and early 1900s. They were probably originally placed in the graves or hoards which were uprooted by subsequent farming activities.
7. Original daggers in this study were assigned a short code number – D, S, or L – to simplify identification. Thgis number also indicates the collection. Thus D = Danish National Museum in Copenhagen, Denmark,
8. About those numbers (a search for simplicity): Each dagger replica in this study was assigned several numbers according to the set of which it was a part. For instance, Dagger #240 (the last one to be embraced by the present "Production Model") received the following numbers:
   04EC19 – (The Working Number). The 19th stone tool of any kind made by EC (Errett Callahan) produced in 2004. (He also made other stone tools than daggers).
   #240 – (The Dagger Number). The 240th dagger replica of any kind produced in this study, in chronological order. Not all were selected for analysis for they included preforms, miniatures, and daggers of other types than type IV. This is usually given at the beginning of the caption.
   #88 – (The Study Number). The number of the set of 88 daggers, selcted from daggers 8-240, which were analysed to create the "Production Model". These 88 were scrutinized for over 9000 bits of information. This number is usually given at the end of the caption. Daggers made subsequent to #88 are given thair regular dagger order number, once assigned (i.e. #242, which came after #88). Usually the reader only has to deal with the dagger number and the study number.

Hugo Nami

Preliminary experimental observations on a particular class of bifacial lithic artifact from Misiones Province, northeastern Argentina

Abstract
In the south of the South American forest, in the province of Misiones in northeastern Argentina, there is a particular class of bifacial stone tool with a boomerang-like form, commonly called "curved cleavers". The sickle gloss observed on some pieces suggests that they are probably related to the processing of vegetal matter. This kind of artifacts characterized the so-called Humaitá tradition that lasted between c. 7000-1000 BP. Based on experiments, the preliminary observations of the manufacture of this artifact are reported. Stages of manufacture, the probable techniques using for making them and other useful technical observations are considered.

Introduction

In northeastern Argentina, at the border of Paraguay and Brazil, there is a rich and unexplored lithic archaeological record. Among the many stone tools, a particular class of bifacial-flaked artifact with a boomerang-like form, commonly called "curved cleavers", is noticeable. Until now, no detailed typological, functional or technological investigation has focused on this artifact. Hence there are no previous studies devoted to its reduction sequence, particularly the identification of early stages, preforms and finished products.

In order to create a realistic baseline that allows us to understand some aspects of the reduction sequence of this particular artifact, I here report the preliminary experimental observations considering stages of manufacture, the probable techniques used for making the artifact and other useful technical observations.

Archaeological background

In southeastern South America in the area covered by south Brazil, north-east Argentina, west Uruguay and east Paraguay, most archaeological sites without projectile points have, from a normative perspective, been enclosed in the so called Humaitá tradition which is divided into eighteen phases. Radiocarbon dates indicate that this tradition lasted between 7000-1000 BP (Schmitz 1987: Tab. 7).

In temperate zones with dense vegetation and in areas with tropical and subtropical forest, the typical lithic remains characterizing the "Caaguaçu" phase of the Humaitá tradition are rough bifaces. They are called "curved cleavers", "cleavers" and "picks", choppers, chopping tools, scrapers and knives, and are mostly made of chunks and tabular nodules of local volcanic rocks with red and brown tonalities. There are also ground stone tools, such as axes, bolas and metates (Rodriguez 1992:183 p). Curved cleavers are also known as a fossil type of the Altoparanaense industry (Menghin 1955/56).

Since the beginning of 1990s I have carried out several research activities in Puerto Esperanza, north-west of the Misiones province in the Republic of Argentina. The area is characterized by an abundance of archaeological sites, which are being impacted by several human and natural processes: the construction of houses, streets and roads and the erosive action by active watercourses, mainly the Paraná River and its tributaries, respectively.

Primary and secondary sources of volcanic rocks are present in this area. Quarry workshops sites are widespread along the Paraná River with an abundance of workshop activities. There are thousands of lithic artifacts and among them it was possible to see that prehistoric human populations used blade and microblade technologies as well as Levallois-like cores to obtain predetermined flakes (Nami 1996a).

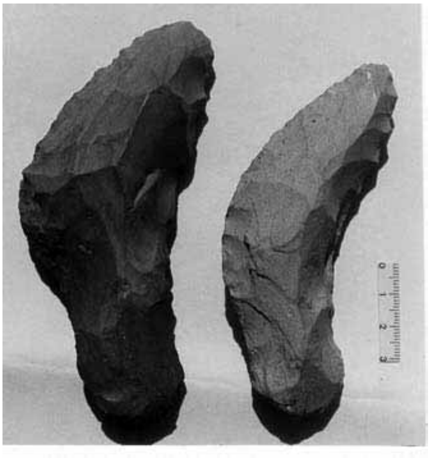


Figure 1. Archaeological specimens of curved cleavers.

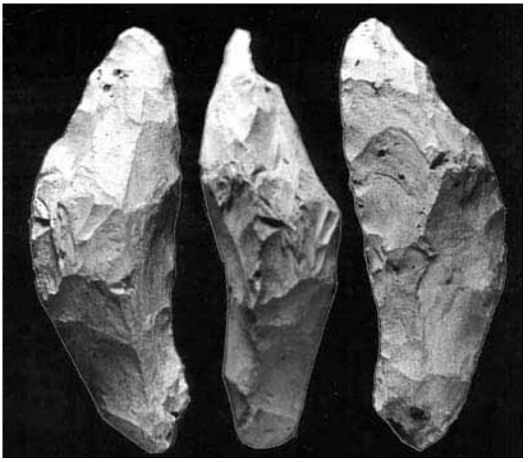


Figure 2. Three views of an archaeological specimen of a cuved cleaver. Scale is the same as in the previous figure.

From a technological point of view, the regional lithic technology is very interesting. One of the more remarkable flaked artifacts is a particular and unusual class of bifacial stone tool with boomerang-like form, commonly called "curved cleavers" (Figs. 1 and 2). They were made of local red/brown volcanic rocks and have diverse sizes ranging from 8 to 25 cm in length and 3 to 5 cm in thickness. Of the few unbroken archaeological pieces observed, the distal part of this particular artifact is pointed and the lower part has diverse forms; some of them have probably been formed to aid prehension. In general, transversal cross-sections vary, but most of them are biconvex, triangular or rhomboidal. Longitudinal cross-sections are very irregular. The flake scars are also very irregular with step and hinge fractures, suggesting that some sort of percussion was normally used in their manufacture. However, there are specimens with a more elaborate flaking pattern and some of them – especially those with rhomboidal cross-sections – have square and sinuous edges. This type of piece sometimes shows narrow flake scars suggesting the use of pressure in the final steps of manufacture. It seems that this technique was only used to regularize the edges by eliminating the remaining bulbar scars from previous flaking. Furthermore, abrasion was carried out in the latter part of the production sequence.

A few clearly finished and used pieces found far from the quarry sites display sickle gloss, suggesting that they were probably employed to process some sort of vegetal material (cf. Semenov 1964:113 pp; Kamminga 1979). Currently, some old Guayaki Indians use a similar wooden artifact to dig in search of vegetal roots (Gherardi, pers. comm. 1995).

Experimental study

Material, flaking implements, methods and techniques

Most of the actual research for this paper was carried out during the period 1995 to 1997 and in 2003. So far, I have made a limited number of experimental specimens (n = 30). Concerning raw material, I used different stones ranging between 1 to 5 lithic grades on Callahan's scale (Callahan 1979:16) belonging to several sources located in Argentina. They are as follows: red/brown local volcanic rocks of diverse characteristics, probably basalts, rhyolites and porphyries (Puerto Esperanza, Misiones province); unheated green chert from Piedra Parada area (Chubut province), black dacite – commonly called "basalt" – (Paso Limay, Río Negro province), volcanic tuff and basalt from Arroyo Sañicó and Zapala (Neuquén province) and finally, industrial glass made in Buenos Aires.

Concerning flaking implements, I employed two small discoid hammerstones of granite rock weighing 120 and 125 g respectively, and a heavier broken ovoid hard hammerstone of 650 g (Fig. 3).

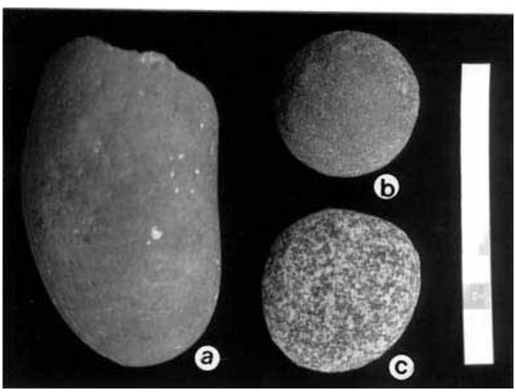


Figure 3. Flaking implements used during the experiment. a) Broken ovoid hammerstone, b-c) discoid hammerstones.

During the flaking activity I used direct, free-hand and anvil direct percussion flaking holding the piece with the left hand and the padded upper leg for support. I changed varieties according to the morphology of the artifact in the reduction sequence. As illustrated in figure 4, I used diverse holding positions during the flaking activity according to the different activities performed during the manufacturing process. As showed in Figure 4k, pressure flaking was applied with the "Ishi stick" (Whittaker 1994).

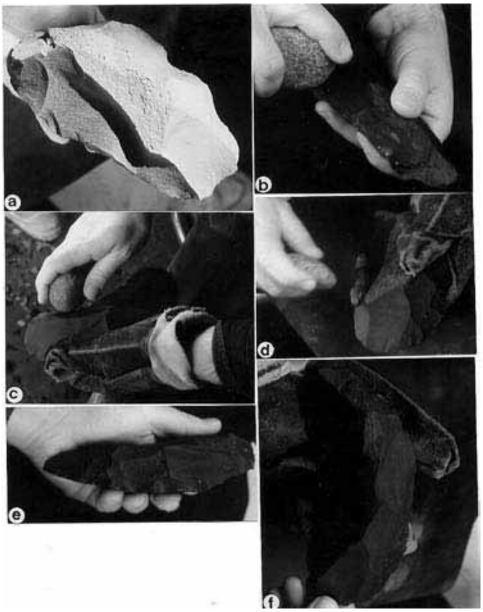


Figure 4. Photographs showing some portions of an experimental reduction sequence. a) Stage 2 flaked from the blank illustrated in figure 5, b-d) Different perspectives of direct percussion flaking used between stages 2-3, e-f) lateral and frontal views of the stage 3 (photographs by María de las Mercedes Cuadrado).

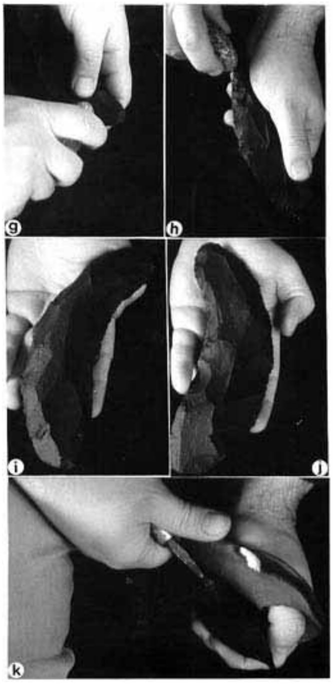


Figure 4 (continuation). g-h) Holding position used to flake the distal part of the cleave curve by hand held direct percussion flaking. Note the use of the fingers under the flakes removed, i-j) flaked stage 4, k) Pressure flaking technique used to regularize the edges (photographs by María de las Mercedes Cuadrado)

Suggested stages of manufacture

Based on this preliminary experiment it is possible to suggest the reduction sequence involved in making a "curved cleaver". For analytical purposes, I divided it into five stages of manufacture. I made the following segmentation by considering some morphological attributes towards the development to the final product. The aim is to build a classification that can be used to predict and retrodict similar material found in archaeological records. To carry out this task, Callahan's seminal work was very helpful in defining and describing the stages of manufacture (Callahan 1979). They are as follows:

Stage 1. Obtaining the blank

This stage might entail the detachment of large flakes by spalling large cores or the selection of adequate tabular nodules or chunks to be flaked in the next stage. The thickness must be the same or a little thicker than the finished product (Figs. 5 and 6).

Figure 5. Tabular nodule of dacite from Paso Limay used in the experimental piece shown in the previous figure.

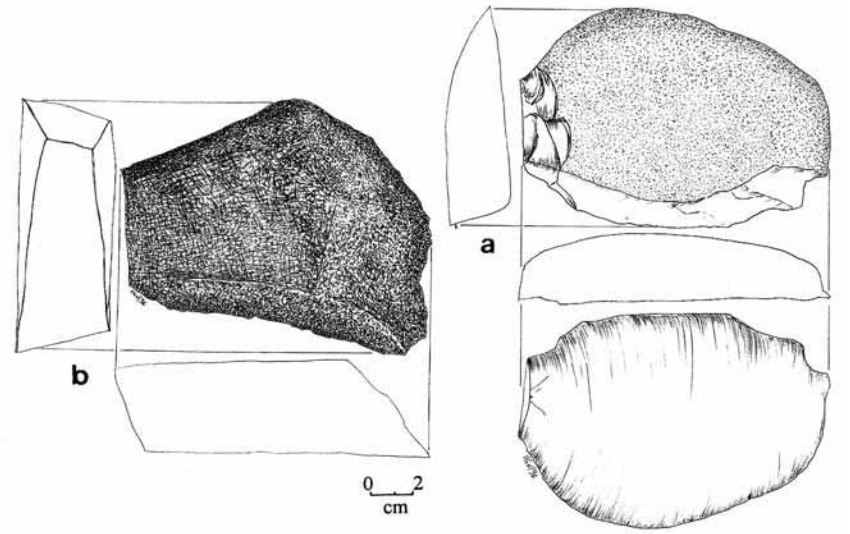


Figure 6. Flake blanks of volcanic rocks from Puerto Esperanza (a) and Zapala (Neuquén).

Stage 2. Initial edging

Here, the blank is flaked to give an edge where there is none or, where the edge is too sharp and low-angled for further flaking, by using hand-held and/or anvil percussion flaking with hard hammerstones according to the morphology of the blank. For those pieces starting from flakes, small hammerstones are useful to eliminate the sharp edges. However, to reach this goal with a tabular nodule, it was necessary to use the heavier hammerstone. At this stage, the piece has diverse forms, ranging from rough bifaces, nucleiform artifacts, partially curved bifaces and diverse irregular artifacts. No platform preparation is needed in this step and the flake scars may cover less than half of the width of the artifact. Edges are very sinuous and irregular (Figs. 7 and 8).

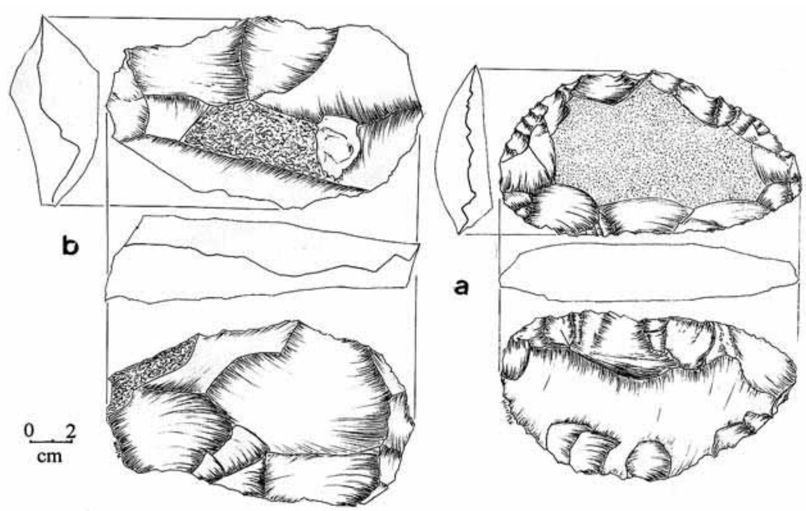


Figure 7. Specimens corresponding to stage 2 made from the flakes illustrated in the previous figure.

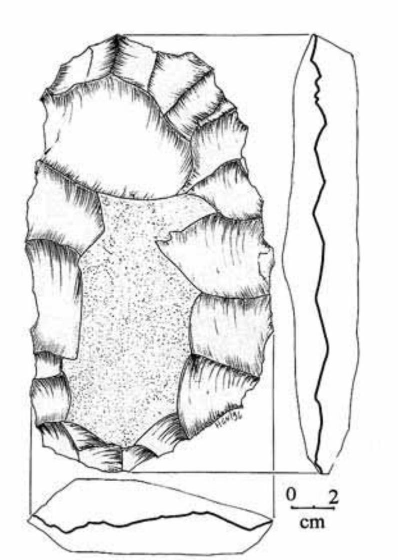


Figure 8. Stage 2 made on a tabular nodule from Arroyo Sañicó, Neuquén.

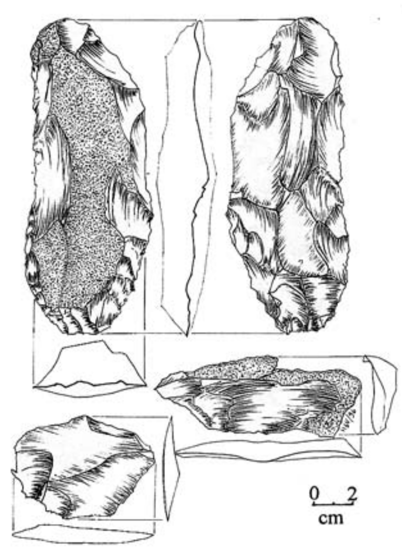


Figure 9. Stage 3 and some waste flakes made of green chert from Piedra Parada area.

Stage 3. Bifacial flaking

By continuing with a smaller stone hard hammer (particularly one of a discoid form), the previously edged piece is then shaped into a rough biface, an elongated oval bifacial form. Thus, the final form is outlined, and shaped into the initial preform of the piece. Generally, the forms are curved and the flake removal sequence follows an irregular pattern. In this stage the pieces have diverse cross-sections: Thick bi-convex, rectangular and triangular forms. Edges are slightly sinuous and more regular (Fig. 9).

Stage 4. Initial shaping

With the aim to reach the final product, at this step a more careful bifacial flaking continues by employing the same strategy as in the previous stage. By continuing with a smaller stone hammer (particularly one of a discoid form), the previously bifacial flaked piece is transformed into a form reminiscent of the finished product. Now the piece is almost shaped into the refined preform (Fig. 4i-j). However, variations in flaking implements might be used in this step and the possibility of soft percussion flaking must be investigated in future research.

Stage 5. Final shaping

After percussion flaking, the product is finished by regularizing the edges by pressure flaking (Fig. 4k). This technique was only used to eliminate the remaining bulbar scars in the edges resulting from the percussion flaking. Furthermore, abrasion was used in the latter part of the production. Figure 10 illustrates some pieces corresponding with this stage.

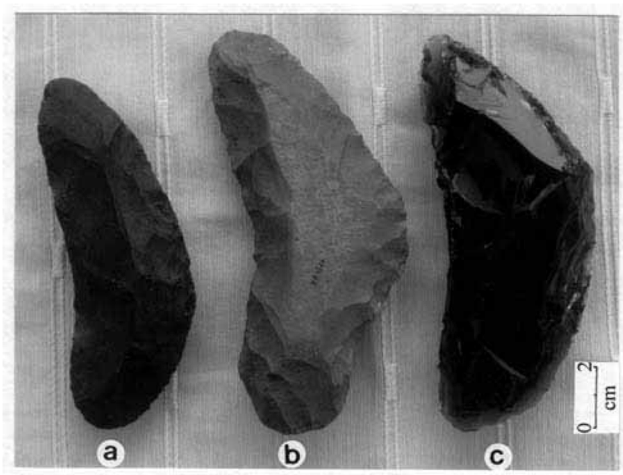


Figure 10. Finished products (stage 5) made of dacite (a), red volcanic rock (b) and industrial glass (c).

Figures 4 to 9 show a few experimental examples of the stages of manufacture previously described.

Some preliminary observations and results

The red/brown volcanic rocks from Misiones showed different textures, hardness and brittleness. The more brittle ones were red basalts with very fine grain which are comparable with other volcanic stones used in this experiment, such as the dacite from Paso Limay. The flint-like materials that I used proved to be a little harder and resistant than the volcanic rocks. Thus, the best available local raw materials for making "curved cleavers" are the volcanic rocks; they might be classified within 2 to 2.5 lithic grades, such as some fine grain red basalt. More resistant rocks – such as the flint-like materials – presented some problems during the flaking, especially when making the concavity in the curve (see below).

The most useful hammerstones vary in size and form, particularly related to the development of the artifact towards the finished product. A large-sized hammerstone of 650 g was employed in stage 2 and the smaller ones – especially those of discoid forms – during stages 3 to 5. Pressure flaking was used only during the final shaping stage. I occasionally used an abrader to create the platforms by forming a certain degree of dullness on the edges.

Specimens resulting from the *initial edging* showed too much variability and some of them might be confused with different kind of cores. In the early stage of manufacture, especially during the *initial edging* and *bifacial flaking*, transversal fractures are common causes of unsuccessful executions (Fig. 11). However, in the *bifacial flaking*, *initial shaping* and *shaping* when the specimen becomes narrow, there is a risk of excessively thick edges forming. In this sense, one of the more problematic areas is the manufacture of the concave part of the curve, particularly during stages 3 and 4. Here the excessively thick edges impeded the continuation of the work. In this case, the piece becomes too narrow and a squared edge is formed, which is a very risky operation during the bifacial flaking (cf. Callahan 1979:113). When the finished product has rhomboidal cross-sections with square edges in the *final shaping,* another common problem is the formation of steep and deep hinge terminations.

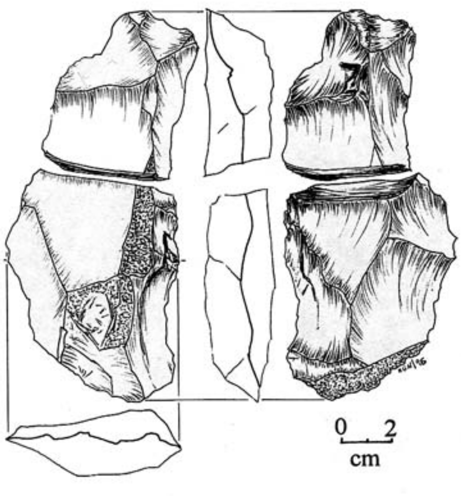


Figure 11. Rejected stage 3 broken during the bifacial flaking.

There are some differences in the debitage according to the stages and mainly this varies in size and form. As shown in figures 12 to 14, debitage from stages 1 to 2 tend to be primary and secondary flakes of large sizes; those from stages 2 to 3 are inner angular flakes of medium size; the debitage flakes from stage 3 to 5 are similar but smaller than the previous ones, and finally the pressure flakes are smaller and resemble the ones usually resulting from this technique. However, some overlapping might exist among the debitage between stages.

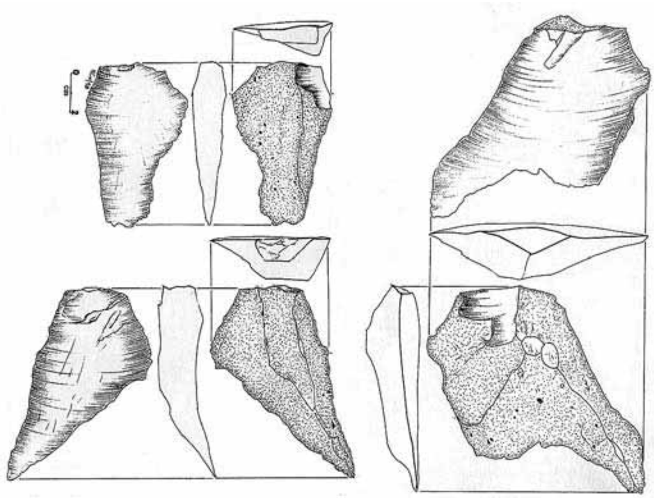


Figure 12. Some examples of flakes-waste resulting from stages 1 to 2 (dacite from Paso Limay).

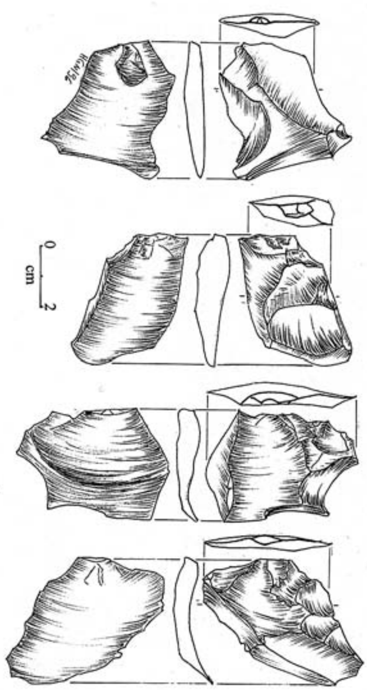


Figure 13. Examples of flakes-waste resulting from stages 2 to 3 obtained with a discoid hammer of 125 g (green chert from Piedra Parada).

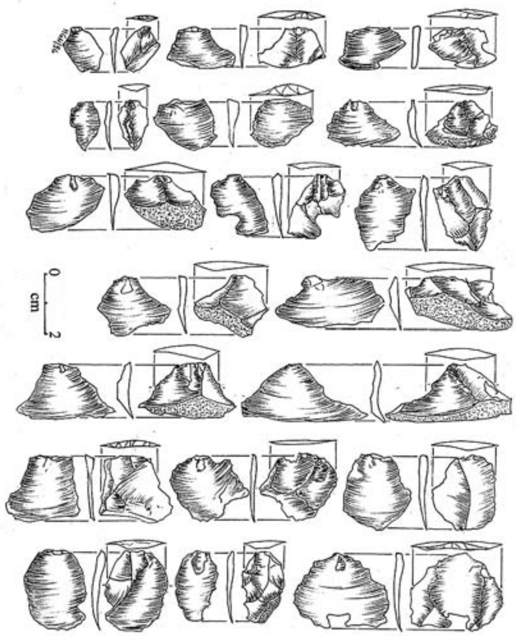


Figure 14. Flakes-waste obtained with the small discoid hammerstone during the flaking the stages 3 to 5 (reddish volcanic rock from Puerto Esperanza).

Final considerations

I consider this report as an initial attempt to reproduce the "curved cleavers". Continuing with more experimental research in order to explore and document the variability existing in its reduction sequence is crucial, especially in the early stages of manufacture, as is the study of the techniques employed, particularly during the final stages. In addition, detailed interactive analyses on both the archaeological artifacts and the experimental baseline are necessary. The early stages of manufacture and the discrimination between preforms and finished products are crucial to understand.

Acknowledgements

My special thanks to José L. and A. Gherardi for their help, support and information during the study of the artifacts examined here, and their help during the fieldwork; to Jan Apel and Kjel Knutsson for the invitation to participate at the symposium; to the Societas Archaeologica Upsaliensis (SAU) that supported my participation in the event; to Britta Wallsten for her help; to E. Callahan for his discussion about this subject; to María de las Mercedes Cuadrado Woroszylo for her continuous help and support; and, finally, to Jan Apel for his invaluable help and kindness during my stay in Uppsala.

Chapter 2

Theoretical Aspects

Kjel Knutsson

A genealogy of reflexivity: The skilled lithic craftsman as "scientist"

Abstract

In this contribution to the workshop proceedings I propose that cultural change in the Scandinavian north in the Early Holocene may be understood as related to a crisis resulting in an activated relationship to the past. The remains of settlements from the Late Glacial hunter-gatherers of the North European plain and the remnants of the pioneering settlement around 9000 cal BC found scattered in the barren hills of northern coastal Norway can, in the early Stone Age and according to this view of cultural change, have been experienced as the sacred times of origins. The argument relates to how culture, reproduced through socialization and embodied habits, in times of dissonance between the lived experience of day-to-day action and its cultural "structure", surfaces and is thus made discursive. Relics from the period of "sacred origins" are in these situations reused to formulate a new culture-bearing narrative.

I use this notion of cultural reproduction in a prehistoric setting to discuss the more urgent topic of modernity's crisis, whereby the profession of archaeology is used as a metaphor for reflexivity and thus objectification and its psychology. I show that the period we call modernity may be the manifestation of a human propensity to go from embedded to disembedded reproduction, thereby activating deeper levels of cognition and thus looking at the world discursively. In times of societal crises this near a-historical quality in the human constitution will form the base for what we call objectification and thus "science". As such, the scientist as a disembedded person must always have been there. Skill is the technical and conceptual ability to relate to the old material world, and the lithic analyst in the present represents the distanced technical aspect of such ability. The conceptual knowledge resides in the present and in mythical narratives/history.

Thus the text is not so much a discussion of the expression of modernity, as its process of becoming. Skill in this setting is the technical and conceptual ability to "read" the relics on which the new representations are moulded.

Keywords: Modernity, cultural reproduction, cultural transmission, skill, materiality, history.

"Landscapes contain traces of past activities, and people select the stories they tell, the memories and histories they evoke, the interpretative narratives that they weave, to further their activities in the present-future". Barbara Bender 2001

"But…at some point in time it just stopped being fun conceiving everything as a text that writes itself, the past as a never-ending narrative, an endless play of signifiers, without signifiedes" Björnar Olsen 2003

"having replaced the ethnographic present as a convention for describing the life of other peoples, we have to think again about the ways in which we understand the past in our own lives". Tim Ingold 1996

Introduction

I started my talk at the workshop by showing a picture of an archaeologist in a familiar setting, crouching under a parasol in the middle of a barren field (Fig. 1). I will in this paper propose that the archaeologist (as culturally disembedded and thus "as-scientist") has always been there and that this way of relating to the world and therefore to the past is one of the important mechanisms that change cultural codes. I am here consciously taking my starting point from a radical and historical unfolding *now,* relating to the effects of the crumbling or at least shaking tower of modernity. It is thus the background of what in western philosophy has been called modernity and its strife for epistemological grounding that is discussed, but through a historical reflection. A reflection that no doubt is formed in the context of an ontological and thus existential worry, in the aftermaths of the "science wars". I thus want to study the past, not as separate from our present, but from the viewpoint of the "the worry", the standpoint from which insecurity is created, as a way of describing a culturally conditioned scientific stance. It is thus an attempt to get an historical or genealogical perspective on the ongoing present, a present that is: "unfulfilled, something incomplete that always led itself to cultivation, socialization and change" (my translation) (Beronius 1991:7). A contribution to the history of a new late modern present engaged in contemplation over reflexivity through an archaeological odyssey marked by long term perspective.

The topic may thus have some general value to a sociological understanding of cultural reproduction, and archaeology as a subject with a possible methodological value because it deals with this historically situated but still general human existential drive in the process of "cultivation" over the long

Figure 1. The archaeologist under a parasol revisiting and contemplating a sacred site is the representation of modernity's objectification; the strive for meaning through reflexivity.

term. It deals with the idea that the modern human is helplessly split, a split in the past, present, ego chain caused by the disembedding tendencies in the post-Enlightment world. I am well aware of the fact that my proposal of its "eternal" presence is *contra* much thinking today. Giddens, for one, explicitly asks himself whether the reflexive knowledge systems so characteristic for modernity and basic to its dynamic character, is specifically western (Giddens 1996: 185). He goes on to say that the radical turn away from tradition that are inherent in the reflexivity of modernity, not only breaks with earlier epochs but also with other cultures. We see in this version of modernity the central theme of disembedding as a cultural process and a view of humans that constantly asks for meaning in the unfolding of life

Although many people living within in modernity would not recognise themselves in this description, I am convinced that the origins of the active engagement in the past we have decided to institutionalize as archaeology and as illustrated by the person making a peephole in the ground on our "sacred places", historically are a result of that existential "drive" for meaning. This drive, as Elisabeth Rudebeck proposes, seems to have universal qualities: "...studying the past…is an existential need, an ethical need and practical need; without pasts we can neither feel, think nor act" (Rudebeck 2000:282).

Identity and the need for the past

The process of fragmentation of fundamentals in life mentioned above threatens the core of personal identity. Oliver Sachs, the American sociologist (in Küchler 1993:48), nots how people become disoriented, helpless, alienated without an identity. That is, when they have lost important parts of their cultural code, the coherence between the structures of social reality and culturally conditioned behaviour (Bauman 1990:185).

Our consciousness then, the idea of a separate Self and thus an identity, is a dynamic synthesis of the past, the present and Ego. A break in that chain, when the past (as remembered) and the present (as experienced) come in conflict, creates amnesia and problems of navigating in the world. In the present nostalgia boom we see one sign of such a break and crisis whereby the past is actively returned to and used as an instrument in constructing values in a shaky present. Our present representations of the structures of social reality are just not good any more, they have to be replaced or renegotiated and as such become materialized. As a matter of fact, this notion of a need for active reflection and thus of "history" is one of the key foundations of modernity (Delanty 1999); a split that created a longstanding separation between culture and nature, where humans became foreigners in their own atomized world and distanced from themselves, their life-path and goals.

This way of actively relating to the past has been explained by social scientists and anthropologists over and over again (Höiriis 1997) as the result of a need to get away from a "survival without meaning and spiritual values" (Arwidsson 2003). That is, the Janus faces of the modern project. It is a way of finding comfort in a (late modern) world that is increasingly becoming more and more complex and difficult to predict and orient in. It is a fragmentation of our life-world that sets the agenda.

Being asked why for example retro designs are chosen, people today tend to answer: "because they look nice". Something being "nice" then makes you think about aesthetics in a new way. I am sure that this way of referring to the outer world relates to fundamental qualities in life such as feeling safe, to feel at home because it relates to a known collective memory of successful practice. As I will show through my archaeological example at the end of the text, aesthetics in connection with social memory and as an encompassing term for a state of mind may very well be an important force in cultural reproduction.

According to Ola Jensen (2002:18), referring to a discussion some 20 years ago, among others, the Swedish philosopher Svante Nordin (1981:69), "All historical interpretation is based on contemporary problems on different levels" and to the ethnologist Orvar Löfgren (1983:34) stating that: "The questions asked of history mirrors existential problems in our own society which demands self reflection: what do we really want with history?". The ontological problems solved by this self-reflection are, it is stated, related to an identity crisis in our own society.

Retro and nostalgia is thus part and parcel of an identity crisis that as an overall structure characterizes modernity. This type of crisis may of course not only be a large-scale social phenomenon but also be experienced on a more intimate and personal level, as the example below will show. Thus, in an article in the Swedish newspaper Svenska Dagbladet, Agneta Lagercranz discusses such a situation with reference to the Swedish politician and medical doctor Christina Doctare's book on how it feels to lose one's imagined or constructed past. In her fifties, Doctare was informed that her "father" was not her biological "father". Due to this her life-world collapses: "*If I am not the one I think I am, nothing else becomes valid*". Showing that this one important insight changes everything else, life has to be rearranged or rebuilt according to this new notion. This is in essence an illustration of the force of historicity in our life continuously leading us to existential reflections of the past. As Doctare amply states ten years after the collapse resulting in a loss of her history as it was understood then, causing a painful loss of ontological security: "*It has taken me all these years to build my identity according to a new life-history*" (Svd 10 October 2002).

The need for the construction of a personal narrative that is congruent with the historical point at which we stand, like Doctare, has been eloquently discussed by Pierre Bourdieu (1996). The "biographical strategy" of the type Doctare uses, he says, is the result of the need to formulate an orderly narrative of one´s life in a situation of insecurity. These narratives show a consequence and stability through understandable correlations often organized as a necessary (teleological) development. The personal narrative has features such as important events, logical connections, and where single events are given the character of causation. As such, these personal narratives echo the structure of modernity's "Grand Narrative": evolution (Landau 1993). In the drive for ontological security in a shaky present then, individuals reuse the past to create personal or collective narratives of similar structure and content and also use the aesthetic qualities of material culture as representations for this story.

It is typical for humans within modernity to be forced to self-reflection, because, as related to a cultural idea of the Enlightment (Delanty 1999), we see a strong element of reflexivity in modernity, a certain propensity for a cultural critique, moral learning and self-transformation (Delanty 1999:2). Modernity is thus defined by reference to the critique of tradition. According to Giddens, the un-dissolvable relation between modernity and radical doubt is a question that – once seen – becomes problematic not only for philosophers of science but, as I have discussed above, existentially worrying for ordinary people (Giddens 1991:31) including archaeologists like myself. This theme, *existential problems and tradition causing radical doubt*, I will slightly expand on here.

Modernity as a retro movement

Pierre Bourdieu has said,: "… in situations in which the habitus in fundamental ways does not coincide with the structure" whereby "it can contribute to change the social structure" (Broady 1991:225). This rupture and loss of identity makes the taken for granted institutions through which we live, visible and….. questioned. Or, as Maurice Bloch argues after fieldwork in Madagascar:

> *"But perhaps the Má Betisek example shows something quite different. It may show that, when in real trouble, we are able to analyze and criticise the very basis of our ideologies, to begin to demystify ourselves and to search for fundamentally different solutions" (Bloch 1992:105).*

In the same vein, after studying the history of the Soviets in the 20th century, Victor Shnierl'man, the Russian anthropologist, says: "The re-inscription of the past in the present becoming more important in times of instability and change in the political system, such as in the 1920s and the late 1980s" (Shnierl'man 1996). Writing on the book about the death of Captain Cook, Marshall Sahlins says that reproduction of a cultural and social system praxis is changed in front of our eyes – especially if it is put in relation to something unexpected and unknown (Magnusson in Sahlins 1988:15).

In this process of crisis and change in relation to something unknown, memories come to represent "the good old days" returned to and idealized:

> *"Every new day is more modern than yesterday. The modern is created continuously every day and gives many people the feeling of not being able to follow with their time. The modern and modernity ares thus put up against something other, namely against the traditional society with its traditional values. …(it)...stands for a time when…all humans had their place and knew it…and where all people were willing to uphold that order" (Lutzen 2003:165).*

Lutzen continues and sees how this longing for a golden age is out of scientific reach reducing history and archaeology to the sphere of ideological fiction.

Anthony Giddens sees this practice (as a reflexive practice and thus an objectified past) creating history as a modern phenomenon and not a principle that can be generalized and applied to all epochs. In his opinion, it is a version of the specific quality of reflexivity within modernity. I will try to discuss this notion here through a reflection on "the past in the past" and how the attempt to bridge the abyss of time possibly has, in a long-term perspective, something to say of reflexivity as a more fundamental aspect of cultural reproduction with long threads reaching far back in time.

The institutionalization of the past-as-object

Science shuns tradition and systematically tries to break its power. Thus, by an active dissociation to and critique of tradition, it is possible to break up conventions by the relativization of them, for example, when as an anthropologist you come home after a long fieldtrip and "see" your own embodied habits in a new light (Marcus & Fischer 1986). According to my view, the cultural critique may metaphorically be paralleled with Gadamer's epistemological concept of the fusion of horizons: "*Only in meeting the unfamiliar…will I be provoked into realizing that my horizons are to narrow*" (Gadamer in Lübcke 1987:163 ff), and as a result of that meeting you are forever changed. The point is that Gadamer, as a philosopher discussing the epistemological grounds for "modernity", shows by this how he has made the past into history and thus to an object out there and therefore something "unfamiliar" that both can and must be investigated.

In pre-Enlightment Europe, the past was not an object "out there"; it was as a mythical past, where: "Oral narratives telescoped, expanded and rearranged segments of the past in line with the significance attributed to them" (Lowenthal 1985:220). According to the "mechanical" perspectives of this time, "Humankind, society and nature were predetermined by a static and therefore unchangeable order (Jensen 2002:42); i.e., in this case, the literary "canons" of the day. It is understandable that an interest in time, change and history in general, was not a central issue then. Despite this, the Swedish archaeologist Ola Jensen continues, speaking of old artifacts: "..people had in earlier times…been interested in prehistoric objects. However, they where not to a greater extent considered to contribute to our knowledge of the past, but mainly obtained their value and explanations from the text" (Jensen 2002:43).

In the late 18th and early 19th century, things changed. According to Ola Jensen, the past, history and antiquities became subjects of enormous interest, and soon, archaeology came to be developed (Jensen 2002:42). From this time, the modern episteme and history (Foucault 1990:217-343 in Jensen 2002:42) became the main principle of how to form and structure knowledge and understanding. An eternal search was embarked upon that addressed issues such as the very roots of humankind itself and the role of people in an ever-changing world. Humanity became a surrogate for God, in that people were now the self-made engineers of history. Simultaneously, the loss of faith in a divinely ordained history (Arwidsson 2003), as the Enlightment proceeded, made the past not only remote, but also fearsomely different. This probably came to be by the comparative scrutiny of datable text and manifold contacts with exotic peoples, making it obvious how unlike the present our own previous thinking was. Consciousness that the past was unlike the present, that people in other times and places did things differently thus came to be central to progressive Western thought. This disembedding process of modernity (Hornborg 1994), created a situation where the past as an object became visible as "a past before us" (Ingold 1996), something that had to be "explained" or understood in relation to a radical revision of how the world was understood at that time; a radical revision of the important narrative that on a less abstract, personal level was discussed referring to Christina Doctare's life history and to Giddens's .

Halbersham (1999:17 in Dobres 2000:54) speaks of this period as the rise of a modern self-defining subject which aspires to take control of its own social relationships, rather than leaving those structures that shape its everyday existence to the authority of tradition carried by texts and/or narratives: "The once sacred, mystical and poetic aspects of culture were replaced by the craft, method, dispassionate and rational study of tangible matter". By this re-evaluation of the present, the world becomes discursive and objectified. In the same vein, the past becomes an object that can or must be investigated because it is "from the outside". But as the Swedish anthropologist Alf Hornborg has put it:

> *"If contextualism is served by a monist epistemology, we may conversely conclude that the "disembedding" tendencies of modernity are part and parcel of Cartesian dualism"(Hornborg 2001:5). In fact: "Decontextualisation and objectification can be seen as two sides of the same coin here".*

Thus, the decontextualized relics become objects detached from the world of the "cultivated human" (Bauman 1990:185) because the code that explained that world had crumbled; when the "body of collective wisdom, rules and proscriptions" (Dobres 2000:5) had shattered.

It is not surprising that at this fulcrum in recent history we find the growth of "archaeology" initiating a process whereby we in 2005 find experts (technically? skilled persons) peeping into a man-made hole in the ground. Archaeology, then, is an institution that as its subject explains the built environment of relics and sacred places, an environment that due to a break in the chain between the past, the present and Ego, was made "unfamiliar" and "foreign". This demystification of culture and traditions, as we saw, also relates to disengaged procedures of knowledge, the formation of historical distances whose fixity on a more general level distanced Us from Them. Modernity in this scenario represents: "(a) decisive transformation in pure ontology" (Cassirer 1951:38).

Through the modern episteme, objects as relics of the past thus came to be considered on the basis of their own internal lives and biographies

(Jensen 2002:45). This puts the question under the changed conditions of the present, meaning that the: "*knowledge seeking subject has become self-relating*" (Habermas 1989) rather than informed by tradition. Soon this loss would become its own tradition or ideology, an ideology that ironically shunned tradition.

Domestication of the past – science as conventional thinking within tradition

Archaeology then, as represented by the archaeologist under the parasol, is a representation of the way modernity *has to* approach the past-as-structure because the past is made into an object through disembedding. This need for digging, recording and reconstructing former life is a child of modernity's feverish "search for ontological security and thus for origins".

Is this active search in the scrap heaps of past events the result of a "break in the chain", a past and a present that is in conflict? Is archaeology really a practice that is invoked in the wake of a lost or threatened identity or is it just "a job"? "The job" being a metaphor for an embedded, unquestioned view of archaeology, archaeology as a naturalized *craft* legitimized through the routines of everyday practice. I will argue that this has bearing on the crucial and complex relation between embodied knowledge and discursive knowledge in cultural reproduction (Barrett 2001).

Kant is said to be the first to (explicitly) break with the metaphysical heritage (read tradition), divert philosophy from the True and Eternal and concentrate on what for most philosophers consisted of the confused, non-existing, the occasional and volatile. The Transient? This is where we see the crack that makes modernity possible, the loss of truth in the critical moments that Giddens speaks of (Giddens 1984). These critical moments no doubt reveal, through disembedding, your cultural code, and it has been the task of critical theory in general to unmask many of the false ideals, repressive practices, exclusionary identities and other fallacies of science and modern culture.

> *"This sort of wisdom and its applications become problematic, however, when the forms of criticism in which it was originally achieved are turned into academic genres of critique and commentary, and the insights are recast as established and legitimated academic knowledge" (Stenlund manuscript 2003).*

Following Stenlund, the problem with much archaeology today, since it has a long history of pretensions of being "a science", is that the "unfamiliar" in the past has become just too familiar again and thrown us into something much more like a "cultural" practice characterized by "routines"; a dealing with the past taking the form of a cultural "tradition" and is thus more akin to a domestic "recalled and chronicled past". In his book "The Order of things: an archaeology of the human sciences (1970), bearing on the French historical epistemologists, Michel Foucault thus talks about "the un-reflected preconditions for our knowledge".

As scientists, David Lowenthal says, we are, "too easily swayed by a spurious likeness, as seeming continuity". We should be wary of anything familiar. This, he continues, precludes the domestication of the past. Or as J. Harvey puts it: "separation is required conceptually in order that continuity and sameness can be made apparent. "the past is brought into the present, but the process requires that its otherness be addressed". (Ingold 1996:221).

Or with the worlds of Sherry Ortner speaking of anthropologists (but this could actually go for any scientists forever trapped in the ideology of a distant view),

> *"It is our capacity, largely developed in fieldwork, to take the perspective of the folks on the shore, that allows us to learn anything at all-even in our own culture-beyond what we already know". .."the importance of maintaining a capacity to see the otherness, even next door, becomes more and more acute" (Ortner 1984:142).*

Even scientists too easily "gloss over…past social realities" (the historical record) thus "weakening contradictions" giving the narrative a "powerful simplicity" making the scientific text (history) into a legend (Ingold 1996:209). The past is in this context not a foreign country but our own, however filtered or sanitized.

The daily routines of scientific work function to legitimize whatever tradition we work within. Thus, in a way, we live and work in accordance with an embodied, non-discursive understanding of the content and aims of our "science. The past is in such situations made to look familiar. "Even for academics, most of the time, the past is not a foreign country but our own". This said because the past is seen as another present. Films are regarded as popular tales set in other times - bridging past and present. "The same mentalities are shown to animate mythical or medieval as modern folk" (Ingold 1996:206). "Elemental passions are enacted on a timeless stage".

Since conventions are embodied habits and therefore "unseen", they are the fundamental, axiomatic preconditions *for* thinking. The discussed idea of the "field of archaeology" today, may very well be understood as such an unseen "habit". If it is so, then its role as a strategy to resolve an identity crisis, which was why it was originally formed as a practice, is lost; it is just something we do in our culture so to speak. Modernity has to start asking questions about itself again. Just listen to Pierre Bourdieu's vision of the true practice of sociology as a scientific discipline:

> *"The sociologist whot studies his own world, the most intimate and familiar, should not like the anthropologist make the exotic familiar, but make the familiar exotic. He does this by breaking with the immediate intimacy he feels for the life-forms and way of thinking that makes them foreign, because they are to well known" (Bourdieu 1984:255).*

Although he is totally wrong about the anthropologist, at least as they want it today, what we see here is a culture that has reified disembedding and thus objectification. The historian E A Carr (as cited in Dobres 2000:10), in the same vein sees distanciation as the (positive, I assume) sign of the modern scientist:

> *"The historian who is most conscious of his own situation is also most capable of transcending it…Man´s capacity to rise above his social and historical situation seems to be conditioned by the sensitivity with which he recognizes the extent of involvement in it" (Carr 1961:53-54).*

Scientists are thus expected to challenge straight in the eye an ontology that makes the world known and safe. Since ontological security is one of the fundamentals of the human existence, this idea of continuous critique for good reasons soon breaks down and the scientific work is turned into a culture or tradition. The good reason being of course the need for "ontological safety". Lowenthal (1985) sees a division between "the scientist" and the public opinion. The idea of a split kept open in western thinking and reified through the idea of a "science", thus seems to have been overtaken by cultural action; cultural action by real people doing real things, albeit getting its legitimate existence within a "field" ideologically cushioned in a culture of "a distant view".

If archaeology does not actively keep this split open, it has, in my view, lost the basis for its existence as a separate field. Hence, "historical empathy" is legitimate from a cultural point of view, a way to present informed and interesting narratives, but not within the field called science and thus not archaeology. Archaeology, as many other processes or reflexivity, illustrates an important force in cultural reproduction: the urge to form cultural conventions and traditions. When traditions are threatened a reflexive perspective is growing, but this is soon to be formalized into unquestioned habits again.

Strain or interest in cultural change

We have seen how cultural change may be understood as the result of a conflict between the structure of an ideational system and daily practice. It is not only typical for mundane life but found also in the core area of reflexive practice, science.

Sherry Ortner has discussed the motivation for action in situations of crisis in terms of two theoretical concepts that have bearing on this discussion of an enforcing crisis: strain theory and interest theory: "although pragmatic rationality is certainly one aspect of motivation, it is never the only one" (…) "need, fear, suffering, desire etc. must surely be part of motivation as well. Further: "the idea that actors are always pressing claims, pursuing goals, advancing purposes (...) may simply be an overly energetic view of how and why people act…". Actors within strain theory (Geertz 1973c) "are experiencing the complexities of their situations" (Ortner 1984:151). Here it is not the aggressive aggrandizer character that is the engine in cultural process (Hayden 1998), but people in the reverse situation, having lost confidence and ontological security, people under threat and strain…

> *"While strain theory does not rectify the psychological shortcomings of interest theory, it does at least make for a more systematic* exploration of the social forces *shaping motives more than interest theory does. Indeed, one may say that strain theory is a theory of the social, as opposed to psychological production of "interests", the latter being seen less as direct expressions of utility and advantage for actors, and more as images of solutions to experienced stresses and problems" (Ortner 1984:152).*

I will argue here that the strain a crisis puts on people, can be seen as a *human condition*. This condition, where malfunctioning cultural codes are made discursive, is further, I assume, an important part of the dynamics of the "structuration" of society (Giddens 1987). As part of a general theory of a human propensity to react in situations of trouble in social interaction, these situations may always have been there.

As we will see below, these periods of paradigmatic changes and discursiveness in relation to cultural codes, the loss of the certainty of how the world is created by tradition, might be the true seeds of cultural change. Archaeology, although still hypothetically, may very well aid in developing, expanding on and providing substance to such theory of "historical structuration" because we are at times "unbound, freely acting and voluntary thinking individuals" (Arwidsson 2003:150), and the past is an object out there. A materialized discursive practice, such as lithic technology, is a key to such a discussion of the long-term, since this way of communicating has metaphorical relations to cosmology as mnemonic devices in reproduction and construction of culture bearing narratives.

Knowledge and know-how

To be able to reconstruct an ancient craft, present day archaeologists or lithic specialists of the kind gathered at The Skilled Production and Social Reproduction Workshop, read stones, stones found by accident, through surveys or on archaeological excavations (Fig 2). I thus see *muscle memory as a vehicle for discursive knowledge*, aiding in the implementation of analyses of, and correct reproduction of the material world. Two questions pertinent to our understanding of this activity have bearing on my topic: the will or urge to do it in the first place and the actual skill necessary to be able to. The will to do so has a different background of course (as symbolic capital), but in general it is typical for modernity and somehow contributes to the construction of the grand narrative. The stones are reinterpreted in the present and are the

Figure 2. A lithic analyst reconstructing old technologies today. Skill manifests itself as the embodied ability – know-how – to reconstruct technical processes, but also as the ability to "read" the stones thus getting close to their discursive qualities. This reflexive reuse of old technologies as recipes for technical production is a representation of reflexivity of mind typical for the distanced "modern". Mikkel Sørensen and Errett Callahan at Lejre Research Centre, 2005.

sources for and stand as representations of past events in that narrative. The past as material culture is thus actively engaged in the present and made intelligible in relation to our view of the world.

The skill necessary to be able to replicate and read stones is a matter of bodily and cognitive experience, something we have several examples of at the workshop. This is the technically skilled practioner "who knows".

The archaeologist or lithic analyst then, in my argument, is but one, the latest one, in a long sequence of "archaeologists". The lithic craft person thousands of years ago, "returning" to old campsites of their past, may actively have used the relics found to recreate a craft using the same objectifying strategy. Not only as "discursive objects or phenomena of the subjects (craftsmans) cognitive experience", but based on the "real" qualities they possess, qualities that "*shape both our perception of them and our cohabitation with them*" (Olsen 2003:88

> *It is true that: "(…) more than any material limitations inherent in the mechanical and chemical properties of natural resources (like lithics) and/or ecological conditions, it is human agents and their webs of social relations and values that are central to the day-to-day (re)production of their material conditions" (Dobres 2000:127).*

But the skilled lithic craftsperson, although firmly situated in his or her cultural context, the craft being reproduced from within so to speak could according to my view, read the stones also within a more a-historic, universalizing frame. Here the "intertwined social and material constitutions of material practice" has temporarily been made separate (*the Present* in Maurice Bloch's (1989) terms, *knowledge* as seen by Jacques Pelegrin (1990), or *re-collective remembering* according to Bergson (Mullarkey 2000:48-55 in: Olsen 2003:97)), making "*the mechanical and chemical properties*" (Dobres 2000) and thus regularities of fractures in brittle solids (Knutsson 1998) more open for evaluation. In this way, knowledge or re-collecting memory is emphasised in the process, mimicking the distanced analytical work of the natural scientist in the true Baconian tradition. This distant view is thought of as being typical of the modern mind. But this is only the surface; underneath this technical relationship to past materialities there is another relation, the relation to history that forces people to "return to the sources" (Bourdieu 1996:63). Since the structure of the cultural field in Bourdieu's world relates to its *specific* history, this return cannot stand apart from it.

Reflexivity and archaeology

The archaeologist can only be understood as a socially informed agent created within the frame of humanity´s all encompassing historicity; as the result of a "drive" to relate to the past as society derives from antecedent conditions, highlighting time and history as causal factors (Gosden 1994). Relating to practice theory, the dialectics of structuration theory and its localization of causality of agency and structure in time and space, one could revitalize the actuality of "the question" once creating the subject of archaeology and formulate a real relationship between the past and the present: to situate ourselves in a radical political present. Here one could, for example, try to add substance to the theory of structuration through an investigation of whether there are any long-term historical consequences of structuration theory that go beyond the anthropological/sociological time perspective (Axel 2002; Drugge & Johansson 1997), questions of whether there are any relationships between disembedding and an activated generative thinking in the reuse of the past (for a discussion of the past in the past, see e.g. Gillian 2001; van Dyke & Alcock 2000; Bradley 1998) or whether there are any long-term historically formed structures that "inflict on the making of the new present" (Thörn 1997:13).

The archaeologist, to return to the situation under the parasol, is from this point of view, "skilled". He/she is the technically skilled practioner that by corporeal engagements with experiences of material culture can discuss the past from a detached position, personified in this workshop by lithic analysts reconstructing old technologies via direct relations to certain a-historic aspects of the present (fig. 2). The conceptually skilled practioner who understands and uses the past in the meaningful context of the present.

I have mentioned the nostalgia boom and see this as an expression of fundamentally the same type of ontological insecurity that formed the preconditions for the growth of modernity. It implies an objectified past. I have also mentioned the specific dilemma of modernity in the present, since the recent critique of the culture of reflexivity has seriously threatened the ontological position of the scientist and therefore the very ground on which modernity rests. Both these present day phenomena relate to an explicitly formulated or implicit existential worry and may be discussed from the perspective of the long-term and as a threatened culture of the present, thus how cultural reproduction may be related not only to the past but to an objectified past.

Returns and the construction of Narratives

The archaeologist setting the stage for this paper returned to a place of previous activities, albeit based on an institutionalized need to relate to the past, put up the parasol and started to dig. What could easily be discussed in relation to a theory of structuration, in terms of the past and its materiality, are signs of returns, archaeologists at work in the past. This has been discussed already (World archaeology 1999, vol. XXX; Gillian 2001; van Dyke & Alcock 2003)) and the archaeological record just overflows with examples. In my talk at the conference I provided quotations from some excavation reports showing that these periods of active return do exist.

> *"Scattered older iron age pottery fragments are a common feature on most Stone Age Sites in the region".*

> *"The large Mesolithic sites were also visited during the Neolithic"*

No doubt, people did return to places of their own past and it can therefore be argued that they had, at least at times, an active relationship to it. To be able to deal with this as part of a more serious theoretical problem, I think we should start by looking a bit closer at the specific processes related to these possible returns. We thus need to explicate material culture and its cultural context in accordance with the theme of his workshop, technology and its specific role in sequences of embedding and disembedding tendencies in reproduction and try to understand the relation between technology and the skilled "practioner who can tell". This relates not only to technical reproduction of a craft, but to the urge to do so, and therefore also to the mythical and structural levels of material culture. We have to look at the context of ancestral legitimation carried by material culture.

The thing as a materialized discourse in the construction of Narrative

We are all surrounded by objects in the built and natural environment: "these brigades of non-human actors that *constrain* direct and help our day-to-day activities" (Olsen 2003:88).

Some of these are relics that come from past events and in accordance with the theme of the Skilled production workshop, I will concentrate on relics from technological events. Sites where the traditional archaeological materials, such as stone tools and debitage are found may have been, as they are in modern eras, important social arenas for cultural reproduction. But the site is thus also a place of tension and therefore promotes cultural change. Material culture, functioning as vital parts of this communication, not least, as I will show below, as references to the ancestral past, will then be active both in conserving structure and in inducing change (Weiner 1992), or as Mark Edmonds says in talking about lithics;

> *"... The creation of technology, the form that it takes, and the manner of its subsequent deployment, serve as powerful media through which people reproduce some of the basic categories of their social and material world. For the same reason, traditions of making and using may also serve as a point of departure in the negotiation of new relations and new meanings."... (Edmonds 1990:56-57).*

Thus, we have to situate and understand the activities (technological) within the larger, meaningful social practices of which they are part and, above all, link them to material representations.

As representations of an idealized past, related, in Marshall Sahlins's version to ancestors or cultural heroes, the *dramatis personae* in important narratives, some of these non-human actors or technological products in the discussed process of disembedding and demystification of cultural codes in situations of crisis, must have become "unfamiliar" and thus had to be redefined. Their value in the past had to be re-formulated in the present contexts, reintroducing them into and helping to formulate the logic of a new cultural code, a new origin and a logic balancing the structure of social reality and daily practice. And even more concretely in Gosden's words: "Longer sweeps of recursiveness are solidly material, as it is the enduring nature of material culture that makes possible life on a scale greater than that of the individual" (Gosden 1994:137).

The past is thus also radically material and thus an aspect of the structures that "constrain, direct and help our day to day activities" (Olsen 2003:88) and, as we will see, we are also not "free floating intellects...detached…from the physical world". But this is not all, as I have tried to argue; this physical world, these traces of past events, are not always embedded as a past with us but objectified in disembedding and thus actively engaged in cultural reproduction as a past before us. As such, despite the fact that they have been deprived of most of their original cultural explanations causing a split between the structures (including material culture) of the social reality and culturally conditioned behaviours, they still as signs "constrain, direct and help". They are involved in social interaction as agents. As lithic analysts we understand these constraints in the form of debitage characteristics informing us about concepts of method technique. Their physical appearances are thus not open to any interpretation. Their new lives as agents are thus formed by the technically skilled craftsman's bodily experiences. It is in this dialectic web of material production and social reproduction that the "physicality of technical activities intersect with the lived meaningful world of human agents" (Dobres 2000:127). As such, the archaeological material record must be understood as a material discourse always in the process of being read.

Narratives and material discourses

An important aspect of the construction and reproduction of identities and thus the context of a reused past are collective rites and rituals. But what keeps together a series of such collective manifestations are "Narratives" (Thörn 1997:24). Narratives or myths contribute a perspective that in a given situation gives coherence and meaning to life (White 1987; Jameson 1989) by giving a name to a human collective and by localizing it in time and space. In this vein, the English historian Eric Hobsbawm in an often cited paper talks of "invented tradition", by which he means "*a set of practices, normally governed by overtly or tacitly accepted rules and of a ritual or symbolic nature, which seek to inculcate certain values and norms of behaviour by repetition, which automatically implies continuity with the past*" (Hobsbawm 1996:1). In this process, old materials are reused to construct new traditions for new purposes (Regner 1999:17).

It is in this latter function I will discuss skill and social reproduction, where the past, material culture and skilled production are brought together, skilled production becoming the vehicle for the construction of new traditions through a materialized Narrative.

The sacred time of origin constitutes in these myths a distant yet vital past against which the present can be contrasted. "The associative conventions of representation in myth make the intermediate times disappear", while the historical "narrative" tends to focus on middle periods or sequences of change which makes the process from past to present seem visible and comprehensible" (Hastrup 1987:261). They represent two different ways of linking past and present typical for cultures with and without written history. That is, whatever narrative is produced, the disorderly past (Lowenthal) may look ordered by hindsight. Because origin points are necessary, false beginnings (Conkey 1993) that imply unidirectional causality (Dobres 2000:11) we have to, the Swedish sociologist Håkan Thörn says, speak of a beginning rather than origins. Beginnings do not exclude that what is the beginning is a continuation of something that has already happened. That a symbolic fight has an historical beginning does not exclude that it has inherited patterns from earlier fights, patterns that vary and achieve new meanings (Thörn 1997:23) We thus stand in front of a continuously enfolding production of meaning, being an amalgamation of the past and the present.

Narratives, historical or mythical, are important in cultural reproduction. They insert the individual into a collective and in a space/time frame encompassing the individual's experience. It presents answers to questions such as who you are; from where you come; where we are heading. Narratives thus construct perspectives that in a given moment give cohesion and meaning to the world. These narratives are so fundamental to cultural reproduction and so universally present that they may be understood in a-historic terms. "The all encompassing process of narrative is actually thought to be the central function of the human consciousness" (Jameson 1989).

As an example I point out the connection between material discourses or metaphors and myth, e.g. Peter Roe's work on South Amerindian materials. Speaking of the mythic level of style, he shows the tight relation between aesthetics and its semiotic value. Myths, we are told, are "sacred stories that…explain the form (structure) and behaviour (process) of things (and sociality) and how they came to be differentiated. Myth therefore can be an important determinant of style. In these situations, the style of material culture represents the overt message in myth, shown by the iconography of material culture. They are surface manifestations of the unconscious patterning of "structure", a structure accessible at the mythical level.

Further on in the paper I will discuss these types of relationships in a case study of the Late Glacial hunter-gatherers of the North West European plain. The Norwegian archaeologist Ingrid Fuglestvedt has proposed that these groups of reindeer hunters had an animistic relation to their environment. In the arts and crafts in such societies, Roe tells us:

> *"The artefact symbolically represents its typological aspect, and recapitulates in the contexts of its processual fabrication and use, the pervasive animism of the world view of the groups that create it. This view of "object as myth, myth as object" is based on the animistic principle of the total spirituality of the world…" (Roe 1995:58).*

Technology in this setting is more than utilitarian items; the artefacts are mythical transforms of creatures which act as the major "natural symbols" in cosmology. One example is the myth of how to explain different levels of skill in basket making in Waiwai in Shefarimo.

> *"Looking at a basket and appraising its waratapi pattern from Urufiri's skin will "trigger" a recitation of this myth, just telling of the myth will "call up" the artefact as example. This process of "mythic empiricism" shows the intimate relationship between myth and material culture. The whole stylistic process, from the selection of raw materials, through the production of the form and its appropriate decoration, to the sex that employs this technology and the type of task for which it is designed, are all systematically linked to the cosmos in animism technology. Microcosm recapitulates macrocosm" (Roe 1995:59)*

The site as a sacred place

Artefacts, their production and use obviously have a strong symbolic and semiotic load in reproducing world-views thus explaining the world through a materialized discourse with mythical content. In the first quotation from Barbara Bender's book on landscape, that forms an introduction to the paper, not only the material "sacred" remains of past events are important in the construction of narratives explaining the world, but the landscape in which they are situated. "Landscapes contain traces of past activities, and people select the stories they tell, the memories and histories they evoke, the interpretative narratives that they weave, to further their activities in the present-future" (Bender 2001).

No doubt the landscape in different ways has to be incorporated into the life world and thus the narratives of groups in habiting that world. Perhaps as the "weeping bird-sound-word" songs of the Kaluli and Gisalo ceremonies in New Guinea evoke powerful images of landscapes, paths and places through which, as they harden in the course of the singing; "living people reconnect with their ancestors in seen and unseen worlds" (Feeley-Harnick in Ingold 1996:215 f). If this animated world was inside the heads of these people, it must at the same time have served as a mnemonic device, bridging the present with past events through material culture.

The built environment, the named and used landscape, is thus a break to "ceaseless change" and might explain the long sequences of continuity in material symbolism that we see in many prehistoric setting. But, as Lowenthal sees this continuity through the memory of man-made environment: "we lack their spontaneous and unselfconscious use of their own cultural conventions" (Lowenthal In Ingold 1996:209). "…we can never fully enter their perceptual world". That is as a past that is with us. "Nothing replicates the past as it was for those who lived it as their present" (ibid:209f). None of us doubts that "people select the stories they tell", the narrative is written from the historical position of the writer, but, as I will argue, there are constraints, constraints activated through the ”discriminant judgement of the (perceptually) skilled practioner" (Ingold 1996:48). The landscape is thus continuously re-read, albeit more so in certain periods than others, but always in a dialogue between the historical present and historical/mythical narratives represented in and carried by sacred places and relics.

