ANALECTA PRAEHISTORICA LEIDENSIA

1989

ANALECTA PRAEHISTORICA LEIDENSIA 22

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PUBLICATIONS OF THE INSTITUTE OF PREHISTORY

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THE WEAR AND TEAR OF FLINT

PRINCIPLES OF FUNCTIONAL ANALYSIS APPLIED TO DUTCH NEOLITHIC ASSEMBLAGES

UNIVERSITY OF LEIDEN 1989

editorial committee: L.P. Louwe Kooijmans / C.C. Bakels

edition of this volume: A.L. van Gijn / M. Wanders

drawings, lay-out and cover: H.A. de Lorm

ISSN 0169-7447

ISBN 90-73368-02-2

Also appeared as doctorate thesis, Leiden, May 2, 1990.

Subscriptions to the series Analecta Praehistorica Leidensia and single volumes can be ordered exclusively at:

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1 Introduction

The present research started when the author wrote a master's thesis about the wear analysis of the Bronze Age flint assemblage from Oldeboorn, Friesland (Van Gijn 1983). Subsequently, a project of the Netherlands Organization for Scientific Research (NWO) was initiated in 1984 under supervision of Prof. Dr. L.P. Louwe Kooijmans. The primary objective of this project was to assess the possibilities of microwear analysis for Dutch flint assemblages. Archaeological investigations included those pertaining to form and function (i.e. would it be possible to predict function on the basis of certain morphological characteristics?) and a study of the economic activities carried out at the various sites. Technical objectives encompassed research into the quantification of wear-traces and into the process of patination. Lastly, a reference collection of experimentally-used flint tools was to be started, with special emphasis on those dealing with the processing of fish. This latter material had been underemphasized in previous research-projects and was considered especially important in Dutch (coastal) contexts.

When the above research project was proposed, microwear analysis in the Netherlands was not yet well-established, and there was much scepticism about the results which could be obtained, especially regarding Palaeolithic assemblages. For this reason a diachronic perspective was opted for, and sites were chosen from various periods. The Middle Palaeolithic sites of Belvédère, the Upper Palaeolithic sites of Emmerhout, Diever and Rolde, the Linearbandkeramik (LBK) site of Beek-Molensteeg, and the Late Neolithic sites of Hekelingen III and Molenaarsgraaf were initially selected. In addition, the possibility was left open to include other relevant material as well.

These assemblages have in common that they are (or were believed to be, cf. *chapter 5*) relatively small, reflecting short-term occupations, and are all well-excavated (i.e. the provenance of the artefacts is known). Moreover, in several cases, such as at Hekelingen III, ecological information was available to indicate the sort of experiments needed as a reference. Lastly, the above-mentioned sites did not only vary in age, but also with respect to the matrix in which the artefacts were embedded; it was thought that this aspect too might be influencing the preservation of the use-wear traces.

In the course of the research, however, the 'test-case' character of the initial proposal turned out to be rather dissatisfying, especially due to the consequent lack of interesting archaeological (cultural) problems to confront. The various sites studied were so individual in character that there was little possibility of comparing them. The fact that the author became a member of the academic staff at the Institute of Prehistory in Leiden (IPL) made it possible to change the content of the research to some extent. It was decided to focus on Neolithic assemblages because of the author's primary interest in this period. Most microwear research had so far been concentrated on Middle and Upper Palaeolithic assemblages and it was considered interesting to meet the challenge of investigating the 'Neolithic novelties' (Keeley 1983). Of particular interest was the apparent continuation, far into the Neolithic, of hunter-gathering-fishing subsistence strategies contemporaneous with farming. As such it was possible to explore the potential of microwear analysis as a means of answering questions regarding functional differentiation of settlements. Only by addressing such current archaeological issues, is it possible to demonstrate the relevance of going through the trouble, both in terms of time and costs, of doing a use-wear analysis.

This change of research objectives had the following consequences for the composition of the samples studied. As Hekelingen III had been the first assemblage examined (1984-1985), and had yielded interesting results, it was retained. In addition, to examine site variation within one cultural group (the Vlaardingen culture, or Vlaardingen-group as suggested by Louwe Kooijmans (1983a)), Leidschendam was selected as a comparison. Molenaarsgraaf was rejected for analysis because of extensive abrasion of the artefacts (possibly due to the sandy matrix). Other Late Neolithic assemblages were also checked, such as Ewijk and Voorschoten (both Vlaardingen-group), and Kolhorn (Protruding Foot Beaker Culture), but these displayed the same problem as the one of Molenaarsgraaf. Of the initial sample, Beek-Molensteeg also remained, because it was believed to be a small site; as all other known Linearbandkeramik (LBK) settlements of the Graetheide Plateau are large, it was thought that Beek-Molensteeg might possibly be an example of a site with a different function. Unfortunately, it soon became apparent that the site only formed a small section of a much larger ('normal') LBK settlement.