I have already pointed out the drive for meaning that is triggered as reproduction for some reason fails. History as a past before us is activated in these circumstances. Not only archaeology but sociology was established as an answer to the same type of cognitive insecurity that characterizes these types of situations. For most of the sociologists at the turn of the century, the historical perspective was naturally important (Thörn 1997:22). Thus, reflexivity as a fundamental strategy in social reproduction might be elucidated by a historical reflection. Or rather, in line with what I talked about in the beginning of the paper, it is about genealogy, a genealogy of a certain mode of attention in relation to reality. Reflexivity in cultural reproduction.

Genealogy is a method whereby one tries to construct an understanding for the soil from which, for example, modern humans come from and in which they still live. What the genealogist asks her/himself is not what actually happened in history, but rather what is still alive from that time and in which special way it is living and thus contributes to the society as "structure". The point of departure is always a question that is put in and about the present (Beronius 1991:14). What I want to illustrate in the archaeological discussion below by putting this question from the standpoint of a prehistoric actor, is how the past is still living in the present even in a long-term perspective. Not as an origin, but as the result of an unfolding production of meaning with strands of historical events interfering with the production of a new present. Instead of origins we can thus speak of a beginning that will not exclude that the beginning itself is a continuation that has inherited patterns from earlier processes, patterns that are varied in a new way and that continuously change. It is the way this process relates to reflexivity that, however, is of prime interest here.

Genealogy in the Late Glacial/Early Holocene

The Late Glacial on the north European plain was a period of dramatic climatic and environmental turbulence. Almost within a lifetime the climate changed from what must have been the warmth of a boreal forest to ice-cold tundra – altering the conditions for life (Fig. 3) (after Engelmark & Buckland 2005). If, like Descola has proposed: "(…) social relationships provide a conceptual model for human-nature relationships" (Descola 1994:330, in Hornborg, 1994:9) then a changing environment must have had important consequences for the social world of these people. Once useful cultural codes became obsolete, an existential worry must have spread among the groups inhabiting the area. The past in Ingold's words, as a conceptual model "became alien to present (some 13000 years ago) experience, it was not any more generative of that experience". To trace or rewrite the genealogy of that present situation became important, a new past had to be created.

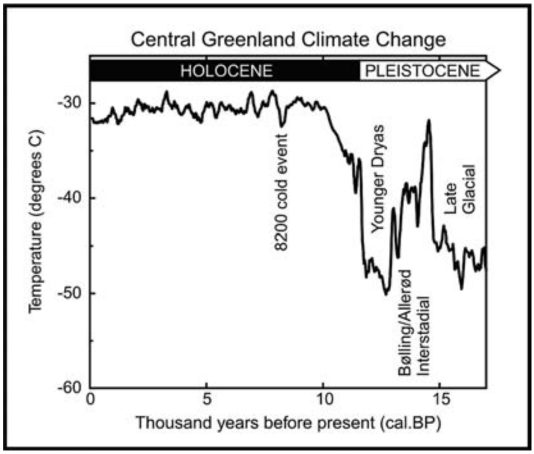


Figure 3. Temperature variations in the Late Glacial-Early Holocene in relation to changes in material culture symbolism or "archaeological cultures".

The new came to be what we know as the Ahrensburgian expressed through a peculiar public material symbolism. But, as the Swedish sociologist Martin Thörn sees it, to understand how the new was new, there has to be some knowledge of the identity of the old (Thörn 1997:20). That is, whether the new in its specific historical position was a reconstitution and re-interpretation of tradition. Thus, it is now that the past may enter the arena, a past represented by relics and sacred places as vehicles for the narratives. Thus, what can we say about the relationship between past and present in that critical time period? I will try to give a historical perspective on that radical *now* that we define as the Ahrensburgian tradition. This tradition was the latest of a sequence of big-game hunter-gatherers in the Late Glacial of northern Europe. Some of the earlier groups may be the historical substrate on which the Ahrensburg public symbolism was moulded.

We meet these groups through the remains of their campsites now lurking under the turf of a rural landscape in northern Denmark and Germany. On the sites we find remnants of culturally defined technological practice through lithic technologies, reduction sequences or rather *"chaîne de opératoire"* varying over time.

The lithic technological traditions we call the Hamburg, Federmesser, Bromme and Ahrensburg groups are found throughout the area; most sites are small and probably hunting stations left there by task groups during inland hunting. Although living in a changing environment, we know that people from these groups revisited old campsites, for example Sölbjerg in south-western Denmark (Vang Petersen & Johansen 1995:22)

Settling close to but many times respecting the outline of the old camp, similar activities organized similarly in space seem to have been conducted, as for example at Jels (Holm & Rieck 1992:Fig. 12). If not only going there to exploit the concentration of biotic "energy" through migrating animals (reindeer) steered by a maximizing strategy, why did they return? What did the Federmesser and Ahrensburgians think of that old camp and the lithics lying around? The point I want to make based on my discussion earlier in the paper but without going into any deeper analysis, is that they knew that site, they had an active relationship with it, it was at that time already part of their built environment and known past and thus a "sacred place". The narrative of its former inhabitants was hooked on to those places in the landscape and onto those relics lying around; the latter may have functioned as actors and representations of *dramatis personae* in the important collective narratives. Perhaps there were even ritual gatherings where the stories were enacted and important social relations of society reproduced through rites and rituals. As the climate deteriorated and the old narratives had to be renewed, a rereading of the "frozen" material discourse represented by the sacred remains may have been one strategy to renew the exemplary material of a myth in accordance with the ongoing historical present. Did this period of turmoil result in a historical reflection and if so *how* did these people reach over the abyss of time?

Bridging cultural difference, bridging the abyss of time

Through experimentation and thus experiencing flint knapping, Bo Madsen, the skilled Danish flint knapper, has himself tried to bridge the abyss of time by reconstructing lithic technologies of the Hamburg, Bromme and Ahrensburg cultures through actively re-reading the stones from the present day "Sacred places of origins". He thereby concludes that "The marked changes in the composition of artefact types and the surprisingly varied exploitation of raw materials during the last millennia of the Ice Age is *radical*" (Madsen 1995:16) (my translation). Although explained in a different theoretical context, the observations made show that the material culture in the Late Glacial when seen as public symbolism, as a material discourse explicating a cultural ethos of the groups discussed, indicates paradigmatic changes in the sphere of cultural reproduction during this period.

I will not go into detail of the differences in this short paper, but looking at the *chaîne opératoire* of the Hamburg, Federmesser, Bromme and Ahrensburg cultures, some aspects important to the present argument can be presented. Looking at changes in method and technique concepts of the lithic

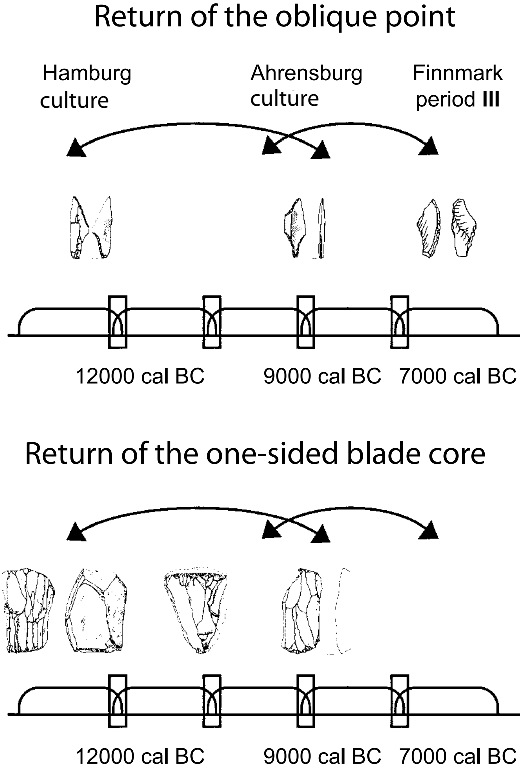


Figure 4. Blade cores from the Late Glacial Hamburg and Ahrensburg cultures. Core geometry, method concept and detachment technique is identical. This may be an example of the reuse of and actual reconstruction based on relics (Hamburg material) found on 2000 year old "sacred sites" by Bromme groups thus transforming the public symbolism to what archaeologists call the Ahrensburg culture.

reduction strategies, two things stand out: 1) Changes in flaking techniques indicate that the Hamburg and Ahrensburg groups used similar or identical soft impactors. 2) The core reduction method, the culturally conditioned system of organizing flake detachments and thus of forming the geometry of the blade core is identical in the Hamburgian and Ahrensburgian "cultures" based as it is on the unifacial, bipolar core (Fig. 4).

The Federmesser and Bromme cultural sequence filling the gap of c. 2000 years between Hamburg and Ahrensburg cultures shows a distinctly different lithic tradition.

Anders Fischer, discussing the technology of the Federmesser, Egtved find in 1988, comments on details of the technique and the flaking implements used.

> *"With respect to the hardness of the flaking implement, the Egtved flint clearly deviates from inventories which indisputably belong to the Hamburg and Ahrensburg cultures" (Fischer 1988:17).*

By looking at the fracture indications (see Madsen 1992), he can show that the Federmesser lithics have been reduced by using hard impactors, something he shows, with reference to Bo Madsen and Söncke Hartz, is also used in the Bromme culture. Fischer further comments on the method of flake removal from blade cores:

> *"One must namely in this case also assume that the flint knapper quite exceptionally forgot the systematic trimming of the core edges, and that he did not as usual work with bipolar cores with striking platforms laid obliquely to each other and with blade flaking along a limited part of the core side. Altogether it should be ruled out that the Egtved inventory originated in the Hamburg or Ahrensburg cultures" (Fischer 1988:17).*

The distinction between the Ahrensburgian/Hamburgians on the one hand and the Bromme/ Federmesser on the other thus did not only relate to variation in techniques. If the bipolar and unifacial blade core was typical of the former groups, the unipolar blade core was typical for the latter

It can be hypothesized that the Ahrensburgian Late Glacial hunter-gatherers' lithic technology (blade making) is a copy of the Hamburgian Modus or Gestures, based in a form of formalization of the sensuous experience. The fact that methods and techniques are similar indicates that the past as Hamburgian relics authored some 2000 years earlier were actively "read" by the Brommian and/or Federmesser groups, and thus indicates a reflexive view of the old flints whereby the muscle memory acted as a vehicle for a much more conscious strategy based on an "objectified" analysis of flaking strategy and type of impactor. The technical reading of the flints and the reconstruction of the operative chain, was however culturally interpreted and contextualized just like any authored "text". There is no room here to expand on this argument, which would be quite possible. It can be concluded, however, that the cultural reproduction in Late Glacial northern Europe included an activated past looked on by the "skilled practioner who could tell" at least technically, within an objectifying strategy. Historicity incorporated something of an objectified past. But as I will argue, the collective memory might have introduced itself as real history by culture bearing narratives carried by the re-used relics in the landscape over millennia. The fact that the Hamburgian tradition was reused was no coincidence but had historical roots.

The need to or urge to reconstruct this technology in all its minute details, including the tanged points, must be understood as a measure of its importance for the Late Glacial hunters, indicating its relation to "webs of social relations and values that are central to the day-to-day (re)production of their material conditions" (Dobres 2002). Based on the finds of large amounts of reindeer corpses in dead ice hollows in the Tunnel valley close to Ahrensburg in northern Germany, some of which seem to be part of sacrifices, the Norwegian archaeologist Ingrid Fuglestvedt wants to understand the reindeer as central in the cosmology of the Late Glacial Ahrensburgian reindeer hunters. She speaks of them, based on a generalizing anthropology, in terms of "non-human persons" that stand in a specific relationship to the human societies: "I have interpreted the reindeer as the good thing…This implies a kinship with religious and moral connotations between man and reindeer" (Fuglestvedt 2004:5).This interpretation is especially interesting in this connection because it presents a possible explanation for the specific change in material communication we see at this time.

It may have been the enforcing climate deterioration that re-introduced the reindeer in the landscape of the Brommean groups. Reindeers that may have been part of the mythological social memory of times past when reindeers where still a role model for human interaction in the Hamburg culture in the Older Dryas. The re-introduced reindeers in the Younger Dryas may, with reference to Marshall Sahlins's study of the dramatic changes on Hawaii in 1788, be called the Captain Cook of the Bromme people; an animal of mythical dimensions possibly representing one of the *dramatis personae* (Sahlins 1988) of culture bearing narratives and thus the catalyst for the new history. But exactly as the case was with Captain Cook and the Hawaiians, the attempt to activate the content of the myths introduced cultural changes. The reuse of the tanged point and the blade technology and the activated ideology that they carried, formed the new present, the Ahrensburg culture.

The Hamburgian relics carried an ideology of mobility moulded on the now physically present mobile reindeer and perhaps social flux going with it. This may have been what triggered the expansionist character of the Ahrensburgians and thus explain why they entered the long journey of colonization to the north. We can see their technology/ideology as archaeological sites in the coastal areas to the north at the onset of the Holocene. Traces of pioneering settlements are found along the west Norwegian border (Waaraas 2001; Fuglestvedt 2001; 2004), expanding into the Finnmark coastal areas (Tommesen 1996; Grydeland 2005) and as far east as the northern coast of the Kola Peninsula (Woodman 1993). This is also where the final part of this paper starts, the colonization of western and northern Scandinavia and the processes whereby the Late Glacial beginnings, once again mediated by the skilled craftsman, contributed strands of influence on the construction of collective identities through a materialized social memory, bridging millennia.

Aesthetics, nostalgia and cultural change in the north

The past is omnipresent as sites with relics in the windblown hills in the north Norwegian coastal area today, and must have been so also in the Early Holocene when the first colonist appeared in the area (Fig 5). Using the same tactics as when discussing the Late Glacial in southern Scandinavia, I will take a short look at the changes in material culture in the early part of the Holocene and relate this to the concept of historicity and genealogy in cultural reproduction. In Björnar Olsen's (1993) overview of the Finnmark prehistory, the early part of the Holocene is characterized by three distinct changes in material culture, named period I to III. Period I is the colonization phase characterized by the material culture of the Ahrenburgian legacy including single edged and tanged points (fig 6:a). Phase two is comparable to the early microblade phase in southern Norway and is characterized by microblade production from conical cores and the use of local and exotic raw materials. Phase III is characterized by the appearance of single edged and tanged point together with transverse and oblique points in the assemblages. We know very little about the blade industry during this period and thus cannot discuss the details of the *chaîne opératoire*. It is from this last period III, however, that I will look at the possible reuse of the past as relics. It is from this standpoint that the genealogy of the tanged point, its relation to a specific historical tradition carried by myths and material culture found on "sacred sites" and the possible importance of reflexivity in cultural reproduction can be discussed.

Figure 5. The omnipresent past in northern Norway today. Sites with debitage from knapping events like this one from the colonist period in the Preboreal, must have been as visible to the inhabitants of this area in later periods of the prehistory and may thus have functioned as material representations of the "sacred times of origins".

In 1993, I excavated a small hunting camp in the south Swedish mountain areas close to Tärnaby in southern Lapland. The site, the remnants of a small hut with a central hearth situated on a small rock in the lake Tärna, contained quartzite flaking debris from the fabrication of points and large amounts of arrow points related to this event. The formal variability was large, going from two-edged tanged points over single edged point to oblique points and transverse arrowheads (Knutsson 1998). The material had, due to point forms, strong affinities to both period I and period III in the Norwegian chronology and it was not until I got the C-14 dates that it was clear that the site belonged to period III, as three different analyses gave a date of c. 6500 BP (c 5400 cal BC) (Knutsson 2005: Manninen 2005). Scanning the region for comparable material it soon turned out that this period was of an "expansionist" character, as it was at this stage in the settlement of northern Norway that the inland was occupied (Olsen 1993). Apart from the known coastal sites, a few localities had been found during survey in inland northern Norway and still fewer (Devdis and Auksojavrri) excavated. Recent work in northernmost Finland has revealed yet another group of sites with similar inventory and C-14 dates (Kankanpää manuscript; Manninen 2005). Apart from Rastklippan, a handful of surveyed and excavated sites of this time period with its characteristic lithic industries are found throughout northernmost Scandinavia today. I will now turn to the past from the vantage point of the beginning of this tradition around 7000/7500 BP (6400 cal BC) (Olsen 1993).

Departing from the notion of the visibility of "the sacred past" in the north Norwegian coastal area represented by the period I lithic assemblages on sites in the coastal area, it comes as no surprise that the change in material culture as shown by period III lithics has strong bearing on period I (Fig. 6:a and b). As a matter of fact, points from the two periods are at times impossible to separate from each other. If culture is materialized as public symbolism (see Ortner 1984 above), the drastic change in material culture in this period indicates a paradigmatic cultural change. The fact that period III so heavily bears on period I aesthetics seem to indicate that period III lithics actually is a material representation of an active effort to copy forms and processes found on period I sites, here, similar to what was discussed concerning the Hamburg culture above, seen as the sacred time of origins providing mnemonic devises for a mythical "history".

Assuming that paradigmatic changes around or slightly before 6500 BC for some reason had forced the hunter-gatherers out of their embedded reproduction and thus called for a nostalgic backward gaze and an objectification of culture bearing narratives, the reappearance of the oblique point tradition as shown in Fig. 6a and b may be interpreted as the result of a pe-


Figure 6 a, b. Oblique arrowheads from two different periods of the north Scandinavian prehistory. Although almost identical they belong to two different material culture symbol systems separated by 2000 years. This may be an example of reuse of the aesthetics from the past whereby the sign qualities of the ancient stones represented something "known and safe".

riod of crisis, whereby the sacred times of origin were activated in attempts to reconstitute part of a crumbling world view. Through an active effort to maintain its culture bearing narratives it materialized as a socially charged technology in the present, thus once again part of the ongoing material discourse. As Jeanette Weiner puts it in relation to efforts to reproduce one's culture, the past is "*activated to bring a vision of permanence into a social world that is always in the process of change*".

Writing of this change in a paper in 2004 (Knutsson 2005), I did not present any attempt at interpretation of why this re-inscribed past was activated specifically at this time in northern Scandinavia. It is tempting, however, in the light of Ingrid Fuglestvedt's discussion of reindeers as non-human persons being part of the hunter gatherer sociality at that time, and the idea of aesthetics and its relation to ontological security, to discuss the return of the oblique arrowheads, devises used to kill reindeer, as caused by the metaphorical relation to the reindeer tied to the cosmology of these groups.

In a recent paper on the early history of the reindeer in Finland the authors (Rankama & Ukkonen 2001) can show that mountain reindeer must have been present in northernmost Scandinavia in 11500 BP. This animal entered in the Bromme world around this time, came to northernmost Scandinavia soon thereafter, and must have been important to early colonists of

Ahrensburg descent in the area. The two authors further conclude that the forest reindeer invaded Scandinavia from the east around 6000/6500 BC.

> *"The wild reindeer in Finland thus appear to derive from two distinct regions and to have used two separate routes in colonizing the area. The forest reindeer migrated into Finland directly from its eastern glacial refugia in Siberia. The mountain reindeer that invaded northernmost Finland from the northwest were descendants of the European Pleistocene reindeer that had migrated northwards along the Norwegian coast freed from ice during the Late Glacial period. At present, a north-eastern migration route through the Kola peninsula cannot be definitely eliminated. During the postglacial Climatic optimum the two subspecies met in northern Lapland, where their distribution areas overlapped. This resulted in the sharing of some morphological features" (Rankama & Ukkonen 2001:13).*

Björnar Olsen has in this context proposed that it was the pine forest expanding from the south during this period that formed the conditions for the inland settlement that we see in period III (Olsen 1993:40). If this expansion also carried with it the forest reindeer we do not know, but according to Ukkonen and Rankama, the timing is good. The northern hunter-gatherers at this time therefore did not only meet a new environment, but also had to adjust to a new non-human actor, because:

> *"From the point of view of the human hunter, the two subspecies represented very different challenges. They also played different roles in the overall economic systems of the human populations exploiting them. The mountain reindeer was a dominant game species for populations that largely depended on it for their winter subsistence, while the forest reindeer was for the most part only part of a much more varied diet" (Rankama & Ukkonen 2001:13).*

In the argumentation above, the reindeer was seen as an important actor with historical roots in the cosmology of the Late Glacial hunter gatherers on the north-west European plain. The forceful climate deterioration that re-introduced a new landscape and with it reindeers also reintroduced a mythologically consecrated reindeer-human. These reindeers became the Captain Cook of the Brommean hunter gatherers, a mythological messenger and therefore the catalyst of the new history. But as in Captain Cook, it was the attempt to activate the mythological material to save the ideological structure that simultaneously introduced the winds of change.

In the north, reindeers were already present and part of the life-world of the early hunter-gatherers. If the reindeer was reintroduced in southern Scandinavia in the Late Glacial, then a new type of reindeer with a totally different behaviour was introduced in northern Scandinavia c. 6000/6500 BC. Assuming with Marshall Sahlins that "if the legend heroes and the prime movers in history all the way down to the dramatis personae of mundane life, represent the concretization of cultural concepts and classes" (Sahlins 1988:37), then the reindeer and its mythological context may have been a mirror of the human sociality in this area. The introduction of a new actor, the forest reindeer with a different ecology must have caused problems. Here reality takes the form of non-human persons: "reindeer-people", in conflict with the mythologically anchored ideological structure that reproduced the cultural codes, were introduced.

The interpretation discussed points towards a context for the change in material communication, taking the form of the oblique arrowhead tradition. I thus present the hypothesis that changes in the natural environment introduce a new actor in the life world of the northern hunter-gatherer societies, a new "non-human person" that did not follow the culturally defined and transmitted rules for behaviour and therefore has to be re-inscribed in the that present. For the archaeologist who approaches oral cultures, it is of the greatest importance to creatively use the discursive qualities in the material culture as expressions for a mythological re-writing. In situations like these, the relics from past events that carried the Narratives became "documents" that had to be reinterpreted.

The sequences of an active relationship to the past in the Late Glacial and Early Holocene that has been discussed here illustrate the historicity within which we all are situated. The detailed analysis and the copying of Hamburg culture lithics show how this must be understood as conducted by a person looking at the world from a detached position, formalization of a sensuous experience and in reconstruction of technical processes mimicking the modern lithic analyst. The Early Holocene reuse of the past is different. Here the aesthetics of cultural materials, relics, seem to be important. Common for both is the active and discursive relation to the past as relics.

In traditional societies, the past is cherished and symbols appreciated because they contain and immortalize the experiences of earlier generations (Giddens 1997:42). Although normally embedded in cultural reproduction as "a past with us" *sensu* Ingold (1996), it may be integrated into the Narratives that create order in life. Through a form of reflexivity in day to day action, all people in a group routinely supervise activities and thus have contact with the reasons for behaving like they do. Tradition is in this scenario a way to integrate this reflexive supervision of behaviour in time and space. This places each activity in continuity between the past, the present and the future.

As I have tried to show in this example by placing myself in a radical *now* at two important and historically specific vantage points in time and space located in the late Pleistocene and early Holocene, we can see how continuities through a sequence of re-readings of cultural materials reappear as part of a material culture within a new context as the production of a meaningful new present. The *chaîne du opératoire* with its materialized sequence of technological events and gestures, no doubt had a strong textual quality making the rereading and its incorporation into a new material discourse historically relevant. Perhaps this can be called an "imaginary tradition" in Giddens's word (Giddens 1997:43), because its identity is founded on an argument based on reflexivity; in essence an invented tradition. But an invention carried by reactivated relics constructed through copying by the skilled lithic practioner "who could tell".

Individual interest or collective strain

Skill is normally related to discussions of craft-specialization in the reproduction of hierarchical structures controlled by aggrandizers. In Brian Hayden's world (Hayden 1995) the aggrandizer is a biological A-person, taking control over the collective knowledge in times of relaxed social control, for example in times of abundance. In this connection we could also remember John Barrett's "crisis of suspicion": (2001:154) when he talks about the relation between how to go on and discursive knowledge.

> *"But there were moments when practioners stood apart from the world of their actions and looked upon that world discursively. They objectified certain conditions as a strategy for acting upon them. Such moments of analysis may have arisen when things did not work, at moments of crisis, or at moments when political authorities sought to extend their authority, to objectify, and thus to act upon, the lives of others. In such situations the dominant social agents were akin to social theorists, formulating a ritual or a political theory of their own world in an attempt to control and analyse that world through their actions. They ascribed an identity for others, objectifying such communities in the legislative schemes of political control. Hierarchically structured forms of systemic integration may therefore be expected to contain agents who objectify some aspects of the social system upon which they may then act".*

Here the interest of aggrandizer individuals is seen as the force that introduces change through reformulating how the world should be understood. Although based on different ideas of what instigates change, both see the discursive situation, which arises when conditions change, as a slot where a "dominant agent" is given the possibility to and thus takes control over the interpretation of the past to further "activities in the present-future". This devotion to interest theory has, at least in Hayden's version, evolutionary underpinnings in terms of the "natural" presence of aggrandizing behaviour.

Strain theory as discussed above seems in this perspective on the Bromme/Ahrensburg tradition to give a better explanation of culture change. The social context of lithic production seems, at least in the sources available to us, the former hunting camps on the tundra, to be one of equal access to skill and knowledge. I refer to flaking floors as they appear in for example Hamburg culture at Jels (Holm & Rieck 1992), the Federmesser culture at Oldeholtwolde and Ahrensburg culture at Sölbjerg (Vang-Pedersen & Johansen 1995). The skill necessary to reread and reproduce the technical operations of the Hamburg culture which forms the Ahrensburg idiom seems to be a group knowledge continuing to be so as the technology and its associated value system changed.

A genealogy of reflexivity: on archaeology, skill and modernity

Modernity-as-crisis has reified the discursive situation of paradigmatic change and the scientists are thus ideologically, through the institutions of science, made into eternal cultural critics. Due to this enforcing ideology they must actively relate to structure - the past. If the past is seen as material traces, then old sites, artefacts, through their sheer materiality, set the stage for the present.

Of course we do not leave modernity and its disembedding tendencies and thus its objectification of the world simply because it is an ideology whose pointlessness has been made visible during the "science wars". This way of understanding has too much "contributed to constituting the social world we now live in" (Giddens 1984:xxxv), and thus made the practice of "science" into a craft steered by conventions. We repeat the diagnostic question for a modernity that reflects about itself. This distant view of the distant view, as Alf Hornborg calls it (1994), is part and parcel of modernity's fundamental agenda and the very writing of this paper is a physical representation of it. Instead of leaving modernity's call for dissociation and reflexivity, because of its inability to account for important aspects of culture as social relationships, value systems, cultural epistemologies, and world-views, I have taken the first personal step discussing more generally its possible importance in cultural reproduction over long sweeps of time. I thereby have to reclaim the need for the problem of actuality that Kant saw, this true "wish to know". Foucault reminded us of the importance of this message sent 300 years ago. "The subversive thinker is the one who explores the actuality of the present. They are the legitimate heirs of the Kantian critique" (Foucault 1989). That is, the question is formed by and has to be put under the changed circumstances of the present, and is thus a radicalization of reflexivity as critique.

This notion of the present takes us close to Michel Foucault's genealogical method that was introduced above as a way of understanding the process whereby the past is meaningful only as a means of getting a perspective on the unfolding of history in a radical now. Following the Swedish sociologist, Thörn, it can be said that "to understand how the new is new, there has to be some knowledge of the identity of the old".

No doubt reflexivity is fundamental to cultural reproduction and change, and although the distant past as material culture is continuously reread in relation to the present, the specific history of that past is always part of the rereading. The lithic craftsman, past and present, has a special relation to this specific past as a skilled reader of technical operations. However embedded in a specific, historically formed culture, the embodied know-how becomes a vehicle for construction of a new world through reflexivity and objectification.

Anders Högberg

Continuity of place: actions and narratives

Abstract
Järavallen is the name of a beach ridge along the south and south-west coast of Scania in the southern part of Sweden. Large amounts of tool preforms, particularly for Scandinavian square-sectioned axes, have been found on three sites along this beach ridge. The several thousand preforms represent tool types from the Early Neolithic to the Early Bronze Age. The three sites have not been much noticed in recent archaeological research. With a basis in a discussion of action and technology these three places are analysed and interpreted as representing traditions involving repeated actions over a long period of time. It is suggested that the production and deposition of the preforms can be seen as an investment for the future.

Introduction

In recent years, several archaeological studies in Sweden and elsewhere have focused on the continuity of place and on phenomena that extend over long periods of time (e.g., Karsten 1994; Burström 1999; Rudebeck & Ödman 2000; Högberg 2002; Bergren & Celin 2004). In these studies, the analysis of activities according to the traditional archaeological periods is replaced by an emphasis on traditions that have persisted over a much longer time. The focus has often been on the "conspatiality" rather than on the contemporaneity (Burström 1999).

This perspective creates dynamics between separate and individual events and the overall impression of all these events, i.e. between individual action and general patterns. Since the archaeological understanding of general patterns is built on traces of individual actions, intentionality is important. In this text, intentionality is not seen only in relation to the creativity and choices of the individual, but also in relation to the accessibility, i.e. what is available to allow action to take place (Hodder 2000:22 pp). Historical and material conditions create possibilities and establish limits. It is within social life that individual creativity has the chance to prosper. This creativity, the intentions of individuals, is part of the interaction between the individual and the community (Barrett 1989, 1994). In this we find the dynamics in the study of conspatiality, and ideas concerning the relationship between individual actions and the general context of these actions.

The purpose of this text is to look into how similar actions, repeated over time on a beach ridge along the Scanian coast, may have created places of special significance and character. The focus is on a particular category of artefacts, preforms for Scandinavian square-sectioned axes, that were deposited on the beach ridge (called Järavallen) during the period from the Early Neolithic until the Early Bronze Age, c 4000–1700 BC. The preforms represent thousands of individual actions, all of which were repeatedly carried out on specific locations during a very long time (Fig. 1).

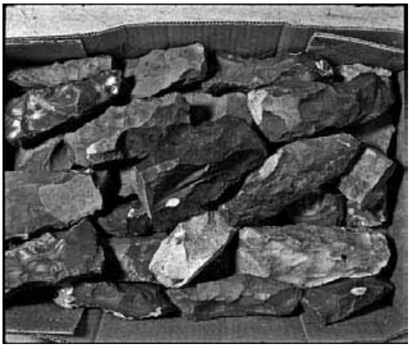


Fig. 1. A selection of preforms from the beach ridges. Photo by Malmö Museum.

The beach ridge Järavallen and the production sites

Järavallen is the name of a beach ridge along the south and south-western coast of Scania in the south of Sweden. It is situated around 5 metres above sea level and was formed by the post-glacial transgressions and regressions of the Litorina sea. The ridge mainly consists of stone, gravel and sand and in some locations small flint nodules are prominent. At three different locations along the ridge, there are natural deposits of large amounts of high quality flint (Högberg *et al.* 2001). These places are named Sibbarp, Barsebäck and Östra Torp (Fig. 2).

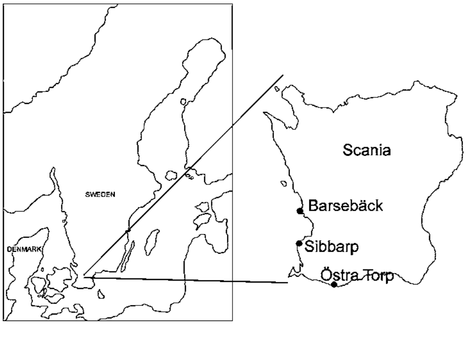


Fig. 2. Map of Sweden and Scania with the sites Sibbarp, Barsebäck and Östra Torp indicated.

These sites show evidence of an abundant production of Scandinavian flint axe preforms. High-quality Danian flint (Högberg & Olausson, in print) has been available and utilised for an extended tool preform production (Fig. 3).

Fig. 3. At the beach ridge Järavallen at Östra Torp, geological layers of Danian flint are visible. The photo shows the author testing the quality of the flint. Photo by Deborah Olausson.

However, what is so extraordinary and remarkable about these places is not only the evidence of the production of thousands and thousands of preforms carried out at the locations, but also the fact that large amounts of preforms have been left at these sites.

During intensive exploitation of the beach ridge by extensive sand and gravel extraction during the late 19th and early 20th century, huge amounts of preforms for square-sectioned axes were found (Kjellmark 1903, 1905; Rydbeck 1918; Hansen 1929; Högberg 2002). Thousands of preforms were collected. For example, in 1912 at Barsebäck, more than 1 000 preforms were found at one single occasion in the ridge within an area of *c.* 400 square metres (Althin 1954).

The preforms represent various types of axes that can be dated to periods between the Early Neolithic and the Early Bronze Age, and which were produced in accordance with different technological approaches. From this it is clear that they represent many separate actions, performed on different occasions (Fig. 4). Excavations have showed that many of the preforms were transported to settlements or other production sites in the vicinity of the beach ridges for the final knapping of the axes (Sarnäs & Nord Paulsson 2001; Högberg 2002).

Fig. 4. A straight axe preform and a preform with a broad edge. Note the difference in size and application of the flake scars between the preforms, which indicates different technological approaches. The preform to the left is c. 22 cm long. Photo by Malmö Museum.

Today, these finds are scattered and many preforms are included in collections of the local farms. Circa 400, most of them from Barsebäck and Sibbarp, are included in various museum collections. On several occasions, these preforms left on the beach ridges have been interpreted as discarded and non-functional (e.g. Glob 1951; Salomonsson 1971). The basis for this interpretation is the idea that if the preforms had been suitable for tool production, they would not have been left behind at the sites:

> *… one has to remember that it is only the discarded preforms that have been left. The adequate preforms were taken away (Salomonsson 1971:81).*

A closer study of the axe preforms in museum collections reveals, however, that most of them are of such quality that regardless of any technological or raw material considerations, they could have been made into finished axes. Hence, the preforms were not left behind because they were discarded due to technological considerations or because they were not suitable for further tool production (Fig. 5).

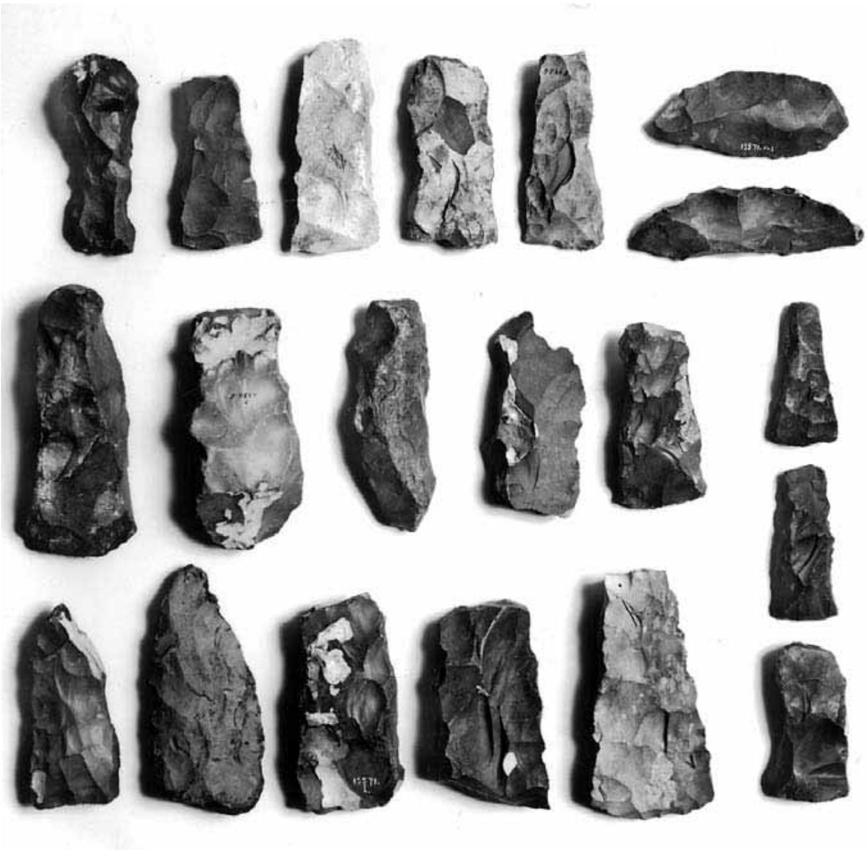


Fig. 5. Preforms from the beach ridge Järavallen at Sibbarp. Note – the two preforms to the upper right are preforms for Late Neolithic/Early Bronze Age bifacial sickles, not for axes. The preform to the lower left is c. 15 cm long. Photo by Malmö Museer.

Another aspect of these finds is that they have been interpreted as the result of actions performed over a short period of time. The places have been labelled as either axe factories or places with ritual depositions. However, looking at the typological aspect of the preforms, it is obvious that they represent preforms for axes which can be dated to different time periods throughout the whole Neolithic and into the Bronze Age (Fig. 6).

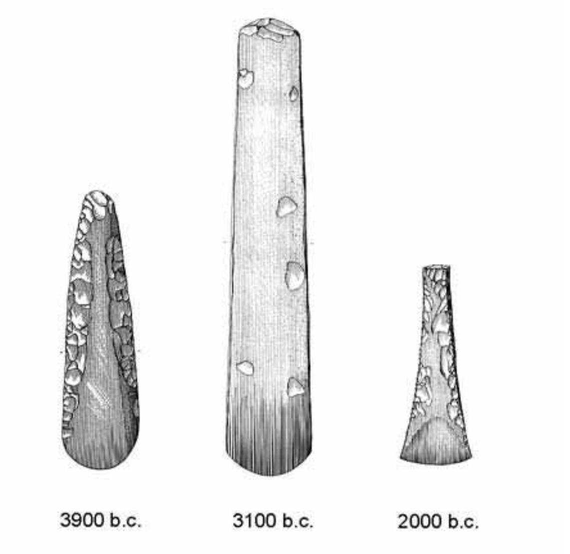


Fig. 6. Scandinavian flint axes can be divided into different typological groups. These groups have chronological significance. The figure shows three different types of axes from three different time periods. The axe preforms from the beach ridges represent different types of axes from different chronological periods. From Vang Petersen (1993).

Thus, thousands and thousands of fully usable and workable preforms have been produced and then left behind at these sites. The preforms represent various types of axes which can be dated to periods between the Early Neolithic and the Early Bronze Age. For the subsequent discussion it is important as a point of departure to state that:

- An extended production of axe preforms has been carried out at these beach ridges.
- A huge number of preforms have been left behind at these places.
- The preforms were not left behind because they were discarded due to technological considerations.
- The preforms were not left behind on single occasions, but throughout an extensive time period.

The significance of the sites

It is clear that the beach ridges were production sites for large amounts of axe preforms. The production was extensive and preforms were transported to other places in the vicinity for further knapping. (It is not unreasonable to assume that the preforms were also transported further away, although this hypothesis will not be discussed here.) Repeated production over an extensive time period created places which were literally scattered with preforms. The places were dynamic in the sense of transformations through different seasons. With autumn storms, preforms were washed out of eroded parts of the ridges; in winter the ridges were covered with ice and snow; come spring, the preforms were once again visible through the melting ice and snow, rain and waves; in summer the preforms became covered with seaweed and plants.

Why, then, were so many preforms left at the beach ridges? Fully functional preforms were produced, but left behind without being processed into finished axes. In order to discuss possible reasons for this, I have chosen to take as a point of departure the actual process of production. Although the production may be only one of several possible reasons for the repeated use of the sites, it is an activity that connects the use of the sites over time. Hence, the production may be seen as the "perpetual variable". The significance of the production and of its organization, and the way that its various purposes and aims came to material expression, probably varied over time. However, the activity that was constant at the beach ridges in the long term was the production of axe preforms.

Action, production and technology

Because the point of departure in this study is production, and because production implies technology, it is important to briefly discuss the basis for the study of flint technology which is applied here. Technology is created and used by people and is therefore something which joins human thought with material action (Schlanger 1994:143). Technology, i.e. the physical creation of things, is a social phenomenon. Intellectual thought is, in its action, a formulation. The performing action is a practical thought. Intellectual thought is manifested in practical action (Schlanger 1994:143). The socially constituted thoughts which have shaped technology are manifested, in action, through the technology. This line of argument is only used here to stress the social implications of technology. The established differences between theoretical thoughts and practical actions (Bourdieu 1977; Broady 1989), or between knowledge and know-how (Pelegrin 1990; Apel 2001) is important to note, but will not be further discussed here.

A characteristic of flint knapping is that several possibilities exist concerning the choices of available techniques and methods for the production of specific objects. Among the different strategies suitable for flint knapping, there is the option of choosing the most suitable for the purpose:

> *Whilst the production of stone tools takes place within broad physical and mechanical constraints imposed by the raw material, the artisan is nevertheless capable of implementing a number of different strategies to create a particular artefact (*Edmonds 1990:57*).*

The actual choice of raw material and flint knapping strategies, however, is not solely based on the evaluation of technological and methodological suitability. Within the cultural framework where the flint knapper works, functional and traditional requirements create needs for specific objects. These needs control the choice of strategies concerning with which raw material, techniques and methods the object will be made (Pelegrin 1990). As the flint knapper has the possibility within the framework of the tradition in which he or she works to choose a strategy for the task, the flint knapper's, and through the flint knapper the community's, attitude to flint as a raw material is manifested in the results of the flint knapper's work, that is to say, in the product and the waste material from the production. Each product is thereby the result of a chain of cultural choices in relation to function, technology and requirements. Each product and the handling of each product is an indication of a conception of the flint as raw material, and therefore the product gives a clue to the understanding of the many decisions that created its shape and use (Högberg 2001*a*, 2001*b*).

Action is essential in technology. Through the study of actions it is possible to approach the culturally conditioned choices which have created the prerequisites for the production of various objects. Therefore it is important to briefly discuss the premises that are used in this context in order to study technology and action.

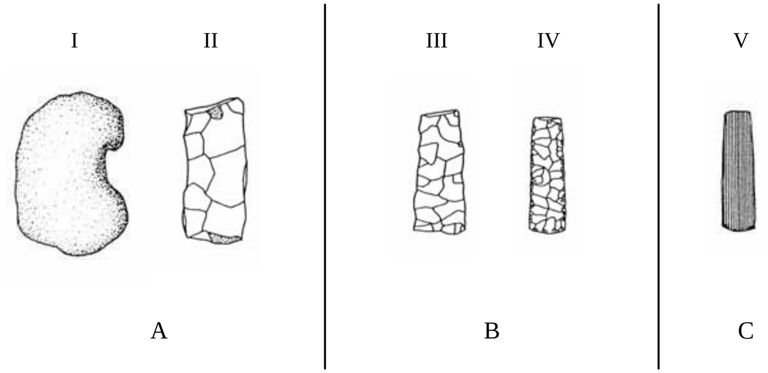
Axe preforms and chaîne opératoire

Technological studies of complex forms of production in which action has been the object, e.g. the production of square-sectioned flint axes (Högberg 1999), flint daggers (Apel 2001) or pottery (van der Leeuw 1994), have shown that specialized production is based on strategies that include several stages of production. These stages are all performed within the framework of what is available to allow action to take place. By studying actions it is possible to gain knowledge of the conditions for these actions. A well-established way to study action, technology, tool production and the handling of tools is by way of *chaîne opératoire* (Inizan *et al.* 1992; van der Leeuw 1994; Eriksen 2000).

Technology and action are intimately connected to the result of actions, i.e., the material culture. It is through the objects that the possibility to investigate actions is presented. Therefore, it is important to briefly return to the axe preforms from the beach ridges in order to investigate how a *chaîne opératoire* for these objects may be analysed. First, however, we must take a look at the premises for a general *chaîne opératoire* for production for Scandinavian square-sectioned axes (Fig. 7).

Fig. 7. A newly made square-sectioned axe, together with the flakes from its production. Flint knapper Thorbjørn Petersen. Photo by Anders Högberg.

The various steps in axe production have been thoroughly investigated in several studies (Arnold 1981a, 1981b; Hansen & Madsen 1983; Olausson 1983a, 1983b; Madsen 1984; Nordquist 1988, 1991; Knarrström 1997; Högberg 1999). It is common to understand this production as divided into five different stages, with the accomplishment of each stage being dependent upon the results of the preceding one (Fig. 8).



I – Collection of raw material II – Knapping of preform	A – Knapping of preform
III – Knapping of blank IV – Axe ready for polishing	B – Shaping of the axe
V – Polished axe	C – Polishing

Fig. 8. *Chaîne opératoire* for axe production, with five stages and three locations related to each stage. Square-sectioned axes are produced with what is known as the quadrifacial method. The basis of this method is a four-sided surface flaking that results in a blank with squared or rectangular cross-section. The production of square-sectioned axes can be divided into various working stages, with the accomplishment of each stage being dependent upon the result of that preceding it, from stage one when suitable raw material is obtained, to stage five and the finishing polishing of the axe.

Steps one and two are generally regarded as having been carried out at the raw material source, place A in Fig. 8 (Hansen & Madsen 1983; Knarrström 1997; Högberg 1999), and steps three and four as having been carried out either at large production sites or at settlement sites, place B in Fig. 8 (Hansen & Madsen 1983; Knarrström 1997; Högberg 1999). Step five, the final polishing of the axe, is generally considered to have taken place at yet another location, place C in Fig. 8 (Hansen & Madsen 1983).

This means that the axe production can be divided into five production stages and into three locality stages, depending on the place where the different production stages were carried out (Fig. 8). If we place the preforms from the beach ridges in this *chaîne opératoire*, they represent stage one and two in the production chain, and, expressed in spatial terms, as belonging to place A. It is important to note in this context that the preforms were part of a chain of action until they were removed from it. In other words, it would have been possible to make these preforms into finished axes. In other contexts, finds of so-called symbolic axe preforms, or axe images, have been made (e.g. Björhem & Säfvestad 1989). These objects are naturally shaped or only slightly knapped flints that have the same shape as actual axe preforms, but they could never have been shaped into finished axes due to bad quality or irregularities in the chosen flint nodules. The axe preforms from the beach ridges are not of this type, but instead fully functional preforms.

A chaîne opératoire for the preforms from the beach ridges

In accordance with the *chaîne opératoire* presented above, it is clear that the axe preforms from the beach ridges had a life-cycle that went from stage two in the production chain directly to deposition. The hypothetical normal life-cycle of an axe, from production to various forms of use and, finally, to discard and deposition (Fig. 9), has been passed over and the preforms were deposited before even becoming finished tools.

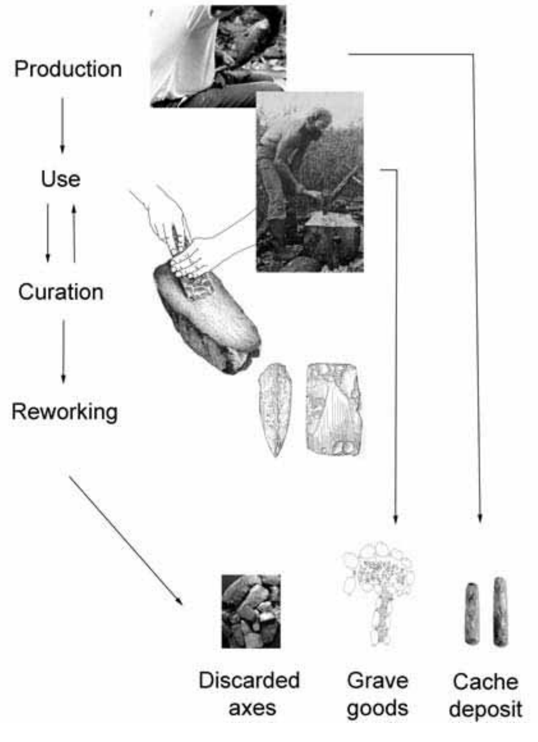


Fig. 9. Hypothetical normal life-cycle for an axe. The preforms from the beach ridges were physically never part of this kind of life-cycle. They were deposited before even becoming finished tools.

However, the finds from production sites within the beach ridges reveal that other preforms from the beach ridges were kept within the production chain and made into finished axes. As a consequence of this discussion, the question arises how a *chaîne opératoire* for axe production concerning axe preforms from the beach ridges may have been organised. Perhaps the preforms left behind were part of the *chaîne opératoire*, in which the production of axes based on preforms from the beach ridge actually contained the production of more preforms than axes, and consequently resulted in a larger production of preforms than axes? A *chaîne opératoire* for the production should perhaps not be seen as a linear process – from *one* preform to *one* axe? Considering the amount of preforms produced and left behind, a *chaîne opératoire* for the production of axes from the beach ridge preforms should perhaps be seen as consisting of an initial production of *one*, *two or more* axe preforms, resulting in the production of *one* polished axe (Fig. 10).

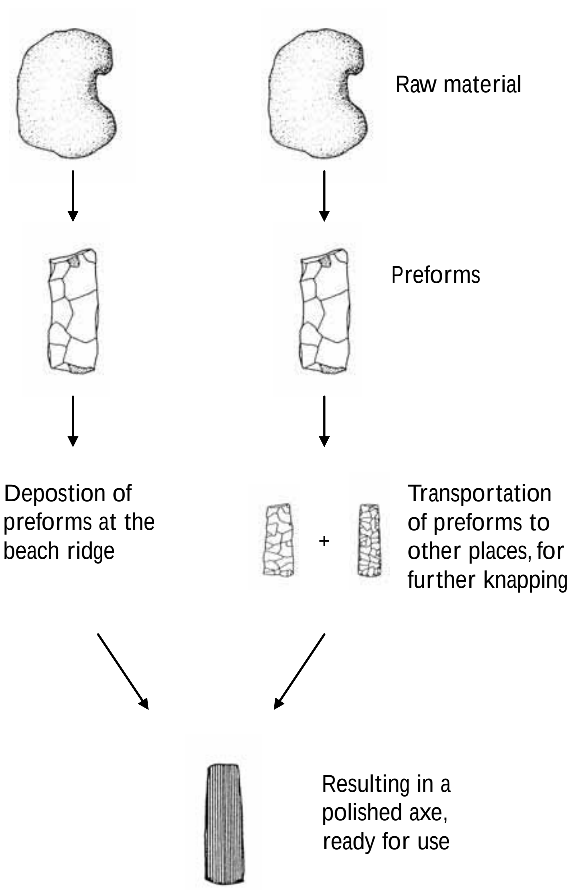


Fig. 10. Suggested *chaîne opératoire* for the production and life-cycle for the beach ridge preforms. A number of flint nodules are selected for the production of two or more preforms. One of the preforms is deposited on the beach ridge, while others are brought along to be made into finished axes at other locations. These actions, both the deposition of preforms on the beach ridge and the transportation of preforms to other locations, were part of the chain of production for axes.

In conclusion, it may be established that the axe preforms from the beach ridges could well have become finished axes. The production of axes included the production of preforms which were removed and knapped into axes and the production of preforms which were deposited on the ridges. Concerning the latter, the hypothetical normal life-cycle of axe preforms was skipped and the preforms were deposited without having been made into axes.

The beach ridges in a new light

Previous interpretations of the beach ridges include a dualism between the terms axe factories and ritual sites. Here I would like to discuss the beach ridges and the finds of axe preforms with the ambition to unite these interpretations. Central concepts in this discussion are technology and action, where technology and action are seen as culturally constituted and as manifesting the thoughts that have shaped them.

Archaeological studies of prehistoric societies and of human action in the past inevitably raise questions of rationality. There has been a long-standing tradition to assume either that humans in the past had the same conception of rationality as people today, or that they were mainly irrational (Damm 1998). This has been the case concerning studies of practical actions such as production and exchange – usually regarded as rational, and concerning abstract phenomena such as ritual and religion – usually regarded as irrational. In this study, the ambition is to look beyond these dualistic terms and to view them as integrated parts of the prehistoric society, or rather as opposites which never existed during prehistory as we see them today (e.g. Edmonds 1999). However, the concepts remain in this text, but only with the ambition to be used as analytical tools.

Production sites, stock of goods and axe factories

Several studies have shown that people value access to high-quality raw materials and that various social groups make efforts to acquire such materials. The relationship between places of natural assets and the significance of these places as raw material sources has been stressed (Højlund 1979; Hansen & Madsen 1983; Edmonds 1995). A basic reason for the use of the beach ridges for the production of axe preforms is, of course, the natural conditions of these sites. The huge amount of high-quality raw material in the ridge was a prerequisite for the use of the place for this purpose. The production of preforms, both those which were transported elsewhere to be knapped into axes, and those which were left on the site, was extensive.

Because the preforms were produced over a long time period, it is, as previously mentioned, not reasonable to interpret them as axe factories in the modern sense of the word; i.e. as "industrial production with a centrally organised division of labour and mechanised production steps, connected by a common exertion and aiming at mass-production" (*Nationalencyklopedin* 1997–98). The preforms have obviously been accumulated over a long time. But what was the reason for this? Within various techno-complexes ideas of availability exist. Several anthropological examples have been described, where tools and raw materials have been stored for future use (Binford 1983). The tools and raw materials have not always been stored with the intention to be used by those who stored them. Binford describes this with the term "insurance gear", and explains the term by using the words of a Nunamiut spokesman:

> *Every time men go out for something they have space in the pack or on the sled on the way out. Good men always say what can I carry that may help someone in the future. Maybe they decide that where they are going there is no firewood, so maybe they take out some extra. Maybe there is no good stone for using with Strike-a-Light, so maybe they take out some extra to leave out there in case somebody needs it later. In the old days … fellows always carried out shiny stones for making tools and left them all over the place so if you needed them they would be around.* (Binford 1983:271).

If this tradition of solidarity is transferred to the discussion of the preforms from the beach ridges, it would mean that an organised habit and tradition stated that supplementary preforms should always be produced and left at the site for future use. If this was the case, the preforms were actually a stock of goods, although not in a modern sense of "stock for the keeping of semi-manufactured products and finished products intended for sale" (*Nationalencyklopedin* 1997–98). However, the argument that these preforms were produced in order to be made into axes at a later occasion is problematic, considering the great number of preforms. This number reveals that the site, after many repeated visits, must have been virtually covered with preforms. Hence, it is unlikely that the notion of availability was the reason for the production of preforms for later use. There were already enough preforms to easily pick up directly from the beach. The tradition to leave all these preforms on the beach ridge probably had another reason than to secure the future availability of preforms.

Ritual deposits

Water and various natural formations are often closely connected with rituals and have been considered important symbols in human conceptions of the relation between the human being and the surrounding world (Karsten 1994; Koch 1998; Edmonds 1999; Bradley 2000; Rudebeck & Ödman 2000). Water and natural formations may be seen as representing aspects of human cosmologies (Rudebeck & Ödman 2000). The beach ridge is a place which connects these attributes, a manifested natural formation located directly by the water. The tradition to deposit objects in or in the vicinity of wetland areas during the Neolithic has been thoroughly studied. The objects thus deposited are usually interpreted in terms of ritual offerings (Svensson 1993; Karsten 1994; Hallgren *et al.* 1997; Koch 1998). Axes were obviously one of the typical types of objects in these depositions (Karsten 1994). It is clear that also raw material extraction and the production of axes may be interpreted in ritual terms (Edmonds 1995; Rudebeck 1998). One example that might be mentioned is Gabriel Cooney's study of social and ritual aspects of axe production and axe production sites in Ireland and Great Britain (Cooney 1998). Cooney describes axe production as an activity connected to ritual and the sites, where this was carried out as permeated with ritual and symbolic aspects (Cooney 1998:110).

Should we regard the preforms left at the beach ridges as the material expression of ritual? A common base for definition of ritual is "a standardised, institutionalised behaviour with symbolic significance, in which the ritual is symbolic in the sense that conventional behaviour expresses a deeper-lying meaning of a religious, magic or other kind" (*Nationalencyklopedin* 1997–98). Hence, rituals are regulated and there is a cultural agreement on the significance of the conventions. However, studies have shown that there may be room for significant variation, where agreements of individual parts of the ritual need not necessarily exist (Damm 1998). In a study of social and ritual aspects of raw material extraction, axe production and axe use in the highlands of New Guinea, Højlund has shown how the significance of axes within a society varies in norm and practice (Højlund 1979). Axes are reserved for men. The male axes and the use of them are associated with a complex social and ritual set of rules concerning how, when and why the axes may be used. This is the norm. However, there are examples when women have sometimes started to use old axes to cut wood within the household. Hence, the norm is challenged by practice. This practice is not normatively accepted and it is not very common, although existent. Although the norm expresses unity, the social and ritual significance of the axe in this society is ambiguous. Rituals may be regarded as open to interpretation and it is not necessary to assume the presence of a general unanimity. The ritual and social significance of things and performances may change, from person to person, from context to context and from one time to another. The unified impression of the ritual is nevertheless a perception of unanimity.

Anthropological studies have shown that stones, animals, celestial bodies and various natural phenomena are often part of rituals. They are the paraphernalia of human cosmologies (e.g. Lévi-Strauss 1962). However, the structures of meaning and the internal relationship within this paraphernalia have proved to be abstruse and difficult to define:

> *The accurate identification of every animal, plant, stone, heavenly body or natural phenomenon mentioned in myths and rituals is a complex task for which the ethnographer is rarely equipped. Even this is not however enough. It is also necessary to know the role which each culture gives them within its on system of significances. Of all these minute details, patiently accumulated over the centuries and faithfully transmitted from generation to generation, only a few are however actually employed for giving animals or plants (or stones) a significant function in the system. (*Lévi-Strauss 1962:53 p*).*

This reveals the complexity in studies of the meaning of various details in rituals, and may be perceived as discouraging. However, what is of importance here is that the meaning of objects and details in ritual is actually stated. They are part of the ritual and they are important in the ritual, irrespective of whether the meaning is elusive or not. This fact has important consequences for this study. The task is to study the objects, the axe preforms from the beach ridge sites, as possible paraphernalia of a cosmology and as manifestations of ritual. The focus is not on the specific significance of these preforms, but rather on the material expression of rituals. The shaping of the preforms, their deposition on the ridges and the transport of selected preforms to other sites (for final knapping) may all be seen as integral parts of a normative behaviour with the symbolic signification of constituting the sites as essential in the collective memory of the community. The important thing in this study is to focus on everyday actions, but also to regard the commonplace as possibly integral to ritualised behaviour. In this context, the preforms were the material expression, the paraphernalia, of this behaviour. The cosmological significance of the sites was manifested in the action to leave behind a part of the production.

The beach ridge and the preforms – an expression of production and ritual

It is clear that some kind of habit, custom, practice or tradition existed which created these sites, where fully functional preforms were produced and left behind on countless occasions. However, there is no reason to see this as the product of either practical/functional or ritual reasons. The functional and the ritual are often different aspects of the same context, so closely intertwined so as not to allow a separation, except for analytical purposes (Lévi-Strauss 1962). The rituals of daily life always exist (Barrett 1989:115). The presence of flint nodules and actual production of preforms for axes were obvious reasons for the significance of the sites as raw material sources and production sites. Axe preforms were produced because useful axes were required. The presence of debitage from axe production, e.g. flakes, at settlement sites are evidence of an extensive axe production. That axes were also used for various tasks is revealed by the many finds of worn, broken and discarded axes in settlement dumps, and by the often complete and unused axes deposited in burials and as offerings in wetland areas. However, the actual leaving behind of preforms on the beach ridges must also have involved some additional tradition. Some kind of cultural notion, a mentality, must have existed which urged or stipulated the flint knappers not only to produce, but also to leave preforms behind.

Continuity of place – actions and ideas

The beach ridges along the Scanian coast reveal a continuity of place, a "con-spatiality", of long duration. The actions taking place there have been guided by expectations of the place, and of the activities that have been performed there, and the expectations have come to a material expression through a specific set of actions. What connects the use of the place through time is therefore not only the place itself, but the place together with the activities that have taken place there. However, the use of the beach ridges through time does not imply that a "continuity of place" should be comprehended as a continuous and repeated knapping of preforms, from the Early Neolithic to the Early Bronze Age.

In his dissertation, Per Karsten discusses the tradition of axe offering during the Neolithic (Karsten 1994). He considers this as a persistent tradition, a tradition and custom which existed throughout the entire Neolithic. The way the depositing of axes was carried out, i.e. the *action* in itself, varied through time, but the general idea, the *tradition*, was most probably the same. Hence, the actions at the beach ridges may have varied and changed through time. Perhaps it was customary during one time period to leave behind one preform for each preform that was taken away, while during another time period it was customary to leave behind one preform for ten preforms taken away. The result might be that preforms produced and left behind during the Early Neolithic were picked up and taken away for further shaping during the early Middle Neolithic. Thus, there may have been great variation in how the activities that took place at these sites were performed, although the same type of objects was involved. However, the thoughts about the place and the meaning of the actions that took place there seem to have been lasting. On repeated occasions, during a very long time period, the places have been visited with the purpose of manufacturing preforms and during this long time period, preforms have been left at the site.

Consequently, the factors linking the use of the beach ridges through time were the conception of the places and the ideas concerning how to act there. I have found it tempting to investigate how this formed people's perception of the place. The people who sporadically or on a daily basis visited the beach ridge or moved around in its areas -- how did they envisage these places? How was a find of a preform for an Early Neolithic point-butted axe comprehended by a flint knapper who visited the place during the Late Neolithic in order to produce a preform for a broad edged thick-butted axe? How did this person "read the older design" and how did he or she perceive the craft that it manifested? What thoughts were evoked about previous flint knappers, the craft, the place and the community of which those knappers were a part?

Oral tradition – narratives beyond the beach ridge

Narratives and oral traditions as social interactions and as tools for communication are important to human beings and may be regarded as general and cross-cultural phenomena (Daun 1999). There are endless examples of the communicative and constitutional possibilities of narratives (Fiske 1993). Existential conditions and the fundamental meanings of human life are investigated by way of narratives. Narratives of origins, being and the future, and their association with human beings, events, objects and places are, and have always been, a fundamental part of myths and rituals (Lévi-Strauss 1962; Bourdieu 1977; Andersson *et al.* 1997). Narratives are essential, both to individuals and to communities.

A central point of departure in this study is the notion of places and landscapes as socially significant during prehistory. Human beings make spatial arrangements. Based on norms the entire environment and specific places are conceived of in terms of intention and use. The cultural organisation of the landscape manifests a spatial organisation of established meanings, norms and values:

> *The landscape is redolent with past actions, it plays a major role in constituting a sense of history and the past, it is peopled by ancestral and spiritual entities, forms part and parcel of mythological systems, it is used in defining social groups and their relationship to resources (*Tilley 1994:67*).*

Places of raw material extraction are significant in this context (e.g. Edmonds 1995, 1999; Cooney 1998). If certain places have been ascribed meanings that are persistent through time and if one can accept that the meanings of places are manifested in material culture, then production sites like the beach ridges discussed here may offer insights into past human thoughts (Edmonds 1999).

The sites were attractive due to natural conditions, and the availability of high-quality flint (Fig. 11).

Fig. 11. The beach ridge at Östra Torp, scattered with flint nodules. Photo by Anders Högberg.

This caused people to seek out these places in order to extract the flint for tool production. Repeated visits through many generations turned these places into meeting places which, by way of the craft, assembled both living and dead, in the sense of memories of ancestors. A flint knapper (man or woman) visiting the place accompanied by a prospective flint knapper (a child) would here meet the flint craft of earlier generations in the shape of tools and styles, hundreds of years old. In this meeting, generations of craft of flint knapping were passed on from older objects and forms through the present and onto future flint knapping. The significance of the site in the mind of its users and visitors was thus verified and reproduced. The preforms left behind by earlier generations may in this have functioned as a reminder of the significance of the site and of the tradition, an affirmation and legitimisation of the present by way of the past and a guideline for future action. Referring to the past is a strong argument in the creation of legitimacy and also constitutes a future warrant of authorities, powers and rights. Access to and the use of the places may have been manifested in this kind of tradition. Hence, a flint knapper who could "read" and understand flint technology was also the person who possessed the knowledge of how to interpret the past. Consequently, the privilege of the flint knapper was to have a code to the past at his or her disposal.

Acknowledgement

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Jan Apel

Skill and experimental archaeology

Abstract
This paper examines a way of combining the unique experience and knowledge that flint-knapping experiments produce, with a more distant and rational way of conducting research, which is the archaeologist's point of departure. In line with a French epistemological tradition, it is suggested that a relational research process, in which these two perspectives are consciously merged, is needed in order to elucidate the social aspects of technology. In order to illustrate this assertion, the Late Neolithic flint dagger production in southern Scandinavia is studied with concepts that allow for a relational perspective.

Introduction

Archaeologists tend to interpret technology from two different perspectives (Dobres 1995; Roux 1999; Torrence 2001). Those inspired by Contextual Archaeology, Culture History and Phenomenology stress the importance of understanding traditional craftsmanship from "the native point of view", while science-orientated researchers maintain that archaeological remains of craft production in themselves are mute and that interpretations must be based on comparative studies conducted from a distance. I suggest that our knowledge of the past as well as the present could gain by *consciously* merging these two perspectives. This ambition is in line with the epistemological tradition in the French philosophy of science, where these two sides of the research process – realism and rationalism – are regarded as complementary in scientific reasoning and that the positioning in such clear-cut epistemological couples lack foundation in scientific practice. Accordingly, science is not entirely a rational practice or simply a question of describing empirical phenomena – it is both at the same time (Bachelard 1984:1 ff; Bourdieu *et al.* 1991; Broady 1991:387 ff; Bourdieu 2004). As a consequence, concepts such as "technology" and "skill" should be studied in ways that, on the one hand, accept the personal experience of the experimental flint knapper/informant, and on the other hand, formalise these experiences with different forms of objectifying techniques.