Parts of the initial NWO research proposal are not presented in this study, but were nevertheless realized and published elsewhere. A detailed analysis was done, involving study by scanning electron microscope (SEM) and energy dispersion analysis (EDAX), of experimental fish-processing implements (Van Gijn 1986a). To investigate the limitations of microwear analysis as a method, an international blind test was organized, in which the author participated (Unrath et al. 1986). Samples of several sites within the Belvédère gravel quarry, such as C, F, and G, were studied (Roebroeks et al. 1986; Van Gijn 1989), while others are still being examined (site J and K). Lastly, a study was made of a typical form-function problem within Dutch archaeology, that of the Late Bronze Age sickles (Van Gijn 1988, *in press b*). The only aspect of the original NWO proposal which has not been realized, forms the analysis of the Upper Palaeolithic assemblages of Emmerhout, Diever and Rolde.

It must be stressed that the present study was done over several years (1984-1989), during which microwear analysis as a method was going through a number of phases (see *chapter 7*). The research presented here was formulated and initiated during the end of the first, very optimistic period, in which microwear analysis was introduced. The large bulk of the analyses was done in the second, 'introspective, self-critical' (Juel Jensen 1988a: 59) phase, during which a number of critical articles appeared, and scepticism and disappointment prevailed. At present, the method is gradually moving into phase three, characterized by a more well-balanced use with an awareness of the possibilities and limitations; the study was finished during this period.

For this reason the work is also a reflection of the changing attitudes of the author towards use-wear analysis in general, and microwear analysis in particular. As such it is, in a sense, somewhat unbalanced at times. Major reason for this unbalance is that, at the outset of this study, it was still generally assumed that we could identify polishes and other wear-traces, thereby arriving at a relatively secure determination of tool function. However, it was soon evident that so many problems prevailed (cf. *chapter 2*), that it was more appropriate to speak of an interpretation of wear-traces. Through time it also became clear that not all of the objectives initially formulated were feasible, while others were outdated, or considered less interesting. For example, research into possible ways of quantifying the texture or reflectivity of polishes is deemed to be fruitless, until the nature of polishes is better understood. This latter subject is clearly beyond the competence of archaeologists and it is to be hoped that some relevant research by surface chemists and physicists will filter through to archaeology. Instead, it was decided to attempt to count (on experimentally used tools with a known function) the occurrence of those attributes easily observable in daily microwear practice. In this manner the inferential limitations of the method can be explored: how high a percentage of each contact substance can we potentially trace in the archaeological record? Yet another, technical, objective of the initial NWO proposal was modified. Instead of randomly performing experiments towards illuminating the character of post-depositional surface modifications, a survey of previously studied archaeological assemblages was done, in order to look for clues as to what factors might possibly be relevant. As to the archaeological objectives, the emphasis was shifted from form-function questions towards those pertaining to settlement function and differentiation (see above). Nevertheless, aspects of morphology and their relationship to tool function were addressed, because the results may provide a clue as to how to sample assemblages more efficiently.

These considerations led to the following framework. The volume begins with an overview of methods and techniques, in which the approach used will be presented in the light of some current debates about the validity of microwear analysis (*chapter 2*). Next, the experimental program is discussed, as well as the quantification of relevant wear-attributes visible on the experimental tools; such a quantification makes it possible to evaluate the representativity of the results obtained for an archaeological assemblage (*chapter 3*). In chapter 4 an overview is given of post-depositional surface modifications (pdsm) present on flint artefacts and the way wear-traces are affected by them. By examining the results obtained from assemblages studied in the past (in terms of frequency of pdsm, matrix from which the implements derive, and age and type of settlement), an attempt is made to isolate relevant factors responsible for the destruction of wear-traces. Chapter 5 deals with the flint assemblage from the LBK site of Beek-Molensteeg; both a description of the technological features, and an analysis of the wear-traces found is provided. The two Vlaardingen sites, Hekelingen III and Leidschendam, are presented in chapter 6. The main objective was to try to unravel their respective functions in the settlement system. In chapter 7 the suitability of microwear analysis for the solution of general archaeological problems is discussed.

2 Methodology and techniques

2.1 Historical overview of the method

Interest in the function of archaeological stone tools began to develop during the 19th century, when information about various 'primitive' peoples around the world reached Western Europe. This was also the time when the theory of evolution became generally accepted. It was realized that the stone tools found in various parts of Britain and France, for example, were the implements of man's predecessors, and not, as was previously thought, the products of natural phenomena. With ethnographic data providing a source of inspiration, various investigators turned their attention to the interpretation of stone tools from a functional perspective. A good example is John Evans' book 'The Ancient Stone Implements, Weapons and Ornaments of Great-Britain', written in 1872. He even observed edge-rounding and striations on scrapers, and associated these phenomena with the working of gritty animal skins. During the late 19th century polishes were first observed: Spurrell was intrigued by the lustrous shine of Near Eastern blades and experimented with different materials in an attempt to reproduce this polish (Spurrell 1892). It was, however, not until the 1930's that it was conclusively demonstrated that this shine was due to the harvesting of straw or cereals (Curwen 1930).

In the West, the real breakthrough for functional analysis came with the appearance in 1964 of the English version of Semenov's book 'Prehistoric Technology', originally written in 1957. Semenov was the first to do experiments systematically and to regularly employ a microscope. Inspired by his work, two others set out to develop his method further: Tringham and Keeley. Tringham concentrated mostly on edge-damage in the form of micro-retouch, to be studied with magnifications up to 100x (Tringham et al. 1974). Her work has been continued by Odell (a.o. 1977), and is commonly referred to as the 'low-power approach'. Keeley emphasized another aspect of use-damage, i.e. polish, and used higher magnifications (100-400x) (Keeley 1980). Soon a debate developed between Odell and Keeley as to the relative merits of their respective approaches (Keeley 1974; Odell 1975). The indicative value of edge-removals was particularly controversial as many factors other than use could produce similar fracturing patterns. Keeley has inspired a number of people, especially in Western Europe (e.g. Anderson-Gerfaud 1981; Vaughan 1981; Moss 1983a; Plisson 1985a; Juel Jensen 1986; Van Gijn 1988); most of them have also incorporated edge-removals in their interpretation of tool function. The strict distinction between low- and high-power approach has, through the years, become less defined, largely because most of those concentrating on polishes incorporate edge-removals as well.

Recent developments include the discovery by Anderson (Anderson-Gerfaud 1981) that plant phytoliths are visible within the polish, enabling the identification of plants on sub-family level. Other initiatives encompass residue studies (Fullagar 1988), and various attempts to quantify polishes (Dumont 1982; Grace et al. 1985, 1987; Beyries et al. 1988; Grace 1989). Important work has been done to investigate the effect of post-depositional surface modifications upon flint and upon the use-wear-traces present (Plisson 1983, 1986; Levi Sala 1986; Plisson/ Mauger 1988). In addition to these more technical approaches, many case-studies have been published and several thousands of artefacts have been examined (a.o. Anderson-Gerfaud 1981; Mansur-Franchomme 1983; Juel Jensen/ Brinch Petersen 1985; Plisson 1985a; Vaughan 1985a, 1985b; Bienenfeld 1986; Beyries 1987). Since 1985 a new debate has been going on, this time questioning the indicative value of polishes (Newcomer et al. 1986). This debate will be addressed in paragraph 7. To begin with, however, it is necessary to specify the various types of damage which occur during use.

2.2 Aspects of damage

As a result of use, several types of damage are inflicted on the tool. They include: 1) edge-removals (or use-retouch as it is commonly referred to), 2) edge-rounding, 3) polish, 4) striations. In addition, pieces of residue can be deposited on the surface of the tool. The sort of damage present depends on many factors. For example, it has been noted that striations are often absent, both on our experimental tools and on archaeological specimens (Plisson 1985a). In the following pages the various types of damage will be discussed in a general way, leaving a detailed description of the wear-traces according to contact-material and motion to chapter 3.

2.2.1 EDGE-REMOVALS

Although Odell (1975, 1977) is the person who has emphasized edge-removals and has developed a descriptive system for them, they have also been included in the 'Keeley-method' from the start (see Keeley 1980: 24-25). The main problem with inferring tool function from edge-removals is that there are various ways in which fracturing can occur, other than simply by impact of a worked material. First of all, it has been stressed repeatedly (Brink 1978a; Plew/ Woods 1985) that micro-chipping results as a by-product of intentional retouching, for instance, a scraper edge. Such micro-chipping is virtually indistinguishable from edge-damage due to intentional use. Secondly, edge-damage can result from non-intentional factors during or after the time of inhabitation, such as trampling, transport and soil compaction (Flenniken/ Haggerty 1979; Vaughan 1985a). In addition, micro-chipping occurs when the flint is excavated, sieved, transported in bulk, or scattered onto tables and rebagged. Tringham and Odell claim that

'... there is no difficulty in distinguishing the damage resulting from deliberate usage from that which results from accidental or "natural" agencies ...' (Tringham et al. 1974: 192),

because these agencies do not usually produce regular scar orientation. However, other experimenters assert that non-use factors can produce both patterned and random flake-scar distributions (cf. Vaughan 1985a).

A third problem with the interpretation of former tool function on the basis of micro-scarring is the fact that there is far more variability in flake-scar morphology, location and distribution than was initially claimed by the early proponents of the low-power approach. Vaughan (1985a) has done an extensive experimental programme (N = 249), and has run Chi^2 tests to detect non-random variability in flake-scar patterns with respect to motion and worked material. Tringham et al. (1974) stated that a longitudinal action produces bifacial, discontinuous scarring, while transverse actions correlate with unifacial, continuous scarring. Vaughan arrived at a different conclusion: while bifacial scarring predominated on tools used in a longitudinal motion (65%), it was by no means absent on edges used for a transverse action (Vaughan 1985a). Even more surprising was Vaughan's conclusion that 52% of the tools used in transverse motion exhibited no continuous scarring. With respect to worked material it has been asserted that the morphological character of the scars indicates the relative hardness of the contact-material (Tringham et al. 1974; Odell/ Odell-Vereecken 1980). The Odells have formulated four hardness categories:

1. soft materials (meat, skin, leaves): the size of the scars is small, with feather terminations
2. soft medium (soft woods): large scarring, usually with feather terminations
3. hard medium (hard woods, soaked antler, fresh bones): hinged scarring of medium-to-large size
4. hard (bone, antler): typified by stepped terminations, of medium-to-large size (Odell/ Odell-Vereecken 1980: 101).