For science-orientated archaeologists it has been essential to create instrumental categories that primarily are connected to the technical aspects of skill (see below), since scientific classification might reveal patterns, of interest to us today, of which the prehistoric agents themselves were unaware. A phenomenological approach, on the other hand, aims at contextual understanding and this requires that the researcher share categories with the agents whose technology is investigated. Thus, the analysis has to be based on folk categories that are embedded in conceptual skill and that are needed to understand skill from a cultural specific point of view. This implies the use of some form of ethno-methodological research strategy that strives towards understanding the experience of the people that are actually involved in the craft that is studied. During flint-knapping experiments, for instance, this tradition would take the *emic* judgements of the expert flint knapper for granted.

In archaeology, these two perspectives were originally discussed in the typology debate of the 1950s and 60s (see Malmer 1965). However, while this discussion revolved around the question of whether or not archaeological types were "real" (realism) or "constructed" (rationalism) the possibility of merging these perspectives was never considered, probably because the subject of Archaeology during this time was under the influence of a "closed" positivist epistemology that denied the importance of subjective experience. As concerns experimental archaeology, the severe critique of *emic* approaches delivered by processual archaeologists, such as David Hearst Thomas (1986) and Lewis Binford, must be seen in this light. This may also explain why the *chaîne opératoire* approach, originally created by André Leroi-Gourhan within the frames of a truly relational epistemology (Levi-Strauss 1988) tended to be reduced to a tool for empirical descriptions of reduction sequences in its various Anglo-Saxon versions (Audouze, 2002; Knutsson & Apel *in prep*).

In the 1980s and 90s, a relational perspective was advocated in a debate of the archaeological use of relational *versus* formal analogies. In this discussion, the importance of the inside-perspective was emphasised, perhaps as a result of the fact that it coincided with the post-processual theoretical debate (Wylie 1985; Ravn 1993). While the notion that most archaeologists use sensually-based as well as different forms of objectifying techniques in their research is self evident, there are great advances to be made if these different phases in the research process are used in a consistent manner. An *emic* (inside) perspective needs to be combined with a modernistic (outside) perspective if we want to go beyond that which is purely cultural and ideological. This is not least important when social aspects of prehistory are discussed and, as I see it, it is a prerequisite for archaeology in general (Apel 2001:9).

From substance to relation

Interpretations produced by proponents of the two traditional perspectives have one thing in common: they have a substantial character whether aiming at instrumental and technically orientated descriptions – based on experiments or distanced observation – or at an understanding of the ideological esoteric rules and regulations that surround traditional technology. In this context, the term "substantial" refers to a phenomenon that has an intrinsic value; an inherent value that can be appreciated by all humans and not only those who have knowledge of the culture in which the phenomenon occurs. During the past 30 years, it has been firmly established by educational sociology that a homology exists between the objective assets of individuals (both symbolic and real) and their cognitive structures, i.e. their personal thoughts and opinions. For two instructive examples from Paris and Stavanger respectively, see Bourdieu (1984) and Rosenlund (2000). These studies demonstrate empirically that substantivist interpretations are ill suited if social issues are to be investigated, since social facts can only be relationally defined. Bourdieu (1987:2) has illustrated this problem in his discussion of "the opinion". An opinion is put forward by an individual and is, in this respect, based on a subjective experience. However, since the opinion is brought forward by a person with a fixed social position, based on his or her symbolic and material assets, it cannot be regarded solely as springing from the individual. The opinion is inevitably coloured by the objective social position of its owner. Any research process that aims toward social interpretations should keep this in mind. Thus, neither of the two traditional approaches, that is the technical/conceptual dichotomy, can be used to properly discuss social aspects, and since one of the aims of this paper is to argue for the social aspects of technology, we have to choose a different path, and aim for a merging of technical and conceptual skill.

Archaeologists in general accept that few artefacts have an intrinsic value independent of the position in the social space of its owner. It is surprising that the awareness of the relational value of things has not resulted in a similar awareness of the relational aspects of social interpretations themselves. By practising a relational research strategy we are forced to clearly articulate and combine the in- and outside perspectives, in analysis as well as in interpretation, and be able to understand specific events in relation to general processes. This may allow us to move beyond the descriptions of individual disparate historical events, leading to an "illusion of transparity" (Bourdieu *et al.* 1991:109) that can be produced by the inside perspective, on the one hand, and by emphasis on the outside perspective on technology and function, on the other hand.

A relational perspective on skill might be formulated as in Figure 1. In order to study the conceptual side of skill, contextual and historical information is required, while the practical side can be studied and analysed from a distant perspective. Since skill, in this context, is regarded as a social fact, it can only be defined as a relation of these elements.

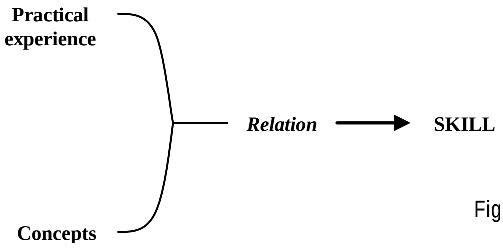


Figure 1. A relational view of skill.

I will explore this possibility by using results from controlled archaeological experiments on the production of Late Neolithic flint daggers. This technology was conducted in a society that most probably did not adhere to the economic rules of present day western societies. However, as we will see, this does not mean that the discussion lacks implications for the view of technology in our own society. Archaeological and ethno-archaeological studies of material culture may, in fact, contribute to an deeper understanding of how material culture affect us today simply because the distant perspective allows us to register aspects that appear natural to us in our own social sphere and, thus, become unobservable.

A definition of technology

In this context, technology is regarded as a coherent system of artefacts, behaviours and knowledge that can be handed down from one generation to another (Schiffer & Skibo 1987:595). This definition enhances the importance of the reproduction of crafts through the generations, something that pertains to the Neolithic production of daggers. The empirical example deals with the organisation of traditional craftsmanship with respect to sequence of gestures and procedures into different stages of production as well as the intra- and inter-site spatial distribution of these stages. The point of departure is that traditional technologies were vehicles for the reproduction of a social order and we assume that the reproduction of traditional technologies through the generations was based on kinship. Convincing arguments for this has been presented elsewhere (see for instance Guglielmino *et al.* 1995; Shennan & Steele 1999; Santillo-Frizell 2000; Shennan 2000 and Stout 2002).

The Production of Late Neolithic Flint Daggers in southern Scandinavia

During the period between 2350-1500 cal BC, diagnostic flint daggers were produced in southern Scandinavia. Over 13,000 of these daggers are known to be distributed over a fairly large area in northern Europe (Fig. 2). Since it is impossible to study the prehistoric production of daggers at first hand, we have reconstructed the production process by conducting experiments and comparing the results with waste products and preforms from prehistoric sites. An initial aim is to define the necessary technical skills needed to be able to carry out different production stages in the making of flint daggers and thus forming the basis of an interpretation for the structure of the apprenticeship system that guaranteed the reproduction of the technology through at least 24 generations.

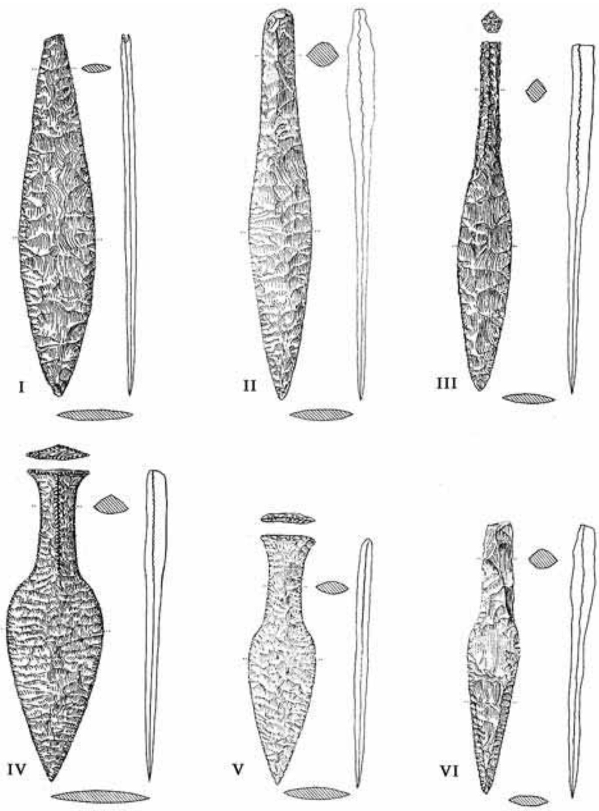


Figure 2. The six main Scandinavian flint dagger types (Apel 2001:234, Fig. 8:1).

Traditionally, there are two ways of defining stages in the experimental production of a flint tool, and these two ways correspond to the distinction between realism and rationalism (Apel 2001:130 f.). Proponents of an inside perspective suggest that stages should be defined from the experimental flint knapper's point of view. Thus, a transition between two stages is defined by a major change in the technique and manner of the flint knapper (Whittaker 1994:201). In order to be a useful tool for archaeologists working with prehistoric sites, this change has to be significant enough to affect the production debitage in a recognisable way. Some researchers argue that a natural production stage occurs when a stage defined in this way coincides with the completion of the mental template that is needed to secure a continued reduction (Callahan 1979; 1986). Proponents of an outside perspective, on the other hand, prefer to work with stage definitions that are independent of any subjectively defined technological changes and instead are based on a division of the reduction sequence into artificially, nominally defined stages (flakes 1-20 = stage 1, flakes 21-40 = stage 2 etc.). It can be suspected that very few flake types of particular stages will be defined if such a division of the reduction sequence is used on an archaeological material. This is due to the fact that researchers who consciously avoid the personal experience of good craftsmen will miss out on the deep understanding that experience gives. However, this understanding has to be balanced by a more formal approach if it is to be useful in a broader scientific context.

In the production experiments with type IV Danish flint daggers that I conducted together with Errett Callahan, eight production stages were defined according to the *emic* perspective: (1) Obtaining raw material, (2) Rough-out, (3) Primary Preform, (4) Secondary Preform, (5) Tertiary Preform, (6) Grinding of blade, (7) Parallel flaking and (8) Retouch.

There are two reasons why these production stages must be defined in the production debitage from the experiments. First of all, from a general epistemological point of view, in line with the introduction of this paper, it was important to supplement Callahan's *emic* definition of the production stages with an independent definition based on an analysis of the production debitage. Such a definition is also necessary when prehistoric sites with dagger reduction sequences are discussed in relation to Callahan's *emic* perspective. Since this was a major aim of the experiments, diagnostic flakes from several of the production stages were defined in the production debitage (a thorough debitage study of the experimental flakes will appear in Callahan, Apel & Olausson ms). Diagnostic flakes from several of Callahan's stages have then been used to identify dagger production sites in archaeological contexts as well (Callahan, Apel & Olausson ms).

An investigation of prehistoric flint debitage from excavated sites in Jutland conducted in 1999 reveals that different bifacial production stages were conducted on different locations in the landscape (Apel 2001:199 ff.). Accordingly, early stages (stages 1-4) were conducted on secluded spots near the raw-material sources at a certain distance from the settlements. A typical example is Fornæs on Djursland (Glob 1951). Here the knapping floor was positioned on a beach below the steep, white chalk cliffs that contain large pieces of flint including a high-quality senonian variant appropriate for the production of flint daggers. Interestingly, the production debitage from these sites seems to contain a high proportion of knapping errors (Olausson 2000:129; Apel 2001:189 ff.). Because of the fact that a high proportion of knapping errors can be a sign of inexperience, we might suggest that apprentices were conducting a major part of the earlier stages at these sites.

The present (generative)--**The past in the present (repetitive)**				
To the site	small beach nodules	blades	square axe preforms	dagger preforms
On the site	Beach nodules were turned into scrapes, stickles and borers with direct and pressure techniques. Artefacts as well as debitage were used and deposited on the site.	Blades were used as harvesting knives and as preforms for transverse arrowheads. Debitage and harvesting knives were deposited on the site.	Axe preforms were knapped and ground into finished thick-butted axes by artisans. Some of the debitage were used as preforms for scrapers and other tools	Dagger preforms were knapped into finished lancet-shaped daggers by artisans. Some of the debitage was turned into bifacial, heart-shaped, arrowheads.
From the site		Transverse arrowheads were used during war and hunting parties.	Thick-butted axes as well as selected flakes were deposited in graves, hoarded and were distributed by a large scale exchange network for prestigious goods	Lancet-shaped daggers, bifacial arrowheads and selected bifacial thinning flakes were deposited in graves, hoarded and were distributed by a large scale exchange network for prestigious goods

Figure. 3. Flow chart of the flint industry at Myrhöj related to the theoretical concepts of Maurice Bloch's concepts "the present" and "the past in the present" (Bloch 1989, see also Apel 2001). In short, the generative aspects of material culture are, just as the generative grammar of linguist Noam Chomsky (1957), more open to individual variation and consequently also to change. In this technological sphere we can expect a certain degree of individual variation. Within the repetitive technological sphere, normative rules that to a high degree are culturally transmitted between generations will govern the technological outcome. In this sphere, formal variation will be low since the technology also carries an important social message.

The later stages of dagger production, however, were conducted at the settlements and the production debitage is often found secondarily deposited in depressions belonging to dwelling structures. Typical examples of such sites are Myrhöj, a settlement with evidence of at least three longhouses containing dagger preforms and production debitage (Jensen 1973; Apel 2001) and Gug, where production debitage was located in a depression, probably belonging to a longhouse similar to the ones at Myrhöj (Brøndstedt 1957; Simonsen 1982; Olausson 2000; Apel 2001). On these settlements, evidence of high quality knapping as well as knapping of lower quality has been recognised. A closer examination of the production debitage from Myrhöj revealed that the production of everyday items, as well as of more elaborate artefacts such as thick-butted axes and daggers, was conducted on the site (Fig. 3). It has also been suggested that the range in the quality of the flint industry at Gug, investigated by Olausson (2000), may be explained in the same way (Apel 2001:199). Thus the early dagger production stages were conducted at secluded and private places, preferably near the natural flint sources while the final stages were conducted on the settlement sites. In order to investigate if this intra-site variation of dagger is related to different levels of skill, we now need a generalised way of evaluating the degree of skill that is based in Callahan's experience.

According to Bachelard (1984), a scientific breakthrough is achieved through a rupture with the folk categories connected to the object of study. In the present case, when the question concerns the degree of skill needed to conduct different stages in the production of Scandinavian flint daggers, we need to make a clear break with the conceptions of skill that everyday language supplies. This was achieved by classifying the stages according to (a) Knowledge and (b) Know-how, two concepts that were introduced into archaeology by Jacques Pelegrin (1990). To use a neuro-psychological terminology, assumed to have transhistorical qualities, we may say that knowledge is a declarative, semantic memory function while know-how corresponds to a non-declarative, procedure/perceptual memory function (Fig. 4) information that is acquired within the body (muscle memory). A subjective judgement of the relative degree of theoretical knowledge and practical know-how was made for each production stage (Figs 5 & 6). Accordingly, the stages that rely on theoretical knowledge and that demand a lower degree of practical know-how are those that can be carried out by apprentices with little experience. Stages that require years of practical training, on the other hand (for instance stages 5, 7 and 8), can only be executed by experienced knappers.

Figure 4. Relationship between theoretical knowledge, practical know-how and skill. The neuro-psychological scheme in the upper part of the figure is from Nilsson (2004), the key words in the lower part of the figure is from Apel (2000:59).

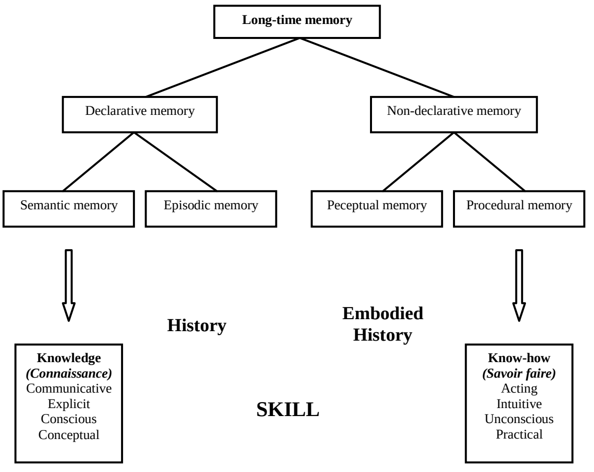


Figure 5. The stages of dagger production graded according to the degree of practical know-how (from Apel 2001:42, Fig. 2:5).

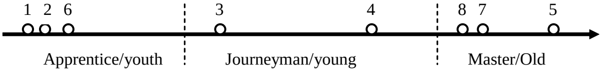
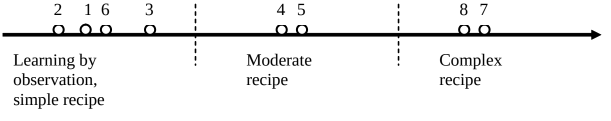


Figure 6. The stages of dagger production graded according to the degree of theoretical knowledge (from Apel 2001:42, Fig. 2:6).



It is intriguing to see that the stages that demand a high level of practical know-how were actually conducted in the settlements. Conversely, the stages that are quite easy from a practical point of view have obviously been carried out on secluded spots, near the raw-material sources. As we have seen, this pattern is further strengthened by the investigations carried out on the prehistoric production debitage (Olausson 2000).

Conclusion

We might be content to accept the view that it is our role, as archaeologists, to describe how a certain technology was perceived in a specific prehistoric context. Concerning, for instance, traditional iron production in Kenya, it would make sense to point out that iron making is surrounded by esoteric regulation that may stem from a fear of super natural powers – fire, certain sounds etc. – involved when iron oxide is transformed into iron. We would also have to accept that the reason for the taboos – for example the prohibition for women to attend the area around the furnace during smelting – is due to the belief that the presence of women will poison the ore and make it useless. However, if we are satisfied with describing these cultural aspects we will have little chance of understanding social aspects that might *not be apparent to the agents themselves.* While I agree that technologies can only be understood through the people who engage in them (Barndon 2004:35), I do not believe that our main goal should be to understand the technology according to its own logic. If we aim at an understanding of social facts we have to move beyond pure observation and put more effort into relating the technology and its participants to their place in a larger social room. The following quote, from Bourdieu's study of the symbolism of the Kabylian agrarian calendar, illustrates this point:

> *Understanding ritual practice is not a question of decoding the internal logic of symbolism but restoring its practical necessity by relating it to the real condition of its genesis, that is, to the conditions in which its functions, and the means it uses to obtain them, are defined* (Bourdieu 1977:114).

What seems to unite the production of flint daggers during the Late Neolithic and Early Bronze Age periods in southern Scandinavia with traditional iron work is the fact that the stages in the production that involve a lesser degree of know-how were conducted in secluded spots in the landscape. Presumably these stages were also surrounded by esoteric regulations (Fig. 7). It would not have been possible to argue for this interpretation without making a clear break with, on the one hand, the conception of skill that ordinary language provides (i.e. to divide "skill" into "knowledge" and "know-how"), and on the other hand, with the observations of the way the in which symbolic and esoteric rules and regulations were involved in different stages of the production (by relating them to the degree of practical know-how involved).

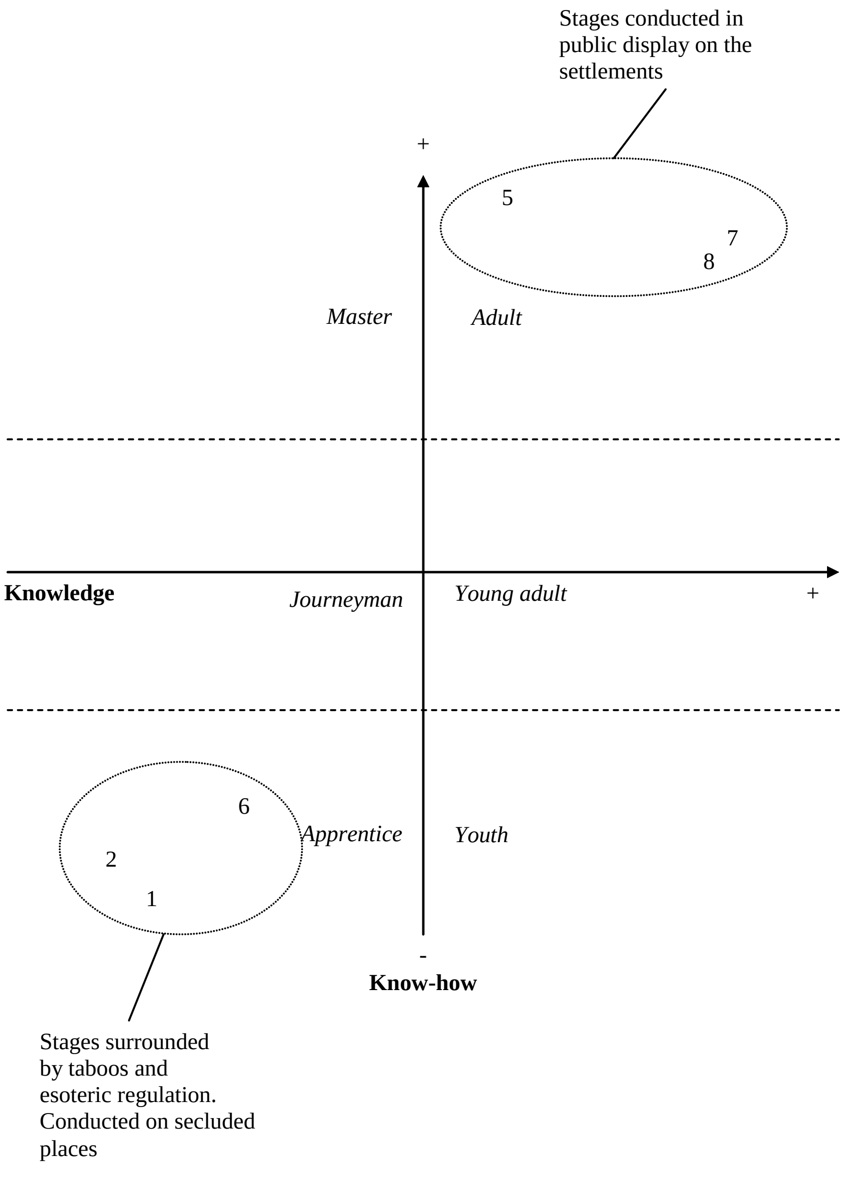


Figure 7. The seven production stages (and a grinding stage = G) graded according to the degree of theoretical knowledge and practical know-how. Note that there is a negative correspondence between production stages that demand a high degree of know-how and those that involve a high degree of secrecy and presumably also esoteric regulation and taboos.

It should be obvious to us that the difference between the inside and outside perspectives can also be found in our own society. It is fairly easy to find examples of how certain technologies are protected from insight by restricting the theoretical knowledge involved. I have collected several examples from western societies and in this context it might suffice to refer to one of these. I have a friend who worked at Arlanda airport, transporting baggage from aircrafts to terminals. If baggage were lost, a report had to be filed on a special computer. This procedure was effectively guarded by a few workers who carefully controlled recruitment. The official line was, of course, that all were supposed to make the registrations. The registration procedure in itself was simple and demanded no sophisticated training and thus, control had to be executed by exclusion. While it may be possible to make this kind of study in our own contexts, it is easier to make them in a cultural context of which you are not a part. This is the true advantage of working from a distant perspective and this is why archaeology may contribute to the field of material culture studies.

Once we avoid the temptation to only try to understand how the prehistoric agents experienced their world, thus avoiding making "accounts of accounts" (Bourdieu 1987), and instead put our efforts into creating scientific categories that break with folk categories, the point may very well be reached when the distance between "them" and "us", cultural as well as chronological, disappears. The knowledge gained through studying material remains of people in other contexts may then be used to study aspects of our own society because we are forced to see ourselves from the outside. We might even realise that the symbolic economy in evidence in traditional technologies is uncomfortably familiar. Perhaps it is now time for archaeologists, engaged in material culture studies, to focus less on writing cultural historical interpretation of how it once was and instead develop a study of material culture that may help us to understand ourselves through our relation to things.

Apel, J. & Knutsson, K., 2006. Skilled Production and Social Reproduction. SAU Stone Studies 2. Uppsala.

Leslie Harlacker

Knowledge and know-how in the Oldowan: an experimental approach

Abstract
The successful production of stone tools requires both the empirical knowledge of stone properties and fracture mechanics and the practical "know-how" acquired only through experience. It has been argued that for simple Mode I flake production among modern humans, knowledge of stone properties and effective striking angles is more important to success than is the know-how gained through extensive practice; however, it is uncertain whether this argument holds true for the earliest hominid stone toolmakers, who were in the process of inventing lithic technology and may have relied equally on both components of skill. This issue can be explored using biomechanical and technological information derived from both human and nonhuman primate (bonobo) flintknappers of all skill levels, allowing kinematic and kinetic parameters to be compared among novice and experienced knappers. If knappers of varying skill levels demonstrate similar flaking biomechanics, this would support the hypothesis that Mode I flaking relies primarily on knowledge, as it would imply that the difference in artifacts produced among the groups is due mostly to the novices' lack of knowledge about proper striking angles and platforms. If, however, they demonstrate differences in their flaking mechanics, the situation becomes more complicated, with a greater role suggested for know-how.

Introduction

The determination of skill from archaeological evidence is a question that has received increased attention from scientists over the past several years (Roux 1994; Roux *et al*. 1995; Minar 2001). For researchers interested in the Palaeolithic, the primary intent in this regard has been to determine the degree of cognitive and social sophistication implied by various stone tool technologies (Wynn 1979; Wynn 1981; Gibson and Ingold 1993; Toth *et al*. 1993; Schick *et al*. 1999) as part of an overall picture of the evolution of hominid intellectual capabilities, including the origins and development of language. Although some studies have focused on the physiological aspects of toolmaking (Marzke & Shackley 1986; Hamrick *et al*. 1998; Marzke *et al*. 1998), these studies have been intended to elucidate the identity of the earliest toolmakers and potential capabilities of fossil hominids more than to shed light on their skills *per se*.

Previous investigations into hominid technological skills have been of two main types: analyses of archaeological lithic assemblages (e.g., Kibunjia 1994; Semaw *et al*. 1996) and experimental investigations into the techniques necessary to produce a given range of artifacts (e.g., Toth 1985; Schick and Toth 1994; see also extensive references in Johnson 1978). Taken together, these elements allow for an estimation of the skills (and by inference, the cognitive capabilities) of the occupants of a particular site. However, the interpretive step from skill assessment to cognitive and/or social assessment is often not given sufficient explication. Specifically, because skill as such is not always defined (or even explicitly mentioned) but is rather usually assumed to be present to the degree that a given technology is difficult for modern experimentalists to replicate, technologies that are more complicated to modern eyes are generally taken as indicative of greater cognitive capacity and/or social complexity (Wynn 1979; Toth and Schick 1993; Mithen 1996). Although this is probably often the case, it does not represent a full exploration of what assessment of skill can tell us. This is especially true in the case of the earliest Lower Palaeolithic (the Oldowan), which is marked by comparatively very simple technologies whose cognitive and/or behavioral implications may not be fully assessed by a cursory assessment of the skill involved in their production. In other words, simply to say that the technology is quite simple and can be produced using a relatively small skill set may be correct, but has not exhausted the interpretive possibilities.

Researchers such as Jacques Pelegrin (Roux & Pelegrin 1989; Pelegrin 1993) have provided a useful interpretive model in their studies of various time periods. By providing a working definition of skill drawn from relevant literature, they allow for more nuanced interpretations of hominid cognitive and social complexity to be drawn from the lithic evidence. This paper will follow their example in choosing a definition of skill upon which to base the discussion. As mentioned above, this approach is especially useful in analyzing Oldowan technology. The aim here will be to further clarify the aspects of skill involved in the successful production of Oldowan lithic technology using both technological and biomechanical information.

Definition of skill

Skill can be defined as the capacity to achieve a given goal using available resources, which results from some sort of learning process (Roux *et al*. 1995:66). For the purposes of this paper, skill will be more specifically considered to consist of two components, *knowledge* and *know-how*, following previous researchers (e.g., Roux and Pelegrin 1989, Apel 2001). *Knowledge* can be understood to include the explicit, declarative information necessary for the performance of a given task (Pelegrin 1990:118) – simply stated, the things that the individual must know in order to successfully perform the task, and which become part of the knapper's explicit memory (Apel 2001:28). Knowledge can be gained through the learning process, either through observation or during direct instruction, or by trial and error. *Know-how*, on the other hand, is perhaps more difficult to define. As implied by Apel (2001:37), its absence accounts for the frustrating experience of knowing exactly what needs to be done in order to achieve a particular result, but being unable to actually do it. Know-how would include things such as muscle memory and an intuitive "feel" for an activity that is connected with body movements (Apel 2001:28); in essence, the elements of successful performance that cannot be taught or learned but must be obtained through extensive practice (Pelegrin 1990:118), and of which the knapper may not be explicitly conscious.

Knowledge and know-how: the Oldowan

In order to consider Oldowan toolmaking from this perspective, it is necessary to first establish the factors that influence the production and form of Oldowan artifacts, and to then classify those factors as being indicative primarily of either knowledge or know-how. The list of such factors is fairly short, including a variety of properties intrinsic to the stone raw material, such as lithology, fracture properties, and the physical characteristics of the cobbles themselves (size, shape, amount of cortex). Other factors are intrinsic to the toolmaker, and include physical strength as well as physiological characteristics of the arm and hand (which are less variable today than in our evolutionary past).

It is argued here that, at a minimum, the factors intrinsic to the stone fall under the heading of knowledge. For instance, the aspiring toolmaker needs at least a basic understanding of appropriate stone types, of conchoidal fracture, and of appropriate platforms and striking angles, in order to successfully obtain useable flakes. This information could be obtained through trial and error (as was likely the case for the very first toolmakers) or through a learning process that might have involved observation of and/or teaching by more experienced knappers. By contrast, physiological characteristics as well as the intuitive "feel" mentioned above would fall under the heading of know-how, along with the muscle memory that develops when an activity is practiced repeatedly.

It might be assumed from the foregoing that knowledge is more important than know-how in Oldowan toolmaking, because arguably more contributing factors are attributable to knowledge than to know-how. This has been suggested indirectly by Apel (2001:21), who indicates that possession of the knowledge referenced above enables a novice to successfully remove flakes from a core, without substantial experience in swinging the hammerstone. However, it should be recalled that both the lists of factors compiled above and the argument just outlined are conceptualized in terms of modern humans (without, it should be noted, the element of performance consistency being taken into account). All of the potential Oldowan toolmaker candidates were, quite literally, a different animal, and at least the earliest of them were inventing the first stone technology from scratch. For these earliest toolmakers, with their very different cognitive and behavioral repertoire, know-how may have been equally as important as knowledge as they began to gain control over finer upper-limb and hand manipulations than performed in our arboreal past. They were performing an activity – stone knapping – that may have had few analogues in their previous activity repertoire, gaining the necessary knowledge and know-how through repeated trial and error. Of course, these early toolmakers are no longer present for observation, but we do have modern great apes (specifically chimpanzees and bonobos) and ourselves as modern analogues from which to triangulate.

The present contribution aims to apply the author's current experimental research into Mode I technology to the question of the relative contributions of knowledge and know-how to successful Oldowan flaking. This research involves examining both biomechanical and technological data to characterize the basic flaking arm swing motion and correlate biomechanical factors such as forces and torques with the technological attributes of the artifacts produced, among both human and nonhuman knappers of varied experience levels. The ultimate goal is to apply the results to the palaeoanthropological record, shedding light on toolmaker capabilities among different hominid taxa. Although perhaps the study's relevance to questions of skill is not immediately obvious, it should be possible to use some of the results to shed light on the knowledge – know-how breakdown for Oldowan technology.

Once the patterns of both technological attributes and biomechanical differences among knappers of various experience levels are determined, predictions related to the above question can be tested. For instance, if knappers across the experience distribution exhibit similar flaking mechanics, Oldowan flaking might be assumed to rely more on knowledge than on know-how; alternatively, if the biomechanical characteristics differ among experience levels, a greater role for know-how would be suggested. The rationale for these predictions is as follows: if flaking mechanics are similar across the sample, the differences in the artifacts produced would be due mostly to the knowledge brought to bear on the task (presumably, more experienced knappers would have a better understanding of these factors and would therefore achieve greater flaking success). If, however, flaking mechanics are different, it is possible that these differences are at least partly responsible for the artifactual differences among the knappers, with the differences in mechanics being attributable to differing levels of know-how associated with different amounts of time spent flintknapping. The pattern of technological attribute differences may also shed light on the knowledge – know-how question; if novices stand out statistically in terms of technological attributes, a greater role for knowledge would be suggested. If, alternatively, differences are seen across the board, know-how likely plays a greater role than previously suggested: given the simplicity of the knowledge involved, it is likely that mastery of it would occur relatively early in the learning process, with further improvements in products being attributable to know-how.

The remainder of this paper describes the study methodology and reviews the results that are currently available from the standpoint of the issues raised above.

Experimental design and methodology

This study was designed to obtain data from as wide a range as possible of knappers, both human and nonhuman primate, within certain practical constraints. Forty-nine human subjects were recruited to participate, roughly divided into three experience classes (novice, intermediate, and advanced) for sample selection purposes. Thirteen of the subjects are novices, 19 intermediates, and 17 are advanced knappers; 39 are men and 10 are women; and five are left-handed. The majority of the novices and a few experienced participants were recruited on the Indiana University campus, with the remainder participating at either a flintknapping field school or an Oldowan-themed knap-in. The knapping school group will be of particular interest, as they participated after several days of intensive instruction by a single master flintknapper.

Novices are defined as having had no previous knapping experience at all. Experienced knappers included in the study range from two weeks' to 47 years' knapping experience; unsurprisingly, then, the distinction between intermediate and advanced knappers is somewhat less rigid. For subject recruitment and preliminary analytical purposes, it has been based on subjects' questionnaire responses and an initial technological survey of the artifacts produced. In general, knappers placed into the advanced category have had at least ten years of experience regardless of knapping intensity; those advanced knappers with less than ten years' experience tend to knap far more frequently than is usual for experienced subjects as a whole. Intermediates average 3 years' experience, and advanced knappers average 15 years. The analyses reported here maintain these preliminary distinctions; however, the results suggest that it will be interesting to investigate the differences among groups defined by more finely drawn distinctions in experience level.

The sample was also tested for the influence of possible confounding factors – physical characteristics and activity patterns that might theoretically influence or alter flaking biomechanics (and thus, possibly, the artifacts produced). These factors included arm and hand injuries, however minor, and participation (including time spent) in any non-knapping activity requiring extensive arm and hand use (reported activities included martial arts, woodworking, and the playing of various musical instruments); these data were collected on the subject questionnaire. The three groups are statistically identical ($p < 0.05$) for all these factors.

In addition to the human subjects, two bonobo subjects with several years' knapping experience were also included (Toth *et al*. 1993; Schick *et al*. 1999). One, Kanzi, has been knapping for more than ten years; his sister, Panbanisha, has been knapping for about six years.

Knapping task and subject participation

The knapping task in this study was simply to produce sharp, useable stone flakes. Each subject was filmed according to a method described below while reducing two stone cores, one greenstone and one chert. This method was chosen for a number of reasons. It is non-invasive and portable, and its expense is relatively moderate compared to other biomechanical analysis techniques. These practical concerns were especially important with respect to the bonobo subjects; they also allowed for a larger human sample to be included.

Prior to the filmed trials, novice participants were given brief verbal instruction consisting of the knowledge necessary to remove flakes (i.e., cobble choice, platform selection, and striking angle). The arm swing was not modeled for them, but they were able to observe other subjects (usually no more than about five other subjects were available for observation by any given novice). Novices were then required to participate in a practice session to become familiar with the task, and to ensure that a sample of flakes would be available for each subject; this practice session was also offered to more experienced knappers, but most declined.

Subjects chose the stones used in the filmed trials from a sample of pre-measured, pre-weighed cobbles. The author chose cobbles for inclusion in that sample based on probable ease of flaking; thus, although cobble shapes varied, most cobbles presented to the subjects were not highly spherical or irregularly shaped. Although this does make it impossible to draw valid inferences concerning cobble choice differences among knappers of different skill levels, it was considered more important to increase the probability that flakes would be produced from as many cores as possible during filming, thereby increasing the sample of flakes that might be directly attributable to a given hammer strike. Hammerstones were chosen from a small sample of granite, sandstone, and greenstone cobbles of varied shape weighing between 480 and 550g; this restriction was imposed in order to make the biomechanical results more easily comparable among subjects. Hammer-stones were allowed to remain in the sample offered to subjects until their mass fell below 480g, at which time they were replaced by a similar, but heavier, stone. All of the debitage produced in practice and during filming was collected, and all artifacts over 20 mm in maximum dimension were retained for analysis.

The task parameters were similar for the bonobo subjects, except that the stone raw materials were somewhat larger than those presented to the human subjects. This was necessary because, due to the anatomy of their hands, bonobos are not able to comfortably manipulate and knap the smaller cores presented to the human subjects; conversely, most human subjects would find it difficult to manage stones of a size that bonobos find comfortable. Bonobos were also filmed reducing more than one core per raw material, partly because of difficulties in persuading the apes to maintain the most desirable body orientations with respect to the camera, and partly because observation of previous video recordings of their knapping styles seemed to reveal more intra-subject variation than seen in typical human knappers, making additional trials desirable.

Filming: method and analysis

Subjects were filmed simultaneously with two Redlake Locam high-speed film cameras positioned at approximately a 90 degree angle to each other, first while knapping the greenstone core, then while knapping the chert core. The goal was to obtain at least three analyzable strikes per core per subject; cataloging of the films revealed that, for the vast majority of subjects, between four and six analyzable strikes per core were obtained. Camera speeds were set at 200 frames per second in order to facilitate the collection of data as close to the instant of impact as possible (in this case, data can be collected up to .005 second before impact). Once developed, films were projected onto a Houston Instruments Complot digitizer, and 21 body landmarks (Fig. 1), the core, and the hammerstone were digitized every fourth frame for each trial analyzed. (This digitizing rate allows meaningful biomechanical data to be obtained while minimizing the time spent digitizing; the digitization of all frames of a trial was found not to contribute additional meaningful information.)

Figure 1. Body landmarks to be digitized for each trial (only visible landmarks are indicated).

Figure 2. The DLT control object, also known as "Sputnik."

Three-dimensional locational data for core, hammerstone, and 21 body landmarks were obtained using a process known as Direct Linear Transformation (DLT; Abdel-Aziz & Karara 1971). Briefly, DLT involves first filming a three-dimensional control object of known dimensions (Fig. 2) placed at the approximate spot where the activity of interest will occur. The digitized coordinates of the control object points, along with the known dimensions of the object, allow a series of camera parameters to be calculated giving the relative locations and angles of the two cameras, along with other technical information (Dapena 1985). An additional set of three to five reference points is also digitized; these points allow the calculation of a moveable reference frame (set of x, y, z axes) relevant to the activity, so that 3-D coordinates need not be reported with respect to a reference frame attached to the control object. Once the camera parameters and new reference frame are computed, they are used along with digitized landmark data to produce three-dimensional location data. These three-dimensional coordinates are then used to obtain biomechanical information about the subject with a computer program customized for the activity in question. Information thus obtained includes body segment locations, velocities, and accelerations (helpful in characterizing the flaking motion); velocity and acceleration data for the hammerstone; and kinetic information such as the forces and torques produced through the arm joints, which can be related to patterns of muscle use. These data are output at time intervals of .02 second. Careful viewing of the films should eventually allow these data to be matched with the exact flakes detached by the blow for which the biomechanical data were obtained; at minimum, the biomechanical characteristics of each subject will be able to be correlated with his or her artifacts in general.

Results

Both the lithic and the biomechanical results presented here are of a preliminary nature. The analyses reported below for the experimental lithics include all artifacts (cores and debitage) produced by the human subjects during the filmed trials; practice artifacts have not yet been analyzed. The biomechanical data presented were obtained from one advanced subject during a pilot study conducted several years ago (Dapena *et al.* in press); analysis of films is ongoing, including both human and bonobo subjects. Inclusion of bonobo lithic data must also await further analysis.

Lithic Analysis

A wide range of technological attributes were collected for the lithic materials (Fig. 3). Each artifact was measured using a Mitutoyo dial caliper to the nearest .02mm, and weighed to the nearest 1g using an electronic scale; angles were measured using a standard goniometer. All statistical calculations were performed using SPSS version 11.0.

Artifact Attributes Collected		
Hammerstones	*Cores*	*Debitage*
Raw material	Raw material	Raw material
Maximum dimension (mm)	Original % cortex	Identification
Length (mm)	Original # flake scars	Maximum dimension (mm)
Breadth (mm)	Original maximum dim.	Length (mm)
Thickness (mm)	Maximum dimension (mm)	Breadth (mm)
Weight (g; pre- & post use)	Length (mm)	Thickness (mm)
	Breadth (mm)	Relative thickness (Th:Br)
	Thickness (mm)	Elongation (Br:L)
	Th:Br, Th:L, Br:L	Platform type
	Flaking mode	Platform breadth
	Percent cortex	Platform thickness
	# flake scars & scars from subject	# platform scars
	# edges	# dorsal scars
	Edge length, edge angle	# dorsal scars from subject
	Max. dim. largest scar (MDLS)	Dorsal cortex %
	MDLS from subject	Core angle (ext. pl. angle)
	MDLS:max dimension	Bulb angle (int. pl. angle)
	Flakes removed	Weight
	Classification	Termination type
	Weight (pre- & post flaking)	Toth type (1987)

Figure 3. Metric and nonmetric lithic attributes collected.

Cores

A total of 111 cores were produced during filmed trials; roughly 50% were of each raw material. Some subjects were filmed more than once owing to technical difficulties with the filming equipment; thus, the total number of cores exceeds two per subject. Approximately one quarter of the cores were produced by novices, with the remainder evenly split between the two experienced groups. The analyses presented here pool both raw materials; future analyses will consider the greenstone and chert artifacts separately.

Relatively few nonmetric attributes were examined for the cores; those of interest include flaking mode (chiefly unifacial or bifacial) and typological classification (types were loosely based on Leakey's typology). Overall, the results reflect more extensive core reduction among experienced knappers. Pearson chi-square tests were carried out comparing the three groups in terms of flaking mode and typological pattern; for both tests, the groups differed significantly ($p<.005$ and $p<.015$ respectively). In terms of flaking mode, the novices did not flake any cores bifacially; most examples of bifacial flaking occur among advanced knappers, with a few examples among intermediates. Examination of type frequencies among the groups reveals that novices had a much higher rate of artifacts classified as cobbles (meaning that no flakes were removed) than did either of the experienced groups; additionally, most of the "tool types" such as choppers and scrapers occurred among advanced knappers, while intermediates displayed the highest relative frequency of cores (flakes removed, but no resemblance to traditional "tool" types). Considering that the knapping task was simply to remove useable flakes, the greater frequency of bifacial flaking and larger number of "tools" among advanced knappers suggests that they were the most efficient group in terms of core reduction, often managing to flake more than one face of their cobbles and even produce some "tools" despite the highly constrained environment of the filmed trial, where each cobble was knapped for less than one minute. Intermediates only occasionally displayed this level of skill, and novices rarely did. These results were confirmed by the results, not presented here, of paired group comparisons.

A total of 23 metric attributes were recorded for each core (Fig. 3). As a first step in the analysis, one-way ANOVA tests were conducted to determine which variables differed significantly among the three subject groups. Statistically significant differences ($p<.05$) were detected for 12 of the 23 metric variables (Fig. 4); an additional three variables had p-values below .15. Such variables will be briefly considered here, because the relative simplicity of Mode I technology may make it worthwhile to examine near-significant results as well as those traditionally considered significant.

Group Means, Core Metric Attributes				
	Novice	*Intermediate*	*Advanced*	*Significance*
Original % cortex	89.8	88.6	83.6	.136
Original # scars	1.9	2.3	2.2	.720
Original MD	127.6	132.4	126.0	.341
Max. dimension	122.6	124.9	111.7	.003*
Length	120.3	123.8	110.6	.006*
Breadth	87.3	86.1	83.5	.541
Thickness	52.2	54.6	50.1	.277
Th:Br	.62	.64	.61	.570
Th:L	.44	.45	.46	.880
Br:L	.74	.71	.76	.221
Percent cortex	85	77	61	.000*
Flake scars	4.5	5.2	6.2	.031*
Scars from subject	2.5	3.0	4.1	.010*
Edge angle	80	80	75	.095
Edge length	79.8	69.8	73.6	.490
Number of edges	.38	.50	.71	.051*
MDLS	51.1	61.8	74.6	.000*
MDLS from subj.	47.8	60.2	73.4	.000*
MDLS:Length	.43	.51	.69	.000*
MDLSsubj:L	.41	.50	.68	.000*
Number of flakes	4.8	5.9	9.2	.016*
Original weight	692	801	744	.096
Post-flaking wt.	646	697	540	.012*

Figure 4. *Significant at 95% level, one-way ANOVA.

The pattern of statistically significant results suggests that much of the variation among the three groups' artifacts can be attributed to the intensity or degree of reduction. Maximum dimension, length, percent cortex, number of flake scars and flakes per core all reflect the degree to which each core was reduced; more tangentially, the relative and absolute largest scar dimensions do as well. The means quoted in Fig. 4 indicate that in general, more experienced knappers tend to produce lighter cores with smaller linear dimensions, less cortex, more flakes per core, and larger scars. Unsurprisingly, then, experienced knappers are able to carry out much more extensive core reduction within the confines of the experiment than are novices. It is also of interest to note that more experienced knappers also tended to produce significantly more "useful" edges on their cobbles, and these edges had substantially more acute angles. These qualities are intimately related to reduction intensity as well (more reduction naturally resulting in more edges) and are mentioned here in that regard; it is unlikely that subjects were intentionally trying to produce useable edges on their cores.

Although relatively little can be deduced from these results concerning cobble choice among the subjects, a few points can be made. Raw material, cobble shape, and weight (to a certain extent) were already somewhat constrained in the sample made available for filmed trials, so the differences we might expect to observe in cobble choice would primarily involve the degree of cortex already removed before the filmed trial. Experienced knappers tended to choose cobbles that were slightly heavier than those chosen by novices, and their cobbles also had slightly more pre-existing scars, though these differences were not significant. There is, however, evidence (presented below) that advanced knappers may have made better use of their cobbles' pre-existing scars than did other subjects.

More detailed comparisons are necessary to determine the relative contributions of knowledge and know-how to the results described above; although these results do indicate some differences among the groups, it is not possible to say from them whether the differences are due to novices' lack of knowledge or lack of practice. To this end, paired group comparisons of metric attribute means were performed using t-tests. Paired group t-tests were also done using skill level cut points – in other words, novices were compared to all experienced knappers, and advanced knappers were compared to all other subjects.

Both analyses using skill level cut points revealed a number of significant differences, with the advanced vs. all others comparison revealing more differences than the novice vs. experienced comparison (Fig. 5). Paired comparisons revealed that advanced knappers differ from both of the other two groups on many more variables than novices and intermediates differ from one another. Details are provided below; however, it is of interest to note at this point that the pattern just mentioned provides initial support for an increased role for know-how in Mode I performance – if knowledge were substantially more important, we might expect that intermediate knappers would be more similar to advanced knappers than to novices, given the relatively small amount of knowledge implied by successful Mode I flaking. At least as regards the core metrics, this does not seem to be the case; intermediates are more similar to novices than to advanced knappers.

Significant Differences from Mixed-Group Comparisons			
Novices v. Experienced		*Advanced v. All Others*	
Percent cortex	.001	Original % cortex	.048
# flake scars	.048	Maximum dimension	.001
Scars from subject	.049	Length	.002
# edges	.054	Percent cortex	.000
MDLS	.002	# flake scars	.016
MDLS from subj.	.001	Scars from subject	.005
MDLS:Length	.001	Edge angle	.029
MDLSsub:L	.000	# edges	.024
Number of flakes	.053	MDLS	.000
		MDLS from subj.	.000
		MDLS:Length	.000
		MDLSsub:L	.000
		Number of flakes	.006
		Post-flaking weight	.005

Figure 5. Values are significance results from Student's t-tests.

Novices vs. experienced knappers

As Fig. 5 indicates, even for a technology as seemingly simple as Mode I flaking, there are substantial differences in performance between those who have any experience and those with no experience whatsoever. Novice knappers were able to reduce their cores much less extensively than were experienced knappers; they left a significantly higher percentage of cortex on their cores and produced significantly fewer scars and less debitage per core. The largest flake scars on their cores are significantly smaller than the largest flake scars on experienced knappers' cores, both in absolute terms and as a proportion of core size, suggesting that they are less efficient than experienced knappers at utilizing the surface area of the core.

It is interesting to note that novices produced cores that are statistically similar to those produced by experienced knappers for a number of linear dimensions and shape ratios; the cobbles they chose are also similar in terms of maximum dimension and pre-existing scar count. Linear dimension similarities can be partially explained by the pooling of intermediates with advanced knappers, while shape similarities are expected given the nature of the knapping task. However, these results also might suggest that, given the indications of more extensive reduction among experienced knappers, at least some individuals with experience are reducing their cores in such a way as to have minimal impact on linear dimensions.

One final attribute merits mention here. Although post-flaking weight does not differ significantly, original cobble weight is near-significant ($p < .058$); this result would likely rise to significance were it not for one novice's highly atypical choice of a cobble weighing in excess of 1 kg. Novices would be expected to choose lighter cobbles, which tend to be easier for a learner to manage; the fact that their finished cores are not lighter than experienced knappers' finished cores provides another support for the argument that experienced knappers reduced their cores more intensively.

Advanced knappers vs. all others

Advanced knappers stand out even more than do novices when compared to the rest of the sample; not only is the difference significant for more variables, but the results themselves are overall more highly significant (Fig. 5). The pattern noted for the previous comparison holds here, with the addition of original percent cortex, maximum dimension, length, edge angle, and post-flaking weight. The first of these deserves comment, as it reveals that advanced knappers chose cobbles with significantly less cortex than did the other subjects. Combined with the results to be discussed concerning platform scars, this result suggests that advanced knappers were choosing cobbles with an eye towards using any pre-existing flake scars as aids in the flaking process, a knowledge-based action that appears to have been overlooked by the intermediate knappers (novices lacked this knowledge entirely). (Given the size of the difference in absolute terms, it is unlikely that this difference in cobble choice had a measurable effect on other variables.)

As noted for the previous comparison, much of the difference between these two groups is related to reduction intensity, this time even more strikingly. Advanced knappers produce cores with significantly less cortex, more flake scars, more edges, and larger flake scars (both absolutely and as a proportion of core length). Their cores are lighter, and they produce more flakes per core. Additionally, in terms of linear dimensions, their cores have smaller maximum dimension and length measurements; this suggests, along with the results mentioned above, that it is the intermediate knappers who are reducing cores in such a way as to leave all linear dimensions similar to novices. All of the above points to advanced knappers achieving the greatest reduction intensity.

The similarities between advanced knappers and all others have primarily to do with the original size of the cobbles chosen, which is expected given the highly constrained nature of the sample made available. Ratios indicating core shape are also similar across the sample, an expected result given that the subjects were not striving to impart any particular shape to their cores. Finally, similarities in thickness and breadth seem to simply indicate that core reduction was more likely to produce differences in length than in these dimensions.

Paired group comparisons

As mentioned above, each possible pair of groups was compared using t-tests. These results to a large extent confirm the results just discussed, so they will not be reported extensively here. Paired comparisons do, however, clarify previous arguments that the intermediate knappers are driving those results, revealing that although advanced knappers produce quite different debitage from either of the other two groups, novices and intermediates are statistically quite similar, differing significantly only in that intermediates leave less cortex behind, produce larger scars, and choose heavier cobbles to flake. Although these results do suggest that intermediates reduce their cores more extensively than novices do, the difference is not as profound as that between the other pairs, nor is it supported by as many individual variables.

Implications

Overall, the technological analysis of the cores points to a rather complex pattern of differences among the subjects. Although novices, as expected, stand out statistically from experienced knappers, advanced knappers stand out equally dramatically when compared with a pooled group of novices and intermediates. Finer-grained comparisons between pairs of knapper groups reveal a surprising similarity between intermediate and novice knappers. This raises interesting implications for assessing the relative contributions of knowledge and know-how to knapper performance across the experience groups. It is logical to interpret the difference between novices and all experienced knappers as being due primarily to knowledge factors; because although novices were verbally given the necessary knowledge, it is far from certain that they effectively assimilated this knowledge into their performance. However, it would be unwise to apply that reasoning to interpret the difference between advanced knappers and all others. The knowledge required to produce Mode I artifacts is limited enough that it can be acquired within a short time span (Apel 2001:29), an assertion supported by the author's personal experience participating in a flintknapping school; therefore, it would not be reasonable to assume that intermediate knappers possessed appreciably less of this knowledge than the advanced group, especially considering that most intermediates had been knapping for over a month. Thus, although novices may not have had sufficient knowledge to perform consistently, intermediates certainly did, yet they still did not flake as successfully as the advanced knappers, which points to the possibility that know-how plays a larger role than previously suspected in Mode I knapping performance. This argument is supported by the similarity between novice and intermediate knappers; the main difference between these two groups seems to be that intermediates produced slightly more flakes than novices, while finishing up with largely similar cores. Additional support for this view can be found in the results of the debitage analysis.

Debitage

A total of 729 flakes and fragments > 20mm in maximum dimension were collected and analyzed. The results presented here will include analyses limited to the whole flakes, as they retain the most technological information; additional analyses are currently in progress that include all platform-bearing debitage (whole flakes, split flakes, and proximal fragments).

The 333 whole flakes represent 45.7% of the debitage; about 70% of them are chert and 30% greenstone. Advanced knappers produced approximately 45% of the whole flakes. A number of nonmetric attributes were examined for the sample, including raw material, platform type, termination type, and Toth type (Toth 1987). Chi-square tests revealed significant differences among experience levels for raw material and termination type ($p<.002$ for both variables). Frequency data indicate that advanced knappers produced many more greenstone flakes than did the other two groups combined, both absolutely and as a proportion of total flakes produced; it remains to be seen whether biomechanical differences can account for this apparent performance differential, and by extension whether know-how becomes more important when a more difficult raw material is knapped. Novices also produced more step and fewer feather terminations than did experienced knappers, suggesting perhaps less-skilled performance; other termination types were too infrequent for conclusions to be drawn.

Although the groups did not differ significantly in terms of the pattern of Toth types produced, it is worth noting that advanced knappers produced flakes of type IV-VI (non-cortical platform) in larger numbers than did others, which supports the evidence previously discussed for the cores indicating greater reduction intensity among advanced knappers. The similarity in platform type across groups may be reflective of the simplicity of the technology, or it may reflect mechanical constraints (hypothesized to operate by Dibble and Pelcin (1995)) that model flake removal as determined by certain platform characteristics (which would imply that among the flakes actually removed, a relatively narrow range of platform traits would be expected).

Group Means, Whole Flake Metric Attributes				
	Novices	*Intermediates*	*Advanced*	*Significance*
Maximum dim.	42.7	43.2	49.6	.030*
Length	34.3	35.5	40.7	.048*
Breadth	34.8	36.4	38.9	.298
Thickness	6.7	7.7	8.8	.094
Rel. th (Th:Br)	.20	.21	.23	.153
Elongation (Br:L)	1.1	1.1	1.1	.594
Platform breadth	21.0	20.6	23.6	.260
Platform thickness	7.3	6.4	7.6	.363
Platform scars	.43	.32	.58	.013*
Dorsal scars	1.9	1.6	1.7	.439
Scars from subject	1.7	1.2	1.4	.036*
% dorsal cortex	42	41	42	.938
Core angle	79	83	80.6	.047*
Bulb angle	102	98	103.6	.050*
Weight	15	20	25	.233

Figure 6. *Significant at 95% level, one-way ANOVA.

The metric variables were subjected first to a one-way ANOVA test to discern patterns of significant difference among the groups (Fig. 6); nonparametric chi-square tests were used to confirm these results. The results indicate substantial similarity in flake characteristics across experience groups, which is perhaps unsurprising given that only whole flakes were considered within the context of a very simple experimental task; indeed, it is perhaps more remarkable that any differences could be found. These differences include maximum dimension, length, number of platform scars, number of dorsal scars made during flaking, core angle, and bulb angle. Flake weight was also significant using the chi-square test.

In general, novices produced smaller flakes, both in linear dimensions and weight, although they are close to the intermediates; advanced knappers are more separated from the rest in this regard. Advanced knappers also produced more platform scars than did the other groups, which may be a reflection of their more effective use of pre-existing flake scars in initiating their own flaking (i.e., better platform choice). These results support the contention from the core analysis that advanced knappers reduced their cores more intensively.

Fig. 6 also reveals some surprising results. Flakes produced by novice knappers have the highest number of dorsal scars, followed by advanced and intermediates; additionally, these flakes have core and bulb angles similar to advanced knappers' flakes, while intermediates have more obtuse core and more acute bulb angles. In contrast to all the other results presented thus far, these variables place novices closer to advanced knappers than to intermediates. The results regarding platform angles may be explained as due to reduction intensity differences: although all subjects had the same (very brief) amount of time to reduce their cores, advanced knappers produced substantially more debitage than did other knappers. Their average core and bulb angles may approach novice values because the highly constrained circumstances of the experiment did not allow them to manipulate their cores and choose platforms as carefully as they would normally, forcing them to utilize less favorable platform angles as the trials progressed. Contrary to what we might expect, the greater number of dorsal scars found on novices' flakes may reflect their inexperience; novices are more likely to have repeatedly struck their cores in approximately the same place, thus guaranteeing that their flakes would have more dorsal scars than would flakes removed by an experienced knapper utilizing more of the cobble surface. It is difficult to say whether this indicates a lack of knowledge or know-how; both are likely to be at work.

Despite the foregoing, the whole flakes produced by each group do not point toward differential reduction intensity as strongly as do the core results; most differences in whole flakes have to do with overall size, which is greater for advanced knappers. Other differences in the whole flakes indicate a higher, more consistent level of skilled performance among advanced knappers (termination type, platform scars, core and bulb angles, dorsal scars). Variables that would indicate reduction intensity, such as the dorsal surface cortex percentage and Toth type pattern, are similar among the groups. For the present study, the analysis of the cores provided the best evidence of differential reduction intensity, while the debitage analysis provided other information.

Implications

The whole flake analysis presented above provides additional support for the conclusion that advanced knappers show greater reduction intensity than do less experienced knappers, and additionally furnishes evidence for more highly skilled, consistent performance among the advanced knappers. Whether this difference is due to greater knowledge or know-how among the most experienced knappers is not certain; however, a preliminary estimation can be made.

As previously mentioned, advanced knappers removed greater numbers of larger flakes than did the other knappers. Some features of these flakes indicated greater knowledge (i.e., the use of pre-existing flake scars to provide striking platforms), and some features were ambiguous (core angles might indicate choice or a response to the constraints of the experiment). Consideration of a few other variables that did not show significant inter-group differences may help clarify the issue. In particular, platform dimensions were statistically similar across groups; interestingly, core angles were almost identical for novices and advanced knappers, with intermediates standing out. Evidence from controlled experiments (Dibble and Pelcin 1995:437-438) indicates that for a given core angle, there is a certain range of platform thicknesses that will allow flake detachments, and that this range is smaller for more obtuse angles (like those seen here). The similarity for both these variables for novices and advanced knappers suggests that novices perhaps only removed flakes when they happened to hit upon the proper values for these variables, while advanced knappers produced more flakes because they had better control over these variables – in other words, they were able to strike their cores more precisely, an indicator of greater know-how. Intermediates have slightly higher core angles and slightly thinner platforms than do the other two groups, suggesting that their intermediate number of flakes produced may be due to their exercising less control than the advanced knappers but still managing to remove more flakes than the novices due to striking the cores with more force (which is necessary with higher platform angles). Paired group comparisons and analyses including all platform-bearing debitage are underway, which should provide more insight into the debitage patterns presented preliminarily at present.

Discussion

Taken as a whole, the results for the lithic analysis conducted to date support the conclusion that know-how is an important contributor to Mode I flaking performance, which contrasts with previous expectations that knowledge would hold much greater importance, and that once the knowledge was (quickly) mastered, successful and consistent performance could quickly be achieved. The present study suggests that although knowledge is indeed quite important, its chief contribution may be in the very earliest stages of skill acquisition, as indicated by the clear distinction between the cores produced by novices versus all experienced knappers and by the pattern of similarities and differences involving the whole flakes. Novices do stand out; however, for both the cores and (preliminarily, for most variables) the whole flakes, they resemble intermediates more than intermediates resemble advanced knappers. The simplicity of the knowledge involved here makes it unlikely that this is due primarily to steadily increasing levels of knowledge among more experienced knappers; the surprisingly striking distinction between advanced knappers and all others reinforces this assertion. It seems likely that although a certain level of easily-acquired knowledge is necessary for flake removal, increased know-how acquired only through long practice is needed to produce the kind of efficient, consistent performance seen among the advanced knappers. These results will be enhanced in the future by more extensive analyses of the data collected, including separate analyses of each raw material.

The results discussed above clearly demonstrate that there are differences in Mode I flaking performance among individuals of different experience levels, at least insofar as this performance may be assessed through the artifacts produced. In simplest terms, more experienced knappers tend to reduce cores more extensively, producing more flakes that are generally larger in size than those produced by less experienced knappers. It has been suggested above that this is due to advanced knappers' more effective use of the knowledge presumed to be shared to some degree by all the other knappers (i.e., greater know-how). Additional support for this interpretation would be obtained if flaking biomechanics are found to differ substantially among the three experience level groups, with less variation occurring among the most experienced individuals. It is to this evidence we now turn. Unfortunately, analysis of the biomechanical data is in a very preliminary state, but information from the pilot study can provide an example of the sort of data obtained, and some preliminary inferences can be made.

Biomechanical analysis

The pilot study, conducted in 1992 (Dapena 1993; Dapena *et al.* in press), involved one advanced knapper. The methodology used was the same as that described for the present study, although subject body position was slightly different. Two trials were analyzed; one trial is defined as lasting from the instant the hammerstone loses contact with the core until the instant before the hammerstone strikes the core on the next arm swing. Kinetic chain modeling was used, so that the arm was modeled as a four-link kinetic chain consisting of upper arm, forearm, hand, and hammerstone. Using this approach, forces and torques at the elbow, for instance, are understood as resulting from a combination of elbow musculature action and the forces exerted on the forearm by upper arm motion through the elbow joint. In addition to joint torques, hammerstone velocity was also calculated throughout the trials. All results presented below pertain to this study.

Results

Hammerstone speeds, unsurprisingly, were greatest just before impact; speeds were 8.3 and 9.0 m/s for the two trials. Because the subject also moved the core upward to meet the hammerstone, a combined impact speed was calculated, giving a result of 8.8 and 10.1 m/s respectively. Wireframe sequences were drawn for the trials, and torque plots were generated; an example involving the shoulder torques is given (Fig. 7). These sequences reveal that the flaking motion is not a simple planar flexion and extension but rather a clearly three-dimensional overarm motion, and torque plots reveal that the shoulder musculature is most important in producing the flaking motion, with the elbow musculature also contributing; movement across the wrist joint is largely a flail action caused by muscle activity further up the kinetic chain (Dapena *et al.* in press).

These data allow a relatively detailed picture of the flaking motion to be developed. For example, consider the shoulder torque plot given in Fig. 7, which depicts the muscle activity surrounding the shoulder along the three axes shown to the left of the plot. The negative torques produced from times A through E show that the shoulder was flexing and externally rotating and abducting; during this time the elbow was flexing. These muscle actions halt the downward motion of the core and accelerate the arm and hammerstone upward. About .25 second before impact, the torques reverse as the knapper swings the hammerstone toward the core and the elbow extends (Dapena *et al.* in press). A similar picture involving all three joints and velocity data for hammerstone and core will be developed for all subjects filmed for the present study, allowing for a fuller picture to be obtained regarding the flaking arm-swing.

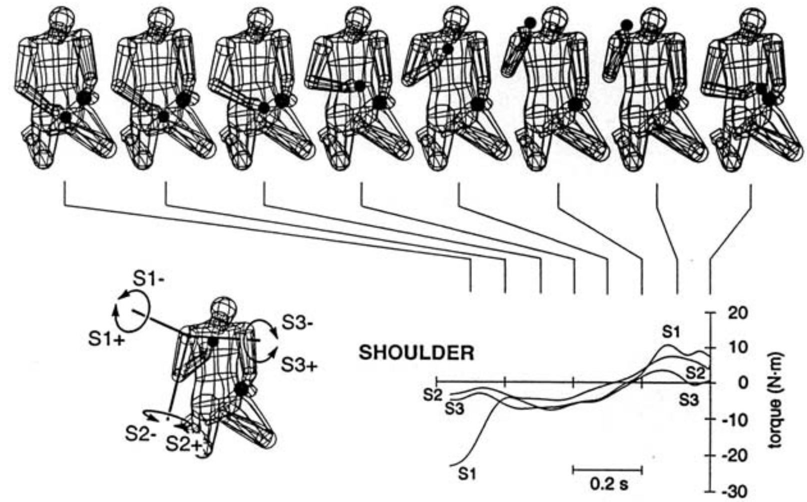


Figure 7. The sequence of wire-frame renderings at the top depicts the downswing. The torque plot for the shoulder is at bottom right, and an illustration of the three torques is at bottom left.

It is interesting to note that, in comparison with athletic activities such as baseball pitching, Mode I knapping appears to require relatively little strength (Dapena *et al.* in press); the torques produced through the elbow and shoulder are substantially less in knapping than in such sports activities. This might in itself be taken as evidence that know-how is less important – strength develops over time, and if little is needed, then extensive practice will not be necessary. However, there is much more to successful flake production than generating the needed force, such as control and consistency. An initial viewing of the films reveals a wide range of variation in the basic flaking motion, with some subjects displaying more control and consistency than others; the biomechanical data to be obtained from these films will enable the characteristics of the arm swing to be related to the quality of the artifacts produced, allowing us to determine both the mechanics of a successful swing and how frequently those mechanics are to be found among each experience group. Initial data suggest that there will be noticeable differences in flaking biomechanics among individuals and possibly between groups as well, supporting the argument made on the basis of the lithics that know-how may play a substantial role.

Conclusions

This study represents an attempt to apply an experimental approach to the question of skilled performance regarding the earliest known technology, Mode I or Oldowan flaking. Skill has been defined as a combination of knowledge and know-how, whose relative contributions may be assessed to give a more detailed picture of the capabilities implied by the technology.

Although results are still fairly preliminary, and many more analyses are planned or underway, it seems safe to conclude at this point that knowledge is not solely or perhaps even primarily responsible for the variation observable in Mode I flaking performance. Novices, who can be expected to possess rather less knowledge than experienced knappers, do produce artifacts that stand out statistically; however, advanced knappers also stand out from their less-experienced colleagues, with intermediates resembling novices more than advanced knappers in many respects. (Biomechanical results are preliminarily expected to follow a similar pattern.) Because the knowledge needed in the context of this experimental study is so limited, it seems reasonable to conclude that knowledge is quite important in shaping performance among novices, but that as more experience is gained, it is the acquisition of know-how rather than additional knowledge that results in further gains in performance efficiency and consistency.

This conclusion has implications for the study of hominid technological evolution in general. Although it is recognized (Toth and Schick 1993) that stone tool technologies represent at least a minimum indication of the cognitive sophistication possessed by their makers, breaking down skilled performance into knowledge and know-how enables further directions to be suggested. Cognitive attributes that are assumed to be present on the basis of Oldowan technology tend to be based upon the factors previously mentioned that would fall under the heading of knowledge, such as raw material choice and fracture mechanics (Toth and Schick 1993:349). However, if know-how is also quite important in refining Oldowan flaking performance and increasing efficiency and consistency, additional behavioral inferences can be suggested on the basis of Oldowan technology. For instance, since fairly extensive experience seems necessary to consistently and quickly produce large numbers of flakes, we might infer that Oldowan hominids would have benefited from finding the time to practice their toolmaking skills. The large numbers of tools recovered from many Oldowan sites hints at an efficiency that may indeed imply that such practice took place. Indeed, the acquisition of know-how through practice may have been even more important for early hominids, many of whom possess anatomy that differs from our own. The additional work to be done on the data sets discussed in this paper will soon result in more definite conclusions concerning knowledge and know-how in the Oldowan, and enable such inferences to be refined, further enhancing our understanding of hominid technological evolution.

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Simple production and social strategies: do they meet? Social dimensions in Eastern Fennoscandian quartz technologies

Abstract
Lately, anthropologists and archaeologists have emphasized the social dimensions of all technologies. However, it is also well known that the quality and quantity of lithic resources affected the organisation of the prehistoric use of lithics. In areas where good-quality knappable raw material was either scarce or absent, simple lithic technologies often prevailed. These are not easily converted into reconstructions of social strategies of the past. This paper discusses the problems and possibilities in deriving social information from lithic assemblages in Eastern Fennoscandia where good quality flint does not exist.

Introduction

Due to its geological history, Eastern Fennoscandia (Fig. 1) is largely devoid of good quality flint-like raw materials. This has been the main factor affecting the archaeological lithic record. The lithic assemblages found within the present-day borders of Finland represent almost exclusively different kinds of "ordinary production" (*sensu* Pelegrin 1990). Technologies were mainly based on simple platform and bipolar-on-anvil cores. Only a few examples of more elaborate technologies of knapped stone have been reported (e.g., Rankama 1997). The most common lithic raw material throughout the prehistoric era was vein quartz, available either as rounded cobbles or as quarried pieces. Other local raw materials, such as quartzite, porphyry, sandstone and quartz crystals, were used to a lesser degree. The flint technology, which, according to traditional thinking, relied almost exclusively on imported raw materials (Manninen *et al.* 2003), is in line with the rest of the simple knapping technologies.

Figure 1. Map of Eastern Fennoscandia. The geographical term Fennoscandia covers an area consisting of Norway, Sweden, Finland, the Kola Peninsula, and parts of Russian Karelia. The geologically defined Fennoscandian Shield is devoid of natural sources of flint.

From the beginning of the Mesolithic to the end of the Stone Age the archaeological stone tool record in Finland consisted of two parts: knapped and ground stone tools. This division of stone tool technology is by no means as clear-cut as it seems, or, indeed the only possible way to classify the lithic material. Technologically, as well as functionally, these two categories overlap with each other: e.g., some axes were manufactured first by knapping and then grinding, and some projectiles were knapped whereas others were ground. In this paper the term "lithics" refers to knapped stone alone.

The table in Figure 2 gives an idea of the general outline of the lithic raw material situation in Finland from the beginning of the Mesolithic to, and including, the Early Metal Age. It must be emphasized that the table reflects the traditional archaeological knowledge concerning the matter and does not go into detail, especially about all the variety of other than knapped raw materials. It is clear that on-going research may change it considerably. We have also omitted Lapland from the table, because the raw material situation there is different and including it would have made the table overly complicated.

calBC	*Period*	*Quartz*	*Flint*	*Other major raw materials*
1900	Early Metal Age	Dominant	Eastern straight based flint bifaces imported (copied in Finland in quartzite and quartz)	Ground slate, quartzite, jasperoid
2350	Late Neolithic	Dominant	Imported western flint: sickles and a few daggers	Ground slate, porphyry, soapstone etc., indigenous and imported rocks
3200	Corded Ware	Dominant	No flint	Ground diabase and other indigenous rocks
3600	Late Comb Ware	Dominant	Imported eastern flint decreases: bifaces, but less raw material	Ground slate, porphyry, other indigenous rocks, imported igneous rock
4000	Typical Comb Ware	Dominant	Fair amount of imported eastern flint: small bifaces and raw material	Ground slate, porphyry, other indigenous rocks, imported igneous rock
5000	Early Comb Ware	Dominant	Some imported flint	Ground slate, porphyry, other indigenous rocks, imported igneous rock
7000	Litorina Mesolithic	Dominant	No flint	Ground and pecked slate and diabase, indigenous and imported rocks
9000	Ancylus Mesolithic	Dominant	Some flint imported by earliest immigrants	Ground and pecked slate and diabase, indigenous and imported rocks

Figure 2. Generalised outline of lithic raw material use in Finland during the Stone Age and Early Metal Age.

The lithic technology, and especially the quartz technology in Eastern Fennoscandia, seems very uniform throughout the Stone Age and so far it has not been possible to distinguish regional or chronological traditions within it. This is partly due to the fact that technological studies of quartz assemblages have, until the mid-1990s, been very rare, but also reflects the fact that few regionally or chronologically distinct tool types seem to exist. If we accept that cultural and social traditions always affect the technology employed by a specific group (Lemonnier 1992), the fact that there are clear regional differences in other sections of the material culture, such as ground stone tools and pottery styles, gives reason to expect these to also be found within the quartz technology. How, then, can these differences be detected and social meaning be given to them?

This paper discusses differences in quartz and flint studies and the problems and possibilities in deriving social information from predominantly very simple lithic technologies. Its emphasis is on vein quartz technology. Our perspective on stone tool research will largely be *Fennoscandian* or *North European*, in contrast to the more conventional flint-based research traditions to the south and west. The current research paradigm in Finland is based on the work carried out in Sweden, especially in Uppsala, during the 1980s and 1990s (e.g. Callahan 1987; Callahan *et al*. 1992; Knutsson 1988a). A similar research orientation can also be seen in other parts of Fennoscandia (e.g. Nærøy 2000; Olofsson 2003).

"The past in the present" in lithic research

When working with assemblages representing simple lithic technologies, one must be aware of the way in which the history of research tends to guide our thinking. For example, it is not often that one comes across studies discussing bipolar-on-anvil technologies, especially in European literature. Ironically, it is almost more common to see drawings of bipolar cores misinterpreted as burins or wedges, a mistake that is a direct consequence of a lack of knowledge concerning this kind of technology. This is an example of what could be called *the past in the present* in lithic research, i.e., a convention transmitted in the scientific community, concerning how lithic studies should be conducted and what to study. Conventionally, simple technologies are not interesting and are therefore easily overlooked. In quartz studies the weight of these scientific conventions has caused severe problems over the years (Knutsson 1998). The fact that vein quartz fractures somewhat differently than flint was not explained in a satisfactory way until quite recently (Callahan *et al*. 1992; Knutsson 1998; Rankama 2002).

When studying long-lasting traditions of vein quartz use one has to try to avoid direct comparisons with flint. At the same time one is faced with the fact that nearly all the research literature is based on flint or other fine-grained raw materials that are for the researcher, as they were for the prehistoric flint-knapper, much easier to work with than vein quartz. In vein quartz assemblages such things as ripple marks, bulbs of percussion, and sometimes even complete flakes are uncommon. This causes difficulties when research avenues that have been found fruitful in other materials are attempted in vein quartz. The quartz analyst runs into difficulties, not only because many of the traditional research methods are not applicable, but also because of the pressure exerted by the current trends in lithic research that may not prove practicable in vein quartz, either.

To make things even more complicated, some varieties of quartz, such as smoky quartz, rose quartz, and quartz crystal, often do fracture much like flint and for this reason, among others, must be considered not to be the same raw material as vein quartz. This does not mean, however, that vein quartz is a bad raw material – it is just very different from flint. In order to give analysts used to studying flint a possibility to understand the nature of vein quartz assemblages we will briefly discuss the differences between vein quartz and flint.

Problems in Eastern Fennoscandian quartz assemblages

Lithic analysts aiming to understand the social aspects of vein quartz use will encounter serious problems compared with those one has to cope with in flint studies. Most of these problems derive from vein quartz material itself and it does not matter what kind of a research strategy one is following.

First, the provenience of the raw material cannot be defined visually or, at least at the moment, even through geo-chemical methods. This causes obvious problems for studies of mobility and settlement patterns. In addition, it means that individual knapping events cannot easily be distinguished at habitation sites. Raw material classifications, e.g., minimum nodule analysis (cf. Larson & Kornfeld 1997), and the benefit one acquires through them are therefore not available in vein quartz studies. Admittedly, some types of quartz, such as smoky quartz, are distinctive enough to be recognized in analysis, but they are much less common in prehistoric assemblages.

Questions concerning raw material procurement strategies are not easy to address, either. Vein quartz is a practically ubiquitous raw material in the landscape and occurs both as rounded cobbles in moraine ridges, lake shores, and so on, and as veins in the bedrock, from which it can be quarried with relative ease (cf. Broadbent 1979; Manninen & Valtonen 2002).

Distinguishing flake scar features in vein quartz is also problematic. Since vein quartz is a macro-crystalline and partly transparent and translucent material that often has internal flaws, it does not have easily observable and smooth fracture surfaces of the same kind that we meet in flint-like raw materials. Diffuse or non-existent bulbs of percussion and the absence of ripple marks make flake scar directions often difficult to detect, especially in flake fragments. To complicate things further, irregular surface features in vein quartz can be mistakenly interpreted as retouching (Siiriäinen 1981:8p; Schäfer 1990:89; Lindgren 1998; Cornelissen 2003:13).

Figure 3. Refitted quartz flakes from the Leakšagoadejohka 3 site in Utsjoki, Finnish Lapland, showing radial and bending fractures (Manninen 2003:Fig.11).

Although the characteristics of quartz and flint overlap, the general character of vein quartz is very different from flint. Like flint, quartz has a conchoidal fracture. Usually the dominating fracture types in vein quartz, however, are radial and bending fractures (Fig. 3) that break the flake into smaller fragments (see Callahan *et al*. 1992; Huang & Knutsson 1995; Rankama 2002). Because of this, a lithic tradition based on vein quartz is likely to make use of these fracture types and only secondarily of the conchoidal fracture (see Rankama 2002; Rankama 2003). The fragmentation of flakes, in addition, makes the debitage look unfamiliar to an analyst used to studying flint-like raw materials. In addition, the fragmentation also makes refitting studies more complicated, since even the fragments of a single flake may have to be fitted back together before attempting to refit a flake removal sequence (see Manninen 2003:63pp).

Simple technologies, especially the use of bipolar reduction, are often explained as the result of an attempt to maximise the use of lithic raw material, and this is undoubtedly often the case (e.g., Andrefsky 1994:384). To a degree, the use of different reduction methods and techniques is also known to be material specific. Quartz users all over the world seem to have relied on bipolar reduction (Siiriäinen 1977; Flenniken 1980; Huang & Knutsson 1995; Kuhn *et al.* 1996). The frequent use of bipolar reduction on quartz is not simply because other methods or ways to produce flakes could not have been employed. It is well known, for instance, that microblade and bifacial concepts have been applied to quartz. The main reason for the wide use of bipolar reduction is probably the fact that quartz seems to be especially well suited for it (cf. Flenniken 1980; Kuhn *et al.* 1996), and therefore the use of bipolar reduction has been an active choice made by the knappers.

It is worth noting, however, that although quartz knapping methods are rather similar around the world, there are also clear differences in assemblages separated in time and space. No doubt these are the result of different traditions manifested as different kinds of behavioural acts. Although the quartz assemblages in Eastern Fennoscandia do not meet any of the five axes or points Gero (1989:93pp) has suggested as helpful when assessing social information in stone tools (rarity of raw material, artifact size, artifact longevity, number of production stages, restrictiveness of production), we will in the following paragraphs consider some current research trends in studies pertaining to social strategies in prehistory and their applicability to Eastern Fennoscandian quartz studies.

Social dimensions in lithic technologies

Anthropologists and archaeologists studying technology have lately stressed the importance of the social dimensions of all human technologies (e.g., Lemonnier 1992; 1993; Pfaffenberger 1992; Dobres 2000). No matter how simple a human technology is, it is nevertheless largely dependent on its social surroundings, since, for example, the acceptance of a technological innovation by a community may be dependent on the existing social system (Lemonnier 1992).

Discussions of age groups and gender in archaeology have been important and opened up new insights into the study of archaeological assemblages (e.g., Gero & Conkey 1991; Moore & Scott 1997; Kamp 2001). They have reminded us that archaeological assemblages are the result of the different actions of a variety of individuals and groups. As a result, lithic assemblages, often treated as cold statistics, have become more human. In line with these discussions, learning processes and apprenticeship in general have become important research topics (e.g. Minar & Crown 2001).

Age and learning

Several scholars have recently published papers dealing with the learning processes involved in more elaborate methods of flintknapping (Fischer 1990; Pigeot 1990; Högberg 1999; Apel 2001). The simple knapping methods employed in prehistoric Finland did not require a prolonged learning process. Beginners learned the methods employed in a specific tradition by observing how the older people used stone. Children playing tried to copy their parents' actions (see Knutsson 1983; Finlay 1997; Crown 2001) and at some point, when old enough, were shown the raw material sources and the correct ways to manufacture the necessary edges for tools and weapons. One could easily envision initiation ceremonies tied to certain age groups and segments of transmitted knowledge. Unfortunately, learning processes of this kind are only rarely observable in the archaeological record (but see Knutsson 1983; Finlay 1997), because of the simple and uniform appearance of the end products, regardless of whether they were made by a skilful knapper or a beginner.

From the researcher's point of view, the problem with the rather simple technologies is the low level of cognition and motor skill required to perform them. It is easy to employ a method that does not require previous knowledge and special learning, in which the common gestures of everyday life are enough to perform the action successfully. This makes it possible for an individual to switch between different simple flaking methods whenever need arises, provided that there are no social or cultural restrictions to prevent it. From this it also follows that we usually cannot distinguish individual knappers from vein quartz assemblages and study, e.g., their level of craftsmanship.

In an important early paper, Knutsson (1986) addressed the role of children as possible manufacturers of small bipolar-on-anvil cores. Although he abandoned the explanation, the consideration of children's presence at archaeological sites is of importance here. Since a nodule-smashing kind of bipolar-on-anvil reduction is probably the simplest way to reduce stone it seems likely that it is also the way children started to practice quartz knapping. Modern people with no previous knowledge of flint-knapping also reduce rocks into smaller pieces this way (Callahan 1987:63). At sites where children were present their role in producing part of the assemblage we are studying today may have been considerable. This can have a significant effect on the platform vs. bipolar reduction ratio that several authors have studied in Sweden and Finland, especially when applied to inter-site comparisons.

Although children are difficult to detect in Eastern Fennoscandian lithic assemblages, in some cases it is still possible. An illuminating example of a child's knapping product was identified among the bipolar-on-anvil cores at the Råvåsen site in Southern Ostrobothnia, dating to the Late Comb Ware Period. Among the analysed lithic material, consisting mainly of different products of bipolar-on-anvil quartz reduction, a bipolarly battered feldspar "core" was observed (Hertell & Manninen in press). The feldspar is of a light colour and resembles vein quartz very much. Feldspar, however, was not used to make tools at the site and does not fracture the same way as quartz or any other commonly used lithic raw material when bipolarly knapped. It is therefore very likely that this "core" is the product of a child imitating an older knapper but not yet able to recognize the correct raw material, i.e., not possessing the task specific knowledge.

Gender

Some researchers have emphasized that the making of stone tools must have been everybody's business (Gero 1991:170; Lindgren 2003:182). However, it is evident that everyone in the past did not always do everything. Women are known to have made and used lithic artefacts in many societies/communities and their impact on the formation of the lithic assemblages must in those cases have been significant (Gero 1991). However, it is equally likely that in other societies women did not participate in stone tool manufacture and use.

It is even possible that men normally made stone tools, e.g. scrapers, even if women mostly used them (Osgood 1940:440p).

As Gero has pointed out, the assumption that tool manufacture and use, which is often a male activity in contemporary Western world, was restricted only to men in prehistory is flawed (Gero 1991). It is, of course, equally wrong to argue that men or women must have done something in the past simply because we want it to be so, that is, because that is the way we think the world should work. The hunter-gatherer's or early horticulturalist's worldview does not need to agree with our present concept of equality.

Archaeological finds (Flenniken 1980) and ethnographic examples (see Knutsson 1988*b*:14) indicate that in some parts of the world small unmodified quartz flakes were hafted in a manner that is analogous to the use of backed microliths. It has been suggested that during the Stone Age in Finland (Hertell & Manninen *in press*) and Sweden (Lindgren 1994) small quartz flakes and flake fragments were also used this way. Consequently, it is possible to extend Finlay's (2003) ideas about multiple authorship in the use of microliths also to Fennoscandian quartz technologies.

Eastern Fennoscandian quartz studies have not, however, so far proceeded far enough to be able to assign specific, partial or complete, *chaînes opératoires* to gender or sex groups. The continuous lithic scatter at most sites suggests that at many sites everyone must have been familiar with and possibly involved in quartz technology. As noted above, due to the short history of studies of quartz technology, the analysis of reduction strategies has not so far been able to distinguish specific regionally or chronologically restricted quartz working traditions, let alone those of smaller groups or individuals. Lindgren (1996; 2003), however, has studied this question in Eastern Middle Sweden and suggested that the two quartz reduction strategies observed at Mesolithic sites in the area could be related to social groups, possibly divided along gender lines.

Power and Prestige

In various archaeological and ethnographic contexts elaborate stone objects have been associated with power and prestige (e.g., Apel 2001), but finding comparable examples among simple technologies is a different matter. Quartz is a common mineral in Eastern Fennoscandia. This makes it unlikely that it would have been an exotic commodity during the Stone Age, although some special types of quartz, such as smoky quartz and quartz crystals, may again constitute a special case. In addition, as a result of the nature of the raw material, artefacts made of quartz are not large. This, together with the informal character of the tools, may suggest that the visual appearance of quartz was not an important aspect to those for whom it was the everyday raw material. However, the white and shiny colour as well as the transparent and translucent nature of the raw material must have enhanced the visibility and the visual appreciation of quartz artefacts. These characteristics may even have had a special meaning for the users of flint, who were not accustomed to them in stone (cf. Bang-Andersen 1998; Carlie 1999; Darvill 2002).

If we accept that the ordinary, simple production of vein quartz implements was available to practically every member of a community, it is difficult to distinguish any features to which one could attach prestige value. However, one part of the lithic record in Eastern Fennoscandia was almost certainly not available to everyone, and it could be suggested that its social meaning could be transmitted by extension, as it were, to quartz implements. With this we mean the imported flint objects that appear in Finnish Stone Age material more or less simultaneously with Comb Ware pottery that have recurrently been found in burials together with other prestigious materials, such as imported amber (e.g., Edgren 1966:93, Table 3; Torvinen 1979; Halinen 1997).

The main flint implement types found in these burials are pressure flaked bifacial points of various shapes (e.g., Manninen *et al*. 2003), which are not easy to manufacture from vein quartz. Nevertheless, vein quartz bifaces were made, sometimes with considerable success. It is not difficult to imagine that a bifacial quartz point brought prestige not only to its owner but also to its skilful manufacturer, who may or may not have been the same person. In a sense, then, it could perhaps be said that in a simple technology, the same way as in more elaborate technologies, complicated objects brought prestige to their owner and manufacturer.

Social dimensions in quartz assemblages?

Since quartz was an integral part of the lives of the Stone Age inhabitants of Eastern Fennoscandia, it is obvious to us that quartz processing must, indeed, have been a social act in the past communities. We have discussed above some of the social dimensions that become apparent in quartz assemblages when looking at them from a perspective based mainly on flint studies. But what could the vein quartz assemblages in themselves offer for the study of prehistoric social strategies? One aspect of lithic technology that can be studied especially well using predominantly vein quartz assemblages is the way in which raw material selection and use was controlled socially.

The general character of quartz technology in Eastern Fennoscandia is quite uniform. This raises questions since, due to the differences between vein quartz and flint-like materials, there must also have been different ways of looking at vein quartz as a raw material in prehistoric times. When forced to use quartz, a knapper coming from a tradition based strictly on flint probably looked for the more flint-like pieces of raw material (e.g., quartz crystals) that enable one to carry out a *chaîne opératoire* learned with flint even when using quartz. A knapper from a mainly vein quartz using tradition used quartz in a different manner because he or she was not looking for a substitute for flint but a piece of quartz that was suited for knapping in the way learned from other knappers used to vein quartz. As a consequence, the assemblages produced by these two hypothetical knappers turned out very different (cf. Manninen 2003:81p).

These different kinds of perception concerning quartz can, in fact, be detected in the archaeological material. The above-mentioned Comb Ware period flint and quartz bifaces are a good example. Bifacial pressure flaking was not used in working quartz before the flint raw material import began, and after it ended, it was not until the so-called straight based arrowhead (made mainly of flint and fine grained quartzite) was introduced in the Early Metal Age, about a thousand years later, that quartz bifaces reappeared in the Finnish archaeological record.

The usually quite crude appearance of the quartz bifaces indicates clearly that vein quartz is not a raw material that lends itself well to making formal tools. It is much better suited to making only slightly modified edges for composite and expedient tools. This disparity between vein quartz and flint-like raw materials is the reason for the uniformity in the vein quartz assemblages: the differences are so pronounced that they generated a unique lithic technology not directly comparable to flint technologies (cf. Rankama 2003).

However, as simple as this kind of technology may seem, plenty of task specific knowledge had to be learned. It is known, for example, that non-potters cannot estimate the dimensions of a pot that can be manufactured from a given ball of clay, whereas potters can (Wallaert-Pêtre 2001:481). This reminds us of how individuals relying on, for instance, vein quartz had to learn through practice how much quartz would be needed in certain tasks or over the winter, or how long a certain piece of raw material or a tool edge might last.

A pragmatic approach to lithic reduction methods and the use of lithics, such as the one suggested here to have developed in Eastern Fennoscandia, would have made a technology flexible and well suited for a colonization process (see Åkerlund *et al.* 2003:xxxvii). In Finland the use of simple knapping methods, however, was not restricted to highly mobile groups. Quartz reduction in semi-sedentary pit house villages seems to have been mostly as simple as among the more mobile groups (see, e.g., Rankama 2002), perhaps emphasizing its firm association with cultural preferences. In this sense the concept of "the correct ways to manufacture the necessary edges of tools and weapons" (above) also has a social dimension: it can mean simply technologically correct, but also socially correct, i.e., the way we (as opposed to they) do it.

Since culture is reproduced through learning (see Minar 2001), the fact that vein quartz maintained its importance as a raw material, even when other more easily flakeable raw materials were available, could be seen as an indication of socially transmitted preferences. It is also a good example of the fact that good conchoidal fracturing *per se* was not necessarily the factor that made a raw material preferred in prehistoric times. It should be kept in mind that according to ethnoarchaeological examples, conchoidal fracturing has not always been important to flint-using groups either (Miller 1979; White & Thomas 1972:278p).

The flint-like materials, nevertheless, must have had a special significance to the traditionally vein quartz using groups (see Holm 2003). The factor that made flint-like raw materials special, however, was not that they were petrologically different. Petrological categorizations are a modern construction and do not necessarily correspond to the categories used by prehistoric knappers (see Stout 2002:704 for an ethnographic example). It is possible that prehistoric knappers classified raw materials according to fracturing qualities and considered petrologically different stones to be the same raw material. Consequently, some quartzes and some flints may have been classified as the same raw material in prehistoric times.

Were the technologies so simple after all?

We have grouped most of the Eastern Fennoscandian lithic technologies above under the term simple technology. These so-called simple technologies, like all technologies, should, however, always be seen as parts of larger technological systems, and attempts should not be made to explain them in isolation from other components of the systems. Ethnoarchaeological data allows us to estimate, for instance, that making a haft with stone tools probably took a much longer time than making the simple stone blade of the tool (see Hayden 1979). If the simple quartz technologies of Eastern Fennoscandia were used mainly to produce edges for composite tools it would probably be the hafts that had most of the visible cultural or social meanings attached to them.

It must be emphasized that even though the general picture of quartz technologies in Fennoscandia and adjacent areas seems rather simple, this does not automatically mean that the whole technological system was simple. Quartz tools that have residues of adhesive material still attached to them have been found both in Sweden (Broadbent 1979:Fig. 78) and in Finland (Meinander 1954:Abb. 22). This implies that at least these quartz "tools" actually were only a small part of the complete tool. The complete tools may have been very complex and time-consuming to make.

If one considers, for instance, the Eskimo scrapers with their handles ergonomically shaped to fit the owner's hand (e.g., Nelson 1899:Pl. XLIX) or the Kwakiutl wood working adze in Figure 4, the term "simple technology" is not the first thing that springs to mind. The fact that the blade was easy to manufacture does not mean that the tool as a whole was simple. For this reason one should not hastily interpret simple-looking retouched quartz flakes or flake fragments as expedient tools, although many of them probably were. This, of course, is valid for other raw materials, as well. Since stone tools are often the only part of a technological system that has survived, one cannot estimate from the lithics how sophisticated or "skilled" a given technological system was, even if mainly expedient stone tools were used. The technology of the Wola (Sillitoe & Hardy 2003) is a good example of this.

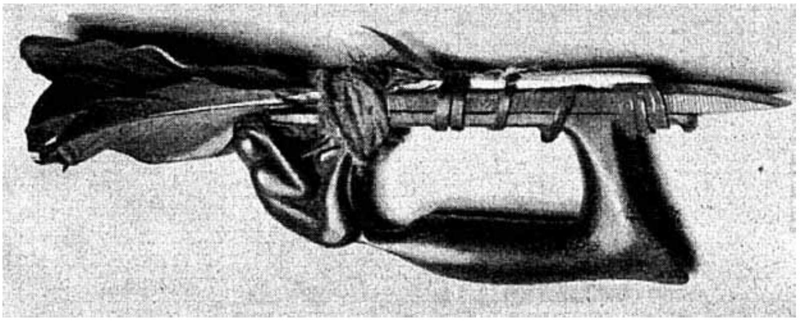


Figure 4. Kwakiutl adze for woodworking (from Buschan 1922:Abb. 28a).

New perspectives in Fennoscandian lithic studies

At this point it is time to consider what the new approaches recently introduced in Fennoscandian quartz studies could in the future offer to the subject at hand. The examples above have made it clear that many of the methods borrowed from lithic studies dealing with flint-like raw materials will not get us very far. It is also obvious that, most probably due to the special character of vein quartz, formal tool typologies attempted in order to bring order to vein quartz assemblages in Fennoscandia have failed to work (Siiriäinen 1981; Knutsson 1998).

Fracture analysis

Fracture analysis, which was developed in Sweden in the early 1990s, has enabled researchers to understand the fragmentation of quartz flakes during reduction and give meaning to the quartz flake fragments that were previously considered impossible to analyse (e.g., Callahan *et al*. 1992; Lindgren 1996; Räihälä 1999; Rankama 2002). Due to its novelty there naturally is still much to be tested in the reliability of some of the applications of the method (cf. Manninen 2003:55p) but understanding the fragmentation that occurs in vein quartz reduction and recognising the fragment types is essential for all types of quartz analyses.

The way in which quartz fractures in distinct fragment types (Callahan *et al.* 1992; Rankama 2002) offers possibilities not available when studying assemblages produced by technologies in which these fracture types were not taken advantage of. For instance, if particular fragment types were selected as tool blanks, it is easier to see which piles of debitage should actually be regarded as collections of blanks put aside for future use, and which ones should be considered pure debris from tool production (see Rankama 2002; 2003).

Chaîne opératoire analysis

The *chaîne opératoire* or technological approach (sensu Chazan 1997) has reached Eastern Fennoscandia slowly, but the possibilities it offers to quartz studies are considerable. Although the methods used to reduce vein quartz were simple, at least in Finland there are, nevertheless, differences in them that go beyond the technological tripartition (freehand platform, platform-on-anvil, bipolar-on-anvil) suggested by Callahan (1987) in his pioneering work on the lithic technology of Eastern Central Sweden.

Simple operational schemes do not have as many readily observable characteristics that can be considered cultural or social markers as the more elaborate methods (see Pelegrin 1984:84). Clear differences can, nevertheless, be seen even in simple knapping methods even when all the sequences of a chaîne opératoire cannot be detected. Figure 5 compares two instances: a partial operational sequence from the Leakšagoadejohka 3 site in Utsjoki, Finnish Lapland, reconstructed by technotypological analysis and refitting (Manninen 2003) and a core from the Rävåsen site in Southern Ostrobothnia (Hertell & Manninen in press). Both examples represent simple platform methods.

Site	*Leakšagoađejohka 3*	*Rävåsen*
Site type	Small 2 x 2 m knapping floor near the raw material source (river bed)	Large occupation site with pit houses
Raw material	Rounded cobble, c. 3-5 kilograms, shape slightly angular	Rounded cobble, c. 400 grams, shape oval and flat
Source	River bed near site	Unknown
Stage 1	Cobble opened by smashing against rocks	Opening flake struck using natural rounded surface as platform
Stage 2	Large piece (c. 2 kilograms) decorticated with large flake removals	Alternate bifacial flaking using scars from previous removals as platforms
Stage 3	Several flake removals from a single platform	Discoidal core (280 grams) rejected with part of the cortical surface remaining
Stage 4	Core taken away from knapping floor	

Figure 5. Interpretation of partial *chaînes opératoires* from two Finnish Stone Age sites: the Leakšagoadejohka 3 site in Utsjoki, Finnish Lapland, and the Rävåsen site in Southern Ostrobothnia.

The differences in these two examples cannot at present be directly connected with specific cultural or social traditions. It is important to note, however, that the knapping methods represented by the examples are clearly distinguishable from each other. This gives hope that more examples of different operational schemes can be detected in future analyses and interpreted as cultural or social markers, making *chaîne opératoire* analysis the long-awaited substitute for formal tool typologies in vein quartz studies (cf. Manninen 2003).

The *chaîne opératoire* concept understood as the study of the whole system of stone tool manufacture, maintenance, and use and expressed, e.g., as a flow model (see Rankama 1989/1990; Rankama 1997) may also bring forth differences in attitudes towards different stone tools and raw materials that may have social or cultural significance.

Conclusion

In this paper we have briefly discussed the problems of deriving social information from the most common artefact category in the Stone Age assemblages of Eastern Fennoscandia, namely, vein quartz tools and debitage. The difficulties that must be addressed in vein quartz studies have been contrasted with the possibilities available in flint studies. These difficulties are largely the result of the nature and appearance of vein quartz as compared with flint. It is also worth noting that the difficulties become problems only when research methods and objectives found fruitful in studying other raw materials are uncritically applied to vein quartz studies.

It should be remembered that although "quartz as a raw material has a bad reputation among archaeologists" (Cornelissen 2003:2) it is dangerous to assume that this was also the case among Stone Age peoples. Qualities that make a raw material easy to study do not necessarily make it better to use. The starting-point in lithic studies should not be in conventional ideas of what is a good raw material or what are the most sophisticated or skilled ways of flintknapping. A skilled quartz-user, for instance, knew how to make the best use of the properties of that particular raw material in specific cultural, social, and environmental circumstances.

Quartz studies require an orientation that differs from the one employed in studies of flint-like raw materials. Although quartz was sometimes used in the same manner as flint, this was not always the case. Conchoidal fracture was not always a factor that made a raw material desired. In addition, like wines, quartz assemblages are not all alike. Some quartz assemblages have clear counterparts in other raw materials, but at least in Eastern Fennoscandia, a different completely vein quartz-based technological tradition also developed.

It is difficult to say to what degree traditional customs, rituals or taboos may have restricted the use of quartz in this tradition to specific individuals, groups, or genders. Grave finds indicate that during certain periods some quartz items were considered valuable enough to be placed among funeral offerings. It should be remembered, however, that grave furnishings did not necessarily have the same meanings among hunter-gatherers as in our contemporary or in agricultural contexts (cf. Knutsson 2000) and that raw material was not necessarily the factor that regulated the value of an artefact.

At Eastern Fennoscandian Stone Age sites quartz is normally scattered all over the habitation area, suggesting again that vein quartz was available to everyone. The knowledge concerning quartz procurement, reduction, use, maintenance, and discard was transmitted from generation to generation and learned in everyday situations. However, to what degree we will be able to distinguish the social dimensions of quartz use from other features, such as the effects of mobility, raw material availability, and so on, in our archaeological material, is a completely different matter. In Finland lithic analyses have so far concentrated on individual sites. As a consequence, it is not yet possible for us to try to understand the effects of different complex factors on the formation of the lithic record in a complete settlement system.

Quartz reduction in Eastern Fennoscandia seems mainly to have been rather simple and the know-how needed to work quartz easily acquired. It also seems that the *chaînes opératoires* were not complicated, in other words, they did not involve several and/or difficult production stages. It is likely that tool production was not restricted or specialized. These things make some of the recent research trends in the anthropology of technology, such as the study of learning processes, the transmission of skills, and the like, usually ill-suited for quartz studies. Therefore the study of simple technologies should not be restricted to only those social strategies that have been investigated in connection with complex lithic technologies.

Technologies that are based predominantly on vein quartz but have also used other raw materials offer a better opportunity to study, e.g., the social aspects of raw material use and the mechanisms of the transport of exotic raw materials, than do technologies relying exclusively on flint. It is essential, however, to continue looking for cultural and social variation also within pure quartz assemblages. It is equally essential that the methods employed in these studies are not selected on the basis of their popularity in current lithic research but purely on the basis of their applicability to the specific characteristics of vein quartz assemblages. Refitting and replication, used together with *chaîne opératoire* analysis, for example, are ways to explore the potential of quartz as a source of significant social information.

Acknowledgments

The authors wish to thank the organisers of the symposium *Skilled Production and Social Reproduction* for the opportunity to participate and bring forth our ideas about Eastern Fennoscandian lithic assemblages in a social context. The writing of the conference contribution and this paper was partly financed by a grant form the Jenny and Antti Wihuri fund to Tuija Rankama.

Bradford Andrews

Skill and the question of blade crafting intensity at Classic Period Teotihuacan

Abstract
Defining the scale and organization of Classic Period Teotihuacan's obsidian tool industry is an important research objective. One question of interest is whether its craftsmen were full-time or part-time specialists. This paper assesses the craftsman skill reflected by surface collections from workshops as a means for inferring specialist labor intensity. Skill is measured by tabulating the frequencies of attributes that represent core-blade production errors. Comparing this information to core-blade workshops from Epiclassic Xochicalco indicates that Teotihuacan may have had only part-time blade producers.

Introduction

This paper addresses an issue related to the organization and scale of Classic (A.D. 150-700) Teotihuacan's (Fig. 1) obsidian tool industry. These two dimensions of production encompass the social contexts in which crafts were made, how many craftsmen were involved, how often they worked, and how many items were produced. By the 1980s, claims were being made that Teotihuacan contained hundreds of part- and full-time workshops servicing the needs of consumers not only in the city, but also throughout much of the Mesoamerican region (Sanders and Santley 1983; Santley 1984; Santley *et al.* 1995; Spence 1981). These claims have been used to support inferences about the overall complexity of Teotihuacan's economy (Millon 1973, 1981, 1988; Sanders *et al.* 1979).

In a landmark article in 1986, John Clark (1986) suggested that Teotihuacan's obsidian tool industry had been greatly exaggerated. Addressing one issue he raised, I examine the same data used to support the proposed monumental scale of the core-blade industry to explore the question of labor intensity, defined here as the amount of time a specialist spent making crafts. Specifically, I examine artifacts from the San Martin complex, arguably one of the most intensive obsidian tool workshops that is located in the northeastern sector of the city (Fig. 2; Andrews 1999:276-281, 2002:48; Spence 1981, 1986). Unfortunately, the inferential validity of these data is suspect because they were collected from the surface (Clark 1986). My purpose here, therefore, is to use them to formulate an alternative perspective about labor intensity at the workshop that will require future testing with subsurface information.

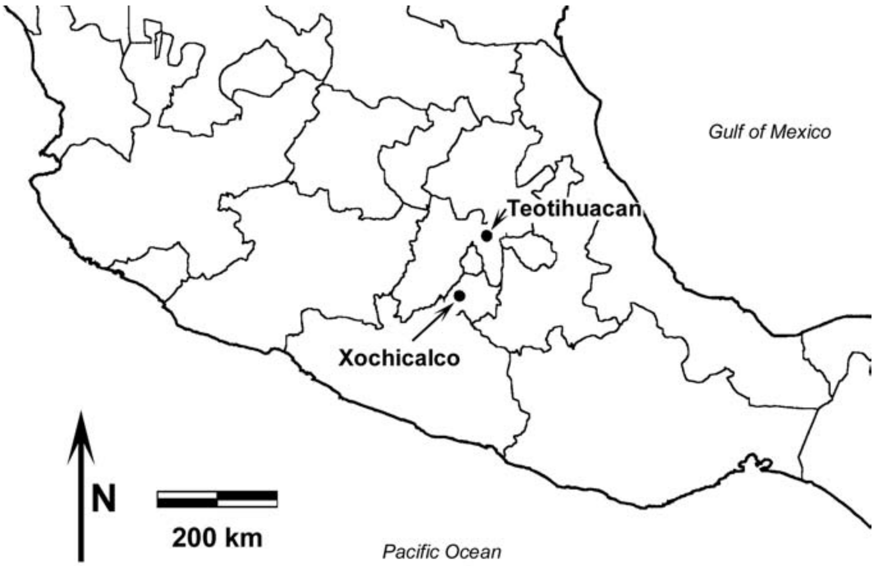


Figure 1. The Locations of Teotihuacan and Xochicalco in Greater Mesoamerica.

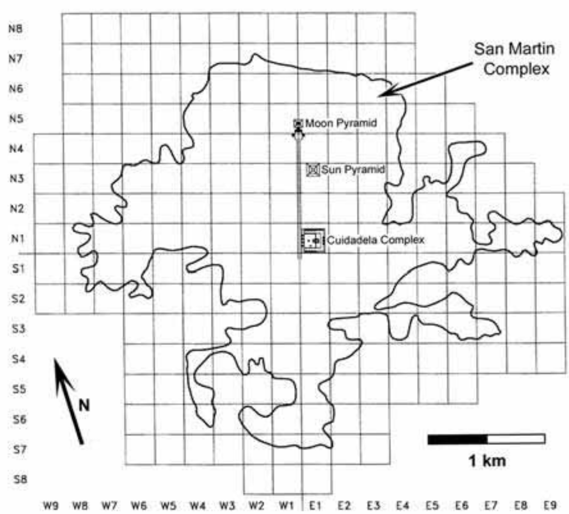


Figure 2. The Location of the San Martin Complex in Teotihuacan.

I suggest the San Martin data, when compared to valid subsurface information from a workshop at Epiclassic (A.D. 650-900) Xochicalco (Fig. 1) indicate that San Martin's craftsmen may have been part-time specialists. If so, then we must wonder whether other, generally less impressive, blade-producing contexts in the city were also operated by part-time specialists. This perspective has important implications for understanding the nature of craft production at Teotihuacan, and the city's overall interdependent socio-economic structure.

The following discussion begins by describing the San Martin and Operation H workshops, and then defines skill as it pertains to this study. Next, I address the artifact attributes used to measure craftsman skill and how they were quantified. The third section presents the analysis of craftsman skill. The final section discusses the results and implications of my study.

The Workshops

While subsurface data are needed to confirm whether many of Teotihuacan's "workshops" were actually production contexts, the inhabitants of the San Martin complex were involved in the specialized manufacture of blades and bifaces during the Classic period (Fig. 3). The workshop consists of three conjoined residential compounds covering about 2 ha, housing an estimated 140 to 300 people (Spence 1986). The array and density of obsidian tool byproducts at the workshop, and their direct association with residential architecture,[1] suggest that it was occupied by cooperatively organized extended families[2] involved in flaked stone tool production (Andrews 2002:48).

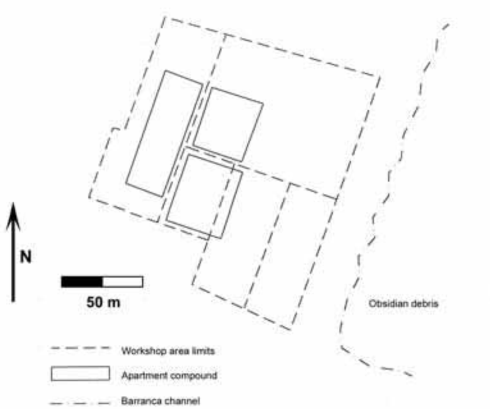


Figure 3. Map of the San Martin Workshop Complex at Teotihuacan.

At Xochicalco, excavations of the Operation H workshop have revealed a considerable amount of core-blade byproducts and knapping tools associated with multiple activity areas (see Hirth n.d. for a detailed discussion of these data). This context was a single large residential compound with three conjoined patios (Fig. 4) that housed an extended family of 10 to 20 people (Hirth 2000:tables 7.1 and 7.3). As such, both the San Martin and Operation H workshops represent comparable social contexts of production, although the family unit at San Martin was much larger.

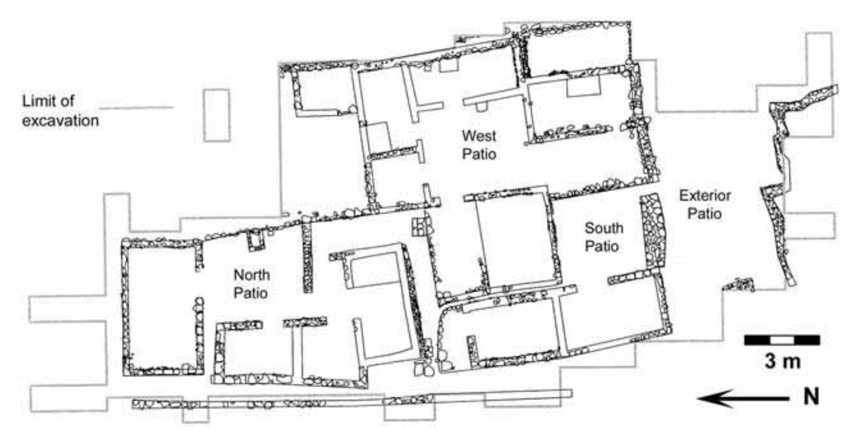


Figure 4. Map of the Operation H Workshop at Xochicalco.

The Concept of Skill

Since my question addresses crafting intensity, it revolves around the concept of part-time versus full-time specialization, a dichotomy that is too constraining because it forces workshops into two categories. Instead, I advocate placing workshops along a continuum that allows us to rank relative levels of labor intensity. This perspective is useful because it permits more realistic comparisons of intensity than the traditional part-time/full-time dichotomy (Andrews 2003; Costin 1991, n.d.; Tosi 1984).

The labor intensity at which specialists were involved in production can be inferred from measures of craftsman skill (Andrews 1999, 2003). This perspective assumes that, in most cases, more skilled craftsmen will be those who worked most often because they were the most practiced at the techniques or gestures necessary for making their crafts.[3] By techniques or gestures I am referring to the concept of know-how, defined as the intuitively directed body movements associated with making a specific craft under a specific set of conditions (e.g. raw material type and form, and knapping tools); know-how is a form of physiological memory that can only be honed through practical experience (Pelegrin 1990:118).

For this discussion, I distinguish two qualitatively different types of skill: artisanal, and efficiency. Artisanal skill refers to the physical motions abilities associated with the production of high quality ceremonial/wealth items (Apel 2001, Clark 1986:44, Clark and Parry 1990; Rathje 1975:414, Sheets 1978:66). This type of craft production usually favors a high level of labor invested per unit output (Hayden 1998:11); emphasis is placed on producing an aesthetic item that transmits social information (Helms 1993, Inomata 2001:324, Torrence 1986:45). Consequently, artisanal skill is measured by the outward qualities of a finely crafted product. This type of skill can be difficult to quantify because it is often based on emic aesthetic qualities.

In contrast, I suggest that efficiency skill is generally associated with the production of utilitarian items. Here, lower levels of labor are invested per product to make a practical item that may be more uniform and standardized at higher levels of specialization (Hayden 1998:2; Schiffer and Skibo 1997). In contrast to artisanal skill, efficiency skill must be measured by looking at populations of items. One approach is to assess the proportion of errors in an assemblage because efficiency skill should be "…positively correlated with specialization, and therefore industries with fewer mistakes…will be more specialized than those [with more] mistakes or less command over the productive process" (Costin 1991:40).

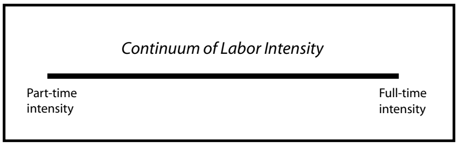


Figure 5. Continuum of Labor Intensity.

Efficiency skill as a measure can be conceptualized as a part- to full-time continuum (Fig. 5). Minimal labor investment in the absence of economies of scale presupposes the view that specialists at the part-time end of the spectrum have lower efficiency skill than their full-time counterparts. Part-time specialists are less efficient because they do not engage in the number of repetitive activities often associated with a standardized production process (Rice 1981:220). In contrast, full-time producers are more proficient at performing the gestures related to their efforts because constant repetition of these actions promotes greater competence. If economies of scale come into play, then the range of activities performed by each worker is reduced leading to an increase in the frequency of specific activity performance (Costin

1991:33-43, n.d.; Rathje 1975:414-416; Rice 1981:220; Torrence 1986:42-43). As a result, full-time specialists are expected to make fewer errors than part-time specialists, all other things being equal.

I evaluate efficiency skill by looking at proportions of errors in the San Martin and Operation H assemblages. By definition, errors represent the failure to reach a desired outcome (Clark 2003:222). Accordingly, to identify errors one must be relatively certain of a craftsman's intention (Clark 2003). For Mesoamerican pressure blades, the intention was straightforward: the production of long, regular blades with parallel sides and prismatic cross sections.

Errors

Given the blade-maker's intention, most researchers agree that two common core-blade errors are hinged and overshot blades (Fig. 6) (Andrews 2003; Clark 1997, 2003; Clark and Bryant 1997; Crabtree 1972; Santley *et al.* 1995; Sheets 1975, 1983). A hinged blade does not travel the length of the core, but rather, terminates with a fracture plane that curves outward from its ventral to dorsal surface. Hinges can be identified from the scars they leave behind on cores (Fig. 6a), or on the distal ends of blade sections (Fig. 6b). In contrast, overshot blades occur when a blade's ventral surface curves inward towards the bottom of the core, thereby removing considerably more core distal mass than intended (Fig. 6c; Clark and Bryant 1997:123; Crabtree 1972). The forces promoting these errors are described in detail elsewhere (Andrews 2000; Clark and Bryant 1997; Santley *et al.* 1986; Sheets 1978).

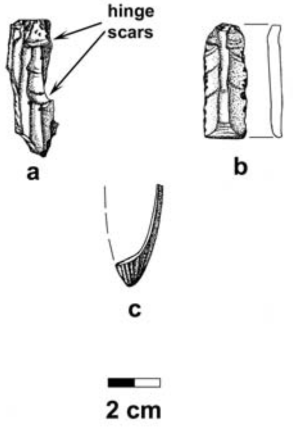


Figure 6. Errors used in the analysis:
a) hinge scars visible on a core artifact,
b) proximal blade section with a hinge termination,
c) distal section with an overshot termination.

Identifying errors is relatively easy. The more challenging proposition is devising a method with which they can be meaningfully quantified. Elsewhere, John Clark (1997) maintains that errors must be quantified against a measure of blade output. By definition, however, suitable blades were exported to the consumers so they will not be available to count in workshop deposits. Without a doubt, errors as unsuitable byproducts will be over-represented at workshops, a phenomenon Clark (1997, 2003) refers to as the Brandon Bias. Discarded items such as core artifacts, however, can be used to estimate blade output. First, one must estimate the number of blades available from the average-sized core reduced at a site. This number can then be multiplied by the number of core artifacts to estimate the blade output represented by an assemblage. Consequently, the number of blades with hinge terminations can be divided by the estimated output to derive a hinge frequency.

This method assumes that the proportion of core artifacts in an assemblage has not been altered. This assumption is unlikely to hold true for the San Martin data because it is a surface collection. Prospecting of this location since the Classic, for usable tool stone or simple curiosity, has probably resulted in the differential removal of artifacts such as exhausted[4] cores because of their unique shape and size.[5] As a result, the core artifacts in the San Martin collection probably do not accurately reflect its blade production.

As an alternative to Clark's (1997) method for quantifying efficiency skill, I suggest an approach that quantifies errors as ratios of specific classes of related artifacts (Andrews 1999, 2003; Hirth and Andrews n.d.a). This option is based on the assumption that any blade has a direct potential relationship to the incidence of a single error. In other words, a blade is either successfully or errantly detached. Since the knapper's intention was to make full-length, standardized prismatic blades, errant hinged proximal sections can be quantified per total number of proximal sections. Likewise, errant overshot blades can be quantified per total number of distal sections. These ratios provide a measure of input that reflects the relative proportion of successfully produced blades.

Although successful blades were exported, data from numerous Mesoamerican blade workshops indicate that significant percentages of snapped blade segments were discarded (Hirth *et al.* 2000, 2003; Clark and Bryant 1997; Healan 1986:table2, 1990:cuadro 1; Parry 2002:table 4.1 & 4.2). Discard of these artifacts relates to the segmentation of blades into usable sections and the modification of blades into more specialized tools, such as projectile points and eccentrics. Snapped blade segments that were too small to use effectively were discarded. These artifacts, therefore, provide the basis for quantifying the relative rates of hinge fracture and overshot errors. In contrast to core artifacts, post-abandonment scavenging of small discarded blade sections is unlikely to have occurred on a significant scale. I maintain, therefore, that this method is more appropriate for quantifying errors present in the San Martin surface collection.

Three variables are examined in this analysis (Tab. 1): 1) the percentage of hinged proximal sections per total number of proximal sections, 2) the percentage of distal sections with overshot terminations per total number of distal sections, and 3) the number of hinge scars per core artifact.

Variable 1	Hinged Proximals/ Total Number of Proximals
Variable 2	Overshot distals/Total Number of Distals
Variable 3	Number of Scars/Core Artifact

Table 1. Variables used in the study.

The data

While both blades and bifaces were made at San Martin, my analysis is concerned with blade-making skill. Furthermore, I have selected only the Pachuca obsidian artifacts to assess the skill of the San Martin craftsmen because this material constitutes about 92 percent of Teotihuacan's core-blade assemblages (Andrews 2002; Spence 1981). In contrast, I use only the gray Ucareo and Zacualtipan obsidian artifacts to assess skill of the Operation H craftsmen because these materials constitute 86 percent of Xochicalco's core-blade material (Hirth 2002:83). I have chosen to do this because evidence suggests that fracture mechanics vary according to raw material; hence, my analysis focuses on the tool stone most familiar to the core-blade craftsmen at each workshop. Theoretically, it should provide a measure of their highest levels of respective skill.

Focusing on these data, the errors from the San Martin and Operation H workshops can be quantified. Once again, variable 1 is the percentage of hinged proximals per total number of proximal sections. There are hinge terminations on 1.9 percent of the San Martin proximal sections and 2.0 percent of the Operation H proximal sections (Tab. 2). Variable 2, the percentage of overshot terminations per total number of distal sections, there are overshot terminations on 9.2 percent of the San Martin distal sections, and 7.3 percent of the Operation H distal sections.

Variables	*San Martin*	*Operation H*
	(Teotihuacan)	(Xochicalco)
	1.9%	2.0%
1) hinged prox./prox	(7 hinged prox./365 prox.)	(123 hinged prox./6,148 prox.)
	9.2%	7.3%
2) overshots/distals	(13 overshot distals/142 distals)	(169 overshot distals/2,317 distals)
	1.1 scars	1.9 scars
3) hinge scars/core	(144 hinges/133 cores)	(170 hinges/91 cores)

Table 2. Results of the Efficiency Skill Analysis.

Once again, variable 3 represents the number of hinge scars per core artifact (Tab. 2). In this case, the hinge scar frequency is standardized against the blade scars on the core artifacts themselves, which directly reflect either successful or unsuccessful (hinged) blade removals. Core artifacts include exhausted complete cores, core sections, and core tops. Since exhausted cores represent the last series of blade removals, I include larger-diameter artifacts such as core tops and core sections, generally produced earlier in the sequence, to acquire data on hinge occurrence throughout the whole blade-making sequence. There are 1.1 hinge scars per core artifact in the San Martin data, and 1.9 hinge scars per core artifact in the Operation H data.

Discussion

The hinge data suggest that relative to the craftsmen at Operation H, those at San Martin may have been slightly more adept at controlling the incidence of hinge fractures. In contrast, the incidence of overshot terminations suggests that the Operation H craftsmen had the upper hand. Taken together, however, these data may indicate that the craftsmen from both workshops had similar levels of skill. If so, then these patterns also may have implications for inferring the labor intensity of the San Martin craftsmen. The San Martin workshop was originally placed in Spence's (1981) Regional Workshop category. This category supposedly represents Teotihuacan's most intensive, large-scale workshops with full-time craftsmen that supplied large quantities of tools for extra-local consumption (Santley *et al*. 1995; Spence 1981, 1987).

Based on the estimated labor intensity of Xochicalco's Operation H craftsmen, however, I suggest that the full-time status of San Martin's craftsmen may have to be reconsidered.

Labor intensity at Operation H was calculated according to the amount of time needed to produce blades at Xochicalco. This estimate was derived from several categories of artifacts, including core tops found on the workshop's floor (Hirth and Andrews n.d.b), and quantified experimental assessments of blade-making activities using Xochicalco's core-blade technology (Flenniken and Hirth 2003; Hirth *et al*. 2003).

The estimate was based on a monthly production cycle, to account for periodic waste disposal, and then converted into a figure of annual output. The labor intensity of Operation H's craftsmen, the highest among three domestic core-blade workshops at Xochicalco, was about 35 craftsman days per month, or 420 craftsman workdays per year (Hirth and Andrews n.d.b). Accordingly, the number of production locales strongly suggests that Operation H had two to three craftsmen operating simultaneously, although it could have had a full-time craftsman (Hirth n.d.). If so, then the San Martin craftsmen may also have been part-time because they appear to have had a level of efficiency skill similar to the craftsmen at Operation H. At the very least, this evidence casts doubt on the assertion that the San Martin craftsmen were highly industrious full-time producers.

This study has used the same data set to reach a conclusion that runs contrary to the previously proposed nature of production at the San Martin workshop. That aside, I realize that numerous objections can be raised to this exploratory analysis, including 1) its use of surface data, and 2) the technological comparability of the assemblages.

Setting aside the obvious need for systematic subsurface samples of data, I believe the issue of technological compatibility is essential to consider. For inter-site studies of skill, one thing future research must address is the reality that the core-blade technologies at Teotihuacan and Xochicalco differed. This factor makes comparisons of efficiency problematic (Costin n.d.). Although the core-blade tradition is pan-Mesoamerican, the array of reduction techniques varied widely (Hirth and Andrews 2002). For example, core platforms at Teotihuacan were single facet, whereas they were pecked and ground at Xochicalco. Pecking and grinding produced tiny fracture cones that facilitated easier crack initiation during blade removal. Since Teotihuacan platforms were single facet, requiring generally more force to press off a blade, perhaps greater efficiency skill was required to prevent the occurrence of hinge terminations. Experimental research has shown that blade removals requiring more force can be more likely to hinge because, depending on one's technique, the extra effort can compromise a blade-maker's precision (Andrews 2003).[6] If so, then the hinge fracture data presented in this paper would tend to suggest that the San Martin craftsmen were more skilled. Clearly, such technological differences may significantly affect the feasibility of using skill data to comparatively infer relative levels of blade-making intensity at Teotihuacan and Xochicalco. These questions require further experimental research before we reliably make inter-site comparisons of efficiency skill.

Conclusion

I have counted the number of artifacts with hinges and overshot attributes and derived ratios of these artifacts to support inferences about the relative levels of blade-making labor intensity at the San Martin and Operation H workshops. Based on the relationship between practice and proficiency (Clark 2003), errors made during the production process were used to infer relative levels of blade crafting intensity. All other things being equal, one's skill should relate to the time spent making blades. Since the measures of skill for the San Martin and Operation H craftsmen appear similar, I suggest that both workshops might have had similar levels of part-time intensity.

Following Clark's (1986) article addressing the nature of Teotihuacan's obsidian tool industry, some studies have approached the issue of craft production in the city more critically (Sheehy 1992; Widmer 1991). The earlier model positing a system of monumental scale, however, still seems to be prevalent in the literature (Millon 1988; Santley and Alexander 1993; Santley *et al.* 1995; Santley and Pool 1993; Widmer 1996; see Feinman [1999:81-85] for relevant commentary). Despite the problems with using the San Martin surface data, the intent of this study was to continue to question the earlier ideas about Teotihuacan's craft economy. If the San Martin workshop was a part-time context of blade production, then it is probable that there was enough aggregate demand for blades to support the amount its craftsmen *could have been* produced.

Although local demand would have been high in a city of 125,000 people (Millon *et al.* 1973), the conclusion reached here is consistent with the suggestion that the San Martin workshop and others like it probably did not export vast quantities of tools beyond the city (Clark 1986). This conclusion is also in line with Randolph Widmer's (1991:144) suggestion that the lapidary workshops at Tlajinga 33 did not produce for extra-local export. If true, then it is likely that future research will further establish that the far-flung influence and interdependent structure of Teotihuacan's economy has been overstated.

Acknowledgements

I would like to extend my gratitude to Kjel Knutsson and Jan Apel for providing me with the opportunity to contribute to this volume. Data analysis of the Teotihuacan surface collections and the excavation and collection of the data from Xochicalco was provided by the National Science Foundation research grants 9420202, 9496188, and 9121949. I am indebted to Kenneth Hirth, Jeffrey Flenniken, and Gene Titmus for their help, assistance, and guidance throughout all steps in this research. Many thanks also to Pedro Baños and Seferino Ortega who kindly located the Teotihuacan collections for me and provided me space in which to analyze them at the lab in San Juan Teotihuacan. Moreover, John Clark's meticulous feedback on the original manuscript was invaluable. Anna Backer, Cathy Costin, Rand Gruebel, Akiko Nosaka, and Alan Reed also provided valuable comments. Finally, I greatly appreciate the efforts of Oralia Cabrera and Kristin Sullivan who organized the symposium "Craft Production at Terminal Formative and Classic Period Teotihuacan, Mexico" for the 69th annual meeting of the SAAs in which this paper was originally presented.

Notes

1) The San Martin complex has never been excavated but holes for planting *nopal* cactus and a *barrranca* cut along its eastern margin reveal the direct association of flaked stone tool byproducts with domestic house features (Andrews 2002:48). The location of the workshop on the periphery of the city, and the predominance of Middle to Late Classic ceramics suggest that it was primarily occupied during the Tlamimilolpa and Xolalpan phases (A.D. 300 to 650). Consequently, it is unlikely that the flaked stone tool byproducts represent dumps composed of refuse from workshops located elsewhere in the city. Given the considerably reduced population of the Post-classic city concentrated west of the Avenue of the Dead (40 000, down from a Classic high of 125,000 [Sanders *et al*. 1979]), it is unlikely that Epiclassic (A.D. 650-900) craftsmen would have traveled all the way to the northeastern periphery of the former Classic city to dump their trash.

2) Widmer (1991:144) has proposed a similar model for the organization of lapidary production in the large extended family compound of Tlajinga 33.

3) I recognize that skill is also related to one's innate abilities (Olausson 1997, 2000). I assume here, however, that for workshops in extended family households, the more innately skilled individuals would have been those encouraged to excel in blade production.

4) Exhausted cores are those discarded at the end of their use-lives. Presumably, core-blade knappers regarded them as too small for making blades.

5) Another factor that can potentially affect the number of core artifacts in an assemblage is their differential consumption as a result of lateral cycling. For example, at Otumba and Xochicalco many exhausted cores were cycled into the lapidary industry to make beads (Otis-Charlton 1993; Hirth *et al.* 2003, n.d.). In addition, a significant number of core tops and core section flakes in Xochicalco's workshops were further modified into various scraping tools that were then exported for consumption elsewhere in the city. These behaviors obviously affect the accuracy of any estimate of blade output based on core artifact frequency in a given assemblage.

6) Another technological factor that must be considered is the degree to which different blade removal techniques might have affected error rates. Experimental research has shown that many of the blades at Xochicalco were probably reduced with a handheld technique best suited to the small prismatic cores prevalent in the city (Flenniken and Hirth 2003). At Teotihuacan, in contrast, the pressure blade producing sequence started with much larger polyhedral cores. The size of these artifacts probably required a footheld technique permitting the generation of much more force than its handheld counterpart. More experiments are needed to see if, and under what conditions (i.e. core size, platform type), both techniques are associated with appreciably different rates of production errors.

Mikkel Sørensen

Rethinking the lithic blade definition: towards a dynamic understanding

Abstract

This paper discusses the classification of the lithic blade definition in a historical perspective. Nowadays, there is a general agreement that lithic artefacts are produced intentionally through human action; this change of perception must also be reflected in our definitions. As an illustration to this way of thinking, a new technological blade definition is presented.

The blade definition is used in a new technological study of the Early Mesolithic Scandinavian (Maglemosian) lithic industry – a period in which seven different blade production methods have been identified. The seven concepts, which form a process of technological change during the Maglemosian, are interpreted and explained by means of modern replication.

Some main benefits of the application of technological definitions are: 1) we can focus on human behaviour in prehistory; 2) The traditional archaeological culture concept can be dissolved and human prehistory can be re-interpreted as "traditions" defined by, among others, the use of specific technologies.

Introduction to the problem

Traditional lithic artefact definitions have been advocated by archaeologists whose main goal was to construct a chronology of human prehistory. Today, we have established a general chronology of prehistory and the research focus has changed to address questions such as: how did people live, how did they organise their social life, how did they solve daily problems, and what did they generally think about life? Despite the fact that our research focus has changed, traditional positivistic metrical artefact definitions are often still in use and research results are, therefore, often influenced by redundant static perceptions of human prehistory. One solution to this problem is to create, present and discuss new definitions which include our present knowledge of the *chaîne opératoire* and lithic technology. This paper focuses on lithic artefact definitions, using an example of one artefact type, the blade, and viewing it from a historical perspective.

The lithic blade classification in a historical perspective

A lithic artefact type that we generally perceive as known and agreed upon is the blade.

Blades are often not secondarily worked or retouched and were traditionally believed not to be tools. Neither can they be described as waste since they often are much too regular and as such blades do not fit into our pyramided hierarchy of artefacts (Fig. 1). This problem is often dealt with by placing blades in their own artefact category. Yet, drawing a line between waste and blades just results in more problems when classifying: where do preparation blades and crested blades belong? What about hinged and broken blades? What happens with the atypical or unsuccessfully made blades or rejuvenation blades?