However, Vaughan's experiments indicate that there is a wide range of scar sizes resulting from each hardness category, whereas termination also does not always correspond with the Odells' scale (Vaughan 1985a).

We now arrive at the last problem with micro-retouch, namely that micro-chipping is often absent despite intensive usage. In Vaughan's experiments this phenomenon was noted for 16% of the tools used in transverse motions, and 18% of those employed in longitudinal actions; as to worked material, 39% of the edges involving soft contact-materials and 6% of those relating to hard materials sustained no micro-scarring whatsoever. Obviously, tools were selected for the task at hand which had the most suitable working edges. For example, when having to plane a hard material, it is more logical to select a tool with an obtuse edge, as such an implement is stronger and less likely to sustain extensive edge-damage or even to crumble. Moss (1983b) has demonstrated that edges which have a straight cross-section, are much more efficient for various tasks and do not get damaged so quickly as irregular edges. This relates to Plew and Wood's (1985: 223) observation, that tools which worked efficiently sustained far less edge-damage than those which were obviously inappropriate for an activity.

To conclude this section on micro-scarring, it is clear that there are various problems which limit the interpretation of tool use on the basis of edge-damage. As use-retouch is virtually indistinguishable from manufacturing retouch, it was decided to refrain from incorporating micro-scarring in the interpretation in the case of edges on which intentional retouch was present. Otherwise, used areas were located on the basis of the presence of polish, and micro-scarring was only used as an additional source of information against which the functional inference based on polish, striations and edge-rounding, could be checked. An exception form those edges which display no other (interpretable) traces of wear but micro-scarring. In these cases an attempt was made to infer which motion had been involved, and whether the contact substance had been hard or soft.

2.2.2 POLISH

Use-polishes have been one of the more intriguing aspects of functional analysis and the source of much speculation and debate (cf. Newcomer et al. 1986, 1988; Moss 1987a; Bamforth 1988; Hurcombe 1988). Semenov (1964) observed the presence of polish on his experimental and archaeological tools, but as he made extensive use of metallization, differences in the character of polishes were difficult to observe. It was not until the pioneering work of Keeley (Keeley/ Newcomer 1977; Keeley 1980), that the idea of polish types, associated with various contact-materials, was spoken of. Defining what constitutes a 'polish' has proved to be very difficult, mainly because the phenomenon is still very poorly understood. Keeley does not provide a definition; the first to have done so is Vaughan, who describes a micro-polish as:

'an altered flint surface which reflects light and which cannot be removed with acids, bases and solvents' (Vaughan 1981: 132).

However, this definition is problematic for two reasons. As Plisson has demonstrated, it is now clear that various chemical agents can affect polishes quite drastically (Plisson 1983, 1985a, 1986; Plisson/ Mauger 1988). In addition, recent research indicates that the micro-polishes we observe are not only a surface phenomenon, but appear to have depth as well (see below) (Anderson 1980; Anderson-Gerfaud 1981). Although everyone seems to agree that, whatever the source and character of the polish, it does reflect light, the most problematic issue is separating *residue* from *polish*. Residue reflects light just as well as polish. Vaughan's (1981) distinction between the two depends on whether or not the spot can be chemically removed. If Anderson is right in her assertion that foreign materials are incorporated into the silica-surface (but see Unger-Hamilton 1984), the distinction between residue and polish becomes difficult to draw, because, for example, phytoliths cannot be removed. My own suggestion, that polish includes everything which cannot be washed off with soap and water (Van Gijn 1986a), is not adequate either: many plant juices, blood remains and the greasy bone and meat residues cannot be completely dissolved with water and soap, although a weak solvent of c. pH 5 is usually sufficient (but see note 1 of this chapter). This means that such traces will not be present on most archaeological tools (with the exception of special preservation circumstances such as dry caves). Modifying Vaughan's (1981) definition by adding the term '*weak*' before 'acids, bases and solvents' (see also Moss 1986a) might be a satisfactory solution to the dilemma.

Whatever definition is given for the term 'polish', the fact remains that the term, as it is used at present, is vague. However, in daily microwear practice, polishes can be described in terms of various attributes, such as brightness, distribution, texture and various topographical features, as well as location on the piece and the extent to which the tool is covered. These will be discussed in chapter 3.

2.2.2.1 Polish formation

Various theories have been postulated as to the origin of polish formation. A first group of investigators adheres to the theory that polishes are a result of friction and that the surface of the stone is abraded ('polished'). For example, Meeks et al. (1982) attempted to demonstrate that polish does not constitute an additive layer, while Diamond (1979) asserted that, under high speed conditions and with a low load, particles were removed from the highest spots on the surface.

On the other hand, there are those who believe in chemical, rather than mechanical, origins of polish formation. Witthoft (1967) was one of the first to adopt the theory of the melting of silica, first proposed in the 1920's by surface chemists. He observed a difference in hardness, i.e. 7 on Mohs' scale for unmodified surfaces, and 6 for polished spots. Moreover, he noted an increase in volume and a decrease in specific gravity of the stone. Both the softness and the increase in volume are characteristic of fused silica. Witthoft added that, when reaping grain, opal molecules from the plant are fused to the flint, adding mass; he considers most of the gloss therefore as additive.

Although Kamminga (1979) supported Witthoft's theory, it was not until the work of Anderson (Anderson 1980; Anderson-Gerfaud 1981, 1982, 1983) that these ideas were further elaborated. Anderson asserts that, due to the interaction of friction-heat, the acidity of the plants, and the abrasive action of dust-particles, the silica of the stone dissolves into an amorphous gel, into which plant particles (opal) can be incorporated. Although Anderson's experiments mainly pertain to plant material (especially silicious species such as *Gramineae*), she has extended her theory to bone- and antler-working: collagen would also be incorporated into the silica-gel (Anderson 1980).

In an attempt to replicate the latter results, two experimental bone-working tools were examined with a scanning electron microscope (SEM), to which an energy dispersion analysis system (EDAX) was attached. With the SEM it is possible to have a three-dimensional view of the flint surface, while enabling extremely high magnifications, whereas the EDAX can determine the elements present on any selected spot. An experimental bone-working tool exhibiting a well-developed polish was sawn in half: one part was subjected to chemical cleaning (a 10% HCl solution and a rinse with KOH, see also section *2.4*), while the other half was only thoroughly washed with water and detergent. The latter fragment exhibited high peaks of phosphor, carbon and calcium when examined with the EDAX (*figs. 1, 2*); spots displaying this elemental composition are considered to be residue. The half of the tool which had been chemically cleaned, however, showed no such peaks: the polish-spots looked different (*fig. 3*) and apparently consisted of silica only, as did the surrounding unpolished flint surface (Van Gijn 1986a). This experiment was replicated a second time with the same results, but obviously this number is still too small to draw a definite conclusion. Moreover, even though no foreign elements were observed, this does not mean that the silica in the stone failed to turn into a gel-state during work. Ion beam analysis of polished surfaces has shown that polished areas contain more hydrogen which supports the gel-formation hypothesis (Andersen/ Whitlow 1983).

The various opinions serve to illustrate the confusion which surrounds the question of the origin of polishes. One problem seems to be that some people examine flint prior to chemical cleaning, while others carry out the examination afterwards (see also Moss 1986a). This has recently been demonstrated by Bettison's (1985) assertion that plant polishes consist of a layer on top of the tool. This idea is diametrically opposed to Anderson's (1982) conclusions. However, Bettison apparently did not chemically clean her tools, so that she was actually examining residue (plant juices) and not polish.

I would argue that the question of the origins and exact nature of polishes is not a subject archaeologists should address because they lack the detailed knowledge of chemists and physicists, necessary to tackle this complicated problem. Still, in the meantime work can continue because, as Juel Jensen (1988a) has already stressed, polish is foremost a visual phenomenon, which can be interpreted by comparison with experimentally induced wear-traces (see *chapter 3*).

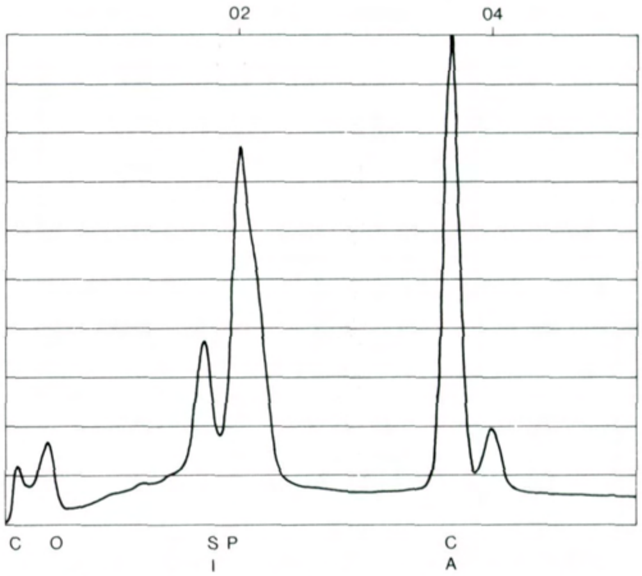


Fig. 1 EDAX analysis of an experimental bone-working tool before cleaning with HCl. Note the high calcium peaks.