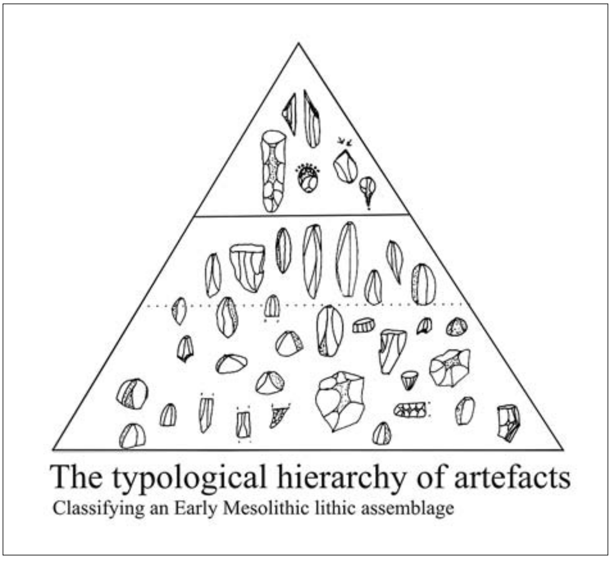


Figure 1. A lithic assemblage classified using traditional typology. Artefacts are perceived as parts of a hierarchy, where the formal tool types are at the top and the remainder (majority of the assemblage - so-called waste) at the bottom. But what about blades? Blades do not seem to be real tools, but at the same time are perceived to be too regular to be classified as waste! Owing to this, blades are often classified as a distinct group situated between the tools and waste in the traditional artefact hierarchy. A problem with this classification is how we define blades in order to separate them from waste (flakes). Where do broken blades belong and what about cortical, atypical blades or blade rejuvenations?

Throughout the history of lithic analysis and classification, many attempts were made by archaeologists to solve these problems through the use of different blade definitions. This author will start out by outlining a short history of the blade definitions and conceptions in relation to theoretical approaches in archaeological history.

During the so-called Early Empiricism (19th century), only a few archaeologists were concerned with blade definitions, a fact that was probably related to the late acknowledgement of the oldest Stone Age. One of the first archaeologists who analysed a flint assemblage with a blade industry was Sophus Müller in his treatment of the shell midden at Ertebølle (Müller 1900). In order to classify and analyse the late Mesolithic assemblage, Müller presented what was probably the first use of a blade and a flake definition in a Mesolithic context. By studying the assemblage carefully he stated:

> *During the excavation, all detached removals that were thought to derive from the blade production were collected. Not only complete pieces, but also broken and small pieces; not just beautiful and regular blades in the most limited sense of the word, together with crested- and edged blades, but also irregular and possible blades. In all, every detached removal that was thought to be produced with the intention that it should be a blade was collected* (Müller 1900:42) (This author's translation).

This specific blade definition included: "... all pieces that, more or less, have the (following) described unique morphology: the oblong, narrow and thin, intended and regular removal with a sharp and straight lateral edge, which is appropriate as a cutting edge" (Müller 1900:42) (This is the author's translation). This definition was put forward in opposition to the following flake definition: "the irregular more coincidental, partly either wide or thick flint detachment, sharp edged, but without a longer well defined cutting edge" (Müller 1900:42) (This is the author's translation). It should be stressed that Müller's blade definition only concerned material from the Ertebølle excavation, and that the definition is therefore specific to a Late Mesolithic artefact assemblage.

It must also be noticed that Müller considered prehistoric intentions in the industry, and that it is on the basis of both morphology and ideas about intentions that he separates blades from flakes. In many ways, Müller's definitions must, therefore, be considered as well in line with what came out of a similar research interests at the end of the 20th century.

During the period of Cultural (normative) Archaeology from 1900 to 1960 (Olsen 1999), blades are defined vaguely on the basis of only a few morphological and metrical criteria. This is seen exemplified in the work of Mathiassen (1948) who, probably on the basis of Müller's work, divided blades in regular and irregular pieces. This less precise terminology was generally not argued for, and no overall definition of blades was presented besides it.

During the period of Positivism in Scandinavia in the 1960s, objective definitions using metrical classifications and sometimes quantifications of specific attributes were often attempted. Althin (1954) put forward the ”A-blade” and ”B-blade” categories, where A-blades have parallel sides and a length–width ratio of at least 2:1, while B-blades do not have parallel sides and a length–width ratio of less than 2:1.

Malmer (1962) is taking the definitions even further, aiming for an “objective metrical truth”. Defining the amount of dorsal ridges proportional to the regularity and the quality of the blade, he formed an index for blade regularity. In 1969, Malmer thus reuses Althin's A- and B categories, but adds the amount of dorsal ridges and the thickness of the blades as metrical parameters to the definition (Malmer 1969). At the same time, he defines microblades as shorter than 5 cm in length, with a length–width ratio of 5:1. It has to be mentioned that Malmer was primarily interested in chronological questions, and that Malmer's metrical definition of microblades is only relevant for Scania and for flint assemblages. However, in general his definitions were used from then on.

From a present day perspective, these attempts can be criticised for two major reasons. First, we now are aware that objectivity is an illusion. The obvious paradox lies with the positivistic definitions themselves: nothing seems more subjective than to force a lithic assemblage into some subjective chosen metrical categories. Second, through the use of one metrical blade definition and the selection of only some aspects of the blade production sequence, the lithic analyst misses the opportunity to recognise different technologies, to specify blade concepts and culture/groups or to interpret social interactions through technology.

In 1964, S. A. Semenov suggested a functional definition of tool types. But since blades were produced using different techniques, and since blades generally are preforms for functional tool types and had multi-purpose functions throughout prehistory, morphology still seemed to be more reliable for classification (Bordes 1969).

In the French tradition of lithic analysis, J. Tixier (1963) presented metrical definitions for blades (lames), microblades (lamelles) and flakes (éclats) in his work of the Epi-Palaeolithic in North Africa. These definitions are based on measurements of width/length and correspond in general with the earlier Swedish definitions, but in contrast to the Swedish attempts, Tixier compiled his definitions on the basis of a specific (Epi-Palaeolithic) context and not as general definitions.

In the French tradition, technology was linked to sociology very early on (*e.g.* Mauss 1927, 1947), and studies involving artefact replication opened the eye for a description of the artefacts based on an understanding of the lithic knapping process. A sociological interpretation of the knapping process was suggested (Leroi-Gourhan 1964), in which artefacts were seen in relation to human acts in the lithic production sequence: the use, the resharpening and the final discard. The technological and sociological perception of lithic artefacts also resulted in an aversion to the use of general formal classifications. This was for instance clearly stated by F. Bordes in 1961:

> *English-speaking authors, among others, make a distinction between true blades and blade-like flakes, ... (A true blade showing traces of previous parallel removals on its upper face, and also having more or less parallel edges). Although the distinction is perfectly valid in theory, it is often difficult to make in practice and will therefore be disregarded (Translation by Inizan et al. 1999:130).*

During the "New Archaeology" 1970–1990, numeric values were needed for a statistical treatment of the artefacts and, here, lithic assemblages presented a perfect subject of study, since they were both numerous and could be measured in many ways. The "new archaeologists" were readily able to use the positivistic metrical definitions from the 1960s as a basis for a quantitative analysis. Today, we often discover that quantitative investigations based on metric classifications contain artefacts produced with different purposes and that each metrical artefact category includes different technological productions. The results of such quantitative investigations are sparse, and can be described as some statistic tendencies which appear to be significant in the assemblage, and the achievement of simple goals such as spatial quantification of the lithic distribution.

The general problem with the quantitative analysis is that the question *why* there are statistical differences cannot be discussed, due to the above mentioned reasons, and therefore, essential questions about prehistoric human behaviour are often ignored when a statistical analysis is carried out.

However, "New Archaeology" also generated an experimental "faction" in which researchers tried to formulate Binfordian "Middle Range Theories" by using experimental archaeology in combination with statistic methods (*e.g.* Madsen 1992; Hansen and Madsen 1983; Knutsson 1988). Many of these studies are based on solid technological knowledge, and in most studies focus changed from measurements of artefacts, towards studies of significant attributes and micro morphologies, an approach which certainly still is valid (e.g. Pelegrin 2000). Nevertheless, the "old" blade definition also survived the first generation of experimental archaeologists, even though a much deeper technological understanding, of e.g. blade production, was gained and expressed during this period.

The new dynamic technological blade definition and Maglemosian blades

Clearly, the time has come to re-evaluate the existing blade definition, but what form should it take? As a result of intensive replication and refitting studies carried out during the last two decades, we now have an elaborated knowledge about flint technology and blade production (e.g. Bodu et al. 1990; Coulson 1986; Fischer 1990; Inizan et al. 1999; Madsen 1992; Pelegrin 1984a, 1984b, 1988, 1995, 2000, 2002, Pigeot 1990; Skar 1987; Sørensen 2000; Sørensen in press (a,b)). Due to this, it seems likely that a new definition could arise from a dynamic technological understanding.

Figure 2. Blade production by means of direct hard percussion using a quartzite stone hammer. The core is held at the thigh and struck at an angle of approximately 70 degrees. The blades are irregular and characterized by e.g. large bulbs, impact cones on the butt. A similar method is carried out during the Bromme Culture (Madsen 1992). Note that this very simple blade production cannot be defined using a traditional definition due to its irregularity. However, the process (strategy and concept) reveals a true blade concept. Photo J. Sørensen.

A study of the blade concepts in the Early Mesolithic (Maglemosian, ca. 9000–6000 BC) in Scandinavia and Northern Germany (Sørensen in press (a), in press (b)) leads to the definition presented in this paper. Having examined the lithic *chaînes opératoires*, and especially the step involving blade production, on six Maglemosian sites and 17 additional sites, it became apparent that the traditional length/width definitions were insufficient. Lithic removals were serially produced from cores and used for microlith- and tool production through the entire period. However only during the late Maglemosian (phase 3,4,5) (Petersen 1973) the serially produced removals made for tools and microliths has a morphology that can "allow" the term "blades" within the definition from the 1960s. It made no sense to this author to describe the Maglemosian as a period where "blades" were produced only

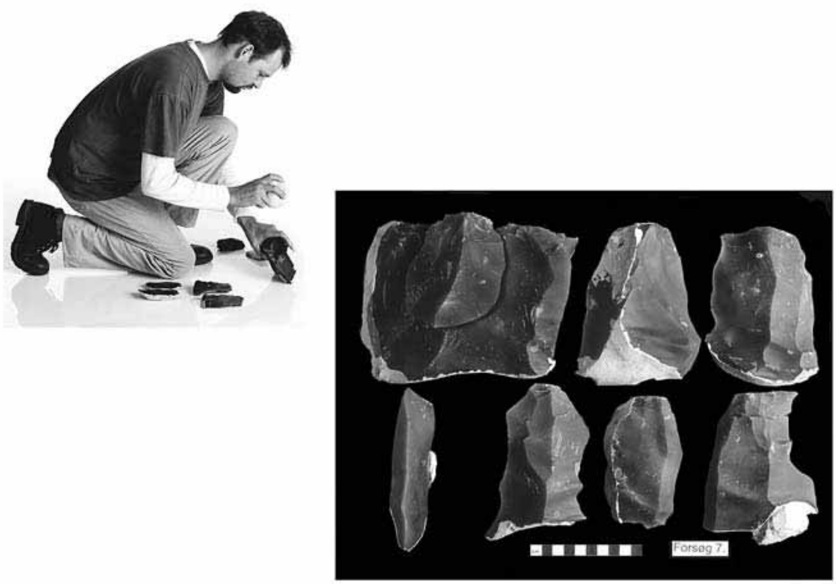


Figure 3. Blade production by means of direct hard percussion using a quartzite stone hammer. The core is held on the ground and struck at an angle of approximately 70 degrees. The blades are large, irregular and characterized by a distinct set of attributes: large bulbs, impact cones on the butt. A study of the prehistoric blade production and a comparison of the blades and their attributes to original and recently produced blades concluded that the direct hard hammer technique was used during the earliest Early Maglemosian Period in Southern Scandinavia. The production of big irregular blades was, during the Early Maglemosian and the Ertebølle Period, used to make preforms for "flake axes". Note that this very simple blade production cannot be defined using a traditional definition due to its irregularity. However, the process (strategy and concept) reveals a true blade concept. Photo J. Sørensen.

within the last phases of this period, when the concept for this production existed throughout the entire period (see also Knutsson 1981).

A further study of the lithic technology within the Maglemosian investigated *how* the lithic blade production methods developed. The investigation comprised analysis of Maglemosian blade attributes from six Maglemosian sites (one from each phase), series of thoroughly documented replicative studies, and the use of knowledge about the relation between attributes and specific knapping techniques. This investigation resulted in the following interpretation of the technological development in blade production methods and techniques during the Maglemosian: In the Early Maglemosian (early phase 0), a simple blade production method (technological definition) in which irregular removals were serially produced by direct percussion with

Figure 4. Blade production by means of direct soft percussion, using a soft stone (chalk/sand/limestone) or antler hammer. The core is held on the thigh, the platform edge is heavily trimmed by the hammer, and struck in an acute angle (approximately 20 degrees). The blades are thin, irregular and characterized by a distinct set of attributes: small bulbs, lib formation, splintered butts ("fracture lanquette"), and pronounced waves/ripples. Note that many blades produced by this simple blade production cannot be defined using a traditional definition due to irregularity. Photo J. Sørensen.

a hard hammer stone from uni-polar cores, were performed (Fig. 2). In this period, as in the rest of the Maglemosian, blades were used for microliths and blade tools. However, within the Barmosen group (Johansson 1990) a special blade method was used for the production of heavy broad blades: it was performed by a hard hammer from large uni-polar cores with flat fronts; the blades were used as flake axe preforms (Fig. 3). During the next phases (late phase 0, and phase 1,2) a method in which thinner irregular removals were serially produced by direct percussion with a soft stone or antler hammer was conducted. Cores were generally single fronted, often uni-polar but sometimes also dual-platformed prismatic. A typical core attribute during this period is the approximate angle of 70 degrees between front and platform (Fig. 4). Within the Late Maglemosian (phase 3), the technological climax of blade production arrives. Technically complex processes, which for the first time involve a separate concept for micro blade production, are

Figure 5. Blade production by means of pressure technique (debitage), using a composite pressure tool with antler tip. The core is held in a loose "V" shaped clamp, supported at the bottom. The pressure stick is flexible. During the moment of debitage the stick is pushed while, at the same time, it is moved towards the edge of the platform, resulting in a blade removal. The blades are thin, regular and prismatic, characterized by the following attributes: a combination of lip and bulb, lens shaped butts, and regularity, lack of waves/ripples. Photo J. Sørensen.

conducted by pressure flaking (Fig. 5). At the same time, indirect percussion appears for the first time in Scandinavia. The indirect percussion is employed for the macro blade production (Fig. 6). Both micro- and macro blades are, during this period, very regular, prismatic and straight. Cores are typically used up to a circular conical "bullet shape". Towards the end of the Maglemosian (phase 4,5) techniques are in general maintained, however core morphology is changed towards oblong keeled micro cores (handle cores) (Fig. 7) and heavier macro cores with (more) curved fronts, resulting in heavier and more curved macro blades (Fig. 8). The reason for the increased curvature might be that cores are now unsupported at their bottom (e.g. Bordes and Crabtree 1969). These late Maglemosian blade production methods are maintained, with minor changes in core morphology and technique, during the Kongemosian period (middle Mesolithic of southern Scandinavia), and perceived as the classical blade and microblade productions of the Mesolithic Southern Scandinavia.

Figure 6. Blade production by means of indirect percussion, using a curved red deer punch. The core is held between the feet, supported at the bottom, while the punch is gently hit by a billet of hard wood (elm). The blades are thin, regular and prismatic, characterized by the following attributes: a combination of lip and bulb, lens shaped butts, and regularity, straightness, lack of waves/ripples. Photo J. Sørensen.

Concerning the blade production, the conclusion was that serially produced removals made for microliths and tools were produced throughout the entire Maglemosian by the same overall idea (serial production of blades from plain platforms). However, the removals were produced by means of different methods and techniques, which resulted in distinct changes in morphology of the removals. Further, the study demonstrated that seven different concepts of blade production were conducted during the Maglemosian and that a technological change took place such that four traditions (groups), each with its own concept of blade production, existed diachronically during the Maglemosian (Fig. 9). The fact that blades were recognized through a study of the lithic process, and not by metrical or morphological definitions, made it possible to put forward an alternative technological chronology, which facilitates relative dating of blades, cores, punches and pressure tools from the Maglemosian (Sørensen in press (a,b)), whereas the traditional typological chronology, consisting of 6 phases, is based only on frequencies of one artefact type: the microlith (Petersen 1973).

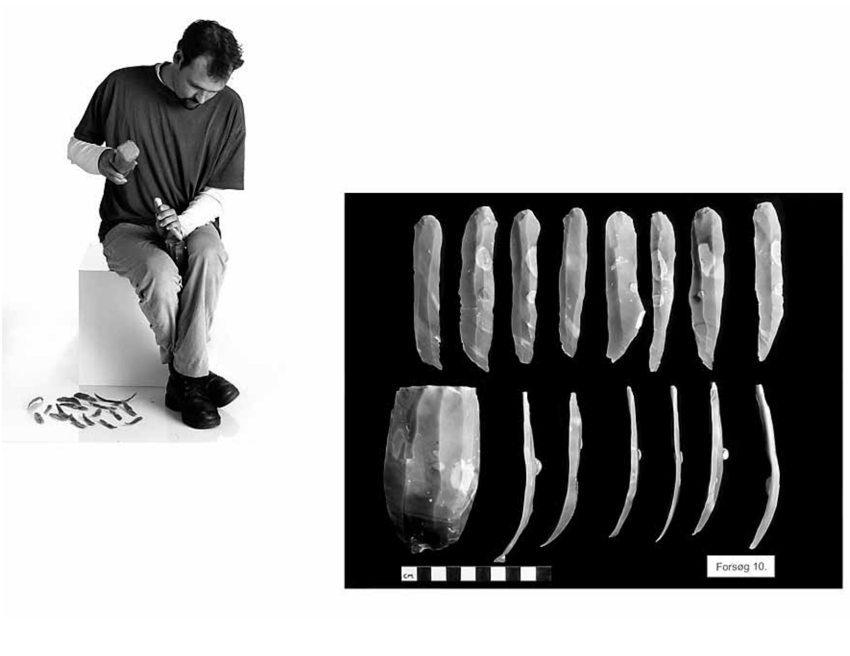


Figure 7. Blade production by means of indirect percussion, using a red deer antler punch. The core is held between the thighs. The blades are regular, curved and prismatic, characterized by a distinct set of attributes e.g. a combination of lib and bulb, lens shaped butts, regularity and curvature. Photo J. Sørensen.

Another problem concerning a metrical based blade definition was that it included removals from steps of other technological productions, e.g. from the trimming of macro blade cores and from core axe production, but at the same time clearly excluded intentionally made, but fractured, blades.

The question that arose while analysing the Maglemosian blade industry was basically how to describe and classify the lithic material from the step of the blade production without being forced to refit the entire lithic material (which would be an impossible, illusory task)? This question was solved by defining blades as results of a production made by clearly identifiable intentions. The material intention for the blade production was seen as the stage in the *châine opératoire* in which blades were chosen for tools (namely microliths). In other words, the new blade definition would concern "removals made with the intention of being tools or preforms for tools". Serially produced removals, intended to be preforms or tools, from each period of

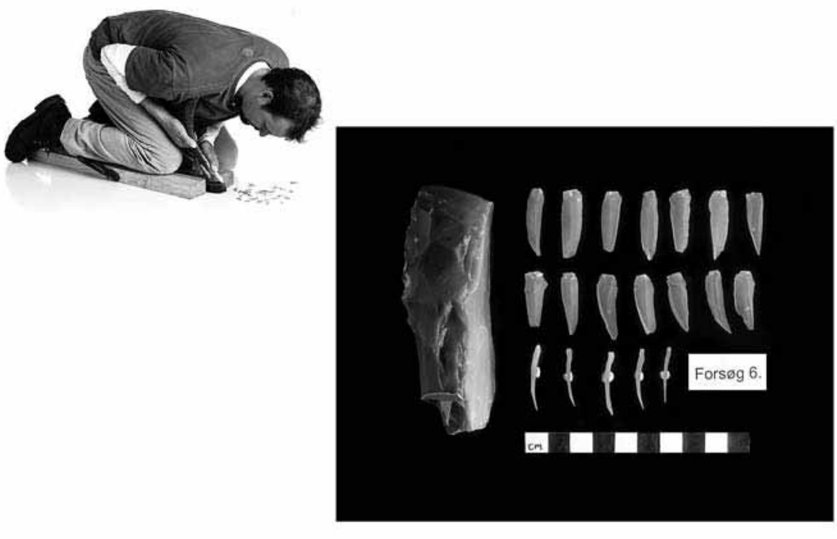


Figure 8. Blade production by means of pressure technique (debitage), using an antler pressure tool. The core is fixed in a wooden device by two "jaws". The pressure stick is only slightly flexible. During the moment of debitage the stick is pushed while at the same time it is moved towards the edge of the platform, resulting in a blade removal. The blades are thin regular and prismatic, characterized by a set of attributes such as a combination of lip and bulb, relatively large lens shaped butts, regularity and lack of waves/ripples. Photo J. Sørensen.

the Maglemosian could then be termed "blades" and be described differently on the basis of morphology and attributes diagnostic to their technical manufacturing.

According to the concept of the *chaîne opératoire* and in accordance with today's technological knowledge of diagnostic attributes, the following new dynamical technological definition of a blade can be presented:

"A blade is a serially produced removal made with the intention of being a tool or a preform for a tool. Blades in the same industry are produced by the same technique, method and mental representations and are characterised by a similar morphology and the same set of diagnostic attributes".

This definition includes serially produced removals, which could not be included in earlier definitions on grounds of their irregular morphology, even though they were serially produced for distinct use. The new blade definition can also include blade fragments as long as they have the same morphology and set of attributes as other blades within the industry.

Some examples of serially produced removals that can now be redefined as blades are:

1. The production of large removals for flake axe production. This blade concept was predominantly used in the Early Maglemosian Period in Southern Scandinavia, (the Barmosen Group), (Johansson 1990) and also in the Ertebølle Period (Müller 1900) (Fig. 3).

2. The production of removals for the manufacture of transverse arrowheads in the Neolithic Period. This production concept can be described as a serial production of irregular broad blades from discoidal cores.

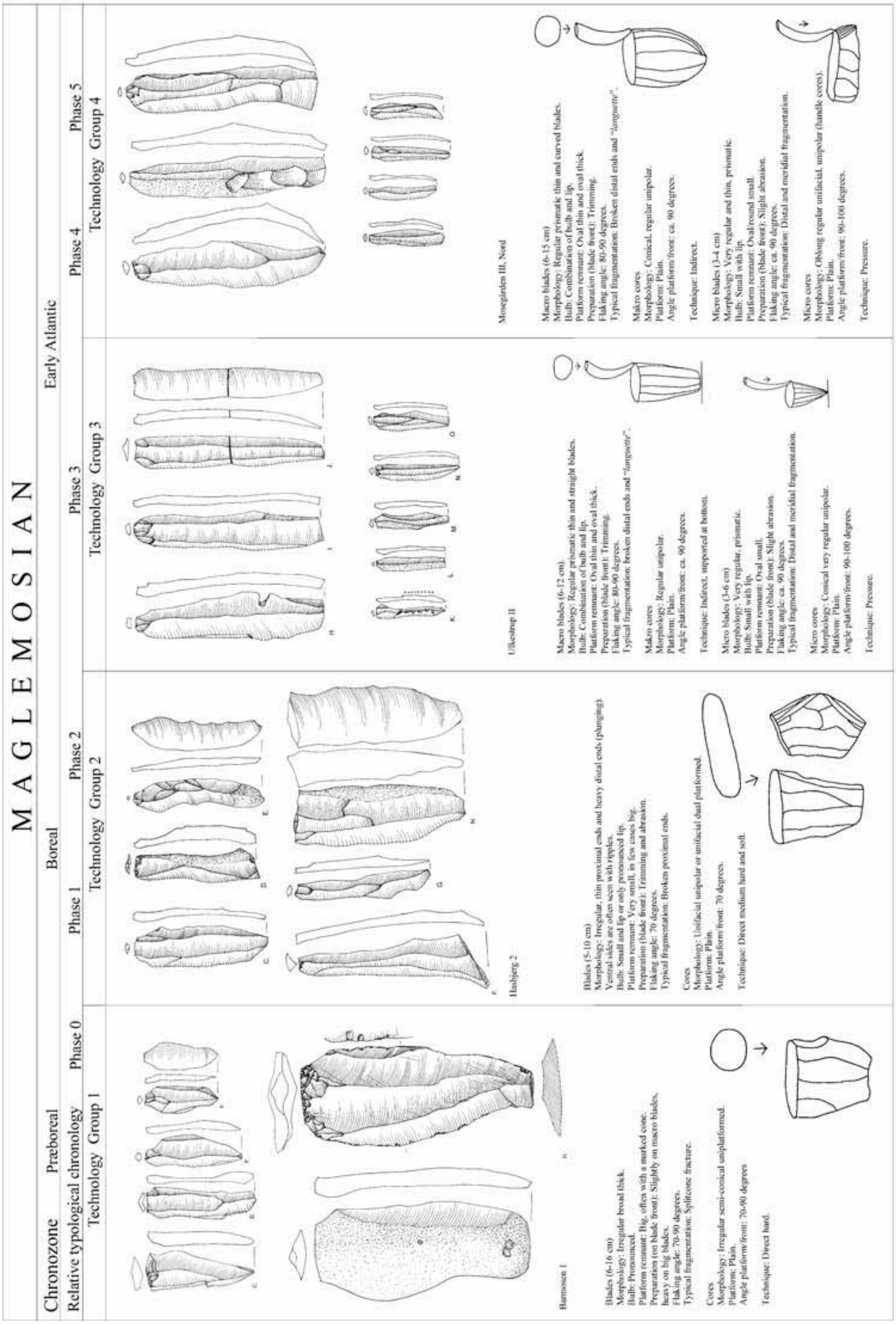
3. With regard to the Levallois method, intentional serially produced removals from Levallois cores should be classified as blades. This means that when a recurrent Levallois method (*i.e. recurrent unipolar, -bipolar* or *-centripetal*) method is applied (Boëda 1994) the results will be removals defined as blades. Meanwhile, when only a single removal is made from a prepared Levallois core, (*i.e.* the *preferential* or *classical* method), the intended removal must be defined as a flake. In praxis, this difference in naming the Levallois removals will be hard to maintain because it is hardly possible to judge from the Levallois removal itself whether it is produced serially or preferentially. However, the preferential method, when investigated, is interpreted to be rare compared to the recurrent method (Schlanger 1996). Owing

to this, this author will argue that removals detached from Levallois cores in general, and in agreement with the common perception (Inizan *et al.* 1999), should be defined as blades.

As a consequence of including intentions in artefact definitions, flakes, as opposed to blades, can be defined as:

- Waste removals (i.e. serially produced removals which are knapped off to *shape* cores and blanks).
- Removals which are not serially produced.

Figure 9. The Maglemosian chronology based on a study of blade technology (Sørensen in press (a, b)). Seven different concepts of blade production were conducted during the Maglemosian in a technological development . Four traditions (groups), each with its own concept of blade production, existed diachronically during the Maglemosian. The fact that blades were recognized through a study of the lithic process, and not by metrical or morphological definitions, made this alternative technological chronology possible. The chronology facilitates relative dating of blades, cores, punches and pressure tools from the Maglemosian, whereas the traditional typological chronology, consisting of 6 phases, is based on frequencies of one artefact type: the microlith. (Analysis and figure by M. Sørensen 2001. From thesis "The Maglemosian Blade Concept" (Sørensen in press)).


MAGLEMOSIAN
Chronozone
Præboreal
Boreal
Early Atlantic
Relative typological chronology
Phase 0
Phase 1
Phase 2
Phase 3
Phase 4
Phase 5
Technology Group 1
Technology Group 2
Technology Group 3
Technology Group 4
Barmosen I
Blades (6-16 cm)
Morphology: Irregular broad thick.
Bulb: Pronounced.
Platform remnant: Big, often with a marked cone.
Preparation (on blade front): Slightly on macro blades, heavy on big blades.
Flaking angle: 70-90 degrees.
Typical fragmentation: Splitcone fracture.
Cores
Morphology: Irregular semi-conical uniplatformed.
Platform: Plain.
Angle platform/front: 70-90 degrees
Technique: Direct hard.
Hasbjerg 2
Blades (5-10 cm)
Morphology: Irregular, thin proximal ends and heavy distal ends (plunging).
Ventral sides are often seen with ripples.
Bulb: Small and lip or only pronounced lip.
Platform remnant: Very small, in few cases big.
Preparation (blade front): Trimming and abrasion.
Flaking angle: 70 degrees.
Typical fragmentation: Broken proximal ends.
Cores
Morphology: Unifacial unipolar or unifacial dual platformed.
Platform: Plain.
Angle platform/front: 70 degrees.
Technique: Direct medium hard and soft.
Ulkestrup II
Macro blades (6-12 cm).
Morphology: Regular prismatic thin and straight blades.
Bulb: Combination of bulb and lip.
Platform remnant: Oval thin and oval thick.
Preparation (blade front): Trimming.
Flaking angle: 80-90 degrees.
Typical fragmentation: broken distal ends and "languette".
Makro cores
Morphology: Regular unipolar.
Platform: Plain.
Angle platform/front: ca. 90 degrees.
Technique: Indirect, supported at bottom.
Micro blades (3-6 cm)
Morphology: Very regular, prismatic.
Bulb: Small with lip.
Platform remnant: Oval small.
Preparation (blade front): Slight abrasion.
Flaking angle: ca. 90 degrees.
Typical fragmentation: Distal and meridial fragmentation.
Micro cores
Morphology: Conical very regular unipolar.
Platform: Plain.
Angle platform/front: 90-100 degrees.
Technique: Pressure.
Mosegården III, Nord
Macro blades (6-15 cm)
Morphology: Regular prismatic thin and curved blades.
Bulb: Combination of bulb and lip.
Platform remnant: Oval thin and oval thick.
Preparation (blade front): Trimming.
Flaking angle: 80-90 degrees.
Typical fragmentation: Broken distal ends and "languette".
Makro cores
Morphology: Conical, regular unipolar.
Platform: Plain.
Angle platform/front: ca. 90 degrees.
Technique: Indirect.
Micro blades (3-4 cm)
Morphology: Very regular and thin, prismatic.
Bulb: Small with lip.
Platform remnant: Oval/round small.
Preparation (blade front): Slight abrasion.
Flaking angle: ca. 90 degrees.
Typical fragmentation: Distal and meridial fragmentation.
Micro cores
Morphology: Oblong regular unifacial, unipolar (handle cores).
Platform: Plain.
Angle platform/front: 90-100 degrees.
Technique: Pressure.

Explaining the technological dynamical blade definition

The new blade definition can be supported through refitting, replication and technological dynamical classification:

Refitting: the ideal, but time-consuming approach

A strong argument for the new definition is the study of blade production through refitting. Several investigations of *chaînes opératoires* through refitting, especially on Palaeolithic assemblages, clearly demonstrate that what we so far have understood as blades, in general, are serial-produced removals with the same set of attributes and a similar morphology (*e.g.* Coulson 1986; Skar & Coulson 1989; Skar 1987; Pigeot 1990; Fischer 1990; Fiedorzcuk 1995; Johansen 2000; Bodu et al. 1990).

Lithic replication: the experimental approach

During two decades of personal experimentation with Mesolithic flint-technology, blade replication and comparison with prehistoric material, the author, as well as several other modern knappers (*e.g.* Bordes & Crabtree 1969; Flenniken 1987; Madsen 1992; Pelegrin 1984(b); 1988; 1991), have come to the conclusion that blades have to be serially produced in sequences with a consistent technology, *i.e.* the working tools (hammers, punches, billets, etc.), the angle of percussion, the force applied, the preparation of each blade (trimming), and the morphology of the core have to be identical to achieve even blades in a production. In addition, the (modern) knapper soon realises that the same main intention is required throughout the entire process of blade production in order to fully succeed. This intention can be described as a visualised representation of *an ideal blade*.

It is generally experienced that this consistency in technique, method, and concept of the blade production results in removals (blades) with the same set of diagnostic attributes and a similar morphology (Figs. 2-8).

The technological dynamical classification: the realistic approach

The third method is the dynamic technological classification which is outlined by R. Schild (1980). Two observations suggest that blades are serially produced: (1) Regular negative removal scars on core pieces and rejuvenation flakes show that a series of removals (*i.e.* sequence) have been produced. Since the scars have the same appearance (size and morphology) it is probable that the removals has a similar morphology, have been produced using the same technique and have the same set of attributes. (2) The fact that cores (at least in the European Palaeolithic and Mesolithic) are generally found fully exhausted and not preserved from the step of blade production (ready for the next blade) suggests that blade production was generally carried out in one coherent process. Blades must therefore commonly be regarded as having been serially produced. The conclusion of the dynamical technological analysis of blades and blade production is that blades in most prehistoric cases were not produced as single events. Instead, a blade production must generally be characterised as a serial mass production from one core at a time.

Discussion

When analysing lithic assemblages and trying to define concepts on the basis of blade productions, a methodological problem is that not all blade productions on a site or within a culture/group are technically of the same quality. This problem can be explained through differential skill levels, as not all individuals will be able to perform the ideal concept of the production within the same group. Several technological analyses of lithic artefact assemblages have suggested that children will play with lithics and simulate the production process without being conscious of the concept, while apprentices, due to lack of knowledge and know-how, will not always be able to carry out the *chaînes opératoires* typical for the technological tradition (e.g. Knutsson 1986; Apel 2001; Bodu *et al.* 1990; Fischer 1990; Högberg 2001; Pigeot 1990; Karsten and Knarrström 2003). In this respect, it seems clear that not every lithic *chaîne opératoire* in an assemblage can be described as typical for the culture/group itself.

The logical solution to this methodological problem is to find and describe those *chaînes opératoires* which contain (and lead to) the curated tools, and to regard these as the norm in the investigated group/culture. This argument can be supported using the rationale that those *chaînes opératoires* that contain curated tools must be produced by trained knappers who are able to perform the concept of the group/culture. As a general rule, a lithic analyst trying to define the typical working concepts in a group/culture should avoid describing training sequences, expediently made household productions and simulations as intentions carried out typical for the group/culture. In contrast, archaeologists analysing a synchronous situation, describing single prehistoric events and social interactions, should be aware of all the different *chaînes opératoire*, since they represent different human actions, individuals, learning situations and social relations on the site.

This author is well aware of the fact that the new dynamic technological blade definition will be more difficult to use than the former metrical definitions. Archaeologists using the new definition for assemblage analyses require a good general knowledge of lithic technology to be able to recognize the *chaîne opératoire* for the blade production and state the specific blade morphology. Unfortunately, the dynamic technological methodology is still not commonly used and only some prehistoric cultures/groups are sufficiently described, a fact that often leaves archaeologists who want to understand and work with lithic dynamics in a "pioneer" situation. Due to this situation, it is necessary to describe what kind of studies and methodologies are required for a dynamical understanding of lithic production. Fortunately, the solution to this question is well demonstrated in a number of case studies (e.g. Bodu et al. 1990; Boëda 1988; Coulson 1986; Fischer 1990, Johansen 2000; Madsen 1992; Pelegrin 1995; Schild 1980; Skar 1987) which all successfully use one or a combination of the following three methods in explaining technological methods and concepts: refitting, lithic replication and/or dynamical technological classification.

A conclusion is therefore that a dynamic technological understanding of lithics can be acquired through the use of one, or better still, a combination of the above named methods. Another issue this author would like to stress, is that the blade definition presented can be used successfully in analysis where the research questions are refined towards diachronous or social matters, while in cases where the goals are limited and descriptive, metrical based blade definitions can certainly be used. The crucial objective that should be accepted onwards is that more than one definition within a problem area can exist, and that archaeologists should always explicitly state the chosen definition. We also have to accept that changes and developments of our definitions, which update and reflect current archaeological research, are a must if archaeology will develop.

An important problem area encountered with the discussion of dynamic technological definitions is the continued use of the traditional archaeological term "culture concept". The archaeological culture concept was put forward in close relation to static morphological definitions of artefact types, and the associated theory centered on the idea that artefact types found concentrated in specific regions or areas could be seen as expressions of human cultures. The focus on the archaeological "culture" has ever since been both politically and archaeologically problematic. Archaeological cultures, determined on the basis of simple stylistic differences, have often been implicitly understood as cultures/societies in an anthropological meaning, which has led to severe misunderstandings (e.g. Kossinna 1936). In changing the focus towards processes and employing dynamic technological definitions, archaeologists will be able to define artefacts in relation to the process, from procurement to discarding the finished artefact. And, as both technological and social ideas are expressed in the process (e.g. Mauss 1979; Leroi-Gourhan 1964; Lemonnier 1990) this methodology reveals and traces technological and social traditions, as well as individual expressions, whereas traditional morphological analysis primarily reveals stylistic changes. By implementing a dynamic understanding of lithic technology and combining this approach with analysis of other cultural aspects, such as subsistence strategies, architecture and art, archaeologists are enabled to overcome (problematic) perceptions of lithic artefacts as undisputed, categorical trademarks of "archaeological cultures". The advantage of this change can introduce light and shade into our perception of prehistory.

Conclusions and perspectives

The new dynamic technological definition is, when used in many studies, advantageous to the earlier definitions because its foundation is based upon prehistoric human intentions as manifested in lithic sequences. The use of the new definition will therefore also facilitate interpretations of human acts and social aspects of the prehistoric life.

In a wider perspective, this author finds that our artefact definitions should relate to human behaviour and cognition rather than to chosen metrical categories. The crucial focus of future research in lithic assemblages must therefore be to understand and explain `reasons and purposes´ in human acts, rather than to use supposedly "objective" definitions together with numbers and statistics to create more archaeological cultures. One step towards this goal is to expand our knowledge about prehistoric technology and incorporate intentions into our artefact definitions.

A future consequence of the use of dynamic technological definitions (as the one put forward in this paper) is that they can enable us to dissolve the problematic focus on "culture concepts" and favour human behaviour and cognition. Perhaps the most important advantage of changing our artefact definitions towards the dynamical technological approach is that prehistory can be re-defined and "re-established" in terms of social traditions or societies, based on the concepts, methods and behaviour of the people who made them.

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Chapter 3

From Experience to Interpretation

Nyree Finlay

Manifesting microliths: insights and strategies from experimental replication

Abstract
Experimental replication has been an underdeveloped tool for exploring routines of microlith production. This paper presents the results of two replication experiences and explores the constraints of traditional approaches, reflecting on the inferences for understanding microlith manufacture both in replication and in relation to later mesolithic archaeological assemblages from sites excavated as part of the Southern Hebrides Mesolithic Project, western Scotland. Concealment and visibility emerge as key metaphors for engaging with the various routines of microlith production and the performativity of manufacture is explored as a means to consider both group and individual actions and identities.

Introduction

The aim of this paper is to consider insights derived from experimental replication and the dialogue that exists between modern engagements with microlith manufacture and the information that can be teased from detailed analysis of archaeological assemblages. Replication as a contemporary practice has tended to focus on the production of 'exceptional' items like the Danish daggers (as evidenced by Apel 2001; Apel and Nunn this volume) rather than the apparently more simplistic objects that are often the mainstay of the archaeological record. This has been clearly detrimental to our appreciation of the range of techniques and other subtle differences that can occur in manufacture. In this paper, I wish to reflect on the constraints of traditional representation and present observations derived from the results of two short programmes of lithic replication. In terms of structure, the paper is divided into four sections where my point of departure moves from conventional ways of representing these artefacts to the presentation of experimental and archaeological perspectives, to finally reflect on production as an exercise in revealing and concealing self and group identities.

Refocusing the microlithic gaze

Traditions of representation and presentation of microliths in both text and in illustration tend to promote a dominant view of the microlith that is at odds with the mode of production. This creates what I have termed the 'microlithic gaze' of conventional analysis (Finlay 2000*a*; 2003). While the dorsal surface orientation is promoted to convey technical details such as arris scars and directionality of removals, it is highly unusual to see the ventral face depicted unless it is to show invasive retouch or edge damage. Yet, the simple fact remains that the conventional surface orientation of microliths as presented in archaeological illustration and discussion is not that experienced during manufacture. The majority of microliths are modified from the ventral surface and this is the plane view of the piece when retouched. Therefore, there is a reverse symmetry of the experience of microlith manufacture versus the idealised view of the microlith as presented in conventional archaeological discourse. Equally, the vertical arrangement of microliths in lithic illustration is a feature of page layout that is more concerned with economy than a vehicle to challenge representation. Yet, if we consider the hafting of the finished piece, taking the most dominant stereotyped reconstruction of these pieces as the points and barbs of an arrowhead, then the directionality of movement and alignment is horizontal not vertical. The modes of presentation and the microlithic gaze also promote a particular plane symmetry that conditions form recognition (Rock 1973; Washburn 1989). This has an impact on typological classification and conditions the analysis of what are essentially the same forms (Finlay 2003). In addition the two-dimensional world view this creates conflicts with the three dimensional reality of the finished piece. Significantly, the effects of this microlithic gaze are brought into sharp focus during microlith manufacture.

Modern microlithic replication

Microliths have not been subject to the same traditions of experimental replication as other classes of lithic objects. In contrast to the wealth of literature available on the manufacture of bifacially retouched artefacts, such as projectile points (e.g. Callahan 1979; Young and Bonnischen 1984), there are few guides and sources that consider microlith manufacture. There are a few notable exceptions (for example Tixier 1963; Inizan *et al*. 1999) but the coverage is generally rather superficial and there has not been the same depth of engagement as is the case with other more 'challenging' items such as bifaces. Microliths are perceived as quick and easy to manufacture, not requiring a high degree of lithic skill. There are no kudos attached to their contemporary reproduction; advertisements within the popular replication literature, such as *Chips* for exquisite replicas of these artefacts are rare if not non-existent. As such, microliths are overlooked not only within the repertoire of modern knappers, but detailed academic discussion of technological features is generally sparse. One aspect of microlith manufacture that tends to be discussed is the significance of the microburin technique, particularly in relation to the Levantine material (see Goring-Morris 1987; Henry 1989; Kaufman 1995). The microburin has acquired almost monumental status in discussions of microlithic technology at the expense of other aspects of microlith manufacture such as the execution of retouch and sequences of modification, not to mention discussion of related issues such as blank selection and breakage rates during manufacture. Yet while the microburin has been read as a cultural signifier and afforded a degree of significance, it has rarely been the subject of detailed experimental replication particularly in recent decades (early exceptions include Vignard 1934; Barnes 1947). Equally, while the theoretical possibilities of explaining microlith variability as the product of remodelling was the topic of extended debate (Neeley & Barton 1994; Fellner 1995; Goring-Morris *et al*. 1996), it was not informed by replication.

Experiencing replication

The general neglect of microliths in the broader replication literature presented difficulties when designing a series of replicative experiments to explore the construction of variability and its relationship to the manufacturing process. The lack of precedents for this type of research resulted in trial and error being one of the dominant forces, and it is evident that methodological strategies need to be further developed to explore issues of microlith manufacture effectively. However, the action of making microliths is in itself instructive and informative, raising issues that will not derive from the examination of archaeological material alone. Several sessions of experimental replication were undertaken to contribute to definitions of microlith production and explore the various aspects of manufacture and choices available with regard to technique. The impetus for this was the analysis of a number of archaeological assemblages, and reflections on the inferences from replication are considered below. One of the dominant factors in much modern and informal lithic replication is the lack of familiarity with techniques and the limiting constraints of skill and ability. Knapping is not, after all, a common practice in contemporary society and this raises a suite of issues regarding the efficacy of replication as a mode of understanding and the paradox of familiarity and dislocation that it often brings to our engagement with stonecraft.

Microlith manufacture can be considered as an act with three or more parts: the manufacture of suitable blanks; the transformation of blank to microlith and finally the manipulation and selection of pieces for use leading to their integration into a haft. It is the first two elements that are of direct concern here. The production of suitably sized blanks is evidently the more skilful aspect of microlith production and the extent of standardisation at this stage no doubt impacts on the amount of retouch required to alter the piece into the desired form. Exploring this first part of the microlith *chaîne opératoire* is constrained by the paucity of experienced knappers. As well as providing analogies for the past, modern experimental replication is also a form of contemporary social praxis. It is the latter aspect that is often overlooked and biased via the attention given to the proficient individual at the expense of the novice (Finlay forthcoming). Moreover, the collective and communal aspects of tool production as a shared experience are often negated.

The results of an informal session of replication reveal the variety of modes of retouch and enable us to consider the more performative aspects of production. As part of a group replication programme to consider consistency in blade production (Finlay forthcoming), three individuals spent a couple of hours making microliths from the blanks they manufactured in an earlier stage. A total of 25 blanks were modified. Prior to the session, two of the participants had made microliths on an informal basis and both had considerable experience of analysing Scottish Mesolithic material over several decades, the third had no previous experience of microlith manufacture but had previous sporadic knapping experience over two years.

A random selection of microliths from an archaeological assemblage was shown to the knappers as rough templates for size and shape. Given that this was an initial exploration into microlith manufacture, no explicit instructions about desired forms was given. Each person made microliths from their own blanks and the tendency was to work through all the suitable blanks from one core rather than select out the most suitable blanks from the entire sample. No instruction was given as to how the microliths should be manufactured and the use of the microburin technique was left to the discretion of the individual. The debitage from each microlith was collected and separately bagged. All three were seated at the same table, yet each had individual preferences in the techniques of manufacture (Fig. 1). Knapper 1 used the combination of an antler point and hammerstone fragment with a pointed edge, with the former the preferred tool. The anvil stone was supported in the palm of the hand under a piece of leather and the antler used as percussion tool to modify the blanks. This method enabled a very methodical and precise method of backing to be used. In contrast, knapper 2 preferred to use a small quartz hammerstone; the blank was placed directly on the top of a flat beach pebble anvil, resting on the table on top of a leather support, to collect the debris. An antler point was also occasionally used. Finally, knapper 3 used a very angular anvil stone and utilised the sharp edge of the anvil, the blank was held against the edge using the overhang to modify the blanks by the use of a pebble percussor.

Figure 1. Group replication study: preferred techniques (knappers 1-3, left-right).

In practice, the nature of the blank emerged as an important factor as it placed constraints on what could be produced and the time taken to modify pieces. Admittedly the sample of blanks available to the knappers were clearly constrained by their (in)ability to consistently produce small blanks that would require the least amount of modification. The blanks selected as suitable for microlith manufacture were characterised by inner regular pieces that were blades or blade-like flakes. The criteria used to separate out these pieces from the spread of debitage were the regularity and thinness of the blank and a degree of parallelism with feathered edges. The size and morphology of the blank emerged as an important factor. Much of the time was taken up by the trimming of the blank, the thicker the piece the more effort required to trim the piece and this was particularly the case for knapper 1 and is represented schematically in Fig. 2. While length and breadth can be modified by retouch, the thickness of the blank cannot be altered without recourse to invasive retouch, unless the thickness of the piece is variable. Blank thickness was the stated reason for discard for one piece by knapper 1, where two attempts were made at manufacture, and three of the microliths made by knapper 2.

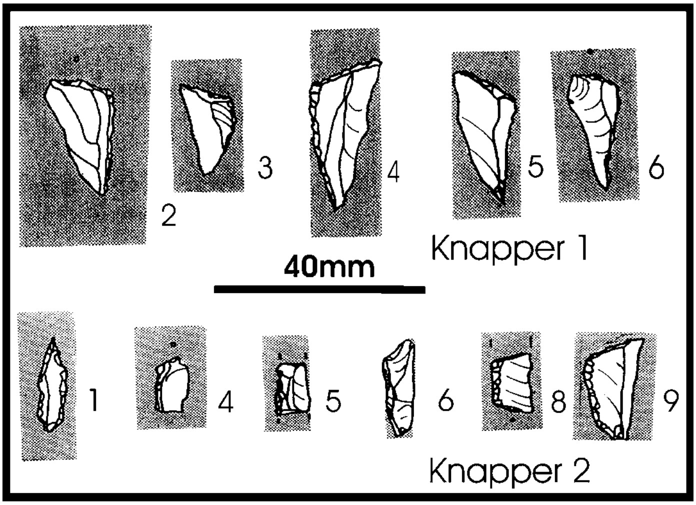


Figure 2. Group replication study: selection of microliths produced by knappers 1 and 2 (numbers refer to order produced, grey-tone depicts size of original blank).

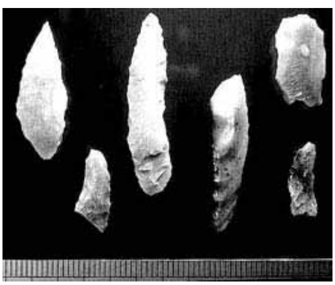


Figure 3. Group replication study: Knapper 3 'imitation' microliths.

The form of the blanks as well as the technique adopted placed constraints on the ability of knapper 3 to fashion microliths. These pieces could easily be distinguished by pronounced *enclume* retouch and the bidirectionality and irregularity of the retouch types (Fig. 3). It is questionable whether the constraints of the blank form would have been overcome by more conventional methods of retouching as none of these attempts even resembled microliths. In this case, inexperience and lack of familiarity clearly limited performance as much as the blanks worked and the method used. In this respect, this technique has produced pieces that generally approximate the shape of microliths but in no way reflect the correct use of techniques. Parallels can be directly drawn with examples of children's play and imitation as identified in the archaeological record (Högberg 1999; Högberg forthcoming). Here the novice knapper has produced pieces that imitate the basic form but used inappropriate methods of retouch to create them.

Slight differences in the method of manufacture could be discerned on the end products. However, it was not possible to differentiate between knappers 1 and 2 for essentially both were using the same mode - direct pressure supported by an anvil, even though there were slight differences in their technique and the finished pieces. The retouch on the microliths produced by knapper 1 is very regular and even, whereas that for knapper 2 is slightly more variable. This may reflect the predominate use of a pebble in contrast to the antler point favoured by knapper 1. However, it may also be a reflection of the extra time spent by knapper 1 and her more methodical trimming of the blank. Despite the use of a supporting anvil, *enclume* retouch is only present on one piece by knapper 2, which was made using an antler point.

Choices of modification

In order to explore the implications of subtle differences in technique and develop methodologies for recording variation, a separate programme of experimental replication was conducted by the author. Discussion will be based on the experiences of producing around 100 microliths as a discrete replication programme. The informal group replication outlined above revealed that subtle differences were employed by these knappers who were all engaged in the same task of producing microliths. A range of techniques was adopted: the use of both stone and antler retouchers with the blank resting on an anvil stone. There is another method of executing the retouch and that is by scraping the blank along the edge of a flint pebble or edge of core or chunk to modify the blank. This produces retouch that is akin to that produced by using a stone on an anvil. By supporting the blank in the hand it results in less breakage due to the fact that contact with the stone was more even than when resting on an anvil. Three techniques were used to make microliths, 67% were made using a stone to execute the retouch, 22% with an antler tine and 11% by scraping the blank along a flint pebble. Using a stone percussor is the quickest and easiest method, the natural bevelled end of the stone tended to produce a more concave profile to the retouch edge in plan. This method also generated a large amount of fine debitage that had to be removed from the surface of the anvil to prevent breakage. *Enclume* retouch was only present on one in ten blanks. The use of an antler tine produced retouch that could not be macroscopically distinguished from that produced by stone. The size of the point enables more precision but it was much slower to execute. Finally, simply scraping the blank along a stone produced quite fine retouch with a smooth profile. This method places most pressure on the hand, as the piece had to be kept level. Notching was not possible unless the stone had an angled edge, such as the use of a core edge. Where this was present, it could be used to create a notch and was effective at realising a microburin. The debitage produced by scraping the piece against another edge tended to be smaller in size fraction and this was more easily dispersed than with the other methods.

Quantifying differences resulting from the various techniques was difficult to identify on the completed pieces given the variation in the size and form of the original blanks. The blanks used were not uniform in terms of size and thickness as well as the location of arris scars. Moreover, many were incomplete having lost their platforms during manufacture. Given that many of the blanks were already missing platforms, it was not necessary to use the microburin technique in every instance. It was also often easier to trim the proximal end with retouch rather than remove the bulb. While the constraints of blank thickness on the ability to produce a finished microlith can be anticipated, breakage resulting from the manufacturing process itself cannot always be predicted. A selection of the microliths produced are illustrated in Fig. 4, these have the original form of the blank outlined in grey tone. As can be seen from this figure the extent of the blank lost during the manufacturing process is variable. The average reduction in length was 9.7 mm (8.8 mm Stdev) and 3.6 mm (3.17 mm Stdev) in width. Manufacture time varied from 45 seconds to 5 minutes and was influenced by technique and blank form. In these various experiences of producing microliths, there were clear limitations in terms of the character and type of form. The blanks used were not standardised in terms of their overall dimensions and technological attributes. This was one of the main limiting features, given the large degree of variability present in the blanks used. Yet this also encapsulates many of the problems with modern experimental replication per se, namely that examining proficiency in one element of a given chaîne opératoire is conditioned by proficiency or at least consistency in other aspects. The accommodation of variation in blank form is one of the key features in microlith manufacture and this would also have been a factor in the past. Even if it is not so extreme an issue as seen in the replication experiences described here. It is clear that we need to see more detailed accounts of replicating microliths. The methodology of recording and illustrating the blanks prior to reduction at least enables the constraints of blank form to be represented, even if the influences are more subjective in interpretation.

Approximately 20% of attempts at manufacture ended in failure, with the irretrievable breakage of the blank. Breakage did not appear to reduce through time, as it was often a question of the original blank form. Many of these fragments do not even retain evidence of retouch, as they broke with the first application of pressure. Blanks were backed until arris scars limited

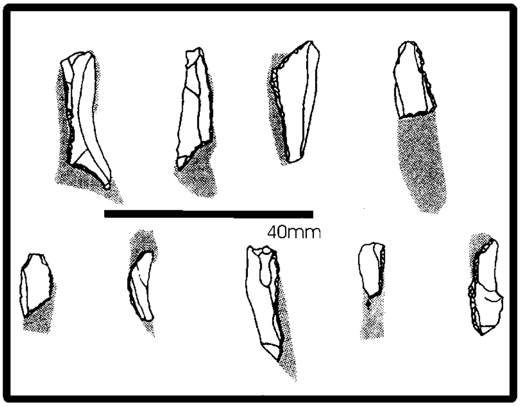


Figure 4. Individual replication: selection of microliths showing original blank size and extent of reduction required.

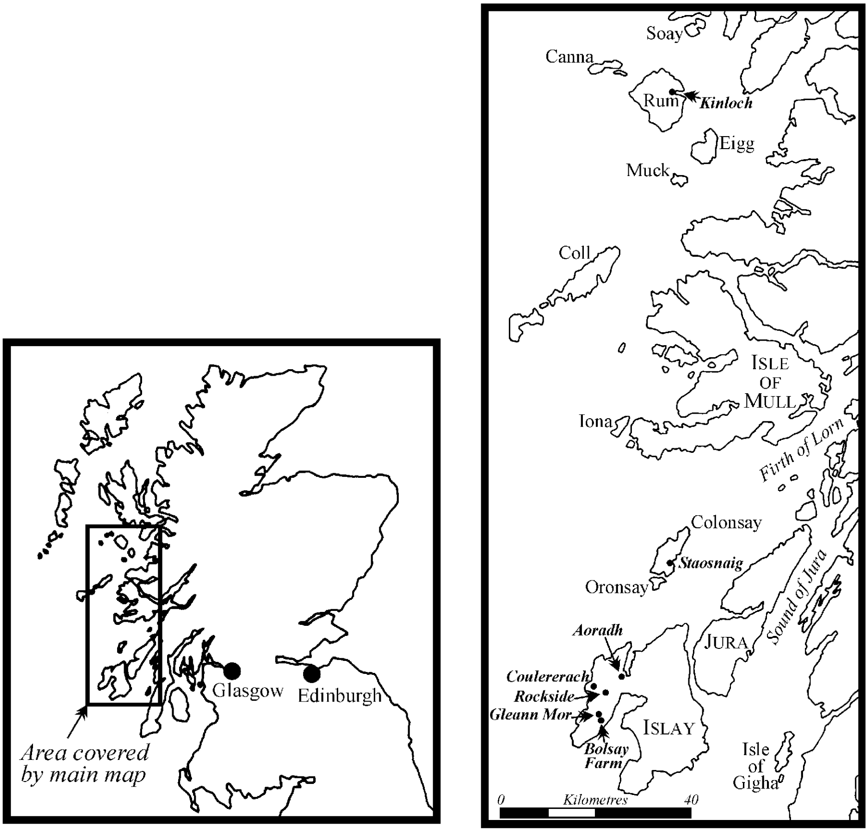
further removal or the shape approximated the required form. The location of the dorsal arris scar affected the ease by which a blank could be further trimmed. This can be seen in some of the illustrations of the pieces made, by comparing the blanks with the final product. Several of the microliths have arris scars close to the retouched edge. The fact that the blanks used to create microliths were quite variable limits the inferences that can be made regarding the consistency in realising form and potential expressions of individuality. The issue of technique is an important one and has not been subject to much discussion within the wider archaeological literature on the Mesolithic. There are a number of options when faced with the manufacture of a microlith. These are influenced by the nature of the blank selected and how the retouch is to be executed. However, it is evident that the technological choices open to the mesolithic knapper would also be conditioned by experience and the routinised modes of production.

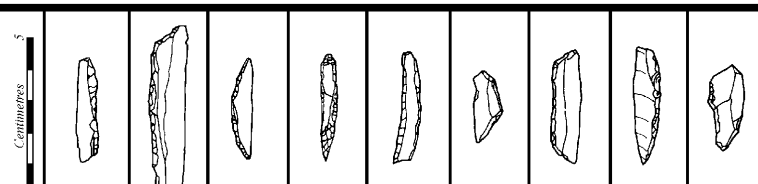
Archaeological perspectives

The experimental studies outlined above were conducted in conjunction with the examination of a suite of archaeological assemblages dating from 7500-6000 cal BC excavated under the aegis of the Southern Hebrides Mesolithic Project (SHMP) from the islands of Islay and Colonsay, off the Scottish west coast (Fig. 5; Mithen 2000). Several of these sites are palimpsests where the accumulated actions of several generations of mesolithic knappers are represented and where continuity in these basic forms and routines in production are seemingly maintained over several millennia. Here the repetition of tasks would have connected present with past and future action. The archaeological assemblages created a number of challenges when exploring microlith production and the transformation of blanks to finished microliths. Detailed attribute analysis was conducted on 2600 microliths and fragments and around 440 related pieces such as microburins and truncations (Finlay 2000*b*). This was undertaken in conduction with detailed core and debitage analysis with the goal of reconstructing the microlith *chaîne opératoire*. Examination of the archaeological material illustrates some of the problems in trying to define and determine blank preferences and technological choices in microlith production. At these sites, two basic microlith forms predominate: backed bladelets and scalene triangles supplemented by a suite of other types as can be seen for two sites Bolsay Farm and Staosnaig (Fig. 5). Many retain bulbs of percussion. Determining original blank dimensions was problematic, given the extent of modification, and the fact that original blank length could only be ascertained for eight microliths out of 1530, although it could be gauged by combining microlith and microburin lengths.

No apparent patterning was noted with respect to microlith form and the frequency of arris scars and types of distal terminations. Comparison of the size dimensions between scalene triangles and backed blades is also not statistically significant to suggest the selection of different blanks for certain forms. However, microwear analysis has shown that the more angular the scalene form in plan on the ventral surface, the more probable the presence of wear traces (Finlayson & Mithen 1997). This suggests that the primacy of the ventral surface during backing may also be important in terms of influencing selection criteria. It also demonstrates the tenacity of the microlithic gaze and the failure to acknowledge the three dimensional properties of these objects. Several factors remain unknown at present; one of these is the direction of orientation of the blank during backing. While the surface orientation in terms of the execution of retouch is overwhelmingly ventral, what cannot be ascertained is the position the piece was held on an anvil nor indeed whether a more fluid mode was adopted with the piece rubbed against another surface to facilitate the retouch.

It is commonly assumed within the literature that truncating the blank with the use of the microburin technique is facilitated by using an overhang (e.g. Inizan et al. 1999: Fig. 33). However, this was not my experience of the technique during manufacture; rather it was achieved by notching the blank on the flat surface of the anvil and applying pressure, not at the edge. The ease by which the microburin technique was successful appeared to relate to the thickness of the blank and the angle at which pressure was applied. Several of the most successful microburins were accidentally produced while retouching or notching the blank as it rested flat on the anvil. Attempts to remove some of the thicker bulbs had to be abandoned as these could not be easily notched and were too thick to apply the requisite pressure. Another





	Backed Blade	Scalene Triangle	Crescent	Needle Point	Double Backed Blade	Triangle	Trapeze	Leaf Point	Indeterminate
Bolsay Farm	294	590	27	9	6	5	10	17	11
Staosnaig	142	47	2	6	5	0	5	6	5

Figure 5. Location map and types of microlith present at archaeological case study sites.

observation was that many of the successful attempts at removing the bulb of percussion by this method did not result in a characteristic microburin product. Rather, fragments with some or no retouch present were created. There are other ways of realising a microburin such as creating the notch on a prominent edge and applying slight pressure. One of the most noteworthy aspects was how the use of the microburin technique did not always result in a discernible waste product, and that it frequently produced debitage that would be unrecognisable as such. Therefore, we can consider that the visibility of this method should be related to factors such as blank form, thickness and more than likely to the subtle variations in executing the technique. Within the SHMP assemblages, there are examples where the constraints of blank thickness are clearly a determining factor in the preservation of distal microburins. In light of this, it is perhaps no surprise that despite the prevalence of distally retouched scalene triangle forms in the archaeological assemblages, most microburins are proximal and the ratio is 1 microburin: 4 complete microliths.

In the SHMP assemblages there does seem to be some support for the basic routines of production as produced via replication; however, the microlith is archaeologically visible and identifiable due to the presence of retouch. The question remains as to whether suitably sized debitage and fragments had equivalent biographies. Yet within the processes of modification we can see consistency in practice even if this resulted in variability in the end product (over 53% of the microliths analysed are unique combinations of the attributes recorded). The basic actions and routines of side and end modification are present. The dominant mode for scalene triangles is the longitudinal backing of the left lateral side and distal end, but there are single examples from three sites that produce a scalene triangle morphology that is fashioned on transverse flake segments. Equally, there are only two pieces where the internal geometry of the piece contradicts the basic scalene triangle form. Moreover, the evidence from microburins and *lamelles à crans* indicates that the longitudinal alteration was undertaken before modification of the end of the piece. In terms of retouch, direct retouch from the ventral surface predominates and the frequency of enclume retouch is variable. Overall, it could only be identified on 7% of pieces and at one site, Staosnaig, Colonsay, it is present on 17% of the backed blades. While this could be used to support different production routines, it is also likely to reflect other factors such as blank character. Overall, there is little evidence to support the remodelling of microliths from one form to another, both in terms of the size ranges and the presence of inverse retouch. Thus, the pattern identified within this dataset reveals variability in microlith form, but consistency in practice as far it can be discerned in terms of patterns of surface orientation and routines of execution. Identifying the mode of retouch was more problematic and was limited solely to macroscopic examination. Here the constraints of the blank created difficulties in assigning the piece to a particular mode and the lessons from replication suggest that equating retouch with mode (given the under-representation of *enclume* retouch) is problematic, it cautions against assuming mode of modification and here microwear evidence and more replicative studies would be useful.

The impression gained from the archaeological sites is one of superficial conformity in the routines of production. Yet the actions may have been constant in relation to the sequence of modification, while the mode of backing was highly variable. Indeed, this flexibility in realising the same end product may have been a salient feature: variation within acceptable social constraints and functional needs.

Discussion: the performativity of microlith production

In this section I want to consider the production of microliths described above as a form of performance, and the more performative aspects of microlith manufacture as an exercise in concealment and (trans)formation. Christina Lindgren (2003) has explored how sources of raw materials are controlled and the location of production secluded and used to create social tensions within a group. Here I wish to consider how we can apply this metaphor of concealed and hidden action at the level of individual. Influenced by Judith Butler's take on performativity, in particular the notion that it is 'a reiteration of a norm or set of norms', to the extent that it acquires an act-like status and that 'it conceals and dissimulates the conventions of which it is a repetition' (Butler 1993: 12), we can consider the role of microlith production as the visible expression of social values and thereby consider its role in social reproduction. The idea of technology as performance has been discussed in the past (eg. Lechtman 1977; Lemmonier 1993), but it can be recast along with more recent perspectives on the social dimensions of technology to reconfigure a given *chaîne opératoire* (Dobres 2000). The entire process of microlith production and use can be read as a play between visible and concealed action. At times, the various events that contribute to the creation of a piece are either clearly visible or obscured. The production of blanks marks the most visible stage of production. Given the small size of the blank, the transition to modified piece is accomplished by sleight of hand. The action is often concealed from the maker, the hand obscuring the visibility of the action. Here it is what is known, felt but perhaps not seen that is significant as the piece is altered via retouch. Thus, the simple action of backing can be seen as an extension of the self as the microlith is created with some of the agency of the maker transferred to the piece. To the onlooker, this modification, this (trans) formation is accomplished, often with little effort and frequently with some speed, yet it is not entirely visible. Clearly, the visibility of this action is conditioned by the mode of modification, whether an anvil stone is used and the manner the piece is held. It is more often than not felt rather than witnessed by the maker. Yet if the replication modes are analogous then it is questionable whether even the orientation of the piece in the hand could always be discerned by others without close scrutiny. In this sense, subtle variations serve to challenge and subvert the conventions of production. The metaphor of concealment whereby the piece is hidden in the hand continues into the hafted form. The use of mastic and the form of the haft means that the final form of the piece would also not be identifiable in the finished product. Of course, not all microliths would have needed to be hafted and the form of the complete tool form might not always conceal the form of the piece. However, the process is one where there is a clear interplay between concealment and visibility where what is known and not seen is important. This can be read in a number of ways for it is also a means by which the ownership and identification of the maker, their action and the artefact are made present or absent. Individual action is revealed and equally hidden or suppressed at different stages. The wider visibility of the skills and techniques used in blade production through to the more concealed modification of backing is one such shift. Another is the relative visibility of the microlith at the point of selection and the concealment in the hafting of the modified piece. In this regard, microlith manufacture can be regarded as embodying elements of a 'technology of enchantment' in the sense developed by Gell (1998; 1999) in relation to the anthropology of art. The process of production is captivating not only in terms of the performance of production but also in transforming some of the agency of the maker to the piece.