2.2.2.2 Polish quantification

It was soon realized that wear-trace analysis is a very subjective enterprise (Ahler 1979). Keeley already attempted to quantify certain polish attributes (Keeley 1980: 62-63). A determination of the 'brightness' of the polish could be obtained by measuring the amount of light reflected from a standard area of polished surface, using bright-field illumination and the light meter of a camera. The problem was to find spots where the polish extended across the entire standard area, something which seldom occurs. If the polish spots cover only a small percentage of the standard area, the reading is influenced by the surrounding unpolished surface which reflects less light. Keeley also attempted to quantify the 'texture' of polish spots, using dark-field illumination, in which smooth polishes reflect little light, while rough polishes a lot. However, also in this case, the size of the standard area was such that the texture of the unpolished stone interfered too much. Keeley mentioned some additional drawbacks of these two procedures as well: the time-investment and the low reliability due to the area problem (Keeley 1980: 63).

Another attempt at quantification of polishes involves the use of interferometry (Dumont 1982, 1988: 25-32). This is an optical technique capable of measuring the differences in distance between a reference mirror and the surface of the object which one is studying. Two beams of light are emitted, an object beam and a reference beam, forming alternating light and dark bands. Deviations from linearity of these bands, or variations in their widths indicate changes in surface elevation of the object studied. These variations can be photographically recorded (Dumont 1982: plates 11, 12b), and translated in a numerical fashion (Dumont 1982: 208, 1988: 27). In this way depth of striations can also be measured, as well as the degree of penetration of the polish, within the range of elevations of the original microtopography of the stone. This latter feature indicates the surface deformability of the contact-material (Dumont 1982: 209-212). The major drawback of this attempt at quantification is, again, the requirement of well-developed, sizable spots of polish, since the unpolished surface is so irregular that it causes a very complex interferometry pattern (Dumont 1982: 208).

The most recent approach concerns texture analysis (Grace et al. 1985, 1987; Grace 1989). Grace uses a digitizer to translate the visual image, divided into a large number of cells of 0.25 x 0.25 μm, into grey tones. His grey tone scale ranges from 0-255, so that very small differences can be detected. The value of each cell is subsequently plotted in a scatter diagram. By this method Grace claims to quantify the texture and intensity of the polishes. However, the main problem with Grace's analyses is that he is working with tools which were only briefly used and consequently exhibit very little polish (see Grace et al. 1985: plates 1b, 1c). As a result, too much unpolished surface is being included in each frame and subjected to the texture analysis. It is therefore not surprising that the polishes do not cluster according to contact-material involved, but that, instead, briefly-used tools group with unused surfaces.

From these, perhaps rather detailed, outlines of techniques to measure certain polish characteristics, such as brightness, texture and topography, it should be clear that none of them has proven to be completely successful. The main problem is always that polish spots are often so small that they do not extend across the entire 'standard area'

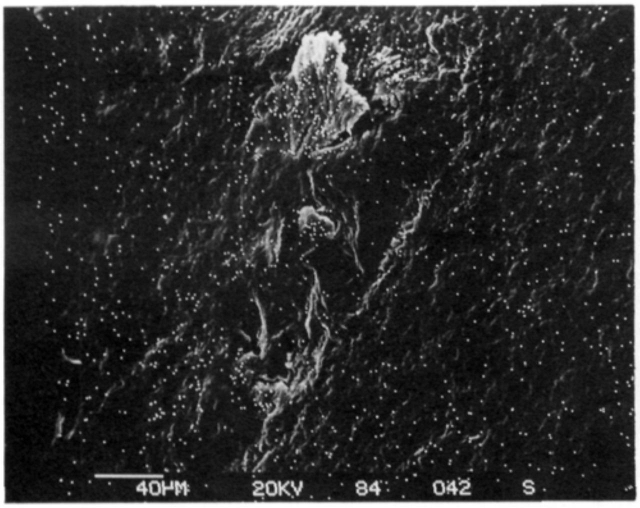


Fig. 2 SEM photograph of one of the spots yielding the graph of fig. 1; the white dots indicate the concentrations of calcium.

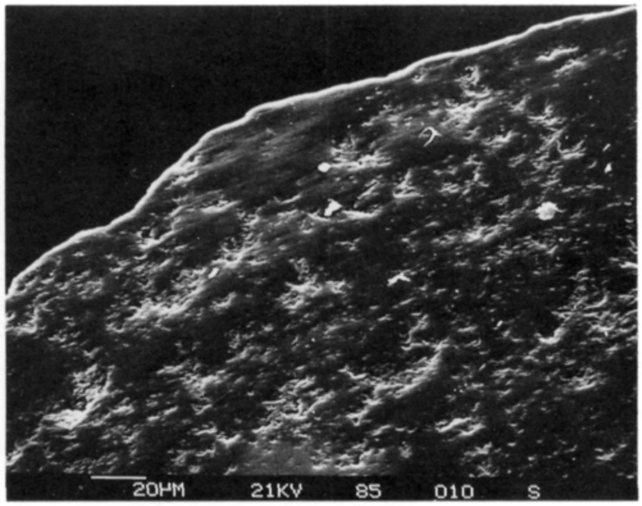


Fig. 3 SEM photograph of bone polish, consisting of Si only (after treatment with HCl).

being examined. The presence of unpolished surface in the area measured skews the results. It also seems a little premature to attempt to objectify a phenomenon, the origin of which is as yet poorly understood (see above). However, even though absolute quantification is so far impossible, the nominal variables, for example the presence or absence of topographical features such as comet-tails, can be quantified to some extent. It is also worthwhile to note whether a polish is bright or dull, and rough or smooth. In chapter 3 an attempt is made to achieve such an assessment, albeit at times subjective, of the occurrence of various attributes.

2.2.3 Striations

Striations were heavily relied upon by Semenov in his functional analyses. Not only did he infer the kinematics but also the worked material from their location, distribution and orientation (Semenov 1964). Keeley (1980) sees an indirect relationship between width and depth of striations and the material worked. He assumes that the size of the use-damage spalls, which splinter off the tool, is to some extent determined by the hardness of the worked material and that also these microchips cause the striations. In actual practice, however, Keeley and others rely on striations mostly for the inference of the motion involved. The argument behind this caution is that the character of the striations is, to a large degree, also determined by grit coming between the tool and the worked material. Moreover, the variability in size of the microchips resulting from contact with a certain material is great. However, whatever the causative factor behind the appearance of striations, their orientation and their distribution on the tool do indicate the kinematics involved (Vaughan 1985a).

As to the way in which striations develop, the variables involved are still very poorly understood, despite some studies (Del Bene 1979; Fedje 1979; Kamminga 1979). Generally, it is assumed that striations are the result of the presence of abrasive particles between tool and contact-material. This theory underlies the assertion that striations can only be employed to infer motion. Inspired by Anderson's research on the origin of polishes, Mansur (Mansur 1982, 1983; Mansur-Franchomme 1983) has arrived at a different theory. She assumes that the silica of the working edge is not in a solid-state, but in a gel-state. Scratching agents act on this gel, not on the solid cryptocrystalline surface. Furthermore, the appearance of the striations depends on the degree of amorphization of the flint surface. As this gel-formation is different for each contact-material, different types of striations occur. Whether Mansur-Franchomme's ideas are correct depends on a verification of Anderson's hypothesis on polish-formation. It is definitely true, however, that scratches are only visible within polished areas.

On the basis of her research on striation-formation, Mansur-Franchomme (Mansur 1982, 1983; Mansur-Franchomme 1983) has developed a classification for striations, which attempts to correlate morphological striae-types with worked materials. Although Mansur's work on the mechanics of striae formation has provided considerable insight, I find her classification far too cumbersome to work with in daily microwear practice.

Recent research has made clear that striations do not occur very frequently (Moss 1983a; Plisson 1985a; Vaughan 1985a). The experiments presented in this study seem to corroborate this result (see *chapter 3*). It is likely that the circumstances under which the work is carried out, for instance dusty or clean environments, are of more consequence than the type of material worked.

2.2.4 Edge-rounding

A fourth aspect of use-damage is edge-rounding: any contact-material rounds the edge of a tool to some extent. Most researchers have been rather vague on the subject. However, the degree of edge-rounding can, in some cases, provide an indication of the kind of contact-material involved. Experiments have, for instance, shown that hide-working causes extensive edge-rounding, especially if grit is added to absorb moisture (see *3.2.2*); this occurs irrespective of whether a transverse or a longitudinal motion is employed. Working bone, conversely, seldom gives much edge-rounding. Differential edge-rounding on both aspects of a tool can also indicate which aspect formed the contact surface.

As with the other categories of damage, one should be cautious about attributing rounding of an edge solely to use. When a tool is embedded in a sandy matrix, for example, it can become totally rounded. This will be dealt with more extensively in chapter 4.

2.2.5 Residue

The last category of modifications which develop during the use of a flint tool is the deposition of residue. In the section on polishes it has already been stressed how difficult it is to differentiate between polish and residue. For instance, are the plant-phytoliths, sometimes present in 'sickle-sheen', to be included in the category residue or polish? If we consider them as residue, then long-lasting phenomena, such as phytoliths, are subsumed in the same category as short-lived phenomena such as remnants of hair, blood[1] and plant-tissue. In the past, it was proposed that we include in the category 'residue' all those deposits which can be removed with soapy water (Van Gijn 1986a). Now, I would extend 'residue' to those deposits which disappear after immersion in a lightly acidic solution (pH = 5). This would thus also include fish-polish type A (Van Gijn 1986a).

Not only can residues be analyzed with an EDAX to detect their elemental composition, but various stains also provide an indication of their character (Fullagar 1988). It has even been suggested that the analysis of blood remains on tools can provide an indication of the animal species which had been butchered or killed with the tool (Loy 1983), but this assertion is not without its critics (Gurfinkle/ Franklin 1988).

Most residue, as defined above, has not been preserved under the soil conditions prevailing in the Netherlands. Percolating groundwater gradually 'washes off' residue. Moreover, in large parts of the country soils are acidic (pH = 4), resulting in a bonding of certain elements comprising the patch of residue. Thirdly, micro-organisms feast on blood stains and other residues. Lastly, there is the process of adsorption which plays a role in clay soils. Clay minerals loosely bind Ca-, P- and C-elements (Van Gijn 1986a; Van der Zee 1986), 'pulling', as it were, these elements off the stone surface: under experimental conditions, this process occurs gradually and is completed after c. 12 hours (*fig. 4*).