Exploring how some of these metaphors of visibility and concealment are expressed in microlith production allows us to consider how these stages may have been imbued with particular significance; not withstanding the subsequent impact of biography to create other meanings (Finlay 2000c). Different techniques of modification introduce subtle differences in the form of engagement with materiality. The challenge lies in developing a body of replication and modern experiences and engagements that can enable us to explore and identify such processes. Here our engagements like those discussed above stand-alone as we muddle through the motor actions and constellation of knowledge required to complete such as task. In the past, the choice of tool used to back the piece may have held significance in terms of individual preferences as well as symbolic meanings. The position of the hands – whether hand held, supported on knees, resting on the ground or another surface – would have conditioned the visibility of various stages and lead to potential elaboration or flourish, as would the spatial location and relative body position of the maker in relation to others or significant features. We envisage this process of production to occur as a sequence of repetitive actions as the maker(s) multiplies the number of microliths and then selects out those for use or hafting. The selection and laying out of the modified or unmodified pieces that formed the final composite artefact would have created further opportunities to make explicit the implicit ownership of pieces, to include or exclude others. Elsewhere I have suggested that microlith manufacture afforded an ideal opportunity for multiple authorship (Finlay 2003). It is the potential communality of production that is a dominant motif. The design of composite implements mitigates against individualism in as much as the multiplicity of component pieces are quintessentially a collective product. Moreover, there is considerable redundancy inherent in the multiplicity of suitable components. The meaning and the stages of transformation of stone into tool can be seen as one expression of the composite character of mesolithic technology. While the techniques used to create these artefacts are relatively simple, skill rests in the consistency of practice that produces suitable blanks. The ease by which microliths are modified argues for the suppression of skill and individualism that is expressed in a fluid way, here techniques can be realised and vary in subtle ways but which often end up conforming to tradition and ultimately concealed in the hafted element.

To conclude, replication is an under-developed and neglected facet of our engagement with microlithic technologies. This can be related to the biases within lithic replication as contemporary praxis that privilege 'elaborate knapping' at the expense of more basic objects. There is also the perception that experimental replication has little to offer given the apparent simplicity of these artefacts. Yet as Lindgren (this volume) and Rankama *et al.* (this volume) argue in relation to bipolar quartz industries, there is much to learn and challenge in our own preconceptions about so-called 'simple' technologies. Microliths may well be easy to make but as objects, their apparent simplicity belies a potentially more complex set of meanings and readings. The 'microlithic gaze' has had a profound impact on ways of both seeing and thinking about these artefacts. Experimental replication has a valuable contribution to make at a number of levels from forcing a different type of engagement with the issues of tool production, through to providing comparative breakage rates and the different attributes created by subtle variations in the execution of retouch. The manifestation of microliths was and is an exercise in (trans)formation. Thinking more metaphorically about this process allows us to consider the relationship between visible and invisible action and its implications for the reproduction of social knowledge.

Acknowledgements

I am extremely grateful to my three knappers Caroline, Bill and Alejandro. The replication experiences were conducted as part of my doctoral research at the University of Reading in 1994 and I thank Professor Steven Mithen for his support and the opportunity to work on the SHMP material. Attendance at Uppsala was partially funded by the British Academy Networks Scheme and support from the Department of Archaeology, University of Glasgow is also gratefully acknowledged. Lorraine McEwan produced Figure 5 and I am grateful for her advice and assistance. Finally, thanks are due to Jan Apel, Kjel Knutsson and all the other organisers and participants at the symposium for fruitful discussion and insights into skilled production, and lastly to Paul Duffy for drawing attention to the more obvious faults herein.

Marcin Wąs

Some remarks on contacts between Late Mesolithic hunter-gatherer societies as reflected in their flint technology: a case study from Central Poland

Abstract

Chocolate flint was one of the popular raw materials used during the Stone Age in the Polish Lowlands. Both the range and the quality of its supply changed together with the cultural sequence from the Palaeolithic to the Early Iron Age. This paper deals with the problem of the use of chocolate flint among the Late Mesolithic hunter-gatherer societies inhabiting the Vistula basin. The economic strategies and flint exchange between flint acquiring (mining) sites located in the Holy-Cross Mountains, and hunting camps found about 250 km to the north, will be discussed. The aspect of transmitting blade core processing concepts in the so-called Janislavician culture will also be discussed. A reconstruction of a contact network based on Mesolithic sites containing artifacts of the same Mesolithic culture will be presented through the tracing of know-how and knowledge in the flint working on these sites. This will allow for a specification of the territorial range of these hunter-gatherer societies, belonging to the same tradition in the 1st half of the 5th millennium BC.

Introduction

In this paper I would like to discuss the interpretative possibilities of using flint technological analyses to shed light on connections between Mesolithic societies. My investigation is based on assemblages of the Late Mesolithic Janislavice Culture (Kozłowski 1989). The "Janislavician" sites are known from the territory of Central and Eastern Poland, Western Belarus and Western Ukraine. The discussion focuses on assemblages from the Vistula basin.

One important aspects of this culture is the use of mined "chocolate" flint (Schild 1976; Cyrek 1995; Sulgostowska 2002). This was one of the most popular raw materials used during Polish Lowland prehistory from the Lower Palaeolithic until the Early Iron Age (Domanski & Webb 2000). Its popularity was probably the result of both its high quality and the rich outcrops. From an archaeological point of view it is important that the outcrops have been localized in the north border of the Holy-Cross Mountains (Schild 1971). It gives us the possibility to study prehistoric chocolate flint distribution.

In the Mesolithic its use was differentiated; in the Early Mesolithic it was used only sporadically, but in the Late Mesolithic, an explosion of popularity took place (Cyrek 1981).

In the Late Mesolithic there was also an expansion of the Janislavice Culture settlements in the area of the outcrops and their neighbourhood. Find inventories from these sites contain about 100% chocolate flint, but individual artifacts of this kind of flint are known from sites as far as 200 kilometres from the area of extraction (Schild *et al.*1975).

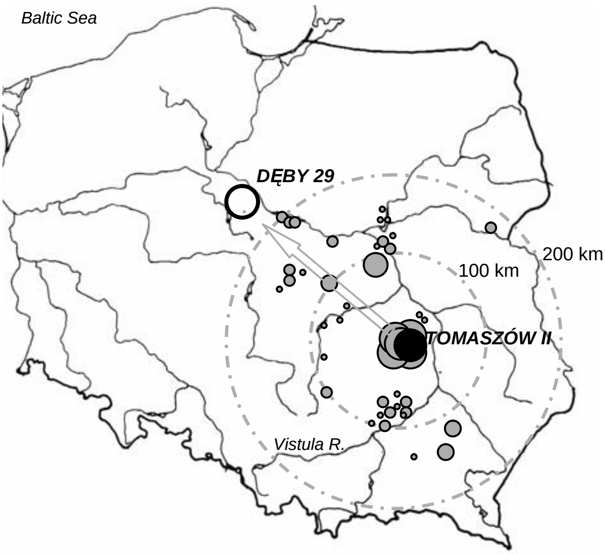


Fig. 1. The frequency of chocolate flint on the sites of the Janislavice Culture in the Vistula basin (after Cyrek 1995). The discussed sites are indicated.

The occurrence of chocolate flint in the inventories of the Janislavice Culture has been interpreted as the result of contacts between societies belonging to this cultural unit. The connection was created only on the basis of chocolate flint presence in the assemblages (Cyrek 1995). It was seen that on the sites near the outcrops all *chaîne opératoire* stages are represented, whereas on the sites far from outcrops, mainly blades or microliths occur. Therefore, in the early eighties, a model of chocolate flint distribution was created that stated that the frequency of chocolate flint in assemblages decreased evenly with the distance between the site and the outcrops, and that chocolate flint is not in evidence on sites more than 200 km from the outcrops (Fig.1). This situation changed in the second half of the eighties after the discovery of the Dęby 29 site (Domańska 1991). This site is situated about 250 km north of the outcrops and consists of about 3100 artifacts made of chocolate flint (100% of the inventory). Therefore, a reconsideration of our earlier interpretations is necessary.

In the following text, the technology of flint processing from the following two sites will be compared: the Dęby 29 site, which is interpreted as a typical hunting camp with numerous microliths, microburins and blades (Domańska 1991), and the Tomaszów II site, which is connected with extraction and procurement of chocolate flint nodules (Schild et al.1985). The sites will be used for testing a hypothesis concerning connections between societies that in the Late Mesolithic of Vistula basin used the same raw material for production of the same type of microliths. One site – Tomaszów II – is situated in the outcrop area and the other – Dęby 29 – 250 km from the outcrops (Fig. 1).

Materials

The general *chaîne opératoire* sequences in the two assemblages can, on the basis of refitting studies, be summarized in the following way:

- Tomaszów II – contains all stages of exploitation: from pre-core procurement to microlith production. It is important to note that procurement and primary reduction of pre-cores and blade cores is well represented in the material. This situation is probably connected with the presence nearby of shafts for flint extraction.

- Dęby 29 – reconstruction of the technology was possible only thanks to the refitting method (Wąs 2004). Almost all stages of production had taken place here, from ready pre-core exploitation to microlith resharpening.

In the context of the discussed problem of chocolate flint distribution in the area of the Janislavice Culture, a comparison of pre-core forms from both sites is interesting. In my opinion, the sites were strategic points of initiation of exploitation and determined further blade production.

In the Dęby assemblage, a form of pre-core has been reconstructed through refitting (a so called "phantom core" due to lack of the actual core) (Fig. 2). It is very valuable because it displays the primary form that was brought to the site. Since no flakes from the pre-core formation were found, it seems that this process took place elsewhere. The refitting shows the conception of pre-core preparation and its transformation into the core for blades. The missing core had a narrow flaking surface, a long, often rejuvenated striking platform, a narrow tip and natural flat sides. For the problem discussed here, the analysis of the pre-core is of the utmost importance.

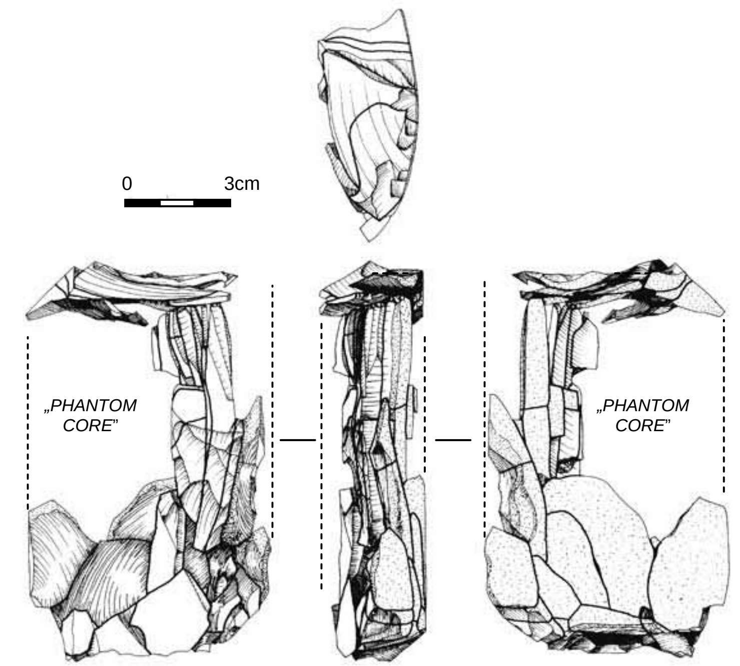
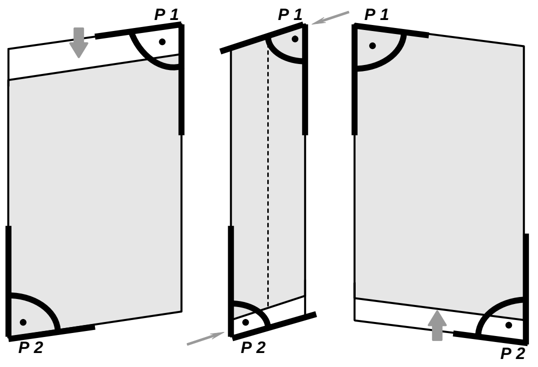


Fig. 2. A refitted phantom blade core from Dęby 29 site.

The pre-core is a flat nodule with cortex sides. The dimensions are about 11 x 7 x 3 cm. The pre-flaking surface had a natural crest. Thus, natural types of flat nodules were transformed into pre-cores. In this case it was done only by reduction of two shorter opposite narrow surfaces. Each of these was formed by strokes from the same direction, from one of the sides of the nodule, changing the orientation (180°). In this way a geometrical, rhomboidal form was obtained (Fig. 3). It is specific because it is geometrical viewed from two directions: *en face* and from the side. The investigation of reduction sequences through refitting demonstrates the way it was done. It seems that geometrical relations between particular surfaces of this kind of pre-core allow exploitation to begin at one of two possible points. It did not impose only one orientation, but the choice of initial flaking was multiple, still retaining the geometry of the pre-core. Moreover, easy rejuvenation of the striking platform or the preparation of the tip of the core was possible at every moment. I think this is a very universal and practical form.

Fig. 3. Scheme of the rhomboidal pre-core preparation based on the “phantom core” refit group from the Deby 29 site (P1, P2 = possible points of initiation of blade core exploitation; arrows indicate direction of preparation).



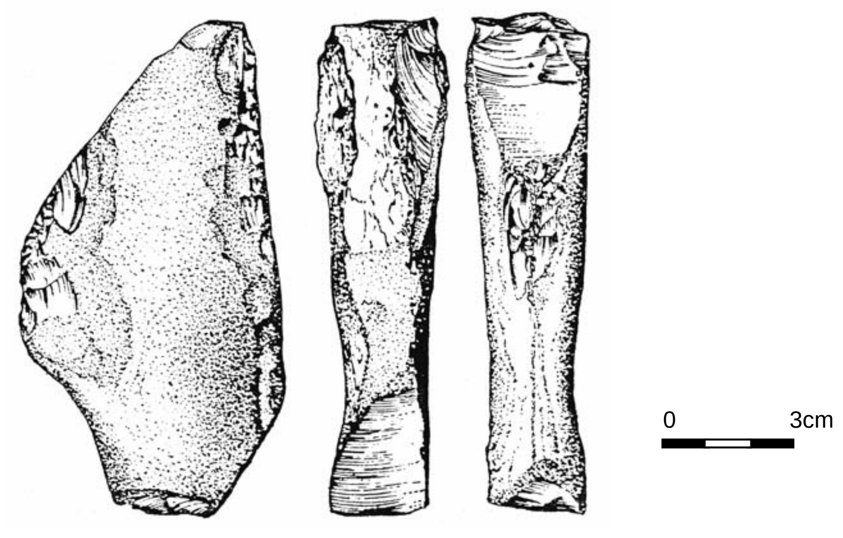


Fig. 4. Unexploited core form from the Tomaszów II site (after: Schild *et al.* 1983, Table XXIII: 6).

A similar, unexploited pre-core form was found on the site Tomaszów II (Fig. 4). Its dimensions are nearly the same as the pre-core from Dęby 29. The preparation of the nodule is connected with the same type of surfaces as in Dęby 29. Only the direction of flaking is different, not from the broader sides but from the narrow surfaces (pre-flaking surfaces). The result was a pre-core with natural, cortex-covered sides, a more or less crested opposite surface and a flat pre-striking surface or tip of core. Viewed from the side it shows a rhomboidal shape similar to the pre-core from Dęby 29.

Discussion

The described similarities between the pre-cores from the Dęby 29 and Tomaszów II sites are, in my opinion, not accidental. They indicate the existence of a real, standardized conception of flat chocolate flint nodule preparation for further exploitation. These similarities imply some form of connection between the sites. This observation has important implications for prehistoric research, pointing towards two paths of explanation:

1. Defining the distance of migration for raw material

2. Defining the size of a territory united by the same techno complex

The first interpretation is general access to chocolate flint sources. Migrations of at least 250 km were possible for members of the Janislavice Culture (Cyrek 1978).

The second explanation involves the existence of a contact and exchange network. Thus the producer of a pre-core ("sender") was aware of the level of "knowledge" and "know-how" of the "consumer" – i.e. a person who reduced the pre-core on another site. The implication of this idea is the presence of direct or indirect connections between different societies inhabiting the Vistula basin in the Late Mesolithic. In this case, the form of the pre-core from Dęby 29 indicates that the Mesolithic people selected good quality nodules for exploitation. From an emic perspective, this was a successful pre-core; it had all the criteria necessary to continue the production of blades. Thus, it was found far from the raw-material extraction area as a completely reduced pre-core reconstructed by refitting. It should also be pointed out that the blade core was not exhausted at the Dęby 29 site; further exploitation probably took place at another site later on.

The identification of the same idea, or a similar concept of method, of pre-core preparation and blade core exploitation on the sites from different regions of the Vistula basin is interesting from a sociological point of view and for investigations of the psychotechnological aspects of flintknapping (Roux 1990; Schlanger 1994). Especially interesting is the problem of "knowledge" and "know-how" which are needed for a skilful use of the pre-core (Pelegrin 1990; Karlin and Julien 1994). Inasmuch as this problem is easy to explain in assemblages from the region where sources of raw material are found, the example from the Dęby 29 site is more complicated. I think that the aspect of learning flintknapping in the Janislavician assemblages, from the perspective of the geographical distribution of pre-cores, strengthens the hypothesis about connections between societies from different parts of the Vistula basin.

The comparison presented above has shown that technological unification is seen not only in standardized forms of microliths, blades or cores. In the case of chocolate flint this unification is also clear in the form of pre-cores, and of course in the idea of its exploitation. I am convinced that this argument confirms the genetic association between Late Mesolithic hunter-gatherers from the Polish Lowland.

What should also be pointed out is the cross-cultural studies that demonstrate that non-local or inaccessible materials are often used as symbols of prestige (Taffinder 1998). Maybe this also applies to connections of exotic raw materials and skilful technologies. This aspect should be investigated in future studies of chocolate flint distribution in the Janislavice Culture.

Kim Akerman

High tech–low tech: lithic technology in the Kimberley Region of Western Australia

Abstract
Australia is one of the few countries in which it was possible to observe and document indigenous lithic technologies as recently, in some areas, as the latter half of the 20th century. Even today in the Kimberley Region of Western Australia and in the Western Desert, there exist Aboriginal men and women, who have made and used tools of stone, and of glass or ceramic in their younger years.

In terms of lithics, the Kimberley region is primarily known for the finely pressure flaked stone, and more recently glass, serrated points used to arm long, light, composite spears. They were also prized as items of exchange. Most other stone tools, apart from hafted edge-ground stone hatchets and chisels, are based on simple flakes and flake-blades with varying degrees of secondary retouch. There is a marked contrast between the technological skills required to produce the points and those used to create the other stone tools used in the area.

This paper will examine the lithic technologies of three distinct cultural areas of Kimberley – The Northern, the Fitzroy Basin and the Dampierland Peninsula – focusing to a degree on the distribution of types and also on the social contexts in which they were made and used.

Keywords: Australia, Kimberley Region, lithics, points, adzes, hatchets, shell tools, bone tools.

Introduction

The Kimberley Region of Australia incorporates the north-west corner of the Continent. Its borders include the Indian Ocean on the west and the Timor Sea to the north. The Great Sandy Desert lies to the south of the Fitzroy River Basin, while the eastern border of the Region is the State border with the adjacent Northern Territory. It is a rugged region consisting of a massive central plateau bordered and dissected by several large river systems. Along the coast, tidewaters may fluctuate nine or more metres. The vegetation is of open sclerophyll woodland type with patches of vine thicket and jungle, especially in the north. To non-indigenous people there are two seasons. The first is called the 'Wet' and is the time of summer (November-March) monsoons, during which most of the annual rainfall, varying from 400 mm to 1400 mm annually across the region, occurs. Winter is the cooler

'Dry' period in the middle of the year. Indigenous peoples across the region recognise six or seven different seasons, marked by very subtle changes in climate, as well as the habits of flora and fauna.

The region is a complex one linguistically. At the time of contact, there were some thirty-one different languages, belonging to six distinct language groups spoken in an area of some 345 350 square kilometres.

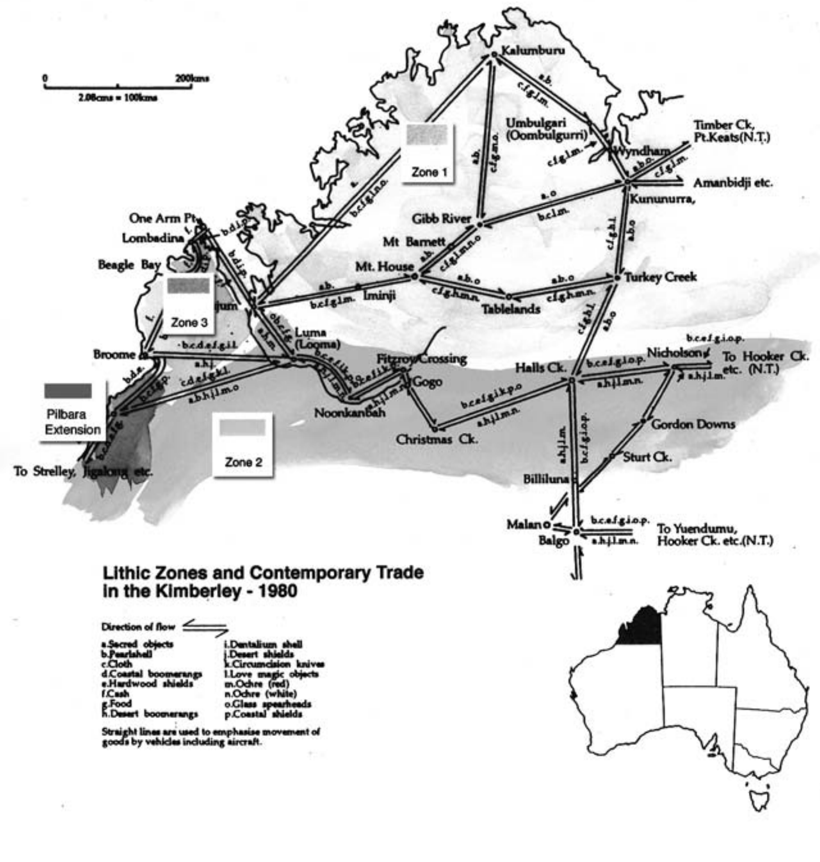


Figure 1. Map of the Kimberley with proposed lithic zones overlaying contemporary indigenous exchange routes.

In 1979, I described the region as containing within it, five distinct indigenous cultural blocs (Akerman 1979a: 234-242). These cultural blocs were differentiated primarily on the basis of social and ceremonial organisation. Two of these areas are very distinct and are in fact bounded by the other three blocs, which also flow into the adjacent geographic regions to the south and east. In terms of lithics and lithic technologies, however, these blocs can be reduced (at a general level) to three broad areas or zones (Fig. 1).

Zone 1 covers the central and northern Kimberley and the Ord River Basin. In the central and northern area, social organisation is based on a patrilineal moiety system, and cosmologically the focus was on Rainbow Serpent and/or Wanjina religious beings. In the Ord River Basin however social organisation was based on the sub-section system and the Rainbow Serpent in a variety of guises, appears to be the dominant cosmological entity among a body of other ancestral creator beings that travelled across the country. On the coastal margin of this area, there was some reliance on maritime resources, but generally, the economy was geared to exploit the wide variety of environments, coastal, riverine, black soil plains and the dissected rocky Kimberley Plateau.

Zone 2 consists of the desert margin where the Great Sandy and Tanami Deserts abut the southern margin of the Kimberley Plateau. Here an arid zone economy, focussing on the seeds of various species of acacias and grasses expands the range of environments exploited beyond the confines of the rivers that define its northern borders. Rainbow Serpents are the major cosmological beings, perceived as occupying major waterholes and springs in a landscape that is densely crossed by far-flung dreaming tracks of both individual and groups of Ancestral Creator Beings.

Zone 3 is that area of the Dampierland Peninsula and adjacent islands north on Roebuck Bay, south along the northern reach of the Eighty-Mile Beach. In this zone, the people possess neither moieties nor sections and had a maritime hunting and fishing economy, relying only upon the terrestrial environment for plant foods and resources and reptiles and small marsupials. These people maintain a cosmology and ceremonial life, primarily based on the activities of a pair of cultural heroes that is quite distinct from that found elsewhere in the Region.

To the south, I have indicated on the map a fourth Zone, which is in fact an extension (in terms of lithics) of the coastal Pilbara area. Here social organisation was based on the 4-section system and there was considerable ritual and economic interaction with people from the wider Pilbara region as well as the desert to the east and the Kimberley proper.

Antiquity of human occupation of the Kimberley

In the early 1970s, Charles Dortch excavated a number of sites in the Ord River Valley. Subsequently these sites were submerged beneath the dammed up waters of Lake Argyle, a huge artificial lake of nearly 6000 cubic metres of water. A basal date of about 18,000 yrs BP was obtained at Miriwun rock shelter (Dortch and Roberts, 1996:24-34). More recently dates in excess of 28,000 yrs BP have been obtained by Sue O'Connor at Widgingarri (Bowdler and O'Connor, 1991:58; O'Connor, 1999); and of 40,000 yrs at Carpenter's Gap (O'Connor, 1995:58-59) and at Mimbi Caves (Balme, 2000:1-5). Widgingarri lies on the northwest Kimberley coast while Carpenter's Gap and the Mimbi Caves are in limestone ranges in the central south Kimberley. Organic materials including plant remains and marine shells (indicative of long distance trade) are found at the lowest levels at the latter sites.

Some rock art in the region has been dated by luminescence dating of quartz grains in mud-wasp nests that overlay the ancient paintings, to be at least 17 500 years old (Roberts, R. *et al.* 1997:696-699).

Stone tool utilisation in the ethnographic recent past

The following observations are based, unless otherwise indicated, upon my own work in the region, which commenced in 1966. Technologies that are the same across the three Lithic Zones will only be described in any detail once and only differences in approach or other pertinent data further developed.

Lithic Zone 1

Heat treatment of lithic materials does not seem to have been practised in the west, northern and central areas of this area, although heat was used to cause fine grained cortical area to exfoliate from sheets of massive quartzite (Akerman 1979*b*:144). Among the Wunambal speakers of the area, this process was called *jaran*. Fires were lit under boulders of suitable material or on the surfaces of quartzite sheets. While the burning destroyed stone in immediate contact with the fire, stone that had lifted further away was not unduly affected. In the east, however, heat treatment was utilised to improve lithic materials.

The lithic assemblage of this area consists of:

1. Ground-edged tools

Stone axe-heads, or more correctly hatchet-heads, were bifacially flaked by men from either suitable cobble material or from larger quarried flake blanks of suitable metamorphic or igneous rocks. While they do occur, axe quarries are rare in the region. The flaked preforms are then edge-ground and hafted by women. Men and women who were familiar with stone axe technology were alive well into the latter half of the last century. One of my close informants had a scar on her right hand where she had been cut with a stone axe, when as a child as she impetuously reached into a hive full of honey being chopped out by her mother. Stone axes are tools that were primarily used by women in the Kimberley, for the extraction of native beehives from hollows in trees (Akerman 1979c: 169-78).

Grinding was generally restricted to forming the edge and rarely covered more than a third of each face of the head. In the eastern area however, about the Ord River Basin, axes often appear to be both more carefully flaked, and more extensively ground than in the northern and central areas (Fig. 2).

Figure 2. Hafted edge-ground axe and unhafted axe-heads from the Kimberley.

Hafting is accomplished by bending a strap of flexible wood about the axe-head and lashing the two ends together, compressing the head between them. Softened beeswax, prepared by mixing it with pounded charcoal or one of several plant exudates, may be placed around the head prior to tying off the helve. In this region hafting adhesives were derived from either the mountain bloodwood tree (*Eucalyptus dichromophloia*); the white cypress pine, *Callitris columellaris*; and the porcupine grass or spinifex (*Triodia pungens*).

Pecking as a means of shaping axes is rare and appears to be restricted to archaic examples, which may also be grooved to facilitate hafting (Dortch, C.E. 1977*a*:23-30). Edge-ground axe technology has an antiquity of 28 000 years in this area (O'Connor 1999:75).

Dickson (1981) examines Australian stone hatchets and other ground-edge tools from a physicist's viewpoint, considering manufacture, hafting, resins and other adhesives and operational dynamics in detail.

2. Grinding and pounding stones

Seed grinding was not a major activity in this area and, unlike other regions, deliberately fashioned grindstones were not made. Suitable slabs or pieces of abrasive stone were used to grind and sharpen stone axe-heads and later, with the introduction of metals, iron spearheads and tomahawks. Ochre grinding was a also major function and small grooved grindstones were used to shape bone and wooden points and more recently wire tools. Bedrock axe-grinding platforms are common only in the eastern area of this zone.

Pounding stones (mortars and pestles – for general terminology relating to grindstones and pounders, see Smith, 1985:24-29) were used to process food and resource materials. Some fruits were pounded prior to being eaten; others such as the toxic fruit of *Cycas media* were hulled prior to leaching and subsequent cooking. In some instances, cooked meat and bones were pounded to a pulp prior to being eaten, especially by the very young or the elderly. Some native tobaccos were prepared for chewing by pounding and both avian and vegetal down was prepared for ceremonial use by being pounded with ochre of the required colour. Pounding stones consisted of a stable boulder of quartzite with a suitable flattish surface on which to rest the object or substance being worked and a rounded river cobble of the same material that was used unhafted as a hammer. There is little evidence to suggest that the butt end of the stone axe was used as a hammer or pounder in this area and, unlike the situation in some other areas of Australia, axeheads themselves do not seem to have been used as anvils or hammerstones.

Stone pounders were used to shape metal tools, and stone anvils used as a platform upon which spearheads were made show abrasion where they have been used to grind the edges of stone pieces being worked and also to reform the working areas of wood, bone or wire indenters. Resins were pounded in the course of manufacture or prior to being used.

Hammerstones were usually fortuitously selected from available cobbles when required, that is, when stones were being checked for quality etc. in the course of hunting or travelling. At home bases however, cobble hammerstones were more carefully curated. Smaller hammerstones, used to preform points etc, were kept within a bark wallet along with other tools and points in various stages of manufacture (Balfour, 1951:273-274).

3. Unhafted blade and flake and core tools

Unspecialised knives and scrapers were made from flake-blades – i.e. flakes whose length was at least twice the width, not the specialised, parallel-sided blades associated with Neolithic Europe or Meso-America. These blades have been described as being produced in a similar manner to the Levallois points of Europe (Dortch and Bordes 1977:1-19; Dortch 1977b:117-119).
Blades (*jarung* - Worora, Ngarinyin language) were usually made of quartzite, the commonest available lithic type in the area. Men flaked the blades but they were used by both men and women for general cutting/scraping purposes. Men used them to cut the culms of *Phragmites karka*, used as spear shafts and also the long thin hardwood foreshafts. From branches of the strong, but soft, wood of the bat-wing coral tree (*Erythrina verspertilio*), men carved their spear throwers. *Jarung* were used to notch the side of a suitable branch of acacia or other wood prior to bending and causing it to split when making axe handles, or to trim sheets of bark that were used to form cradles and trays or water vessels. They were also used to remove the inner bark from some species of trees when making cordage or string.

Jarung may be used without further retouch, or if it required re-sharpening, was unifacially trimmed by percussion. If, of a quality suitable for later reduction into a biface pressure flaked spearpoint, a *jarung* could also be termed *yilera* - 'spearpoint preform'.

Small flakes - often suitable thin, ovate, biface thinning flakes or *iriyela*, were sometimes kept and carried to be used as surgical knives - particularly for cutting the distinctive patterns of cicatrices with which most adults, men and women were adorned. They were also used to cut small therapeutic wounds on backs and shoulders or at the temples. Small flakes of glass were used for the same purpose as late as 1980 (Fig. 3).

Figure 3. Small glass flakes used for cutting therapeutic and other cicatrices. Broken section of glass bottle used as a circumcision knife.

Jarung and *ilera* were carried wrapped in bark wallets by women. Men carried *jarung*, tucked into a cord band on the upper arm, while *iriyela* flakes were carried tied into the chignon or hair-bun, worn by most adult males. The hair often used to carry small objects, speartips, sinew, bone awls etc. Traditionally oriented hunters would sometimes carry a pocketknife on the head by closing the blade on a lock of hair.

Otherwise, as in most areas of Australia, any sharp flakes of stone or piece of glass that is available may be used for a single task, such as butchering and then discarded. It must be remembered that initial butchering of most terrestrial game consists of making a small incision through which the alimentary tract and other internal organs are removed. Most animals are not skinned, and, apart from large sea animals – dugong, cetaceans and turtles, further division of meat only occurs after cooking.

Large fragments and blocks of quartzite that presented cleanly broken edges of 90° or less were used in lieu of stone axes to open beehives or perform other heavier chopping functions as required. These stones were usually discarded on completion of the task at hand.

4. Hafted knives/scrapers

Hafted stone knives and adzes are not recorded for most of Zone.1. The exception occurs in the Ord River Valley in the eastern section of the area where an unmodified pointed cortical flake (l = 50 mm; w = 45 mm; t = 20 mm) struck from a quartzite river cobble was hafted with resin to a stout wooden handle. Known in Miriuwang as *binbalang*, the short stout tool (l = 200 mm) was said to have been used as a knife, chopper or chisel (Akerman and Bindon 1984:368-369). Hafted knives made from both ground-edged and naturally fractured fragments of pearlshell (*Pinctada maxima*) and other oysters with a resin handle were used on the coastal areas (McCarthy 1976:91; Akerman 1995:178). Occasionally, *jarung* was said to be provided with a resin grip on the proximal end of the blade.

5. Pressure flaked spearheads

There have been a number of descriptions of the lithic technology of Kimberley spearpoints. One early and incorrect description of Kimberley pressure flaking by Clement (1903:5), described how a bone indentor was immobilised on an anvil and the piece of stone being worked was pressed against it. Unfortunately, both Balfour (1903:65) and more recently Jelínek (1975:176) based their understanding of Kimberley pressure-flaking on Clement's work. Excellent descriptions of pressure flaking have been given by Love (1917:25–6; 1936:74–5), Basedow (1925:367–70), Idriess (1937:59–62), Elkin (1948:110–13) and Tindale (1985:1–33). Moore (2000:5-17) provides a recent detailed description of the technology involved.

Unlike pressure flaking techniques commonly practised in both the Old World and the Americas, the Kimberley craftsman sits on the ground with one leg tucked under the other, which is extended before him. A stone (about 15 x 15 x 12 cm) is placed in front of the knapper, to serve both as an abrader and as a working platform. This is covered with a cushion of *Melaleuca* bark or today cloth. The knapper usually holds the piece between thumb and forefinger, with one edge resting on the bark. He grasps the indentor across the palm of his other hand, with the tip emerging below the little finger. He places the tip of the indentor on the upper margin of the object piece and braces his wrist and arm before applying pressure by leaning forward with his body, and pushing down and outward with his hand (Fig. 4).

Figure 4. Pressure-flaking glass spear-head. Kalumburu.

Wooden indentors were used for the first stage pressure flaking and stout and fine tipped bone indentors for the second and third stages of pressure flaking, respectively. In the third and last stage the tip is developed and lateral margins are serrated or dentated. Akerman and Bindon (1995:89-99) describe margin treatment on the contemporary and archaeological biface points of northern Australia.

Crabtree (1970:146-153) investigated the Kimberley method of pressure flaking with wooden tools but, as I pointed out (Akerman 1979*d*:79-80), the points that Don was replicating were made of glass and that it was probably likely that they were made with a metal indentor rather than a wooden one. In any case, unless the point was exceptionally large it is likely that all negative flake scars created by flake removal with a wooden indentor would have been removed by use of the bone indentor. The technique, not the tool, may have resulted in Crabtree's outcomes *vis a vis* the Palli Aike points he was attempting to replicate.

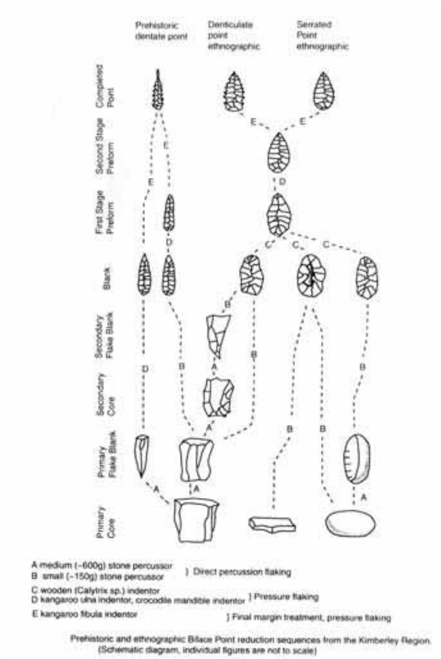


Figure 5. Potential reduction trajectories of Kimberley point reduction sequences. (Modified after Akerman *et al*. 2002).

Sound descriptions of the manufacture of glass points are provided by Porteus (1931:111–13), Idriess (ibid:58) and Mahony (1924:474-475). Idriess details the use of red-hot wire to divide glass bottles into suitably sized pieces. Long lengths of wire were heated in the mid section, and then twisted about the shoulder of the bottle and above the base. The resulting cylinder of glass was divided longitudinally by using hot wire to create a crack and control the direction in which it travelled through the glass. I have also seen the removal of the bases of jars and bottles by filling the vessel with sand and using the wire indentor or wire point of a fish spear to punch out cones of glass around the inner circumference of the base until it dropped free. The bottle was then divided longitudinally with hot wire as described above.

The contemporary reduction sequence of stone Kimberley points follows one of several possible paths (Fig. 5).

More recently Akerman *et al.* (2002:13-42), in an attempt to identify and interpret residues and use wear on points in the archaeological record, provide a detailed description of Kimberley points; their production, uses to which they are put, and their role in ceremonial exchange.

Kimberley composite spears, with a reed shaft and a thin hardwood foreshaft, were among the longest of Australian spears used in conjunction with a spear thrower, with lengths ranging from 2500 mm to 3500 mm. They were however extremely light, the mean weight of 6 spears was 170 g (Akerman 1978:486). These spears were thrown with long, light and slender spear throwers fitted with a hard wood spur, lashed with sinew and reinforced with *Triodia* or *Callitris* resin. Northern Kimberley spear throwers, ranging from 90 cm to 150 cm in length, are among the longest made in Australia. The low mass of the spears, coupled with the length of the Kimberley spear throwers, meant that they could be hurled extremely long distances. There are records of Kimberley spears being thrown 140 yards (about 128 m) with accuracy at 80 yards (about 73 m) being maintained (Stuart 1923:75, 106).

In earlier times, point production was a major occupation for most men, when they were not involved in hunting or ceremonial activities (Love 1936:74; Porteus 1931:113). From both observation and experimental work, it is known that the average (l = 30-60 mm) point can be made in about 15 minutes. Larger stone points generally take longer. With bottle glass points, the main effort in creating points from pieces of curved glass is directed at reducing the concave section. The inner face of the glass is subjected to serial flake removals from either edge until the face is relatively flat. Only then does the knapper tackle the convex face, which is, in effect, set up for optimum flake removal. A single series of flakes is removed from each edge on this face, before serrating the edge and accentuating the tip.

A glass point about 20 cm long can be made from a rectangular piece of bottle glass in about 45 minutes. Glass points made at Kalumburu during the 1970s were leaf shaped, averaging 70 mm long and 15-20 mm wide. Serrations on these points were minute, reflecting the regular and delicate trimming of the margin as the knapper adjusted plan symmetry about longitudinal axis. Glass in the form of wire-broken tabs, flaked preforms or even entire pieces of glass ovenware were often given as gifts to master craftsmen as recently as the mid-1970s. In earlier droving days, pastoral stations (ranches) would bring herds of cattle from the hinterland, to ports and abattoirs for shipping or processing. Aboriginal stockmen (cowboys) would often go to the bottle dumps associated with these settlements and collect glass to take as gifts and trade goods for their relatives back home. Worked glass in the form of reject preforms can be found around the old dumps and also at sites where the stockmen would camp while they tended the herds at stockyards, wells and tanks on the fringes of the town.

Most points for everyday are usually less than 6 cm long, and six hours of knapping could produce about eighteen points suitable for hunting and fighting purposes. A skilled hunter, hunting two or three days a week, would require no more than six points and might replace or renew four points in a week. The constant production of points was as much to make goods for gifts or exchange, as it was maintain a constant supply of spear armatures (Akerman *et al*, *ibid*: 22). Between five and twenty points may be held by a person at any one time.

Because of the nature of the material generally available – either tough quartzites and cherty hornfels of smaller nodules of finer cryptocrystalline materials, large points (l > 130 mm) are rare in this area.

Points were used as spear armatures, as butchering knives (while hafted as spears and unhafted), as circumcision knives, for use in ceremonial decoration and as important trade items. With regard to the latter function, smaller points were exchanged between close kin and friends and used for mundane purposes while larger points (including glass points) usually remained circulating within the exchange system, until they exited the area. Large white chert points that entered this area from the south were also worn as paired head ornaments in some ceremonies. In this case, they were hafted with resin to a short stick handle and placed in a headband to project forward over the temples like a pair of horns. They could also be displayed projecting vertically from the ground. If stone points were not available facsimiles carved from wood and painted white were worn in a similar manner (Petri 1954: plates 4c, 13a and b).

Lithic Zone 2

This region is of great interest, as within it there are a number of stone technologies that incorporate the industries associated with Zone 1 and flake and core-tool based industries generally associated with arid Australia. Ground stone and flaked stone artefacts associated with wood-working reflect the importance in this area of hardwood and softwood spear throwers, bowls and shields; as well as hardwood spears and boomerangs in this zone. These artefacts, apart from the soft wood spear throwers, were not made or used until very recently (as a response to tourism) in Zone 1, and then are only associated with metal tools.

Heat treatment of stone was widespread and associated in particular with a fine-grained white cherty caprock (Akerman 1979*b*). This was quarried from outcrops and breakaways and also occurred in places as relict features within the soil. In the latter case, the stone was mined, pits being dug in the soil to expose boulders and fragments of the material. The process of heat-treatment is said to have been instituted by *Malu,* the Red Kangaroo culture hero.

In 1978, I recorded a Jaru language song cycle that described the Kangaroo flaking boulders of the stone, creating large biface blanks (these resemble some forms of Acheulian handaxes) and heat-treating the blanks. As the stone cooks, the hero constructs a spear, straightening the shaft and foreshaft sections of reed and cane over the hot coals on the stone oven. The two sections are united and the stone is then removed from the oven and a spearhead is created. The head is affixed to the foreshaft with resin. Finally, the Kangaroo mounts the completed spear on his spear thrower and settles it into position with a shake of the wrist, which sets the spear vibrating and balances it ready to throw. It was this song-cycle that Crabtree referred to in an interview with Errett Callahan in 1979 (Callahan 1979:31). Don was under the misunderstanding that the drama was re-enacted at each firing. Firing could be successfully undertaken in about 24 hours with some grades of this material.

1. Ground-edged tools

Hatchets made from dolerites and tuff were commonly used throughout the northern section of this area. Many of them exhibit exceptionally fine bifacial flaking of the preform and more extensive and regular grinding of the cutting edge than seen on hatchets from Zone 1.

Also present are small ground-edged stone tools of dolerite, chert or silicified tuff, that range from < 10 mm in length to about 140 mm and from 15 mm - 40 mm wide. Thickness varies between 5-10 mm. These small tools are generally ground normal to the long axis, although smaller examples may be wider than they are long. They are usually end hafted to short stout handles, but longer examples are hand held. They are termed adzes, rather than chisels, as they are not driven with a mallet, but rather chopped into the surface of wood being worked or dragged in a scraping or shaving motion across it

(Akerman and Bindon 1984:357-373). Hafting was accomplished by either lashing the stone element into a split in the handle or further securing it with resin, or by embedding it in a mass of resin attached to the end of the handle. Akerman (1979e: 81-83) has recorded an example of a finely made bifacially flaked point – a Kimberley point preform – that had been transformed into a narrow-bitted engraving tool by grinding down the tip and adjacent areas.

Elbow-hafted adzes, of the type usually associated with Melanesia or Polynesia for example do not occur in Australia. Australian adzes are tools with either straight or curved handles of wood, to which small ground-edged or flake cutting edges are fixed, usually with an adhesive or by lashing reinforced by an adhesive.

With the introduction of metal adzes were made of a similar type by forcing a sharpened section of metal – often a ground down shearing blade – into a split made in a short stout section of a tree branch. No lashings or adhesives are used to fix the blade to the haft.

2. Grinding and pounding stones

Unlike Zone 1, milled seeds of both acacias and grasses were important elements in the diet of the inhabitants of Zone 2. Both the broad river valleys in the northern section of the area and the more arid southern desert environment to the south support a wide range of plants that provide edible seeds. Grinding plates or millstones were of major importance (Fig. 6). These were slabs of sandstone that were flaked or flaked and hammer-dressed into shape and with one or more grinding grooves that extend across one or both faces and over one end (the distal end). They were used in conjunction with a smaller topstone or muller. Most grindstones show grooves indicative that wet-grinding techniques of seed preparation are being undertaken (see Lowe and Pike 1990:61-62; 95-96). Millstones that had been broken, or were so reduced to be useless, were recycled as mullers and also used as heat retention stones in some forms of cooking. Quarries of sandstone of milling quality were associated with complex mythology that reflected their economic importance. Millstones were an important item exchange in this area.

Apart from the processing of cycad fruit, mortars and pestles were put to similar uses as in Zone 1.

Cobbles or handy chunks of stone between 2-3 kilos in weight were used to outline and bruise off plates of thick bark from the red river gum (*Eucalyptus camaldulensis*) to make trays and shallow bowls. The outline of the desired artefact was pounded heavily until the sapwood was exposed. Continued pounding directed around the perimeter of the exposed sapwood and against the rim of thick bark caused it to lift away. Wedges, crudely fashioned from broken sticks, were used to lift the bark if it adhered to the sapwood too tenaciously. The back of a steel tomahawk if available is often used today instead of a stone pounder.

Figure 6. A Walmajarri woman wet grinding the seeds of the sedge (*Fimbrystlis oxystachya*), using a set of grindstones marangu/ jungari, topstone- and ngamanyan bottom stone. A small wooden tray set under the lip of the lower stone catches the milled seed slurry. Unprocessed seed is in the larger wooden dish beside her.

3. Unhafted blade and flake and core tools

Unhafted flake and blade tools were used for a variety of purposes including cutting and scraping. As mentioned above, the widespread presence of the white chert meant that there was ample material to provide cutting tools without much concern for curation or conservation. Large flakes with a suitable, even unretouched margin were used as hand adzes for fine finishing work on hardwood artefacts as well as being used more vigorously as picks or gouges to remove large quantities of material while roughing out softwood artefacts, particularly carrying bowls. Small steep-edged scrapers made the on lateral margins of thick flakes were also used unhafted as wood working tools

One specialised flake tool was a 30-60 mm long flake, 15-40 mm wide with the distal end invasively flaked to form a convex edge. These were said to be spoons (= *jururri* - Jaru language) used to eat the cooked pulp of the yam (*Ipomea costata*). I collected examples of this implement in 1977 and subsequently similar, but larger implements, have been recorded by Graham (1984: 6-7).

Heavy Flakes and discarded cores without further trimming are used to remove bark and enlarge entrances to moth larvae tunnels excavated in eucalyptus trees. Once the tunnel is exposed at its maximum circumference, a barbed twig made by stripping a forked branch is introduced into the tunnel and the larvae are 'speared' and dragged out. The larvae are eaten raw or cooked.

Specialised core tools of the type known in Australia as 'horsehoof cores' are also found in this area - these are usually single platform cores, of about 500 - 1000 g weight used as chopping or adzing tools. Multi-platformed examples do occur, however (Cooper 1943:Figs. 9-11). They are characterised by series of stacked step-fractures around the perimeter of the platform that often deeply undercut the distal sections of the core. In use the platform serves as the base of the tool and the step-flaked margin forms a steep-edged chopping and planing tool. Flenniken and White (1985:135) suggest that horsehoof cores are in fact normal producer cores showing platform preparation. I have, I think demonstrated that they are tools in their own right and that the process of deliberately creating step fractures was an edge resharpening method that reduced gross weight loss and conserved the mass of the material (Akerman 1993:125-127). Horsehoof core tools do not have a continent-wide distribution and confusion reigns, as many archaeologists cannot distinguish between horsehoof and normal pyramidal cores.

4. Hafted flake and blade tools

The most distinctive formal tool type found here are the adze-stones. Two forms are recognised.

The first, termed in Australia the burren adze, is formed when one lateral margin of a flake is embedded in resin on a wooden handle or the proximal end of a hardwood spear thrower. The cutting edge is formed by the other lateral margin which is unifacially trimmed from the ventral surface to form a steep, strong edge. Subsequent retouching with wood or stone percussors or even by tooth pressure leaves a characteristically step-fractured appearance. This is the result of using minimum force to effect flake removal in order not to dislodge the stone element from the resin-hafting medium.

The other form of adze is the tula. Tula adze flakes are made on flakes with wide and narrow striking platforms and broad and prominent bulbs of percussion. The dorsal surface of the flakes often have a deep negative scar left by the previous removal of a similar, but smaller prominently bulbed, flake immediately in front of the point of percussion of the ultimate flake. These flakes have been termed by Moore (2003:28-29) gull wing flakes. In some areas of Australia Tula adzes can be quite large (striking platforms > 75 mm for example are not uncommon on the Barkly Tableland in the Northern Territory or in northeast South Australia), but in the south Kimberley are generally no more than 25 mm wide. Platforms may be cortical, plain or faceted but are always at an extremely obtuse flaking angle (Inizan, Roche and Tixier 1992:37), often > 120°. Tula cores may be tabular pieces of stone including cobbles, or large flakes. The intention of the knapper is to produce a relatively short and wide flake in which the greater part of the flake consists of the prominent bulb.

The flake is reduced by unifacial retouch that removes all but the bulb and the striking platform into a semi-discoidal shape. Hafting is done by embedding the proximal end of the flake into resin attached either to a special wooden handle or onto the grip of a hardwood spear thrower. The tool is used either in one or both hands in either an adzing motion or as a scraper or gouge, the working edge being that opposite the striking platform and in the same plane. As with burren adzes, subsequent re-sharpening reduces the working edge, leaving a step-fractured margin on the dorsal surface of the flake. Discard occurs when it has been reduced to the point where it is no longer serviceable. Either the step fractures have stacked up until it is impossible to remove them, or the remnant stone is too narrow to remain embedded in the resin and provide a suitable working edge. These 'slugs' are characterised by the presence of the striking platform, a narrow transverse remnant of the ventral surface and the step-fractured flaking present on the dorsal surface, they are usually rhomboidal in longitudinal section. Tula slugs may be recycled by rotating the stone in the resin hafting and using the projecting corner of the platform-ventral surface junction as an engraving tool.

Tula adzes are usually associated with the working of hardwoods common to arid Australia. However, they are also used extensively to work the soft wood of the bat-wing coral tree (*Erythrina vespertilio*). In this area soft-wood coolamons or carrying vessels were used for carrying water and also for storing grain. There appears to be a correlation of those areas, where tulas have been observed ethnographically, with collection and storage of seeds and the presence of large soft-wood bowls. Shields and trays are also made from the same softwood in these areas. It is interesting to note that in some arid areas, such as the Western Deserts, where tulas occur in archaeological contexts but were not used ethnographically, that there is not the same emphasis on softwood artefacts.

Another implement that occurs in this zone and which has been associated with tula adzes in other parts of Australia, is the pirri graver (Kamminga 1985:2-25). This specialised tool is made by reducing a flake with any pronounced area of linear curvature, those that terminated in a hinge or retroflexed hinge were ideal, to leave a narrow stone implement with a smooth convex (in transverse section) base. The hinge is isolated by careful percussion flaking and hafted to a wooden handle with resin so that one end protrudes to form a gouge edge. Fluting of both hard and softwood artefacts is a common practice in arid regions, and these tools were but one of a number of engraving tools made for the purpose. Far commoner was the use of lower incisors of large and small macropods and other marsupials such as possums. These teeth with their distal ends snapped off to create a hard convex-sectioned enamel edge, were far more durable than their stone counterparts. Larger pirri-gravers with shallow arcs of lower of curvature however, produced wider and shallower flutes, than did any of the tooth gravers. Post-contact engravers were made from wire, sections of umbrella rib, and other foraged scraps of metal. Today Aboriginal artisans use commercial axes, chisels and rasps for most woodworking.

In the early historic period, late 19th–early 20th century, two specialised types of hafted knives were used in this zone. In the east, pointed macroblades of chert were resin hafted to form knives of the type generally known as *leilira*. In Central Australia, these knives are usually hafted quartzite or silcrete macro-blades. The Kimberley chert blades are generally smaller than those made of silcrete or quartzite but are used for the same purposes – fighting and ceremonial operations.

In the southern and western areas of Zone 2, a resin-hafted flake was used for ceremonial purposes. This took the form of a small flake – usually less than 40mm in length with convex lateral margins. One margin was haphazardly reduced by flaking and then covered with resin leaving the other margin exposed. Tindale (1965:131-164) describes this type of knife as used elsewhere in Western Australia, in some detail. The edges were initially used without further trimming or finely serrated by pressing against the edge of another flake. When blunt, edges were re-sharpened by unifacial flaking, by either percussion or pressure, including tooth pressure. I have seen instances where refurbishing by percussion has created a steep stepped edge rather than the acute invasively flaked and the edge has been then ground down on an electric grinding wheel, before being re-serrated with the edge of a steel pocket knife.

5 Pressure flaked spearheads

As noted above, it is in this area with a relative abundance of massive white chert caprock and outcrops that heat treatment of stone was a regular feature of lithic technology. The production of spearheads was a major industry – particularly focussed on the great ceremonial exchange cycles of the region. Most points produced appear to have been sent south and southeast into the desert, where the points were particularly sought after as ceremonial knives (Fig. 7). Tindale (1965:156) records the collection of such a point

960 km (600 miles) south of its likely place of origin. As noted earlier, large white stone points from this area were also sought after as ceremonial items in Zone 1.

Figure 7. Large Kimberley points, important ceremonial exchange items and a point hafted as knife.

One reason why these points, rather than large points made from other stone, were elevated in value may be the fact that the heat-treated, gleaming white chert with an almost nacreous lustre, resembled points made of pearl shell. Pearl shell ornaments, by the end of the 19th century were increasingly important items of ritual exchange that originated in the Zone 3 and adjacent northwestern coastal areas. Pearl shell was seen as a manifestation of both water and lightning, and consequently had close associations with the all-powerful Rainbow Serpent beings that were integral to many indigenous cosmologies (Akerman with Stanton 1994:15-17, 19-22). It has been suggested that classic Kimberley point production, in Zone 2, flourished after 1885 (Harrison forthcoming:1-28). This accords well with the expansion of the importance and use of pearl shell in the indigenous Australia (Akerman with Stanton 1994:55-63).

In Zone 2 both the Kimberley composite spear, with stone and later glass or metal tip, and simple wooden spears with plain unbarbed tips or with lashed on wooden barbs were used for hunting. Shafts for either form of spear used in this area were acquired primarily by trade. The phragmites reed, integral to the construction of the composite spear, grew in Zone 1 and the best shafts for the simple wooden spears grew primarily in the southern areas of Zone 2. Each form of spear required a different style of spear thrower. The solid wood spears were thrown with a shorter hardwood spear thrower of the desert style, often equipped with a resin hafted flaked stone adze or scraper at the proximal end.

Tindale (1985:1-33), provides detailed descriptions of pressure flaking of Kimberley points in this zone and Harrison (2002:352-377) discusses cultural factors that ensured the continuation of spearhead production in the area. Harrison sees the continued production of points of stone or glass in the pastoral era, as both a gender and a cultural identifier. Citing the continued production of points by Kimberley men incarcerated on the island prison of Rottnest, nearly 2000 km to the southwest of the Kimberley, Harrison sees pressure flaking as a skill that sets the Kimberley men apart from men of other regions. Prison production of points was also seen as a way in which artefacts, made by a few artisans, could become valuable artefacts of exchange between other Aboriginal men or their white gaolers (*ibid*:360). As recently as 1986 a glass Kimberley point of 100 mm or more could command a price in excess of A$100 among Aboriginal men in Central Australia. Large, clear glass points were seen as valuable tools used for both sorcery and rain-making in the Centre.

Lithic Zone 3

Although there was a relative abundance of flaking quality silcrete: in the form of tabular boulders or slabs of material; that occurred within the more commonly outcropping micaceous schists and sandstones of the area, the range of formal tool types was not as extensive as in the previous zones. There was little in the way of ultramafic or metamorphic rock for the production of ground-edge tools. Unbarbed, simple spears, thrown by hand alone and a range of boomerang types (including a fishing boomerang), clubs were made of hardwood. Women used hardwood digging sticks/spears for harvesting shellfish, fish and small turtles found in reef pools exposed by the fall of the 10m tides of the area. All other artefacts were made from softwood, bark or shell.

1. Ground-edged tools

As mentioned above, stone, such as basalts, dolerites etc, normally associated with the production of ground edged tools did not seem to occur in this zone. Artefacts made of these materials were imported. Locally, ground-edged tools produced locally were made of crystalline silcrete. These ranged from heavy hatchet heads to much smaller flake tools with a grinding restricted to the immediate area of the cutting edge.

Ground-edged axes and chisels similar to those produced in Zone 2 were important trade items to this area. Most wooden artefacts apart from spears, clubs and boomerangs, were made of softwood – usually that of the helicopter tree (*Gyrocarpus americanus*). Pieces of baler shell (*Melo amphora*), fashioned into ground-edged knives and adzes that were used both hafted and unhafted (Akerman, 1975:16-19) were used for much of the woodwork and also said to have been used for lighter butchering purposes. Other tools associated with woodworking were also made from shells. Drills, gouges and chisels, collectively known as *juror,* made by grinding a strong sharp edge on the anterior fasciole of *Syrinx aruensis* columellas were also made and used by the Nyul-Nyul and Bardi of the Dampierland Peninsula of Western Australia. A hatchet of baler shell, from Sunday Island, has been described by Davidson (1938:46-7) and I have also seen two ground-edge hatchet heads made from pieces of clam shell at One Arm Point on the northern end of the peninsula. Hand-adzes were also made from the short, heavy ivory upper tusks of the male dugong (Akerman n.d.:38-39).

2. Grinding and pounding stones

As with Zone 1, milling of grasses and other seeds was not of major importance, and grindstones made of shelly conglomerate and micaceous sandstones of varying grades appear to be associated with the manufacture and maintenance of stone axes and shell tools. Small (> 250 mm x 200 mm) plaques of sandstone showing narrow grinding grooves were used to hone the shell tools. Larger grindstones were also used to clean, shape and polish the large valves of the pearlshell *Pinctada maxima*, into oval ornaments which are ubiquitous to the area.

Pounding stones were used to process fruits of a wide variety of plants. Small cobbles and slabs of country rock were also used as anvil stones to open a range of gastropods that were important dietary elements and which were also used, after pounding to attract reef fish within striking distance with both spear and boomerang. Anvil stones are characterised by pocking and dimpling of one or more surfaces caused by the repeated impact endured in the crushing process - this is not unlike the anvil wear found after prolonged bipolar percussion technique of stone reduction.

3. Unhafted blade and flake tools

In this area, there are numerous exposures of silcrete of varying grades. The finest were used to produce blades and flakes that were used, unhafted, for both woodworking and butchering purposes. Apart from the initial production of the blade or flake there appears to have been little modification of edges. Secondary retouch when it does occur seems to have been limited to creating a casual backing of a blade or flake to provide a more comfortable or safer tool to work with. An analysis of a cache of blades and flakes found away from the quarry source, indicates that flakes and blades with one edge more obtuse than the other (i.e. naturally backed), were the desired form. Unilateral, unifacial retouch was used to create this condition however, if it was not present on a blade or flake with a suitable edge. One flake, in this sample that was much wider than it was long, was apparently selected because the broad striking platform area formed a suitable backing (Akerman 1976:108-116). These blades and flakes were primarily used for the butchering of dugong (*Dugong dugon*) and green turtles (*Chelonia mydas*). Both these animals have thick hides, and in the case of the latter, a tough carapace.

Smaller flakes were used as casual knives when the occasion demanded it, but broken fragments of shell were also used for these tasks.

4. Pressure flaked spearheads

Unlike other areas of the Kimberley, stone-tipped spears were not made or used on the Dampierland Peninsula. They did enter the area as exotic trade items that were passed on but not used - in fact, they were prestige goods. Stone points similarly came into this zone, and were used occasionally as ritual knives.

In the early historic period, the Catholic Church created a number of mission settlements on the Dampierland Peninsula. While some of these catered for the local indigenous population, others served also as centres to which Aboriginal people from other areas of the Kimberley (that is Zones 1 and 2) were resettled. On some sites in the sand dunes near these latter centres pressure flaked glass Kimberley points are occasionally found suggesting that at least some of the immigrant men continued to practise the art of point making in their new home.

Around the town of Broome, on the southwestern corner of the Dampierland Peninsula, glass points in various stages of manufacture are often found. Like the glass points found on Rottnest Island mentioned earlier, these too are ascribed to the activities of Aboriginal prisoners brought into the regional prison from other areas.

Akerman and Bindon (1983:76-80) report on one site in the southern area of this zone where, within a general quarry and blade workshop context, a 3m x 3m area contained 44 bifacial and unifacial points, made of local material. The points were in good condition and any damage appeared to have occurred subsequent to deposition. This feature of the general site area is interpreted as the result of a single episode of experimentation or demonstration of Kimberley point technology, within historic times.

Conclusions

In the three zones described it is clear the lithic and associated glass technology was not the same across the Kimberley (Fig. 8).

Zone 1 Has ground edged axes and associated grindstones; mortars and pestles; simple flake and blade knives and scrapers and pressure flaked Kimberley points. Apart from the hafted cortical flake tools found in the east, knives and scrapers were used unhafted.

Zone 2 Has ground-edged axes and adzes and associated grindstones; mortars and pestles and grindstones associated with the milling of seeds. As well as the casual use of flake tools, there are resin-hafted flake-adzes, hafted engravers and two forms of resin-hafted knife. Heat treatment of stone was widely practised and large Kimberley points produced specifically for ceremonial use and exchange.

Zone 3 Has ground-edged axes of local silcrete, imports axes of dolerite or other stone, associated grindstones. Mortars and pestles occur and anvil stones associated with shellfish processing. Extensive use of ground-edged, shell tools and associated grindstones. Unhafted blades and large flakes of silcrete with naturally or artificially backed margins used for heavy butchering. Kimberley points imported but not used, evidence for manufacture of these points in the historic period by visitors from other regions of the Kimberley.

We can see how in the Kimberley, three different suites of technology abut each other. Even though there is much social interaction between the three areas, including ceremonial and economic exchange systems and intermarriage, the technologies remain quite distinct. This is as much, or more, a factor of cultural identification than a reflection of environmental or economic constraints. Members of each proposed lithic or technological zone appear to be bound by certain cultural constraints from adopting technologies unique to their neighbours. Interestingly these cultural constraints are not applied even-handedly. In the past century, changes in some ceremonial activity and social organisation has occurred, as have some technological changes – the introduction of the didjeridoo from much further east, for example – without destabilising the cultural identity of any one area.

Figure 8. Some of the Kimberley, flaked stone implements referred to in the paper. L-R: silcrete blade, naturally backed at the tip, Zone 3; Top Row: quartzite blade jarung, Zone 1; above – two ground-edged adzes and pirri-graver, Zone 2; glass and quartzite spearheads showing resin hafting. Bottom Row: ground-edged axe head, Zone 1; three tula adze stones in various stages of reduction, Zone 2; large glass Kimberley point, Zone 1; prestige exchange Kimberley point of heat treated chert, Zone 2.

The opportunity to observe traditional technological minutiae, among Australia's indigenous peoples, permits a finer understanding of the complexities of hunter-gatherer responses to many of the day-to-day tasks. This includes the diverse ways in which stone tools are made and used within one small corner of the Australian continent.

Acknowledgements

My heartfelt thanks must go to Jacqui Ward of the Tasmanian Museum and Arts Gallery, who laboured to produce the map and figures tha accompany this paper. Val Hawkes, my wife, read and corrected the many drafts that emerged as the paper was written. Her criticisms were always concise and to the point, ensuring that the final draft was a better paper.

Per Falkenström

A matter of choice: social implications of raw material variability

Abstract
Many studies on lithic technology have focused on raw materials, but variability has not always been a central theme. While technological strategies bear witness to socio-economic patterns, more information can be obtained by looking at one decisive initial step before reduction: the choice of raw material. It is suggested that this choice has social connotations based on individual experience as well as on collective ideas shared by group members. In addition, this may be subordinated to an ideological community, whereupon the choice of raw materials can be valued and ritualised in different ways. Such a choice includes further social considerations that are worth examining. In order to obtain additional information about the choice of raw materials and how they are communicated in society, examples are drawn from other social disciplines with illustrations from ethnographical literature and archaeological investigations.

Introduction

Raw materials offer important information about prehistoric societies. In this article it will be stressed that certain materials are chosen and acquired within established technological traditions. This implies a dialectal relationship between individuals, groups and the materials they choose to use. It is the first step in an operational chain, and it might well be a decisive choice with regard to the technological tradition and future relations with other groups. Will the chosen material be approved within a given technological tradition? Can it be used for daily use or as prestige items in exchange? These questions are crucial in a discussion about the importance of raw materials, how they are used and valued in a social context where stone technology is a part of everyday life. In order to shed some light on this issue, the following themes will be addressed:

- Implications with regard to distance between settlements and raw material sources
- The raw material in social life on the local level
- Raw materials in exchange networks on the regional level

Concerning the choice of raw materials, an attempt is made to discuss these themes within a theoretical framework based on technological and social reproduction. The discussion will be considered partly in relation to ethnographic studies and partly to material culture as it appears on a few archaeological locations in central Scandinavia (Fig. 1).

In northern Scandinavia, diagnostic artefacts and absolute datings account for a high degree of variability, especially during the Mesolithic period, about 8000-5000 BP (Olofsson 2003:13). Less variability can be assigned to hunter-gatherer contexts in the subsequent periods, as late as about 1200 BP. However, the acquisition of different local materials should not be underestimated (Lannerbro-Norell 1987:56 p). A few decades ago, this pattern was explained from a south Scandinavian perspective, i.e. that comparatively coarse raw materials were used as substitutes for flint. Today, this view has changed and is more focused on local and regional conditions (Knutsson *et al*. 1999:106).

It must be stressed that lithic sources only encompass a limited part of the entire material culture. With this in mind, it is not possible to deal with the whole variety of societies practising stone technology. The main purpose is rather to understand how raw materials can be used and valued in the societies discussed here. Hence, by using different sources I will discuss raw materials from a social perspective. They are seen as integral parts of an operational chain, which here is used in the same way as the French concept *chaîne opératoire*.

Social perspectives on raw materials

In societies where stone technology is a part of everyday life, people are inevitably confronted with lithic materials. The significance of the stones may vary a lot, but can barely be seen as isolated in relation to the whole society and its environment. There might be traditions about the landscape, where to find valuable resources and how to use them.

Technology is thus not necessarily limited to material culture. Attempts to widen and contextualise this concept will fortunately explain technological as well as socio-economic strategies. Thus, acquisition of raw materials cannot be excluded from social organisation, division of labour or exchange networks. I see each acquisition event as a choice within a technological tradition. This would require knowledge about the technological process, about the subsequent steps of lithic production and even how to cope with possible social tensions when essential information is learned and communicated.

Certain production stages demand a high degree of individual skill, which can be attained only through practice. Although raw material quality can be estimated by experience, it can never be fully anticipated. The possibility of practising is thus governed by natural availability. Apel has shown that specialised manufacturers live in the vicinity of raw material sources. Far from the source there are reasons to expect only a few persons working with rare materials. Thus, we can expect more people taking part in lithic production where the sources were available to everyone (Apel 2001:28, 100).

With the processual archaeology many methods were launched in order to deal with ancient societies. For instance, lithic analysis has made considerable progress since the introduction of the *chaîne opératoire* concept in the 1960's. In the following decades, functionalistic approaches were challenged when both tools and debris were related to social and economic conditions. Technology was divided into collective ideas in opposition to individual practice and experience. At the end of the century, more problem oriented studies were triggered by microwear analysis and practical experiments. Later on, cognitive aspects were gradually brought into the concept of *chaîne opératoire* (Fèblot-Augustins 1999:193; Eriksen 2000:79). Nevertheless, the new perspectives are by no means unproblematic. Without an oral tradition, find contexts with formal tools, as well as production debris, still produce limited information. Besides, our interpretations are more or less biased by current paradigms and personal experience. Additional information channels are needed.

The initial stage of *chaîne opératoire* is characterised by either direct or indirect procurement strategies (Eriksen 2000:80). The former can be seen as direct contact with the natural source, including quarrying and eventual quality tests. The latter strategy has more to do with exchange or secondary use of the material.

To address the question why certain raw materials have been chosen, a number of factors can be mentioned. These are partly functional or deterministic explanations, involving the practical and economic aspects of stone procurement strategies. According to this view, certain raw materials are seen as suitable for performing certain tasks. Functional interpretations have also been given to quality in terms of flaking properties or expected use of by-products (Taffinder 1987:63). Some materials might also have been chosen due to settlement patterns or simply by local availability (Lannerbro-Norell 1987:68). Other factors have been emphasised in postprocessual research and stress the importance of rituals and social networks in connection with quarrying. Neither perspective can be ignored, but should benefit from ethnographic material and anthropological analyses. Some contributions from other social disciplines will be discussed below.

The use and meaning of rocks – two anthropological studies

The papers presented in this volume make it clear that stone technology should be studied within a framework including both practical experiments and ethnoarchaeological data. The significance of raw materials is especially pointed out in anthropological studies.

Arnhem Land and Western Desert, Australia

Tacon has studied a technological tradition in Arnhem Land, Australia. He particularly mentions the symbolic meanings of quartz and quartzite. These materials and associated rocks were regarded differently in myths and sacred rituals. Light and bright quartz was seen as a powerful symbol of life. Colour and workmanship further reinforced the link with the Ancestors. It also facilitated control of the stone source. Owning tools made from certain raw materials could even lead to increased prestige (Tacon 1991:198 p). Quartzite, on the other hand, was used for trade and ceremonial exchange of items such as spear shafts. While stone points were rare, they were popular exchange objects. The myths of quartzite was similar to that of quartz, but its power as a ready made object made it more valued (Tacon 1991:202). The myths also explain how the rocks were created and thereby reinforcing the contact with the power of Ancestral Beings that were attached to the rocks. "The Rainbow Serpent, one of the most potent of all Beings, swallowed other Ancestors and then was forced to vomit their bones, which then formed the rocky sandstone and quartzite escarpment and other geological features of the landscape." (Tacon 1991:195)

Material of distant origins is a repeated theme in the ethnographic literature. Materials used in social networks are those functionally superior to local materials. Although it is possible to increase the value of a tool through retouching, grinding etc., it is the origin of the material that is most valued or even sacred. Access to certain quarries in the Western Desert of Australia is controlled and maintained through kinship alliances. The acquisition and use can even be controlled within the group, as women are not allowed to use cryptocrystalline rocks (Taffinder 1987:64 p).

The Highlands of Papua New Guinea

Among axe making groups in Papua New Guinea, Burton emphasises the ritual behaviour at quarries. In an area at the Tuman River, several hornfels quarries are scattered along a valley. Each quarry is situated within a clan territory and is owned by its members, although many quarries are overgrown and no longer in use. The material is fine-grained hornfels that is suitable for making sharp edges. All clans at the Tuman River participated in quarrying expeditions and they did so at the same time with intervals of up to five years. However, successful making of axes was not only due to cooperation. Since quarrying was thought to be dangerous, an expedition must not be undertaken without ritual precautions. Animals that appear in myths were killed for the spirit sisters, who were thought to control the quarries. In connection with these and similar hazardous activities, men were not allowed to meet women directly. During the expedition, the men lived in enclosed camps for 3-5 months. Every day the women went to the camp and delivered food on wooden platforms. Quarrying activities were collective tasks and therefore all men involved had reasons to claim an axe. After sharing the raw material they announced that women could enter the camp, destroy it and beat their men in order to drive away the female spirits (Burton 1984:240 pp).

The quarrying organisation employed hundreds of individuals. All lived in a tribal society where large men were the most respected persons, although without real power. Their decision seems to be a consequence of collective negotiations regulated in the belief system. Personal wealth was further restricted when a certain person of each clan was appointed to distribute the axe stone and thereby expressing equality principles. After that, the raw material was regarded as private property, although it engendered individual prestige that was supposed to be transferred to the clan. Most preforms could be manufactured into comparatively small working axes, while only a few were large enough to be valued as prestige items and therefore used in competitive exchange networks between clans (Burton 1984:244).

The fact whether the quarrying was launched by economic demands, social or ritual factors can be discussed. The natural prerequisites in the valley and the location of villages next to them cannot be ignored. One might suspect a centralised society when looking at the number of participants and the amounts of stone, but on the contrary, one purpose of quarrying activities was to maintain exchange networks and prevent inequality. Rules and rituals were ways to pronounce the significance of the material, increase the worth and the exclusivity of the raw material source.

Natural sources – cultural considerations

With an archaeological perspective, what can be learned from the anthropological studies mentioned above? They can barely be compared with prehistoric societies concerning different sorts of geological deposits. Neither is the anthropological situation convenient to enlighten general prehistoric conditions. However, they show how raw materials can be used in mythology, social structure and ritual behaviour. The studies underscore that it is important to consider raw materials in a wider cultural context.

A techno-economic perspective is well represented in studies dealing with material remains, for instance raw materials, and how they are distributed in the landscape. The distribution of raw materials has been used to discern mobility patterns among Lower and Middle Palaeolithic populations in Europe. While most materials were acquired within five kilometres from the occupation sites, very small quantities were acquired outside that zone. They do not only reflect mobility patterns. The procurement strategy is also seen as a cultural norm with assumed social interaction between different regions (Fèblot-Augustins 1999:208).

Surveys in Brittany in France show that only large flakes of local materials are left at the quarries and the cores are apparently taken away. This pattern has been interpreted as specialised quarry sites in contrast to settlements where flakes of all sizes have been found. The quarries were situated on suitable locations with regard to migration routes of Mesolithic populations. In this case, the raw material quality was of secondary importance (Yven 2004:729 pp).

Quarrying activities can be undertaken either at large outcrops in the ground or in tiny veins embedded in boulders. It would thus be helpful if prehistoric quarries can be found and be related to the distribution of each material respectively. Unfortunately, such comparisons are quite rare due to isostatic uplift, natural erosion and recent vegetation that prevent visibility of already extracted dykes and outcrops. In other cases, hornfels quarries are no longer detectable because of chemical erosion (Berg 2003:285). Apparently, some quarries do not show any traces of use or only of temporary use, while other quarries have been used intensively. General trends can be observed over time but the lack of secured, contemporary events at quarries makes it difficult to estimate the time or social organisation needed to form the archaeological assemblages. Hence, more social factors should be considered to understand how raw materials are used in different societies.

Although quarries often imply good quality, the locations are outnumbered by occasional, usually low quality, moraine deposits. The latter source has been devoted less research in archaeology, especially as similar collecting activities are difficult to assess only from material culture. However, some results on this problematic issue have been presented. In northern Finland it has been suggested that glacial quartz deposits have been collected from stone fields. Along with other activities, although not necessarily contemporary, the quartz was stored and even prepared on the spot (Alakärppä *et al.* 1997:13). It is difficult enough to relate certain raw materials to specific quarries. The possibilities of localising moraine deposits would be even more limited. It has already been discussed how raw materials can be valued in relation to quarries and social events. With Tacon's study in mind, is it possible to think of symbolic meanings concerning acquired materials from moraine deposits?

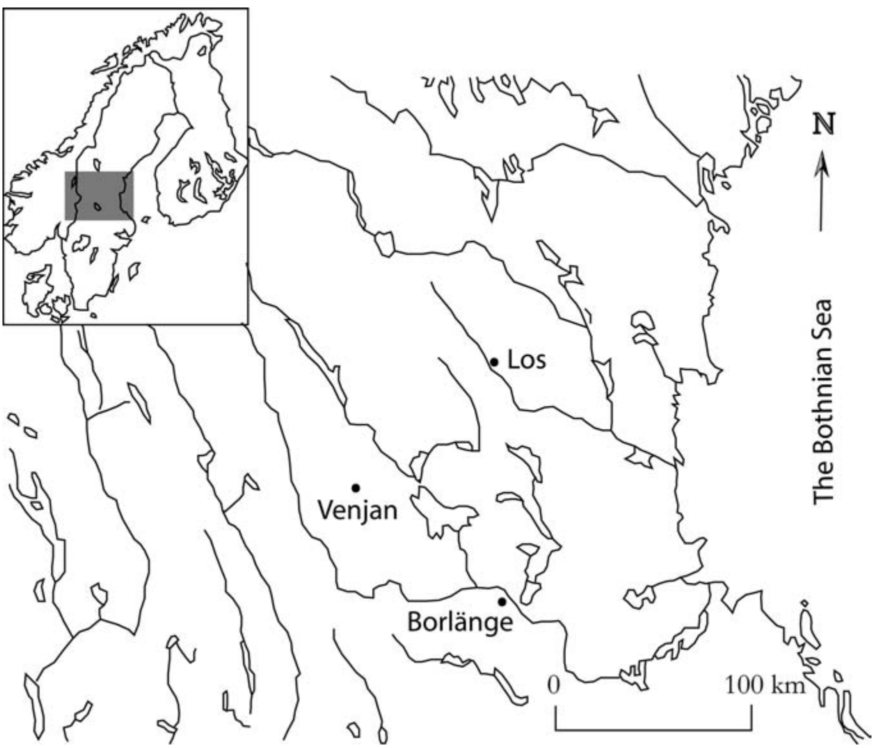


Fig. 1. Area under study with locations mentioned in the text.

Raw materials and their social context have been highlighted in a few studies dealing with axe production in Neolithic societies of central Sweden, just south of the study area in this paper (Fig. 1). In the mid 1990s, several locations were excavated, a few of which proved to be contemporary Early Neolithic settlements. A petrographic analysis of porphyrite materials resulted in three raw material groups. Although no natural source could be found, each group corresponded to separate settlements. The results have been interpreted as that each settlement was a household unit in control of raw material acquisition as well as production and use of thin-butted porphyrite axes (Sundström & Apel 2001:334).

Unless the porphyrite was distributed outside the settlements it might be a valuable local resource. When looking at the technological strategy as a whole, it seems as though different reduction methods have been applied to different sorts of raw materials. Changing reduction methods further reflect choices that are dependent on availability, hardness of the material and skill of the knapper (Eriksen 2000:86). This pattern is also what could be expected in an egalitarian society (Sundström & Apel 2001:332). If by egalitarian structures we mean absence of personal wealth, there will be ways to acquire personal prestige through exchange networks. Nevertheless, the egalitarian system is maintained as long as the prestige is transferred to the whole group. By comparison, how are raw materials used and valued in the Late Neolithic, a period during which more inequality structures can be expected?

Lekberg has shown that long and angular Late Neolithic axes were extracted from quarries, while shorter axes were derived from rounded moraine deposits. Both types have been used as working axes, but the appearance and length of the object, as well as the raw material source, might be signals of social prestige acquired by the owner (Lekberg 2002:198 p). In general, it seems that extraction from quarries is more time consuming than finding raw materials in moraine deposits. The latter is often used for functional purposes and has little social significance. Raw materials from quarries, on the other hand, are more associated with personal status and prestige objects. Somehow, we can expect that the artefact value changes in an exchange system. In line with this argument, even moraine deposits might have symbolic meanings. For similar reasons, the raw material value may change in different stages of the operational chain.

In egalitarian societies it is reasonable to think of talented members who collect appropriate materials for intentional production and use, possibly even to establish or maintain social networks. By providing other groups with raw materials, objects and new ideas, it is more likely that social networks are maintained. The situation is somewhat different in a society with more accentuated social structures, where specialists have to be provided by other group members. Within such a redistribution system it is likely that technological knowledge is maintained within the family unit (Apel 2001:100).

As in Burton's study, the axes might be valued differently in the Late Neolithic society. These values are communicated between group members as they might reflect competition and control over raw material sources and those who produced the axes. It is possible that certain individuals or social groups benefited from the use of raw materials and the products. If raw materials contributed to influential positions in exchange networks, preforms, ready made objects or secondary modifications should also be connected with certain values. The function and value could be estimated already at the source. Ideas and activities that were carried out at the sources could thus be seen as integral parts of the natural disposition of resources, social structures and the belief system in society.

Local investigations – regional implications

Just to the north of central Sweden, the landscape relief is more accentuated in contrast to the plain terrain in the south. With smooth hills, lakes and river valleys the climate and vegetation of the area is more reminiscent of northern Sweden. This is also characteristic for the province of Dalarna in the interior. Even the cultural history has seen different research traditions. While certain areas are well known through excavations, the prehistory of Dalarna is known almost exclusively by surveys of vast areas.

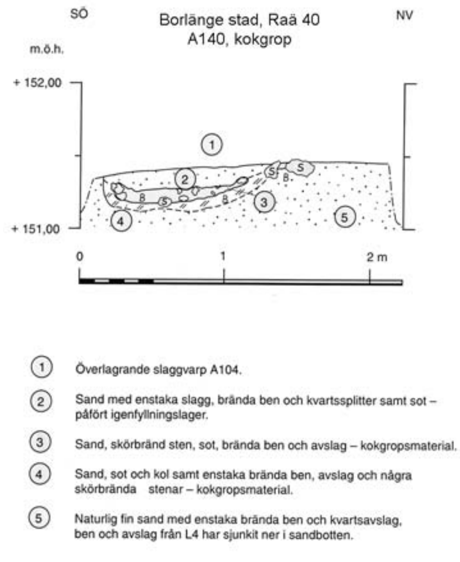


Figure 2. A Mesolithic cooking pit at Tjärna, Borlänge. Digitalisation by Christoffer Samuelsson.

Similar to in southern Norway, there is a decreasing raw material variety at the end of the Mesolithic. Berg has interpreted this pattern as that there was much experimentation with local materials during most of the Mesolithic (Berg 2003:286). How can we explain this strategy? Conical microblade cores are among the oldest known artefacts from this region, dating back to at least 8000 BP (Olofsson 2003:77). They were made of a wide variety of materials. It is possible that the choice of material had more to do with a mobile settlement pattern than with experimentation. Since few investigations have taken place it is difficult to assess migration routes and exchange networks, as well as changing patterns of raw material procurement.

However, one exception deserves special attention. In 1998 a Late Iron Age settlement was excavated in the town of Borlänge in the province of Dalarna. The site contained a cooking pit with fire-cracked stones, lithic debitage and bones of moose (Fig. 2). Apparently the pit did not belong to the Iron Age settlement but was of an earlier date. It contained flakes of quartz, porphyry and silicified tuff. These materials were chosen for production of microblades. The ^{14}C-analysis confirmed that the cooking pit was from the Mesolithic, dated to about 7960±35 BP, and that it probably was part of a temporary hunting stand (Sandberg in press). All the flakes and cores found in the cooking pit were apparently deposited at the same time. They also indicated that at least three different materials were brought to the site and that both bipolar and microblade production were used simultaneously (Fig. 3).

Material	*Core*	*Microblade*	*Flake*
Quartz	5	-	249
Porphyry	2	2	17
Silicified tuff	-	-	8

Figure 3. Distribution of raw materials and number of artefacts in the cooking pit at Tjärna, Borlänge.

While awaiting more data from this district, distribution patterns of other materials must be relied on. Flint was imported into the area, partly from southern Scandinavia and partly from the west coast of Sweden and Norway. Local materials such as jasper and silicified tuff share equivalent characteristics and were probably highly appreciated due to their quality and colour. It is possible that these materials were regarded as prestige symbols. For groups living far from the sources, in particular, these and similar materials might be valuable resources reserved for manufacturing by persons with enough skill and knowledge.

In Los parish, surveys have yielded large amounts of lithic artefacts, mainly in hunter-gatherer contexts. In addition to jasper, flint and silicified tuff, locally available quartz and porphyries dominate the record. A research project at Fågelsjö in Los parish was carried out on two sites: Kvarnbacken, site I, and Sandnäsudden, site II. Surveys in the area indicate several occupations since the Mesolithic period. The sites comprise about 6000 m^2 each and dealing with diagnostic artefacts both sites have been reoccupied. Though not totally investigated they could be delimited and the artefacts were thought to be representative for the investigated areas based on a system of squares that were excavated on regular intervals. The idea is that collected artefacts reflect the same proportions that were deposited in prehistoric times. As a result, distribution patterns on these sites show that locally available quartz and porphyry rocks were brought to the sites to be reworked and used there. On the other hand, rare materials like flint, jasper and silicified tuff were found only as fragments and in small numbers (Fig. 4).

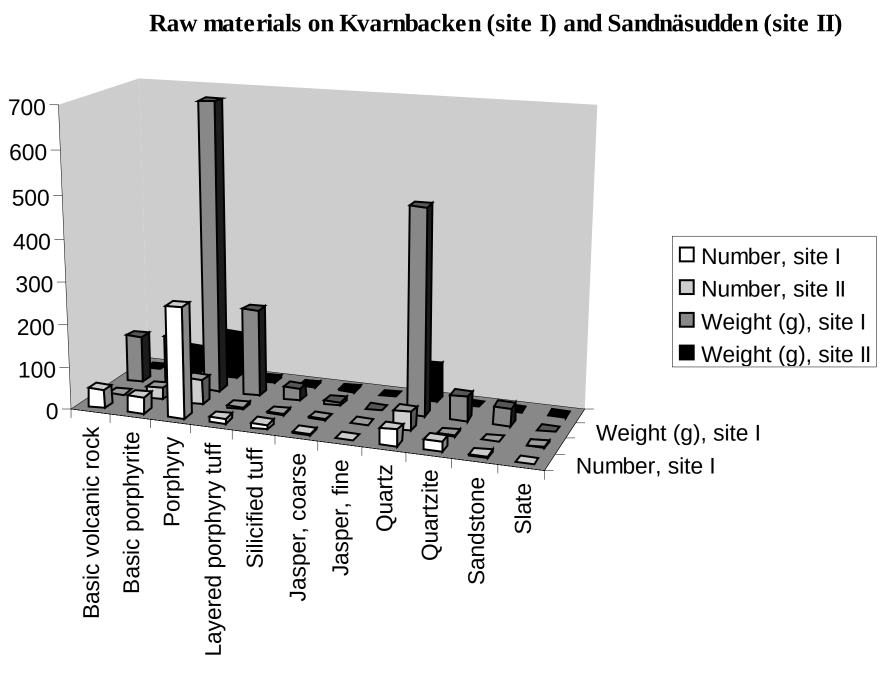


Figure 4. Distribution of raw materials on two sites at Fågelsjön, Los parish. The calculations are based on artefact number and weight. Splinters are not included.

The fragmentation and numbers of finegrained materials probably reflect recycling of at least jasper and silicified tuff, maybe used for social purposes such as kinship and alliance negotiations. This would explain the raw material proportions on site II. Perhaps they were regarded as valuable items in exchange networks. Site I differs in this respect, especially if we consider the domination of porphyry and quartz. These were exclusively local material and quite easily acquired. This site reflects a rather different lithic strategy with raw materials that were chosen to fit local and more functional purposes. Perhaps the choice and use of these materials had some significance for those who visited the site, for instance as a way to express group identity (Falkenström & Lindberg in press).

Experimentation with different materials might be a regular strategy in the Mesolithic, but this behaviour did not come to an end in the Neolithic. Foraging groups showed similar subsistence patterns throughout the Neolithic and the Bronze Age. At the same time, technological and social changes can be observed in northern Sweden by studying bifacial points or daggers made of certain local raw materials, apparently inspired by south Scandinavian flint technology. These have been chosen from quartzitic and porphyry rocks. Other rocks were preferably used for production of knives, scrapers, line sinkers etc. The distribution can thus be followed in close connection to rock sources (Lannerbro-Norell 1987:22).

Knowledge of each rock was required due to different composition and characteristical attributes of the materials. One sort of red and fine-grained quartzite, in particular, available in the Venjan parish, was used to make bifacial points or daggers. Many preforms of this material have been found and indicate that the final products were distributed hundreds of kilometres from the source, perhaps as a part of well-established exchange networks. Corresponding points of volcanic materials are very rare. Only small points have been found, probably because volcanic rocks show cracks and are almost exclusively available as moraine deposits (Lannerbro-Norell 1987:33 pp). Although geological classifications may be helpful to the analysis, petrographic determinations may influence archaeological interpretations. Some rocks are very rare and not always recognised in the landscape. These are described according to mineral composition and current geological processes. As a consequence, it is a challenge to cope with both archaeological and petrographical classifications.

While bifacial technique has been applied to quartzite, slate points have usually been sawed. By using this method, slate points have probably been easier to make, although more time-consuming. This does not necessarily mean that slate was made by everyone. On the contrary, slate from certain sources and of certain colours and texture might have been chosen for other than functional reasons.

The increased use of quartzitic silt stone and slate in the Neolithic and Bronze Age contexts of northern Sweden indicate changing social relations as well as an accentuated degree of territorial consciousness. The raw material sources could thus be seen as places with restricted access. It could have special meaning to those who used it; perhaps they controlled the quarry. Nevertheless, I see the choice of raw materials mainly as collective expressions of group identity, sharing similar ideas of how raw materials have been chosen, extracted, used, re-used and discarded. Different materials have also been produced, consumed and exchanged within and between groups.

Conclusion

To conclude, if raw material sources can be found they offer many perspectives on technology, social organisation and landscape perceptions. Doing so, we have to apply local perspectives in order to understand social reproduction on certain sites. Use contexts of raw materials involve knowledge, skill, rituals, value, exchange *etc.* The factors are interconnected and should partly explain why certain raw materials have been chosen. Furthermore, common and locally available raw materials are used in an interactive dialogue between people and their environment.

The ethnoarchaeological dimension is inevitably connected with a number of methodological problems. Although ethnographic sources are biased in many respects, the information can be used to raise new questions and lead to alternative interpretations. The social perspective in association with exchange and ritual performance are seen as important issues in this respect.

In general, during the Mesolithic and Early Neolithic, the use of raw materials fit well into egalitarian structures. By the end of the Neolithic, distribution patterns show restricted use with attempts to control resources. This would also have consequences on social networks with renegotiations of kinship, alliances, exchange networks, etc. It is possible that some individuals were specialised manufacturers who distributed ready-made products. This might lead to increased prestige and social stratification within local communities. The raw material is thus an important aspect of an operational chain and technological traditions. It plays an active role among people and being so, the life of raw materials is simply a matter of choice.

Apel, J. & Knutsson, K., 2006. Skilled Production and Social Reproduction. SAU Stone Studies 2. Uppsala.

Per Lekberg

Ground stone hammer axes in Sweden: production, life cycles and value perspectives, c. 2350–1700 cal. BC.

Abstract
My studies of stone hammer axes from the Swedish Late Neolithic (c. 2350-1700 cal BC) have shown two categories; shorter axes with rounded sections produced through the pounding of natural cobbles from beaches or riverbeds, and longer axes with square sections, produced by the flaking of quarried stone. The difference in accessibility and controllability of both raw material and technology between these categories makes it possible to understand the simple shaft-hole axe distribution – and thus the contexts of the previous studies and clusters of such contexts – from a value or wealth perspective. The accumulation of such value or wealth could then be contrasted against consumption and deposition habits, and studied with the aim to understand the contexts, their topographical setting, and thus create a social topography of the landscape.

Introduction

The social organization of society of eastern central Sweden in this period of time can be studied in the contextual formation of the landscape and the accumulation of wealth, as is displayed in the dispersal of finds and monuments that in Swedish research tradition are called Late Neolithic. As I will touch upon towards the end of the paper, research would benefit from harmonising with European Bronze Age studies, thus considering the period as the Earliest Bronze age of Scandinavia. In fact, that is what I will call it throughout this paper. The archaeological understanding of the period has long been difficult for archaeologists, owing to a relative lack of research in and beyond the field, and self-inflicted academic isolation. This has limited the interpretative potential of the few scattered excavations that have been conducted by leaving them with little or no conceptual framework. Consequently, archaeological studies on this period have suffered from a relative lack of source material and a fragmentary, sporadically mapped cultural landscape, making it hard to get a grip on the period and to extract some knowledge from its remains. In this unclear situation, however, a few archaeological materials are potential sources for fruitful research. One of them, and maybe the largest in numbers, consists of ground stone hammer axes, or so-called simple shafthole-axes, defined with Scandinavian archaeological terminology.

An abundance of these stone axes has appeared as stray finds in ploughed soil all over Scandinavia. The idea of this study is that they possibly represent a former cultural landscape of graves, votive sites and settlement sites, decayed through millennia and finally rendered invisible by the plough. If contextualized once again, the axes might unveil this hidden cultural landscape and thus open it to research. In Norway and Sweden alone, the hammer axes number in the tens of thousands (Östmo 1977). The provinces of Østfold in south-eastern Norway, Dalsland, Västergötland in western central Sweden and the Mälar valley area in eastern central Sweden are the node of the Scandinavian distribution. Following this, the predominant view of researchers during the second half of the last century has been that the axes are Scandinavian artefacts. Only a very few archaeologists (for example Hagen 1954) have considered the fact that they have a pan-European contemporary Bronze Age distribution from the Aegean via the Balkans, the Black Sea steppes, Bulgaria and Belorussia up to Scandinavia. Many researchers of latter decades have come to the conclusion that however abundant in numbers, the hammer axes are too poor in typological elements to make a study worth while. Despite this, the hammer axes have been considered and studied during the last century as one of the key artefacts of the Earliest Bronze Age of Scandinavia. The studies have mainly concentrated on typology for the sake of chronology, an approach that has opened up few paths towards a conceptual framework of society and cultural landscape that could be archaeologically fruitful in discussing the social and political structures of the Earliest Bronze Age. In 1957, when Mårten Stenberger stated that research on the hammer axes was an important task for further understanding of the Earliest Bronze Age, researchers had already been trying to get some sense out of these perforated stones for almost a century.

My interest in Earliest Bronze Age society, its social structure and its political organisation led me to reconsider this mass material. As mentioned above, I assumed that the axes represented a structured use of the landscape and thus that they might prove vital in understanding this cultural landscape and the society behind it. Consequently, I found it necessary to adopt a different perspective on the study of the axes. This perspective included production, consumption and deposition studies, together with the contextualization of stray finds, aiming at understanding the furnishing and social topography of the landscape. This social topography and the society that it mirrors is understood and described mainly from a Marxist theoretical standpoint as one of institutionalised inequality and accumulation of wealth. An insertion of this society in its chronological, cultural and geographical surroundings in Europe and western Asia indicates interesting results. The diffusion of ideas, knowledge, styles and material culture has been conducted within and between elite groups with vast contact networks.

Studies of production, consumption and deposition

Background and ideas

In trying to bring about a contextualization of the axes, and thus the unveiling of the hidden cultural landscape of Earliest Bronze Age central Sweden, the main idea is the following:

If different contexts of deposition – graves, hoards, settlement sites – can be connected with regular, describable and cognitively understandable morphological differences in the hammer axes, it should be possible to create an analytical link between morphology and context that reflects prehistoric choices in the acts of deposition. Such a link makes it possible to discuss the reason for these choices, i.e. the norms for dealing with material objects, and thus it creates an opening for studying the society. Furthermore, the analytical link between morphology and context makes it possible to see and study the sum of these contexts, the cultural landscape, by mapping the different contextual types. This requires recontextualisation of stray finds by morphology. This in turn demands that we establish stray finds as objects that have once been deposited in contexts according to norms of deposition, but which later on have been robbed of their context by the plough.

As I mentioned previously, more than one researcher over the years has considered the morphology of these axes as poor in typological elements. One might say that their morphology could be viewed as homogeneous in its heterogeneity. By this, I mean that the material as a whole has been homogeneous enough to motivate the classification of the axes into a single category, based upon morphological likeness. However, the material has been considered sufficiently heterogeneous and poor in typological elements to reject most attempts at meaningful typological differentiation. In my view, this is largely a problem of perspective. If one regards all apparently intact axes as newly manufactured, it is understandable that a possibly inherent differentiation of the material may remain invisible. Instead, I have chosen to view the relatively irregular dissimilarities in shape mainly as the results of the deposition of axes in different stages of consumption, and thus taken the biography of the objects into account in the archaeological analyses (Kopytoff 1986:64ff). As mentioned previously, I thought it possible that an analytical link between morphology and context could enable a discussion about the norms for deposition and other dealing with material objects, thus facilitating a study of the society. Kopytoff's anthropologically well founded theoretical discussion about the change in meaning and value in the biography of an object makes it evident that such an approach can deepen the analyses of the socio-economic structure imbedded in the cultural landscape.

Lives and lengths of axes

Schematically, I argue that most axes were originally manufactured in relatively large sizes – about 20-35 cm. The raw material was mined in suitable dikes, probably situated not far from the place of production, or picked up as cobble blanks as suggested by Fenton (1984) for the Scottish material of similar axes. The technology applied in the production of the axes seems to have varied a great deal, depending on the nature of the raw material, and I will return to this more extensively below.

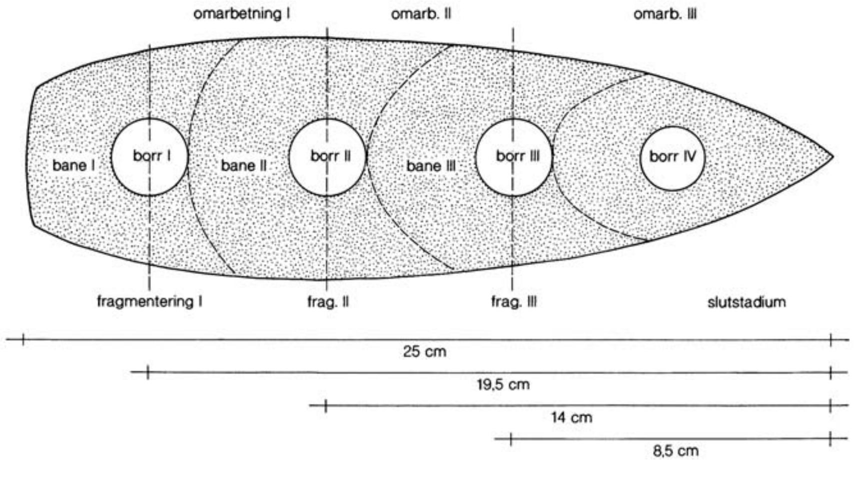


Figure 1. Principal drawing of revision phases ("lives") of an originally 25 cm long hammer axe. The straight dashed lines represent fractures by the shaft holes, the bow-shaped dashed lines represent revisions to create new axeheads. Drawing by: Alicja Grenberger.

If put to practical use, the originally long axe was then consumed in sequences (Fig. 1), any of which can be described as follows. After breaking in two across the shaft-hole, the edge part of the axe was reworked into a new axe by drilling a new shaft-hole and creating a new butt by knapping and/or pecking (Fig. 2). In most cases, the creation of a new butt completely annihilated the remnants of the old shaft-hole. Sometimes, though, it can be seen as a small, polished, vertical groove in the butt end and/or as a heart-shaped butt end on an axe that otherwise, to all intents and purposes, looks quite new. The sides of the axe were sometimes also reworked, in order to retain the proportions of the axe. This means that in many cases, all traces of reworking have been extinguished from the reworked axe, so that it in fact looks like a newly manufactured axe. Repeated polishing of the edge is also a kind of consumption that slowly shortens the axe, thereby affecting the number of possible re-workings.

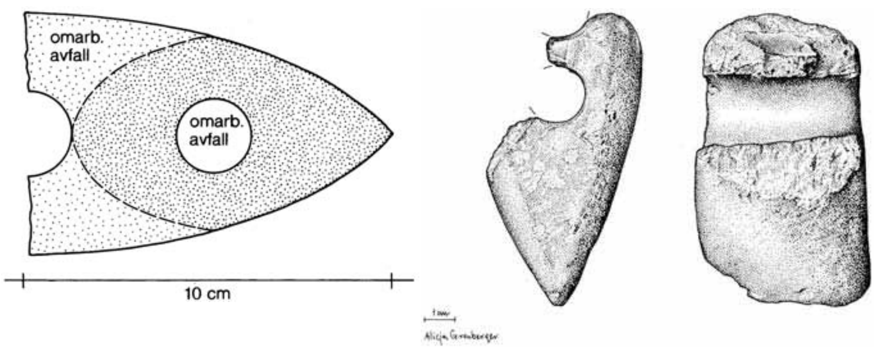


Figure 2. (a) Principal drawing of a visibly revised edge half of a hammer axe. The dashed line represents a revision to create a new axehead. Drawing by: Alicja Grenberger. (b) Revised edge half of a hammer axe from the settlement site Lugnet, Österuda parish, Uppland, central Sweden. Drawing by Alicja Grenberger

At some point in the series of lives of an axe, it was taken out of practical use and deposited, almost always intentionally and as a result of norms of axe deposition - in one context or another. With reference to the principles presented above, axes could be deposited at any stage of consumption, consequently being of varying fragmentation statuses and lengths when placed in the depositional context, and thus also when found in our time. This is, I think, the most plausible explanation of the morphological variation seen in the archaeological record of these axes. Indeed it is also a prerequisite for this study.

As mentioned above, the hypothesis of consumption sequences or "lives" of hammer axes renders possible a discussion of the use value contra function in the depositional context and thus about the standards and norms of the depositing society. Also, a contextually based differentiation in the distribution of finds can be viewed as the result of prehistoric choices depending on cultural standards in the depositing society. The varied picture of the stray finds in our museum assemblages is the result of the bringing together of objects with different contextual origins, removed from their original depositional contexts, most often by ploughing, and thus this contextual differentiation is hidden.

For example, let us for a moment consider the lengths of hammer axes. The length variation in the material is, in my view, a result of the fact that axes were deposited in different stages of consumption. The question is, then, whether these depositions took place (a) randomly, without being influenced by judgements about the length of the axe, or (b) under the influence of a set of cultural rules or standards, stipulating *what* could be deposited *where*?

If alternative (a) is the right one, it is required that the length distribution within a large-enough group of hammer axes from any given, Earliest Bronze Age, archaeological context category – graves, settlement sites, hoards or whatever – must cohere with the length distribution of the stray finds in the museum collection. Furthermore, there should not be any obvious differences in length distribution between axe-groups from different contexts, if large-enough materials have been studied.

The prerequisite, on the other hand, for establishing alternative (b) as the right one is that the length distributions of axes from different contexts should not be coherent, either in comparison with each other, or with the length distribution of the stray finds in the museum assemblage.

If it is possible to show a contextual differentiation in the simple shaft-hole-axe material, implying that the deposition was guided by cultural standards, it may be stated that:

1. The axe length (stage of consumption) was an important factor in the prehistoric choice of depositional context for the axe, and therefore

2. The axe length (stage of consumption) might be used as a differentiating tool in attempting to form contextual hypotheses for distributions of stray finds.

My first aim may then be expressed as follows. By investigating qualitative similarities and differences between axe groups from different contexts, I will try to establish the contextually based differentiation of stray finds, i. e. finds torn out of their depositional contexts. The aim of this is to understand the patterns of production, consumption and deposition of the hammer axes and thus to create a tool for forming hypotheses about the organisation of the Earliest Bronze Age cultural landscape.

Context studies

I have conducted three studies of context populations, treating axes found in graves, axes found in hoard contexts and axes found on settlement sites. First, 55 hammer axes found in Earliest Bronze Age graves in Sweden (Segerberg 1974, 1978) were compared with 923 axes (stray finds) from the central Swedish province of Uppland. The purpose of the study was to decide whether the distributions of sets of qualitative variables in the two materials deviated from or cohered with one another and to draw preliminary conclusions about the fruitfulness of pursuing this path of investigation. The result was positive, since distinct differences were noted between the two distributions. After this, the 55 grave-context axes were compared with 53 axes from hoards or votive contexts in the southern Swedish province of Scania (Karsten 1994).

Finally, the grave and hoard finds were compared with 58 axes and drill cores found in excavated settlement sites from all over Sweden. The variables under discussion when comparing axes were the axe length and the damage to the axes. A prerequisite for the study was the presumption that all damage, at least on the context-affiliated axes, was inflicted before deposition. In order to compare the lengths of the axes, it has been necessary to include only axes that are not obviously damaged in a way that has affected their lengths. Axe length is to be understood as the distance, measured in centimetres, between the butt and the cutting edge of the axe. Forty-nine of the 53 axes from hoard contexts that meet this requirement have a length span of 9.7 cm to 30 cm, with a medium span of 17.9 cm. For 33 of the 55 axes from grave contexts, these figures are 7.8 cm to 16.4 cm, with a medium length of 11.2 cm.

It should be noted that the finds from both the hoard and the grave contexts tend to differ in length distribution, not only from each other but also in comparison with the stray finds. Furthermore, the grave context axes seem to be concentrated around the shorter intervals, while the hoard axes, on the other hand, have their pivot of distribution in the longer intervals. The really *short axes (shorter than 9 cm) are lacking in the hoard contexts, whilst the grave contexts lack really long axes (longer than 17 cm)*. Moreover, ten of the undamaged axes from hoard contexts (20%) are axe preforms, while these objects are totally lacking in the grave contexts. There are 27 axe preforms, or about 8% of the total of 358 undamaged axes in the stray axes from Uppland. The term "preform" is used here to define an incomplete axe that can be identified as an Earliest Bronze Age hammer axe from its general shape but lacks, for instance, a drilled-through shaft-hole. Only nine (17%) of the 53 axes from hoard contexts are damaged, while 22 (40%) of the 55 axes from graves are damaged.

On the studied settlement sites, *there are no undamaged axes*, only fragments and preforms (Figs. 3, 4 and 5). There are altogether six preforms in the settlement site material, and five of these come from one and the same excavation. Most of these preforms are comparatively short.

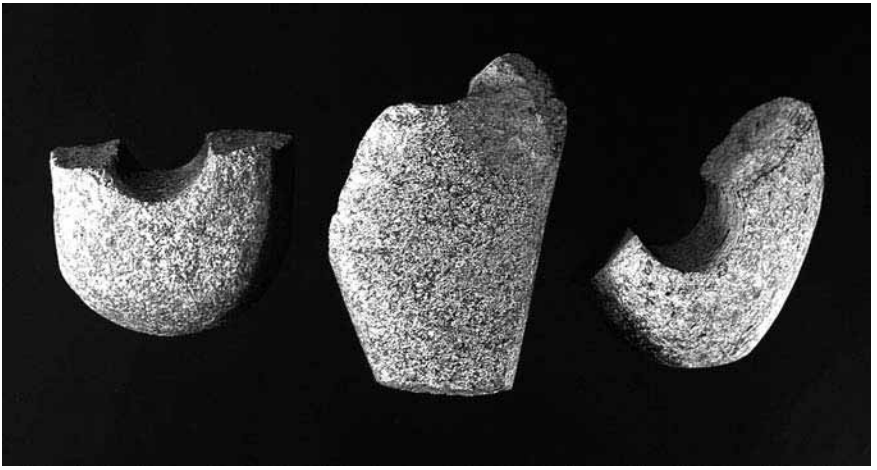


Figure 3. Typical finds from settlement sites. Photo of fragmentary hammer axes from the settlement site Gröndal, Lunda and Husby-Ärlinghundra parishes, Uppland, central Sweden. With the courtesy of RAÄ/Uv Mitt.

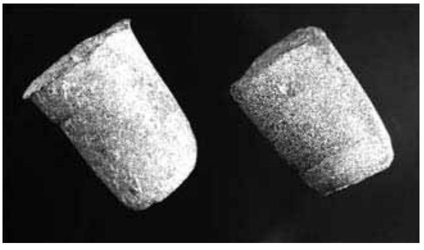


Figure 4. Photo of drill cores – results of the process of shaft-hole drilling with a pipe drill - from the settlement site Gröndal, Lunda and Husby-Ärlinghundra parishes, Uppland, central Sweden. With the courtesy of RAÄ/Uv Mitt.

Figure 5. Photo of cobble axe preform, left before completion of the shaft-hole drilling, from the settlement site Gröndal, Lunda and Husby-Ärlinghundra parishes, Uppland, central Sweden. With the courtesy of RAÄ/Uv Mitt.

In my view, the results presented above clearly show that there is a contextually explainable differentiation in length and quality, inherent in the simple shaft-hole-axe material. Comparisons of the distribution of length and fragmentation categories between the two analytical categories of stray found axes and context-found axes show that they most likely represent the same structures of action, i.e. the formation processes for the two population are so similar it is hard to distinguish between them (Fig. 6a-b). However, when dissimilating the context-found axes into context categories, this likeness disappears. Instead, the distribution shows a clear, context-dependant morphological differentiation between the axes from graves, hoards and settlement sites (tab. 1; Fig. 7 and 8).

Table 1a. Distribution within different consumption-phase categories of all context-found axes.

	Intact	Fragments	Preforms	Sum
Settlements	0	54	6	60
Graves	45	9	0	54
Hoards	35	2	10	47
Sum	80	65	16	161

Table 1b. Distribution in percentage within consumption-phase categories of all context-found axes.

	Intact	Fragments	Preforms	Sum
Settlements		90%	10%	100%
Graves	83%	17%		100%
Hoards	74%	5%	21%	100%
Sum	50%	40%	10%	100%

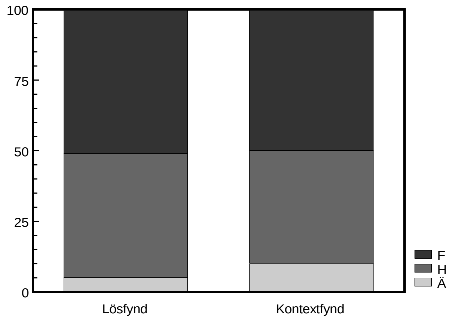


Figure 6a. Distribution into fragmentation categories of 1359 stray-found hammer axes from central Sweden (to the left; "lösfynd") and 167 context-found hammer axes from southern and central Sweden (to the right:"kontextfynd").

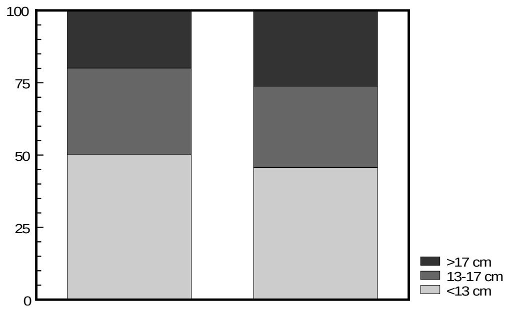


Figure 6b. Distribution into length categories of 645 stray-found undamaged hammer axes from central Sweden (to the left:"lösfynd Up/Sö/Nä") and the context-found undamaged hammer axes from southern and central Sweden (to the right:"kontextfynd").

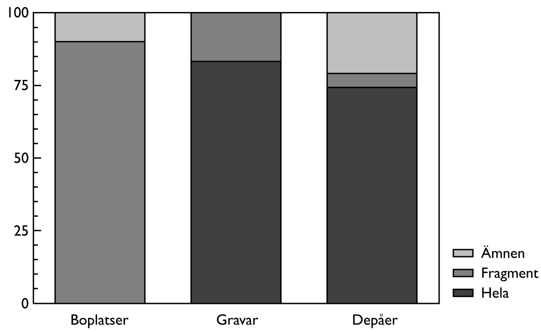


Figure 7. Distribution in percentage of fragments ("fragment"), undamaged ("hela") and blanks ("ämnen") within context categories ("boplatser"=settlement sites, "gravar"=graves, "depåer"=hoards) of all context-found axes.

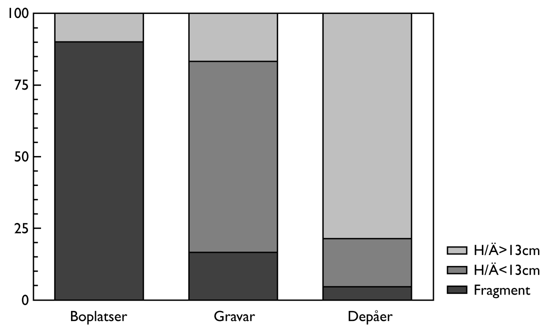


Figure 8. Distribution in percentage of fragments ("fragment"), short undamaged axes/blanks ("H/Ä<13cm") and long undamaged axes/blanks ("H/Ä>13cm") within context categories ("boplatser"=settlement sites, "gravar"=graves, "depåer"=hoards) of all context found axes.

Thus, it is likely that Earliest Bronze Age Scandinavians were guided by norms delimiting the size and shape of axes suitable for deposition in different contexts. Recalling what I previously stated about the use-lives, consumption and functional value of axes (see above), it may be reasonable to regard grave-axes as having been deposited in their last life, most hoard-axes in or before their first life and settlement axes mostly after their use-lives. In a perspective of potential practical use-value, hoard-axes may be viewed as more valuable objects than grave-axes. Furthermore, it is reasonable to conclude that the results show a tendency that can be used in forming contextual hypotheses for stray finds, namely that over-17-cm-long axes and axe preforms represent hoard contexts, whilst axes shorter than 13 cm commonly represent graves, and axe fragments and short preforms represent settlement sites. Simple studies of morphological variation in context-attributed axes have hence been the basis for creating something that can be called a contextual typology. This tool for contextualization has enabled the transformation of locations of stray finds into hypothetical places for depositional contexts, thus making a contextual furnishing of the landscape possible.

Production, value and wealth

The studies related above have dealt with the morphology as a product of choices and norms related to depositions of different kinds. However, the results of these studies have limited potential for analyses of the accumulation of wealth, and thus for aiding in the discussion of economic and political power (Earle 1997), if no acceptable line of argumentation can link different shapes of axes or even different kinds of contexts with higher or lower value in any evident way. Aiming at such a line of argumentation, and as a result of observing indications of different modes of production, I have focused on the production of hammer axes.

An observation of production differences in the material, where some axes had obviously been produced by flaking technique, while others showed no signs of this, gave rise to the question if different kinds of raw material are more or less suited for the one or the other mode of production. An analysis of the raw material of a large number of hammer axes from four provinces in central Sweden showed, not surprisingly, that most of them were made of diabase (Kresten 1998). This kind of rock has been sought for and used in different cultures around the world for axe making (Olausson 1983; Bruen Olsen & Alsaker 1984; McBryde 1984; Pitts 1996; Le Roux 1998). Consequently, no direct analytical ties could be established between signs of the mode of production, nor any difference as to what kind of rock to choose as raw material for the axe.

Instead I looked more closely at the relationship between the production technology, the different sources of raw material and the cross-section of the finished object. Fenton (1984:218), and partly also Olausson (1983:18), believes in secondary provenience for the raw material of most ground stone axes, considering that cobbles and loose rocks are relatively easy to obtain. This view has also dominated French research, but Pierre Petrequin and his colleagues sees this explanation as being too simple (Petrequin *et al.* 1998:282). Their fieldwork in Irian Jaya has shown that only axes not meant to be objects of value were made of cobbles. The reasons are said to be that cobbles from riverbeds etc. often were too dry for being suitable for knapping, and also that not enough raw material for an economically acceptable quality production could quickly be obtained. This division of the axe production – into household production and the making of valuables – is thus in Irian Jaya connected with a diversified procurement and use of raw materials. In the household production, preforms have been made out of small or medium-size cobble blanks with simple-to-learn technology. The production of the large, valuable axes requires, on the other hand, often mining of outcrops or regular dikes and part-time specialists with relatively high technological skills, transforming the angular blanks into square-section preforms and axes (Fenton 1984:237; Petrequin *et al.* 1998, Fig.3). In some societies in Irian Jaya and New Guinea, the axe length and the rock it is made of are connected to the display of status of the carrier; only high-quality preforms over 20 cm in length are considered valuable enough for status and prestige transactions (Petrequin *et al.* 1998:294ff; Burton 1984:244). These studies give example of societies where technological differences in the production of axes can be connected to a differentiated raw material procurement, on the one hand, and to value differences on the other.

Our view of the social complexity of a society is highly dependant upon the way we see its techno-economic situation. The stone axe raw material that Fenton (1984) describes can be found just about everywhere in the near neighbourhood of Scottish Neolithic and Bronze Age man, the procurement of preforms is fast and easy, the raw material is hard to control and the production requires no advanced technological skills. On the other hand, McBryde (1984:268ff) shows how two neighbouring Australian groups cooperate in working and controlling a certain dike known for its good raw material, a situation somewhat like the Tungei in New Guinea who display an in-tribe cooperative way of working the dike and distributing the preforms (Burton 1984:235ff). Also, at Plussulien in Bretagne, France, it has been estimated that several million tools have been made, equalling twelve people making about ten tools a day for about 2000 years of use (Le Roux 1998:375), and at Plancher-les-Mines in the east of France the estimate is 200 man-days' work per year for the 400 years of use, accepting continuous use (Petrequin et al. 1998:304ff).

The foremost purpose for mining, as opposed to collecting the raw material, is wherever you choose to direct your ethnographic eyes, getting socially potent prestige objects. The value in such an object is not primarily functional. Brian Hayden maintains that

> *The purpose of creating prestige artifacts is not to perform a practical task, but to display wealth, success, and power. The purpose is to solve a social problem or accomplish a social task such as attracting productive mates, labor, and allies or bonding members of social groups together via displays of success".*

Thus, he sees the logic and the strategies, i.e. the technology, connected to the production of prestige objects as being completely different than in the production of practical objects. Easily accessible raw material, low demands on work intensity, organisation, technological knowledge and practical know-how are directly negative and destructive to the value of a prestige technology. Because of the drive to copy high-status behaviour and prestige objects, the raw material procurement for, and production of these objects must thus be connected with such difficulties that reasonably few can have access to them (Hayden 1998:11f, 41).

Table 2. Min-, mean- and max-lengths for 122 hammer axes with squared-off vs. rounded cross sections.

Cross section	*MIN (cm)*	*MEAN (cm)*	*MAX (cm)*
Squared-off	4,7	13,8	25,5
Rounded	7,1	11,6	17,5

My results show that there is a difference in the length distribution of axes with rounded vs. square cross sections (table 2). In a studied material from Uppland, consisting of 122 hammer axes, the mean length for rounded sectioned axes is 11.6 cm; no axe is longer than 17.5 cm, while square section axes means 13.8 cm and maxes 25.5 cm. Thus, length and cross section cannot be said to be independent of each other. Instead, there is a clear tendency that long axes (longer than 18 cm) always have a square cross section and small axes (smaller than 12 cm) always have a rounded cross section. What could then be the reason for mining some of the raw material? Especially when it is clear that it takes longer per finished axe, it is more risky and requires a higher extent of organisation of labour mining raw material than collecting it. My view is that the long hammer axes with square sections first and foremost are objects of value, even if they also are practically useable. In this case they are results of a prestige technology with the purpose of producing an abundance of objects for socially important transactions of different kinds. The existence of such axes in hoards or votive deposits strengthens the probability that they are objects of value. The ones that have not ended up in hoards or votive deposits have been used practically (and of course as prestige objects at the same time) and consumed, shaft-hole by shaft-hole. The short to middle-length hammer axes with rounded sections, on the other hand, should be viewed as copies; produced locally out of cobbles that have been collected and pounded/pecked into shape and used mainly as household tools.

But is the technology required for producing a long hammer axe really complicated enough for it to be described as a prestige technology? I have not made experiments of my own yet, but from the examples of such work I have read, and indeed referred to in this paper (for example Petrequin et al. 1998; Kars et al. 1991), I would say that it is definitely hard enough. Altogether, the working time, moment of risk and organisation of labour required for finding the right raw material, mining it and producing flawless, 30 cm long hammer axes or preforms for them should be at least as difficult as the production of the prestige axes mentioned in the European or Oceanic examples: "Knapped blades, 20 cm long or more, need a high-level know-how and could have been the responsibility of specialists…" (Petrequin et al.1998:306). That is probably the reason why the Tungei tribe only considered axe-blades over 20 cm long as being valuable enough for bride-prices, and one reason why common work-axes were shorter than 15 cm (Burton 1984:244).

Moreover, the discussed axes from France and New Guinea are axe-blades, and thus lack the shaft-hole of the hammer axes. The special time perspectives, difficulties and hardships of shaft-hole drilling should then also be taken into account. As far as one can see, the drilling was a time consuming phase of the production. Experiments conducted by the Danish amateur archaeologist N. F. B. Sehested at the end of the 19th century showed what a delicate process it can be. Too vigorous drilling and not enough water in the grinding medium set the drilling machinery on fire and created tiny heat cracks in the stone, rendering it useless. Too much water, on the other hand, meant that much more force had to be used for keeping the drilling speed reasonably high, and the excess force weakened the stone. At Sehested's experiments, the drilling time per cm was between 30 and 150 minutes, depending on type of stone, drilling apparatus, drill bit material and grinding medium (Sehested 1884:26ff). Other experiments have shown that it takes about two hours per *millimetre* drilling in diorite, even if the speed is slightly higher with a pipe drill than with a massive drill (Rieth 1958:108; Fenton 1984:227). Also, the axe preform is weakened during and by the drilling, which probably constituted yet another threat to the production of long axes, stretching the time span and work amount per finished axe even more. This might be the reason for so many hoarded preforms exhibiting a partly finished shaft-hole. Showing, in this way, that the preform did not have micro-cracks that would ruin it in drilling, would certainly have enhanced the value of the preform even more. In conclusion, a reasonable interpretation of these results is in my view that the raw material for axes with square sections derive from primary sources, while the raw material for axes with rounded sections is mainly cobbles picked from ridges, beaches, streams and riverbeds.

The study of the relationship between raw material and technology, and the social and societal consequences of this relationship, on which this paper is founded is theoretically based upon and inspired by research by N. F. B. Sehested (1884); A. Rieth (1958); A. Laitikari (1928); M. B. Fenton (1984); J. Apel (2001); B. Hayden (1998); D. Olausson (1983, 1998 and 2000); E. Weiler (1994 and 1997); C-T. Le Roux (1998); J. Burton (1984); P. Petrequin et al. (1998); L. Sundström & J. Apel (1998); E. Callahan (1987); L. Kaelas (1959); G. Sarauw & J. Alin (1923); I. McBryde (1984); L-E. Englund (2000); J. Taffinder (1998); Å. Hyenstrand (1969) and E. A. Kars et al. (1991). The study has shown that there is a great divide resulting in two axe categories: those probably produced through the pounding of natural cobbles from beaches or riverbeds into shorter axes with rounded sections on the one hand, and on the other hand the longer axes with square sections, produced from preforms created by the flaking of quarried stone (Fig. 9 and 10). The clear difference in accessibility and controllability of both raw material and technology between these categories has made it possible to understand the hammer axe distribution – and thus the contexts of the previous studies (as discussed above) and clusters of such contexts (as discussed below) – from a value or wealth perspective. The accumulation of such value, or indeed wealth, could then be contrasted against consumption and deposition habits (as displayed above) and studied with the aim set at understanding the contexts, their topographical setting and thus at creating a social topography of the landscape.

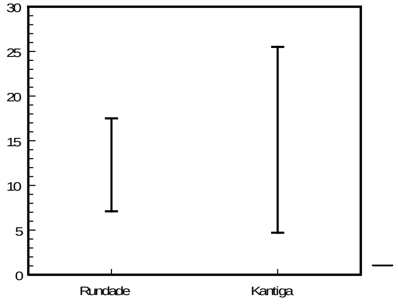


Figure 9. Distribution of length within the groups of rounded (to the left: "rundade") and square cross sections.

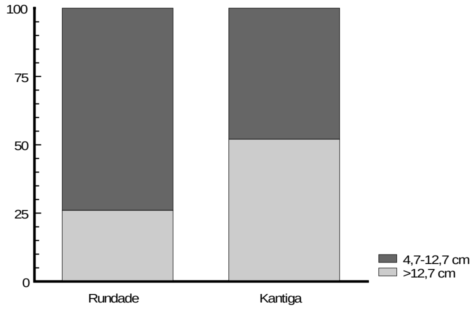


Figure 10. A comparison between the share of axes with rounded (left) or square cross-sections which are longer or shorter than the mean length for the entire analysed material.

Value and wealth are crucial terms in discussing the political economy of a society (Earle 1997). The analytical link for connecting different raw materials and different modes of production with differentiation in value has been established above. Connecting square sections with contexts of deposition in simple statistics shows that value has been deposited unevenly (Fig. 11) – with the most value in hoards, to a lesser extent in graves and to a yet lower degree on settlement sites. In my opinion, this reflects a habit representing a cultural standard regulating the handling and deposition of wealth in the society.

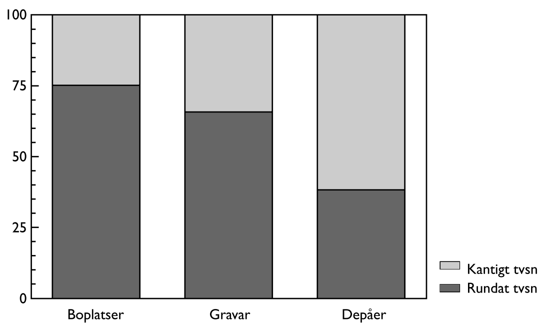


Figure 11. Percentage of axes with rounded ("rundat") vs. squared-off cross section on the different context groups ("boplatser"=settlement sites, "gravar"=graves, "depåer"=hoards).

Returning once again to the idea of use-lives of the hammer axes presented above, this too can be studied from the value perspective within the theoretical framework of Igor Kopytoff's research on the biographies of material things (Kopytoff 1986). Here it is demonstrated that material culture, when used/consumed, can pass through stages of deterioration equalizing a change in value. This means something socially for the people using or even looking at the object. If they are familiar with the practical and cultural meaning of the object – how it can and cannot be used in the different stages or "lives" it passes through – they have biographical expectations on the object. As Helle Vandkilde has pointed out, there is a strong connection between the value of an object and its "exchange rate". Objects that are interchangeable are usually of lower value than objects that are acceptable as gifts (Vandkilde 2000). Thus, what people do with objects can always be compared with the cultural norm for such dealings – it says something about a person if she deviates from this norm. This – the link between object, context, value, norm - is an important point to reach when using archaeology in trying to understand something about the social or political economy of a society. If the norm can be established, so can the deviation, and the rate of deviation from the norm of, as in this case, wealth deposition, might be taken to reflect a similar differentiation in ability to act according to this norm, and in turn connected with an inequality in the distribution of wealth as such in the society.

Returning to the axes and their contexts discussed above, the distribution of consumption-phase categories (preforms, complete axes and fragments) has been shown to be uneven when comparing settlement sites, graves and hoards (Fig. 7 and tab. 1). The settlement sites include no complete axes, mostly fragments and a few preforms. The graves have mostly complete axes, and a few fragmented ones. The hoards display mostly complete axes, extremely few fragments and the highest percentage of preforms. Looking at lengths of complete axes and preforms (Fig. 8) it is obvious that the preforms of the settlement sites are short, the complete axes of graves are mostly short, and the complete axes and preforms of hoards are mostly long. Transformed into use-lives and value in length, the newest and most valuable axes are deposited in hoards, while the oldest and least valuable objects are deposited on settlement sites – mainly as rubbish. The short, rounded preforms found on settlement sites are reworked cobbles, left for one reason or another. The axes that are deposited in graves are mostly short and display a rounded cross section, which shows that they are deposited somewhere between mid-life and the end of their array of potential re-workings.

To conclude, it is obvious that deposition of value is uneven between hoards, graves and settlement sites as context categories, and within these context categories.

The first statement reflects a difference in norms for deposition of valuables, while the second statement reflects the ability within society to adhere to this norm, i.e. the access to valuables. Like Helle Vandkilde (1996:316), I view the hoards or votive offerings as the social groups' collected gifts to higher entities or gods, with the function of marker and producer of prestige and social position in relation to other groups. This means that if the norms and standards for deposition of valuables stipulated that the highest value be hoarded in bogs, for one reason or another, the members of society should do their best in that respect, depositing their most valued or expensive axe for the sake of the collective. The result of this would be that an uneven value deposition within hoards would indeed reflect an unequal distribution of wealth within the social group. From a Marxist perspective, the whole collective hoarding or offering practice can be seen as a strategy for masking inequality, typical of a power structure of an institutionalised hierarchy (Nordqvist 2001:60). Agreeing with this perspective, and accepting the results of the study of deposition and production, I would state that the distribution of value within votive hoards reveals a cross section of wealth distribution pattern of the society under study.

Moving over to depositions in graves, I continue to agree with Vandkilde (1996:316) when she holds graves to be more individually oriented – grave gifts expressing more of the mourners honouring the deceased person's social position in life. However, if we accept the discussion about votive hoards above, the grave goods should be taken as being the next best – the objects that people can afford to lose after offering their most valuable pieces in the bog. In this perspective, the shortness of grave axes makes sense, since objects with a few more use-lives would have been needed for practical purposes. The value distribution, seen in the cross-section of the grave axes, should reflect the percentage of deceased with relatives who could afford grave gifts of higher or lower value.

Votive offerings and graves can thus be viewed as manifested ideologies of the collective and the individual, but as ideological manifestations they lack reflections of the social realities of people (see Nordqvist 2001:62). Settlement sites can include both ideology and social reality, but the specific meaning of studying settlement sites in comparison with votive offerings and graves is the possibility of contrasting socially real with the culturally ideal. The distribution of value within the settlement sphere (that is: within and/or between farmsteads and/or villages) shows what could be afforded to be used practically - consumed to the end of use-lives - and then deposited as rubbish. This means that when it comes to the distribution of value, the axes from settlement sites reveal to a higher degree the factual wealth distribution – that is (in generalised terms): the percentage of rich and poor farmsteads/villages.

To sum up, the production and consumption traces within the context categories result in the following interpretation:

Votive offerings – reflect differences in wealth and social status between groups; give a cross section of the capital distribution profile in society.

Graves – reflect what you can afford after offering the most valuable; give an estimate of the percentage of individuals with families that can afford richer or poorer grave gifts.

Settlement sites – reflect the factual distribution of value between settlement units; give an estimate of the percentage of rich and poor farmsteads/villages.

Looking at the axe materials attributed to context categories in this perspective (Fig. 11 and 12) one could thus express the economic power relations in the Earliest Bronze Age in southern and central Sweden: One fourth (1/4) of the settlement units are inhabited by the third (1/3) of the population that controls two thirds (2/3) of the wealth. This means that the settlement units of the economical elite should be relatively large – with large and/or many houses – settlement clusters and the forming of villages.

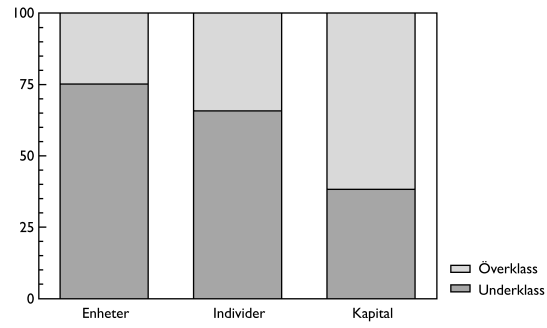


Figure 12. The distribution of wealth expressed in axes with squared-off cross sections (“Enheter”=settlement units, “Individer”=individuals, “Kapital”=capital).

Landscape furnishing

The analytical tools previously forged, as briefly described above, are initially put into operation in the mapping of a contextual and social landscape in eastern central Sweden. Subsequently, in a discussion of the cultural landscape thus defined, and by referring to social theory (landscape theory, Marxist theory) relating the landscape to the social and political organisation of the inhabitants of that landscape, I try to explore some of the Earliest Bronze Age forms of social integration (Lindblom 1991:135; Gansum, Jerpåsen & Keller 1997:18; Appadurai 1986:38; Welinder 1992:45; Bender 1993:3; Hodder 1982; Küchler 1993:85ff; Johnston 1998:54; Knapp & Ashmore 1999:1ff; Schama 1995:35ff, 82f; Tilley 1993:81, 1994:19ff; Donham 1995:53ff, 193f; Bradley 2000:26ff, 152ff). The aim is to understand the landscape, furnishing enough to enable a fruitful discussion about the societal context of such landscapes. The aim is set on understanding more about the social organization in eastern central Sweden during its Earliest Bronze Age. Two areas have been studied, one around lake Hjälmaren in central Sweden and one further to the north-east, in Uppland.

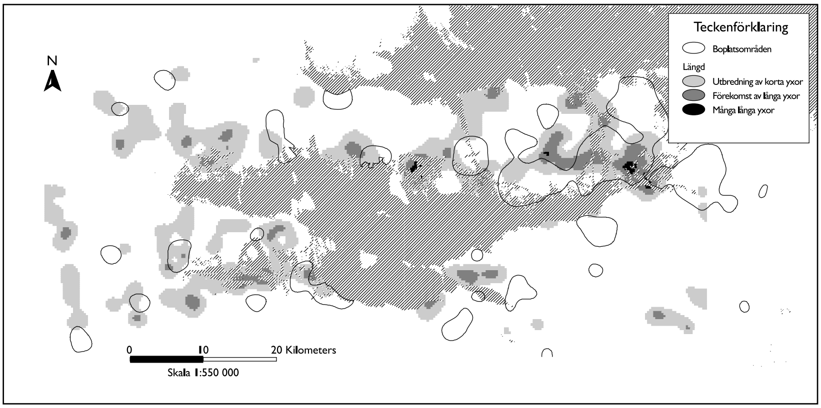


Figure 13. The study area around lake Hjälmaren, with an image of a landscape of the Earliest Central Swedish Bronze Age landscape, created through an interpolation of the distribution of hammer axes of different sizes. The interpolation is universal with linear drift.The legend shows, from top to bottom: Settlement areas (axe fragments); Short axes; Long axes; Many long axes. Map by Karl-Johan Lindholm.

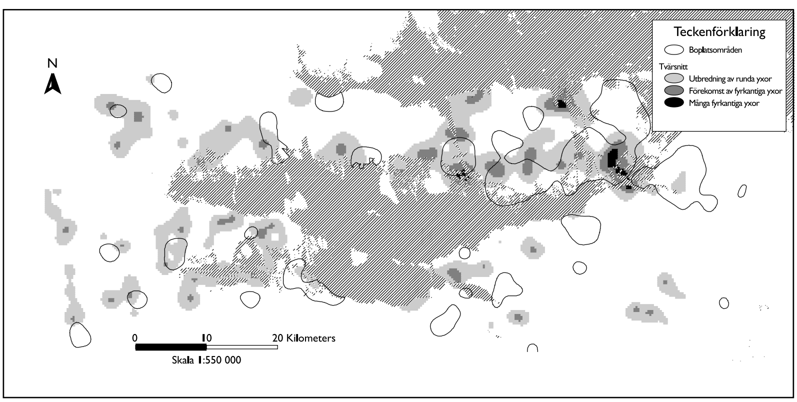


Figure 14. The study area around lake Hjälmaren, with an image of the distribution of wealth within a landscape of the Earliest Central Swedish Bronze Age, created through an interpolation of the distribution of hammer axes with rounded vs. squared-off cross sections. The interpolation is universal with linear drift. The legend shows, from top to bottom: Settlement areas (axe fragments); Axes with rounded cross sections; Axes with squared-off cross sections; Many axes with squared-off cross sections. Map by Karl-Johan Lindholm.

The result of the mapping is a landscape structure, exhibiting a contextually diversified use of landscape zones and landscape elements. The short, grave-indicating axes generally exhibit linear distribution patterns, marking paths and roads along ridges, eskers or waterways, while the long, hoard/votive-indicating axes are most often placed in the coastal zone or at special places along the inland paths, marking nodal points in the landscape, such as fords, harbours and other places of liminal transgression (Fig. 13 and 14). According to the distribution of axe fragments, the settlement sites are located in generally quite evenly distributed clusters that increase in density in certain areas (Fig. 15). They seem to be equivalent to settlement spaces, i.e. 'landscape rooms' that potentially form politically interpretable settlement units of the Earliest Bronze Age landscape (Fig. 16). Grave-marked paths and roads with their holy river-crossings, wells and water holes led to and from these settlement spaces. Furthermore, notable spatial differences in the distribution of valuables between the settlement areas are detected, indicating economic and political relations between centre and periphery and an unequal accumulation of wealth (Fig. 17; see also Lekberg 2002:273).

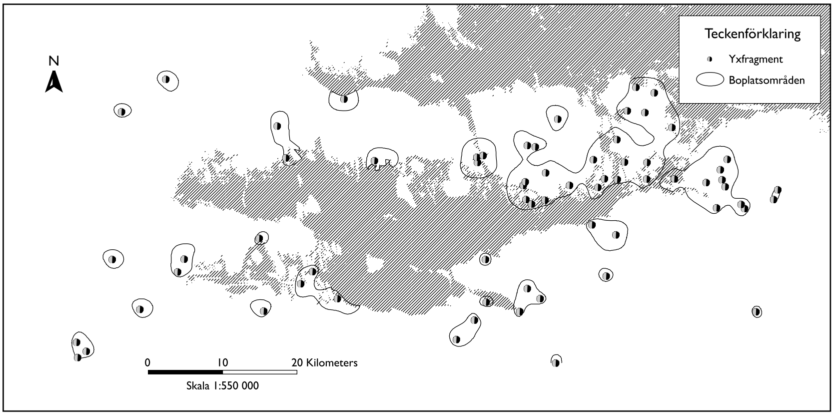


Figure 15. The study area around lake Hjälmaren, with an image of settlement areas within a landscape of the Earliest Central Swedish Bronze Age, created through an interpolation of the distribution of fragmented hammer axes (dots). The interpolation is universal with linear drift. Map by Karl-Johan Lindholm.

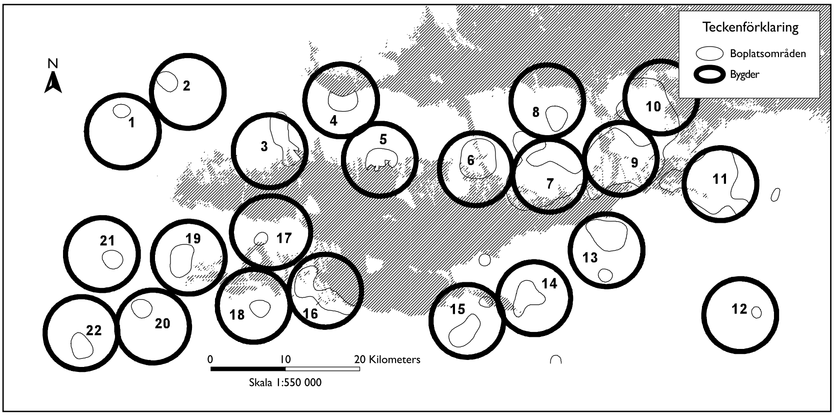


Figure 16. The study area around lake Hjälmaren, with site catchment areas of 10 km in diameter, around the hypothetical settlement areas. Map by Karl-Johan Lindholm.

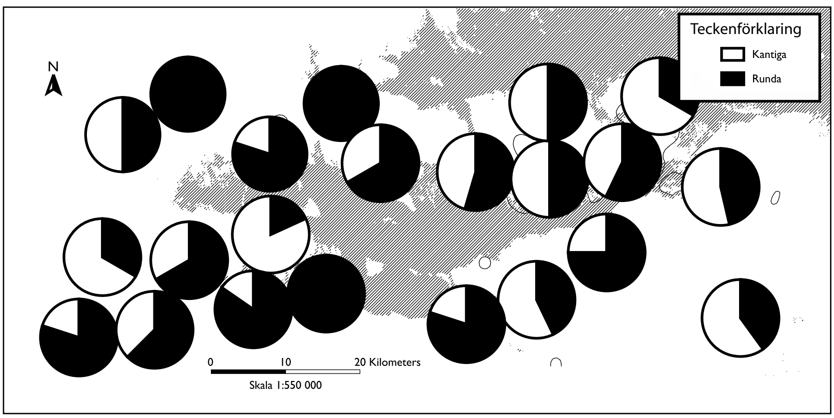


Figure 17. The study area around lake Hjälmaren, with the relative distribution of wealth, in the form of hammer axes with squared-off cross sections, within each site catchment area presented as a pie chart. More white colour in the chart equals relatively more axes with squared-off cross sections. Note that the absolute number in each pie chart may vary between 1 to c. 25. Map by Karl-Johan Lindholm.

The core areas of this accumulation of wealth coincide geographically with areas of higher density in the distribution of the axes that indicate settlement sites and thus theoretically a denser settlement structure and a larger population per square unit of area. Earlier mappings of the distribution of Middle Neolithic to Bronze Age artefacts in eastern central Sweden (Jensen

1989:115ff), amongst them Earliest Bronze Age hammer axes, show concentrations every 25 km or so along the coastal region. These concentrations exhibit a considerable spatial continuity, since they are detectable at least from the Middle Neolithic and well into the Bronze Age. It is thus reasonable to believe that they indeed represent settlement areas in the form of political entities of some kind during a long period of their existence. The northernmost of these concentrations coincides with my test area in Uppland.

Here, the accumulation of wealth during the Earliest Bronze Age took place in the form of both flint daggers and valuable hammer axes, in the same area as the concentration of early Bronze Age valuables. Given that the results are the same both around Hjälmaren and in the Uppland area, it is reasonable to believe that most of Jensen's concentrations work the same way, and that there is in fact a strong continuity in inequality when it comes to the accumulation of wealth that has been made visible in the cultural landscape. I believe that this indicates a society based on principles of hereditary inequality – the mere landscape strategy of utilities cannot solely account for these structures. The results of excavations of Swedish Earliest Bronze Age settlement sites indicate that larger and larger houses were built during the period. The smaller houses of Middle Neolithic character continue to be built alongside these, however, but they are also built separately from the larger houses. This aligns with Per Nordqvist's conclusions: "The observations of collective burials in megaliths, a tension between collective and single graves, buried children in the collective graves and the differentiation of the size of houses at settlements all signal the existence of hereditary social ranking. Since house size differentiation communicates a socio-economic difference, the social rank seems to have been related to an economic dimension. This also points towards a chiefdom level of social integration during the LN because differences in lifestyles can be understood in terms of a social index referring to the degree of economic control" (Nordqvist 2001:216ff).

Furthermore, the results of southern Scandinavian excavations make it reasonable to believe that village organization was in place, at least in some settlements (see for example Artursson 2000). My results show that the richer areas were also the more densely populated and that more people lived in the richer units than in the poorer ones. In the perspective of economic and political power, this might amount to a hereditary elite, dominating clan territories with a core of densely populated, coastal areas, measuring c. 20 x 20 km and extensively settled "uplands", maybe in constant negotiation or feud with neighbouring groups, along dominating means of communication, such as ridges, rivers, fjords and lakes.

Social and cultural context of the elite

The accumulations of valuables and exotica in the cores of at least the richer areas show that these elites were internationally connected, at least in the Bronze Age. It is, however, very likely that there was a continuity in elite control in these core areas and that these contacts developed as early as the later parts of the Middle Neolithic of Scandinavia. The continuity in the use and furnishing of the landscape can be observed back to these times, and the foundation of this landscape continuity might be sought in the reproduction within society of cognitive or mental maps, used to regulate the furnishing of the landscape into an arena of meaning, tradition and ideological reproduction (Cherry & Renfrew 1986:154f; Gansum, Jerpåsen & Keller 1997). Also, almost simultaneous shifts in material culture (for example stone hammer axes) and ideology over vast areas seem to give evidence of direct contacts between Scandinavia and southern Russia as well as the Middle East and the eastern Mediterranean area (Warren & Hankey 1989:11; Kristiansen 1998a:32; Gimbutas 1956:121; Shennan 1986:138ff; Apel 2001a:336; Podborský *et al*. 1993:229; Machnik 1997:152; Ebbesen 1997:75ff; Loze 1997:135ff; Rimantiené 1997:181ff; Buchvaldek 1997:43ff; Marsalek 1999:123ff; Knutsson 1995:190f; Frödin & Persson 1938:218ff; Bouzek 1985; 1997; Wace & Thompson 1912; Blegen *et al.* 1950; Dörpfeld 1902; Blinkenberg 1904:22; Banks 1967a:99ff).

One way for the elites of eastern central Sweden to maintain their hereditary elite status may have been by negotiation with commoners, using foreign but meaningful objects and other signs as symbolic capital, manifesting their kinship with gods and foreign rulers and their subsequent right to dominate and accumulate (Helms 1988:66ff, 1993, 1998:120ff; Kristiansen 1991:27, 1998a:540ff, 1998b:180f; Larsson 1999a:78, 1999b:57f; Willroth 1989:93f; Beck 1996:91f; Piggott 1950:273ff, 1967:134ff, 1983:91ff, 1992:52f; Treherne 1995:108ff; Malmer 1989:96; Renfrew 1993:187). This would, I argue, result in commoners striving for status, copying the material and immaterial signs of the elites, integrating them in regional or local modes of commoner culture, and thus devaluating them as symbolic capital. Such an ongoing devaluation would force the elites to keep on travelling and maintaining contact with their far-reaching networks, to secure the introduction of new symbolic capital into the system (Kristiansen 1998b:333ff; Larsson 1999:49ff; Hayden 1998:33; Nordqvist 2001:258; Elster 1988, 1993; Olsen 1997; Nordqvist 1999). This process can be compared with a siphon; once the suction is established, the system runs itself, fuelled by the urge for prestige.

Such a three-way, s*ocial siphon-model* – within the sphere of the elite, peer-polity interaction networks, between this and the local/regional commoners, and within the regional commoner networks – provides a reasonable explanation of diffusion and typological change in time and space, for material as well as non-material culture (Lekberg 2002). The described process could have played an important role in preserving the social system, in the continuity and change of material and immaterial culture within the vast, transcontinental network of cultural dialects that we call the European Bronze Age. In my view, this cultural network through time and space is not manifested first and foremost by the manufacture and use of bronzes as such, but rather by a new way of life and outlook on the conditions for existence. Seen this way, the Bronze Age in Scandinavia starts with the introduction of institutionalised inequality sometime around the MN – LN transition, subsequently gaining acceptance as a way of life.

Witold Migal

The macrolithic flint blades of the neolithic times in Poland

Abstract
During the last two decades, the number of scientific works dealing with the problems of Neolithic blade procurements using pressure technique has increased significantly. Research on this subject was conducted in France (Pelegrin, see this volume), Russia (Girâ) and Poland (this author). In all these cases, the researchers focused on large flint blades, in Polish archaeological terms known as macrolithic blades. The experiments revealed that in order to detach such large, recurrent blades, various force-increasing devices were needed. Unfortunately, no archaeological remains of such devices are preserved and there are no ethnographical analogies that can be used. The most ancient force-increasing device that could have been known in the east European Neolithic is the wine/oil press. The presence of grape seeds together with the oldest macrolithic blades is known from the territory occupied by people from the Tripole culture. The paper is an attempt to answer the question about real economic conditions determining the existence of developed craft and potential markets for macrolithic blade half products.

Introduction

In the Later Neolithic, the area of central Poland and Ukraine was a centre for an intensive processing, production and distribution of flint artifacts (Balcer 1975). One of the products typical for this period is the large blades made of two types of flint: the grey-white spotted, Thuronian-age flint (named Świeciechów flint from the name of the outcrop) that occurs in central Poland around the Vistula River (Fig. 1), and the cretaceous, Senonien-age flint that occurs in Wolhyn, western Ukraine. The Polish literature on the subject stresses the metric change that occurred when Neolithic peoples began producing up to 34 cm long blades (Fig. 2) with an average length of about 22-25 cm (Migal 2002). These large-sized blades appeared during the middle period of the Linear Pottery Cultures connected with the Tiszapolgar stage, which corresponds to stages BI-BII of the Tripole Culture (Masson *et al.* 1982:175). In Poland the archaeological cultures which are classified in that complex of cultures are "Wolhyn – Lublin White Painted Pottery culture" (Figs 3, 4) and the group "Wycięże – Złotniki" (Fig. 5) (Zakościelna 1996). However, the largest development and distribution of blades processed in such a way were connected with the Funnel Beaker culture (see Balcer 1980,

1983) (Figs. 6, 7) and the Tripole culture (Budziszewski 1995), adjacent to the Funnel Beaker culture in the south. Such blades and cores were also found among Corded Ware culture grave inventories in the southern part of Poland (Machnik 1966:50 p.). As far as we know today, this was the last appearance of macrolithic blade technology.

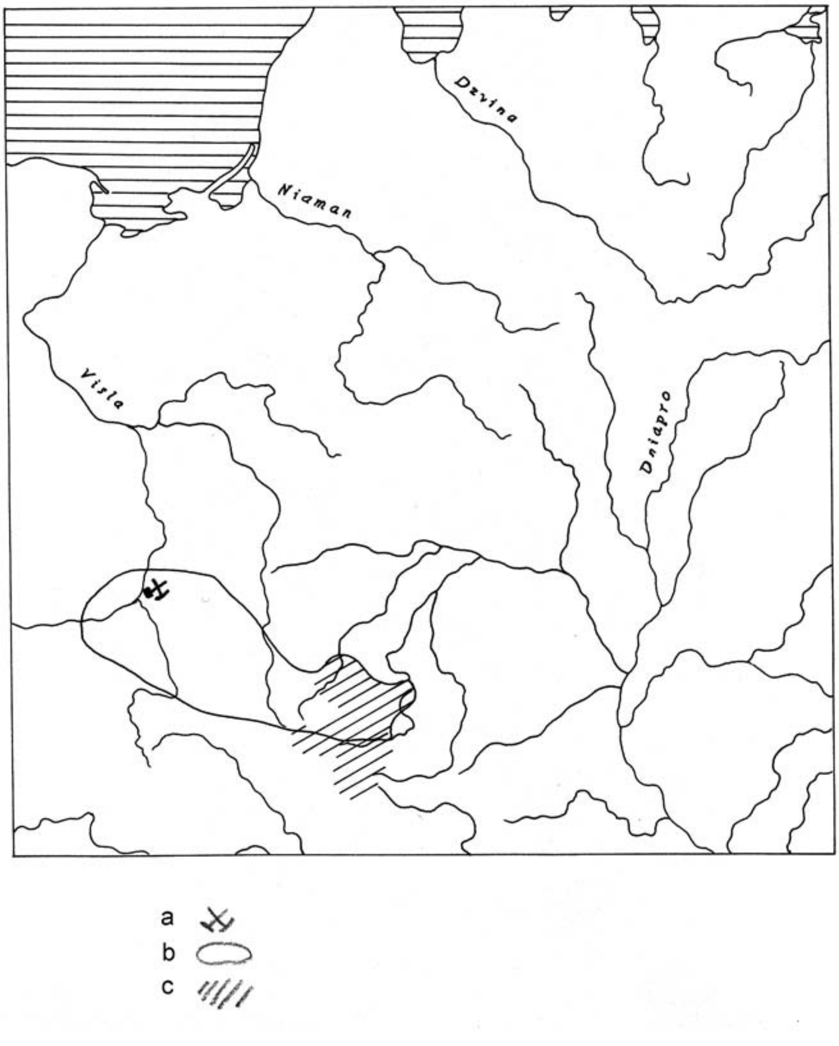


Figure 1. Area of production of long blades among Neolithic societies. (a) Świeciechów flint mine on the Vistula River. (b) Territory of White Painted Pottery culture occupation. (c) Outcrops of Senonien flint in Volhyn.

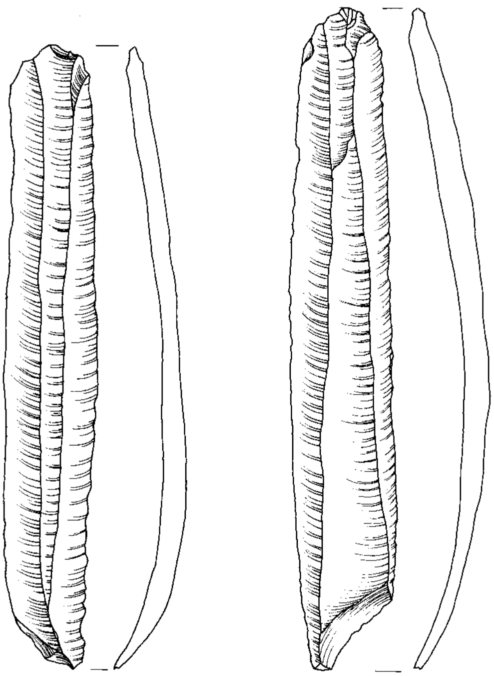


Figure 2. Samples of regular blades from the White Painted Pottery culture. Strzyżów, Lublin district. After Zakościelna 1996. Scale 1:3.

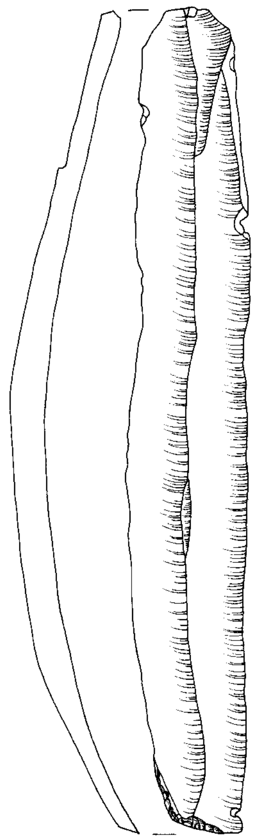


Figure 3. Long blade from the White Painted pottery culture. Strzyżów, Lublin district. After Zakościelna 1996. Scale 1:3.

The morphology of the large cores that produced macro blades can vary according to production context. Among the WL-WPP, rounded striking platforms were used and the cores had a conical shape similar to those of the Tripole culture (Fig. 4). Cores prepared within the Funnel Beaker Culture, on the other hand, are often flat, have triangular shapes and were prepared with two or three side crests (Fig. 5).

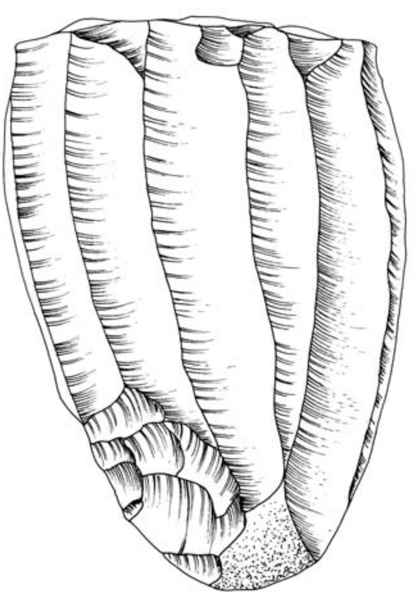


Figure 4. Core from the White Painted Pottery culture. Staszów, Kielce district. After Zakościelna 1996. Scale 1:3.

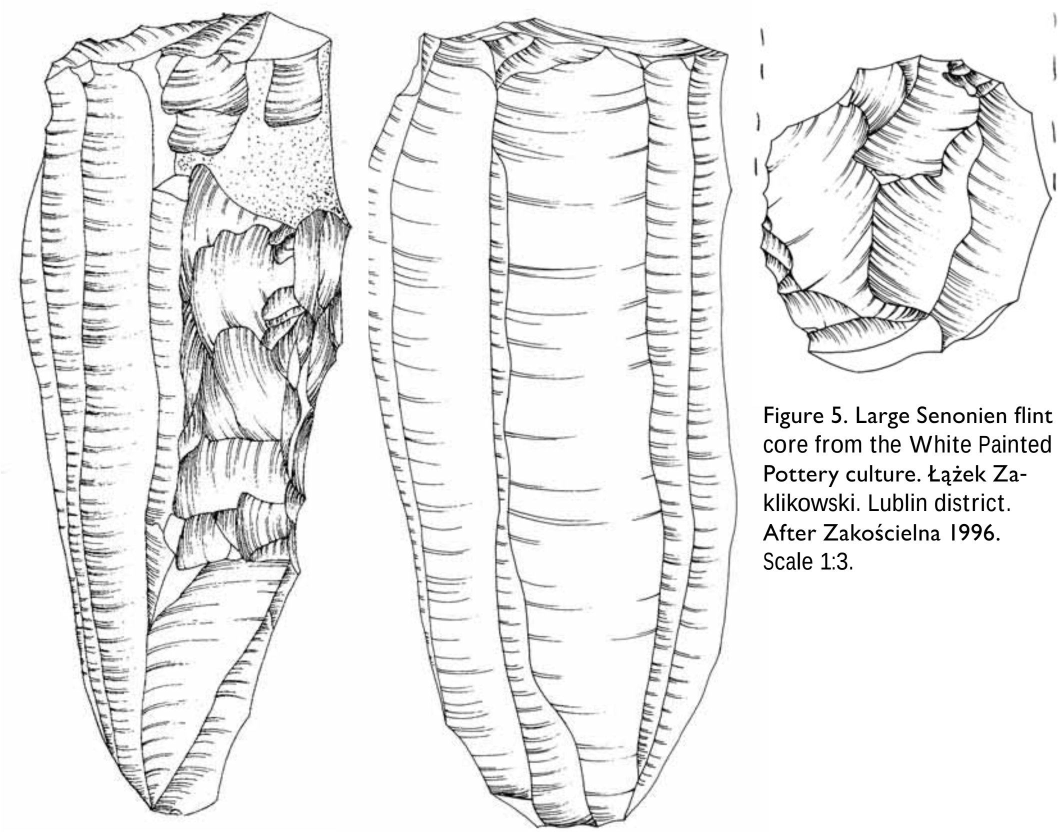


Figure 5. Large Senonien flint core from the White Painted Pottery culture. Łążek Zaklikowski. Lublin district. After Zakościelna 1996. Scale 1:3.

Blade production

There are some factors that may indicate that these large blades were detached with applied pressure. Above all it is the extraordinary regularity of sides and thickness (Figs. 6, 7). Another premise supporting this suggestion is the very strong reduction of striking platform before every detachment – up to 1 cm between two consecutive blades – that is visible in refittings. In the case of FBC, there is one additional factor which relates to the economy of flint raw material and the problem of immobilization of the investigated flint cores during pressure. Together with other archaeologists of the State Archaeological Museum in Warsaw we investigated one of the inventories of the FBC settlement Zlota, not far from a deposit of spotted flint (Matraszek *et al.* 2002). It was possible to refit flint from residue pits. Our first intention was to understand different ways of exploitation of a large blade. A refitting of the blocks revealed a process of reshaping blade cores to quadrangular axes, typical for this cultural group. It was interesting to note that the analysis of different materials (through observation of finished axes) showed that this process was more or less typical for this tradition. Our analysis was also successful in terms of defining the characteristic debitage for this type of production. The process can be described as follows:

1. Shaping the core together with all necessary crests was carried out close to the mine in Świeciechów.

2. Exploitation of cores by pressure was probably carried out in only one or two households (evidence found at Ćmielów (Balcer 2002), Bodiaki (Skakun 1996))

3. Disqualification of cores (reason: size of blades)

4. Accumulation of cores in huts (for example 22 specimens at Bodiaki, see Skakun 1996 or the Sapanów collection at State Archaeological Museum in Warsaw) or reworking them into axes (FBC, Złota, Ćmielów, see Matraszek *et al.* 2002).

The shaping and reworking of cores into axes was no doubt executed with a punch technique and the production of blades by using a pressure technique. It is essential that the third point – on what grounds cores were disqualified – is explained. The loss of metric values of potential blades could be one reason for disqualification. Nevertheless, many cores are much longer than indicated by the negatives of blades. The museum at Zbaraż (Wolhyn) has is a 42 cm long core with negatives no longer than 30 cm. At the same time, the discarded cores show that it would have been possible to extract more blades from them, smaller than 15 cm. Precision in the shaping of sides and backs of the cores leads us to the conclusion that a system of immobilization must have existed which excluded the core's further use after a reduction in dimension. Such a construction must have been large and stable enough to hold out against the great force acting on it in the detaching of blades. In my opinion, this explains both the rigorous shaping of cores and the later stage of discarding.

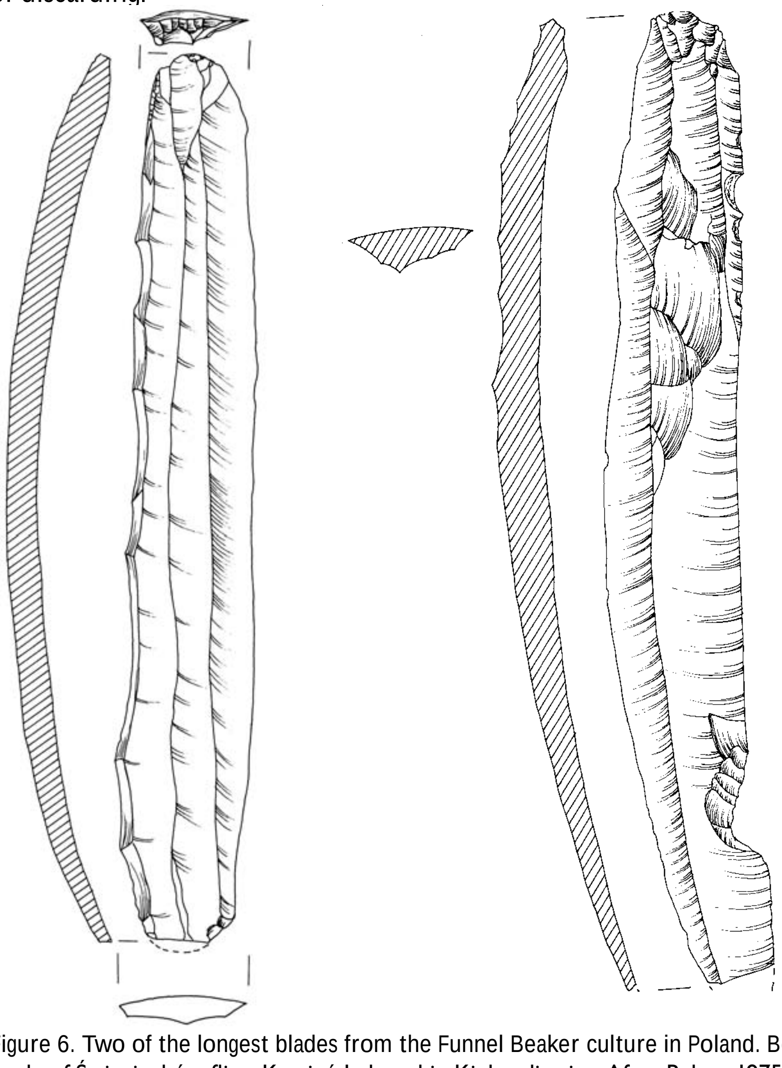


Figure 6. Two of the longest blades from the Funnel Beaker culture in Poland. Both made of Świeciechów flint. Kamień Łukawski, Kielce district. After Balcer 1975. Scale 1:3.

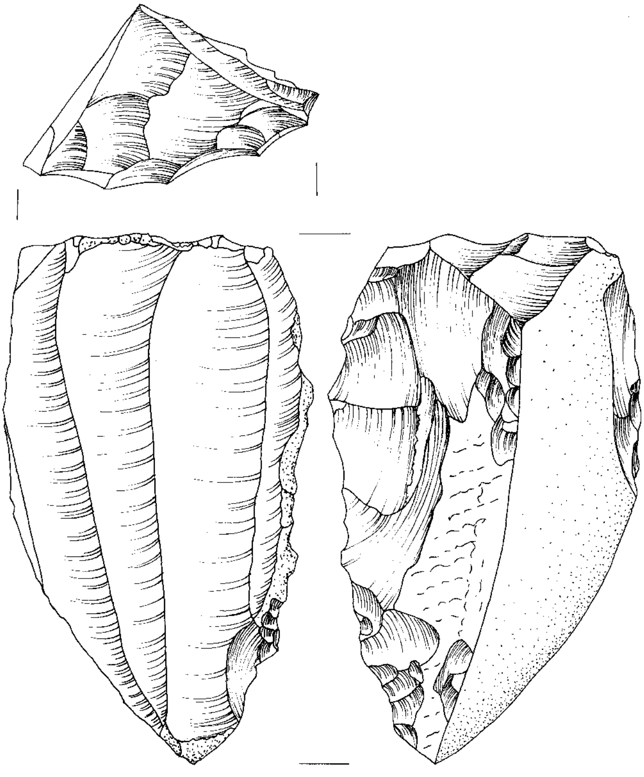


Figure 7a. One core for long blades from the large settlement of Funnel Beaker culture at Ćmielów, Kielce district. Such cores were usually reworked by Neolithic flintknappers into flint axes. Świeciechów flint. After Balcer 1975. Scale 1:3.

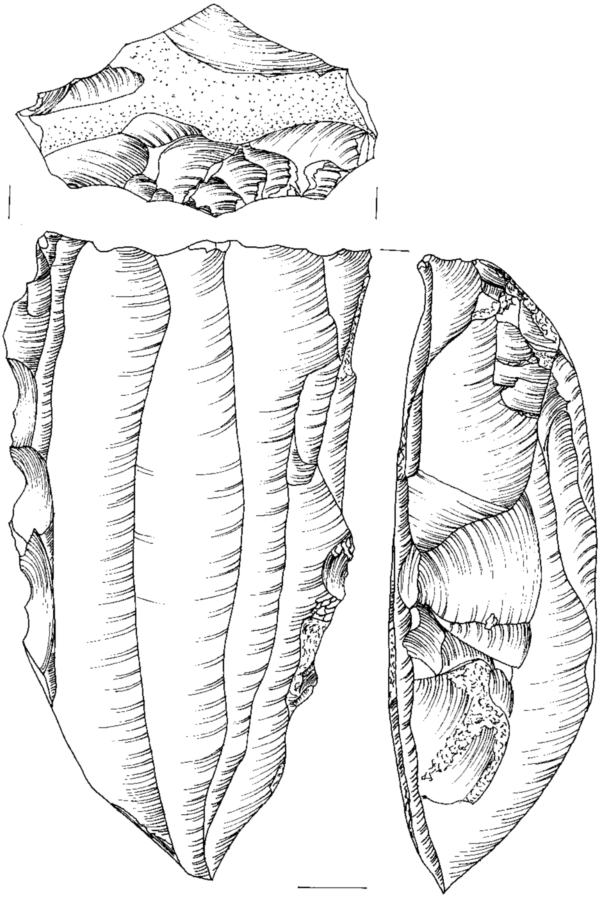


Figure 7b. One core for long blades from the large settlement of Funnel Beaker culture at Ćmielów, Kielce district. Such cores were usually reworked by Neolithic flintknappers into flint axes. Świeciechów flint. After Balcer 1975. Scale 1:3.

Devices for pressuring blades

During the past 15 years, experimental research geared towards getting long blades with the help of devices that enhance pressure have been conducted in Europe. The lever was one mechanism constructed as a way of enhancing pressure. In a construction made by Giria, the core was fastened in a vice. The blades were detached from the core by increasing the pressure on the front of the core using the lever (Giria 1997). By applying this device, the researchers were able to make blades up to 27 cm long (pers. com.). My own construction was placed on a log on the ground as a support in which the core was made immobile in a carved notch. Blades were detached with an antler-tipped wooden pole put through a hole in the upper part of the log. The point of support for the lever had been constructed as a hole in the wall opposite the core. This way of working was very compact and connected with the size and shape of cores. The longest blades were 21 cm, and I could exploit the core to about 15 cm of height. Further study will include an investigation of the bullet shaped high pressure blade cores of the Globular Amphorae Culture (Balcer 1975:204), which typically gave narrow and flat blades (Migal and Barska 2003).

Both constructions for blade detachments mentioned above are results of an intellectual and practical game with clear visible inspirations (in my case the immobilization system is a variant of Pelegrin's fork).

Thus, the experimental work resulted in more questions: Did these force-enhancing devices really exist in central Eastern Europe? If similar devices were known for other purposes it is possible that comparable technical solutions would be used to make flint blades.

The oldest devices to multiply mechanical force used the principle of the lever

Beyond doubt, the oldest known devices for enhancing human muscular force are so called simple machines, the most well known examples of which are the wedge, the lever, the screw and the pulley block or the windlass. The wedge was widely used in flint mining. Evidence for thrusting wedges has been found in mines of banded flint at Krzemionki (central Poland) where flint and stone wedges were used for horizontal splitting of layers of limestone oxfordian rock (Migal 2000). Wedges were not used as axes, but two dozen tools were simultaneously thrust into the ceiling, splitting off plates about 1.5 m in diameter. From the same mines we have evidence of work with a wooden pole lever with which similar work was probably executed. The pole was about 12 cm in diameter and about 2 m long and was used for breaking off large blocks of cast rock. These mines were exploited by the Globular Amphorae population in the early third millennium cal BC. One problem is that long pressure blades appeared in Polish territories 500 years earlier. Furthermore, all such production seems to have existed within a specific definite socio-economic situation.

Socio-economical transformation among the peoples of the later Linear Pottery cultures and the Tripole culture

According to current theories, social transformations of the population of the later Linear Pottery cultures are connected with an agricultural economy that led to changes in social relations. By reconstructing the size of the population of the Tripole culture, Russian researchers have shown that this cultural unit possessed many features of a "civilization", which is marked by using the term "Tripole Civilization". They underline its settled character as indicated by, e.g. the municipal character of the housing estate of the Near East. These "municipalities" cover 20-60 hectares; examples are found at Tsciszovka or Onoprievka in stage B I, and in the later stage (B II) they cover 150-200 hectares (Videiko 1994:21-23). This indicates that the area of the proto-town Maydanetskoye (200 hectares) was settled by *c.* 10,000 inhabitants occupying 2800 buildings. On the other hand, we see advances in the ceramic technology and the development of exchange of copper items (see Videiko 1994:9). At the same time, similar changes occurred within the later Linear Pottery cultures (also called the Lengyel – Polar Complex). In both cases, the transformations were accompanied by a larger cultivated area (in comparison with the later Linear Pottery Culture), as well as an increased exchange of different goods by long distance trade (copper, flint, amber, shells). Other differences seen in the archaeological material are e.g. the gigantic storage amphorae that are accompanied by small cups or mugs with ears (see Sherratt 1987, 1995). Such sets are linked to the production and consumption of wine (Gumiński 1989). In connection with the Tripole Culture of stage B II, specialized pottery workshops are also known. This is evidence of a civilization in progress among the Middle Neolithic populations and of simultaneous specialization in the production of different types of goods.

Unfortunately, the factors mentioned above do not explain the existence of exceptional products such as macrolithic-flint blades. This is not because their beautiful appearance and size were indispensable for production and distribution over large distances. One can successfully execute everyday tasks with far smaller and uglier blades. Thus we have to accept two essential factors as influencing the development of this product:

1. The macrolithic-flint blades had to be symbols of social status, or

2. They were the most important identifying symbols of tribe membership.

Concerning the second factor, it is interesting to note that the finished blades were often distributed outside the range of the archaeological cultures that occupied the areas where extraction and procurement of raw materials took place (in our case, blades from grey spotted flint made by Funnel Beaker producers). Thus, Funnel Beaker blades are found at the territory of White Painted Pottery culture at Ukraine, and blades made of flint from Wolhyn are found in the Funnel Beaker area.

In the case of FBC, one essential factor is the megalithic activities visible in the large constructions of stone, wood and earth in Poland. The constructions clearly show the high degree of organization of these societies through the execution of such large-scale undertakings. In the grave inventories we often find large blades. On the other hand, such broken blades are also found as tools in large settlements in the vicinity of the Swieciechów flint mines. However, although this was not investigated, it seems possible that ready blanks of blades were more appreciated further away from the deposits and places of production. Such blades have larger dimensions and are in a better state of maintenance compared to blades on settlements near the deposit (the longest known flint blade made of Swieciechów flint is *c.* 34 cm long and comes from Kuiavia in central Poland, *c.* 300 km from the extraction area). There is no evidence that the people of the FBC, who received the finished blades far from the deposits, also were able to use this technique to produce blades from local flint. This clearly indicates a high specialization within an archaeological culture.

Another transformation in lifestyle in comparison with the Linear Pottery cultures took place when the people of the FBC occupied poor quality lands simultaneously with an increase in population. In the archaeological material, this is indicated by the appearance of new plants and changes in the system of cattle farming (see Kruk 1973).

Among others, Russian researchers underline that it is precisely during this period that the oldest seeds of domesticated grape-vine found on a settlement at Novyje Rusesti appear. The find is dated to 3620+100 (Bln -590) and thus belongs to the phase BI – BII of the Tripole culture (Masson *et al*. 1982:191, 235).

In the production of must, the largest quantity of juice should be extracted from ripe grapes. The primary method to increase the amount of must is different ways of trampling and crushing the berries and straining the juice (Frankel 1999). It is a well-illustrated way of production and was probably used by producers of wine from early on. On the other hand, the refuse of such a production contains large quantities of juice that are difficult to handle immediately. From the beginning, different machines were constructed for the purpose of increasing pressure to maximise the amount of must. A wide range of constructions existed and attest to the ingeniousness of people living in different wine producing regions. Examples of devices that have been recovered provided the basis for the experimental investigations connected with detaching large blades from flint.

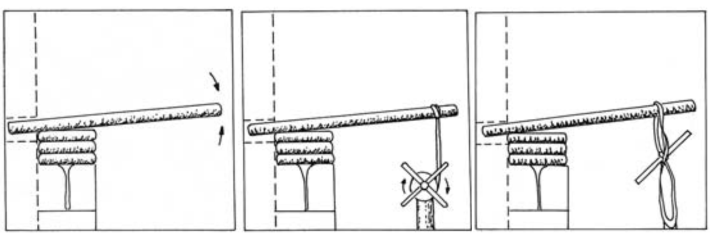


Figure 8. Some ideas how a machine for making long blades would be done. Based on historical- ethnological evidence. After Frankel 1999.

Summary

Macrolithic flint blades with lengths from 20 to 30 cm appear during the Middle Neolithic of east central Europe together with groups of the Tripole culture and Wolhyn-Lublin White Painted Pottery culture. At the time they were produced in Ukraine (e.g. Wolhyn). Large-blade production was also developed in the later stage of the Funnel Beaker culture. Beyond question, this production is connected with the application of force-enhancing devices. With the appearance of such blades we see changes in economy and ways of farming, including grape cultivation and wine production. My hypothesis unites these two facts and emphasizes that a similar construction based on the idea of a simple machine (Fig. 8) was used both for grape must extraction and blade detachment. However, the last blades of this type appeared in the early stages of the Corded Ware culture in south-eastern Poland (mid 3rd millennium); after that, blades were produced differently.

Kim Darmark

Flaked rhyolite from Jettböle: attempts at an experimental explanation

Abstract
Pitted-ware sites situated in the Åland Islands, Finland, often yield huge quantities of lithic debris from a local rhyolite. This source of information has attracted very little scholarly attention. The aim of the present article is to describe a sample of flaked material from one of the most well known middle Neolithic sites - Jettböle. The basic reduction strategy seems to be highly dependent on direct technique and to be of a quantitative nature. Tools are seemingly informal and lack secondary modification. Still, the lithics from this site display some unexpected characteristics, which will be highlighted in contrast with material from a roughly contemporary site. Therefore, a second goal of this paper is to present the results of a series of experiments, which are conducted specifically in an attempt to get a better understanding of the formation processes behind the archaeological material.

Introduction

Jettböle is the birthplace of Stone Age archaeology in the Åland Islands. When it was discovered in 1905, only a few years after the discovery of the first Pitted Ware site in eastern central Sweden, it changed the earlier notion of the islands being uninhabited during the Stone Age. Excavations conducted between 1905 and 1911 resulted in large amounts of finds, especially of the richly decorated pottery characteristic of the Pitted Ware tradition, and of lithic debris. The site became notorious when it became clear that several human skeletons were deposited in the cultural layer, a fact that led to an ongoing discussion about the possibility of cannibalistic practice (Cederhvarf 1912; Nuñez 1995). The anthropomorphic clay figures with parallels in the eastern Comb-ceramic tradition are widely known (Nuñez 1986; Wyszomirska 1984). In 1999 and 2000, new excavations were conducted at Jettböle. During this time, a nearby settlement by the name of Bergmanstorp was also investigated. Bergmanstorp is situated 200 metres east of Jettböle and 4 to 5 metres higher above sea level. The ^{14}C-datings from JI99 range between 3300 and 2600 BC (Storå & Stenbäck 2001: 65), and the datings from Bergmanstorp fall within the same interval (Storå & Stenbäck 2001:

63f.). However, the presence of atypical pottery might indicate an older phase at Bergmanstorp (Stenbäck 2003).

In eastern central Sweden, the Neolithic Pitted Ware Culture emerges around 3500 BC, and is characterized by a return to an economy highly dependent on hunting and gathering. The coastal regions became particularly important, and osteological assemblages are often dominated by marine wildlife (Storå 2001b: 3f).

The main find category at Pitted Ware sites in eastern central Sweden is the decorated pottery, while the amount of lithic debris varies to a considerable degree (Edenmo et al. 1997: 175). In the Åland Islands, several sites display large quantities of flaked material, predominantly rhyolite. The rhyolite from Åland is a porphyritic rock consisting of a grey matrix with phenocrysts of quartz and feldspar. It can be found along the beaches of Åland and to a certain degree in southwest Finland (Nuñez 1990). It is similar to porphyry occasionally found at Swedish sites on the mainland. Even though the rhyolite often makes up the bulk of the finds from Ålandic Stone Age sites, very few studies have taken this material into account. The works that touch upon the subject often approach the material from a formalistic point of view, with the aim of identifying formal tools (Dreijer 1940; Meinander 1957; Nuñez 1990; Storå 1990). It has been demonstrated that this is not a very fruitful way of investigation outside the flintbearing areas of Sweden (Callahan 1987).

The amount of lithics found not only at Jettböle, but also at Ålandic Pitted Ware sites in general, seems to be without rival in eastern central Swedish contexts, where lithic material is often relatively sparse. In order to illustrate this fact I scanned through some excavation reports from Sweden and Åland (Larsson 1995; Olsson 1996; Olsson et al.1994; Storå 1995a; Storå 1995b; Storå & Stenbäck 2001; Welinder 1971), and earlier summaries (Martinsson 1985; Nuñez 1990). The comparison is presented in Fig. 1, which gives the reader an idea of the vast amounts of lithic debris that are unearthed at the sites in the Åland Islands as compared to that encountered on the Swedish mainland.

Site	*Amount of debris*	*m^2 excavated*	*Debris/m^2*
Häggsta V (Swe)	66	350,0	0.18
Häggsta IV (Swe)	291	220,0	1.32
Överåda (Swe)	205	125,5	1.63
Fagervik (Swe)	64	18,0	3.55
Korsnäs (Swe)	3159	136,0	46.45
Kolsvidja (Ål)	11725	220,0	53.30
Jettböle I (Ål)	26208	187,5	139.78
Smikärr (Ål)	20040	125,0	160.32
Åsgårda (Ål)	27232	82,0	332.09

Figure 1. Table showing the amount of lithic debris at various Pitted Ware sites from the Swedish mainland (Swe) and from Åland (Ål).

The characteristics of the lithic assemblages

A study has been conducted by the author involving flaked rhyolite from 1999 years excavation at Jettböle. In order to establish the exact location of the 1905 excavation and to get a reference point as to the stratigraphy of the site, a small trench (4.5 x 2.5 meters) was opened up (Storå & Stenbäck 2001). The old excavation trench was encountered and the total area of undisturbed cultural layer excavated during 1999 was 7.5 m^2. In all, 8100 flakes of rhyolite were collected during the excavation; 33 cores and two hammerstones of the same material were also recovered. In this paper, the material from Jettböle will be compared with material from trench 2 at Bergmanstorp, which was excavated in a similar manner (Storå 1999).

The following characteristics have been noted in the studied material from Jettböle and Bergmanstorp (Darmark 2001):

- The dominating reduction method employed at the site is a direct platform method, probably using a hard hammerstone, judging from the 15 hammerstones found within the trench. Very little evidence of a bipolar method is found within the material. One platform flake in rhyolite has been subjected to bipolar reduction but only to a limited degree. One bipolar core in quartz was found at the site. The use of an anvil method has not been investigated, but the presence of anvils within the trench possibly indicates that this technique has been used. The lithics from Bergmanstorp also display a total lack of bipolar technique.

- The amount of splinters within the Jettböle assemblage is large, 60%. This is valid even though the excavated material was sieved through 0.5 cm mesh, and even though no water sieving was conducted. The original amount of splinters could therefore be somewhat higher than shown by the excavated material. The 60% from JI99 can be compared to the mere 28% from Bergmanstorp, trench 2.

- The complete flakes from JI99 are generally small in size. The flakes have been categorized according to weight, in classes of 10 grams. A dominating part (70%) of the complete flakes from JI99 is found to weigh 10 grams or less. Within this group, most of the flakes are below 3 grams. At Bergmanstorp 39% of all flakes are below 10 grams.

- Formal tools are non-existent. A few flakes have been observed to display signs of secondary modification, mostly in the form of use wear (polish or micro retouches), but deliberate shaping of tools has not been found.

- The flakes that show traces of use have in common that they are large in size, or rather, they fit nicely in one's hand. This could of course be a result of not using micro-wear analysis; the use-wear has been observed with the naked eye only. Therefore, there is a possibility that only the larger tools used for rough work have been identified, while smaller tools have remained unnoticed.

- The cores are mostly polygonal in shape and are the result of an opportunistic strategy, where the toolmaker has used appropriate platforms and has not tried to uphold or create a platform suiting his purpose. Some cores have a constant platform. The relative frequency of cores is higher at Bergmanstorp, where the 74 cores constitute 2.4% of the total rhyolite material. The corresponding value in JI99 is 0.4% (33 cores).

The overall impression after the survey of the material is that there are technological similarities. Judging from the cores, which are often exhausted, both assemblages are the result of a reduction process in its final phase. The goal of the platform reduction at both sites seems to have been the production of larger flakes, using a free-hand method. The most striking difference between the sites is in the amount of splinters at Jettböle that contrasts with the material from Bergmanstorp. The large portion of very small flakes at Jettböle was seen as problematic, since the technology was described as being macrolithic. Further interpretations were hindered by the lack of an experimental frame of reference.

The experiments

Three series of experiments were conducted during the summer of 2003. The purpose of these was to get a well-needed reference to the archaeological material. The archaeological lithic material has been used in cultural interpretations of the site (Darmark 2001), but with hesitation, since the natural fragmentation was not known. Therefore, the experiments tried to imitate the anticipated reduction strategy described above. The lithic debris produced was sieved using a 0,4 mesh in order for it to be comparable to the excavated material. The following questions were asked:

- What is the natural fragmentation of rhyolite? In what proportions are complete flakes, fragments and splinters present at a knapping floor?

- Are the fragmentation and the amount of splinters produced affected by the weight of the hammerstone? This question arose since the hammerstones at Jettböle and Bergmanstorp are different. At Bergmanstorp, only smaller hammerstones (average 400 grams) were found, while the hammerstones at Jettböle ranged from 200 to 2300 grams. The character of the hammerstones was believed to be connected with the characteristics of the lithic debris.

- How common is the occurrence of multiple fractures? Previous experiments showed that the lack of platform preparation or preparation of hammerstones often resulted in the production of several flakes in the same blow. The secondary flakes are often easily distinguished in that they are small, thin and have a crushed “U-shaped” platform. These had also been noticed in the archaeological material from Jettböle and their presence led to the idea that they were responsible for the high degree of small flakes at this site.

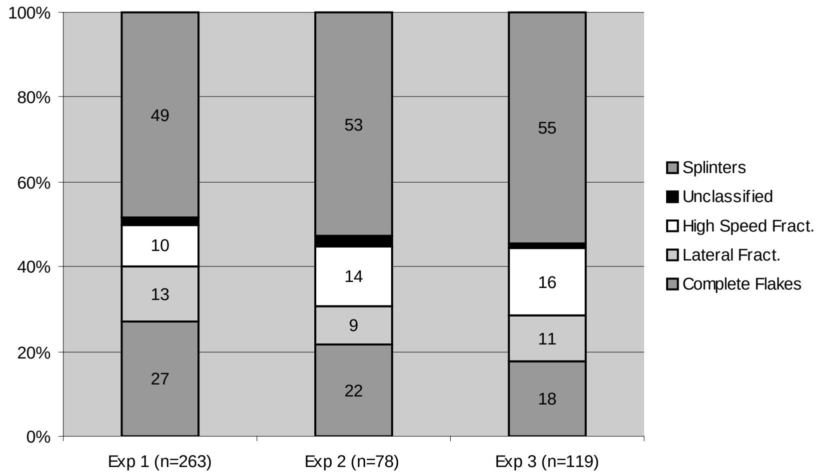


Figure 2. The results of the experimental reduction (%).

Figure 2 illustrates the results of the experimental reduction. Exp. 1 was carried out with a heavy hammerstone of granite, weighing 2600 grams, Exp. 2 with a natural boulder of rhyolite with a weight of 1900 grams, while Exp. 3 was performed with a 600-gram hammerstone of quartzite. The material obtained during the reduction has been classified on a formal basis in the following categories:

- *Complete flakes*. This is a flake with the platform and distal part intact. No attention has been paid to the fact that many of the smaller flakes are the result of multiple fractures and are therefore a byproduct.

- *Lateral fracture fragments*. This category includes proximal, medial and distal fragments.

- *High speed fractures*. Includes middle and lateral fragments.

- *Unclassified*. This category is a result of the fact that many rhyolite boulders have natural cracks within them. When the boulder is struck the force moves along these natural planes and the resulting flake or fragment is hard to classify.

- *Splinters*. Small fragments.

The general trend is that the amount of splinters grows higher as the size of the hammerstone diminishes. The fragmentation in general follows the same trendline. The high speed fracture is marginally more common than the lateral fracture. The amount of complete flakes obtained is highest with the heaviest hammerstone. This is interesting, since the presupposition (judging from the archaeological material) was that the fragmentation would be higher using a larger hammerstone. It seems likely that the nature of the rhyolite, being a very hard, elastic kind of rock, is best reduced with a heavy hammerstone that can produce enough energy to allow the fracture to travel all the way and produce a complete flake.

Concerning the question of multiple fractures, a simplified way of calculating this has been used. The individual flakes have not been classified as the result of multiple fractures. Instead, the number of complete flakes below 10 grams within the different series has been used as a relative measurement to express this. Since the experiments were carried out with the goal of producing larger flakes, the smaller flakes are more often than not the result of multiple fractures.

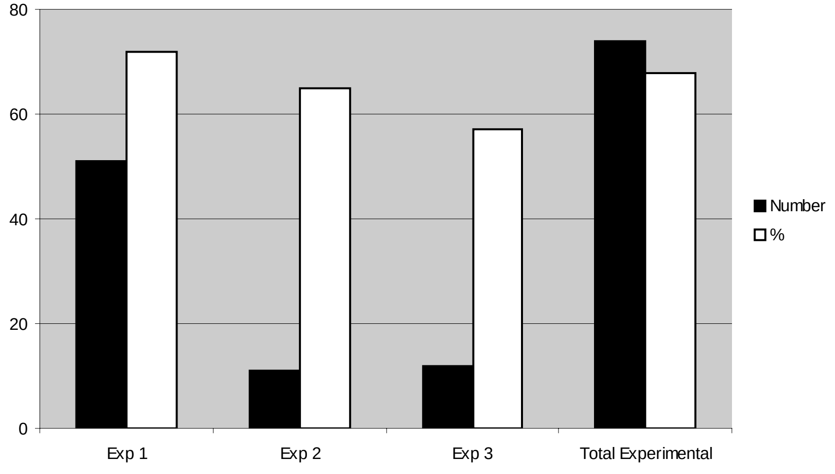


Figure 3. The amount of small flakes within the experimental series, representing the degree of multiple fractures.

As is seen by Figure 3, the amount of small flakes, here interpreted as the result of multiple fractures, is large with hammerstone 1 and diminishes with the size of the hammerstone. This is not necessarily a result of the weight of the hammerstone. The hammerstones used are made of different material. The granite of Hs 1 has the largest crystalline structure, and is therefore more likely to produce more flakes, while both the rhyolite and the quartzite hammerstones retain a relatively smooth surface even after usage. The experiments clearly show that small flakes are commonly produced during the reduction of large flakes, and constitute the bulk (60-70%) of the complete flake category.

Comparisons between the experiments and the archaeological material

The experiments now enable us to look upon the archaeological material through a frame of reference. Figure 4 gives us the following information regarding Jettböle:

- The amount of complete flakes in the assemblage is almost identical to the sum of the experiments. Since the hammerstones from Jettböle range from 200 to 2300 grams, this result is very encouraging.

- The amount of fragments from Jettböle is lower than in the experimental series. Above all, this applies to the lateral fracture fragments.

- The percentage of splinters is somewhat higher than all the experimental series show.

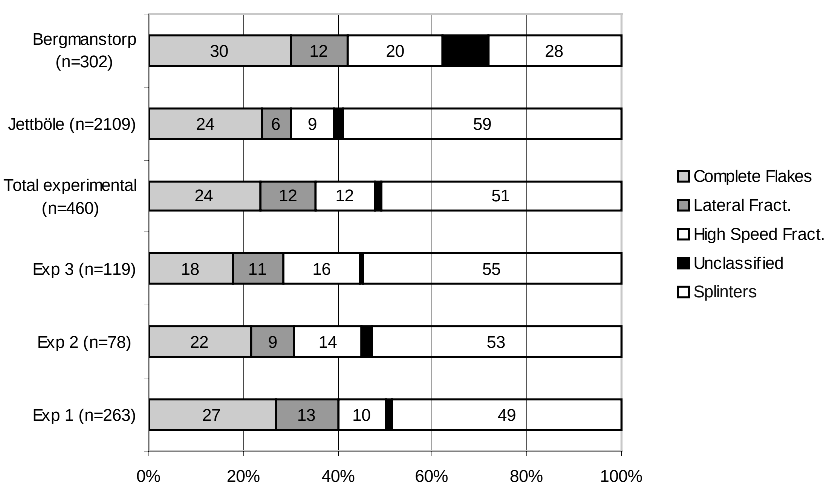


Figure 4. The experimental series compared with the lithics from the discussed sites.

Concerning Bergmanstorp, figure 4 tells us that:

- The amount of splinters is very low, 28 % compared to the 50 %, which is the average in the experiments.
- There are a high proportion of lateral fracture fragments and complete flakes.
- The proportion of unclassified objects is much higher than normal.

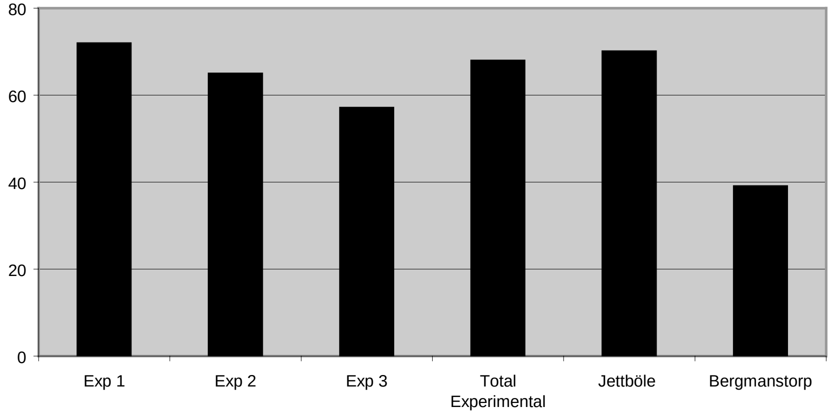


Fig. 5. The presence of flakes below 10 grams within the experimental series compared with the archaeological material.

Figure 5 illustrates the fact that the percentage of small flakes at Jettböle is highly similar to what is obtained during experimental reduction as a result of multiple fracturing. Bergmanstorp, on the other hand, has relatively few complete flakes below 10 grams.

Conclusions and discussion

Originally, Bergmanstorp was viewed as a primary site of reduction, where raw material had been tested in order to establish its quality. This explained the presence of low-quality rhyolite. Therefore, Bergmanstorp was seen to represent a knapping floor, while Jettböle was seen as representing a site where the lithic material had been reduced beyond what was functionally explainable (Darmark 2001). This interpretation is strongly challenged by the experiments presented in this article. It is clear that Jettböle is much closer to an original knapping floor than Bergmanstorp is. The only aspect in which Jettböle differs from the experiments is in a relative lack of fragments. The experiments have also helped in solving the question of the presence of large amounts of small flakes within a macrolithic industry, which are now seen to be the result of unintentional multiple fracturing.

Bergmanstorp, on the other hand, contains a small amount of splinters, which is in accordance with a relative lack of small flakes, in this context seen as the result of multiple fracturing. Combined with the high amount of larger complete flakes, the emerging picture is that of a site where reduction has not taken place. Instead, the already reduced lithic material was brought to the place, possibly to be used as tools or as raw material for tools. The high rate of cores within the trench does not fit well into this picture, however. A total of 33 cores were found in the small area of 7 m^2. Therefore, it seems more reasonable to view trench 2 as a refuse area. This might be further strengthened by the high amount of low-quality rhyolite.

Whether the lithic assemblage at Jettböle is to be seen as primary or secondary refuse (Schiffer 1987: 58) is difficult to ascertain. Splinters are usually seen to indicate primary refuse owing to their small size that easily evades cleaning attempts (Healan 1995). If the knapping is done on a blanket or a fur, even small debris can be collected and disposed of elsewhere (Fladmark 1982). However, the close resemblance between the Jettböle assemblage and the experimental series does show that lithic reduction has been carried out in the vicinity. This is interesting, especially when compared to similar sites on the Swedish mainland. As stated in the beginning, very few Pitted Ware sites in eastern central Sweden show signs of a considerable production of stone tools (cf Gustafsson et al. 2003: 51f, 56). Judging from the depositional strategies and the obviously intensive stone tool production at the Ålandic sites, it seems there would be a difference in function between the Swedish and the Ålandic sites.

The opportunistic and straight-forward nature of the lithic technology at both Jettböle and Bergmanstorp would seem to be the result of a lack of skill in stone production. This, however, is implausible. The choice of a simple technology must be seen as a social strategy. The low degree of know-how within the technology would ensure that the technology was available to anyone (cf Apel 2001: 29). The Pitted Ware hunting-gathering community, living in an age of steadily increasing social complexity, consciously used the easily available technology as a means of reproducing one of the social values important to them: egality.

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Skilled production and Social Reproduction

Aspects of Traditional Stone-Tool Technologies

During a five-day symposium in late August 2003, a group of archaeologists, ethno-archaeologists and flint knappers met in Uppsala to discuss skill in relation to traditional stone-tool technologies and social reproduction. This volume contains 20 of the papers presented at the symposium and the topics ranges from Oldowan stone tool technologies of the Lower Palaeolithic to the production of flint tools during the Bronze Age. The symposium was arranged by Societas Archaeologica Upsaliensis and the department of Archaeology at Uppsala University.

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