On the basis of these findings it is highly unlikely that residue has been preserved on the flint assemblages analyzed in this study. This category of use has therefore not been included in the inferences on tool function.

2.2.6 Relevant variables in wear-trace formation

In the preceding pages the different categories of wear were discussed. However, no mention was yet made as to which factors determine their development; in this paragraph these will be dealt with. The first, very important one, is the character of the raw material from which the flint tool is produced. It is not so much its colour, but its relative coarseness that is of concern. The coarser the flint, the slower is the formation of polish and striations, while the edge is more likely to crumble instead of to develop extensive rounding. A first reason why polish develops slower on coarse-grained flint than on fine-grained material is that the latter binds more water; it has often been suggested that water affects the speed of polish-formation (Andersen/ Whitlow 1983). A second reason that polish develops only slowly on coarse-grained flint is a mechanical one: initially only the higher points (from a microscopic point of view) of the surface will get polished, to join into spots of polish only after prolonged work. In other words, on coarse-grained flint the initial stage of polish formation (generic weak polish as Vaughan (1981, 1985a) calls it), during which no characteristic attributes have yet developed, prevails much longer than on fine-grained tools. This implies that a larger percentage of coarse-grained tools will be interpreted as being 'unused' than would be the case for fine-grained specimens.

A second influential factor is the contact-material itself. Experiments have indicated that certain contact-materials, such as silicious plants and bone, bring about a polish much more quickly than others. Notably slow to develop are polishes resulting from working fresh, green plants, meat and fresh hide. These soft contact-materials also inflict few edge-removals and striations, and little edge-rounding. 'Intermediate' polishes are those resulting from contact with wood, antler and dry hide. This means that meat- or fresh-hide knives and green plant-cutting tools are likely to be severely under-represented in our analysis (see *3.12*). Moreover, even very slight abrasion by the surrounding matrix can cause the traces deriving from these soft materials to become completely invisible. So, while traces resulting from contact with bone or *Gramineae* not only develop much faster, they are also much less susceptible to post-depositional surface modifications.

Motion provides a third influence on wear-trace development. Bone-sawing, for example, causes much heavier edge-

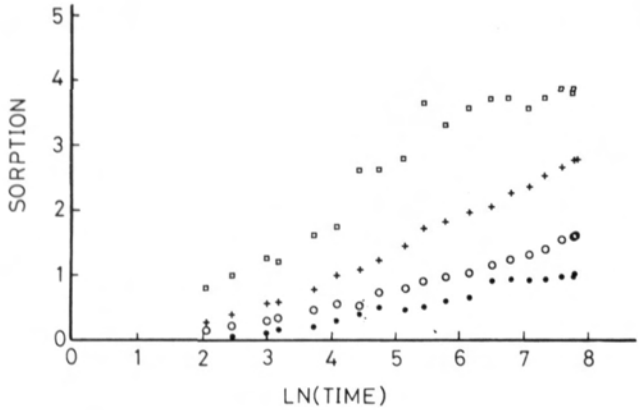


Fig. 4 Sorption of orthophosphate in (mmol p/kg soil) as a function of the natural logarithm of time (time in minutes), for four concentrations of P: 0.05 mmol P/1 (●); 0.1 mmol P/1 (0); 0.2 mmSI P/1 (+); 1 mmol P/1 (□). Measurement technique as described by Van Riemsdijk/ Van der Linden 1984 (after Van der Zee 1986: 25).

damage than bone-scraping, and will remove already formed polish-spots.

The duration of work has already been dealt with in passing when discussing the previous three factors. It should be clear that no direct relationship exists between the duration of work and the extent of the damage; this pertains to all worked materials. It greatly depends on the character of the flint from which the tools are produced, the type of contact-materials, the motion involved, and the pressure exerted. Moreover, it is by no means clear whether a heavily developed polish represents a long period of work, or a brief, but very intensive one. It may also indicate handling by a person who is very inexperienced at the task at hand (see *3.1.3*). Therefore, I prefer not to interpret the duration of work, as done by several researchers (Vaughan 1985a), but rather the degree of wear.

One factor which influences wear-traces, once they have developed, are post-depositional surface modifications. They will be discussed extensively later on in this study (*chapter 4*), but brief mention is warranted here. Traces resulting from contact with soft materials will, independently of the motion involved and the duration of work, often be invisible due to slight surface modifications. The same pertains to most briefly-used tools, and those implements which are used for a longer period but are manufactured from coarse-grained flint. It is thus crucial to assess, for each assemblage, the extent of post-depositional surface modifications, in order to be aware of the possibility that certain contact-materials will be under-rated. Even within one site variations may occur in the extension of such modifications.

2.3 Sampling

2.3.1 On the level of the assemblage

Since the number of pieces which can be examined per day is in the range of 6-10 (unused pieces included; if one has a large biface, one can spend an entire day), it follows that it is almost impossible to examine an entire assemblage. Inevitably a sample has to be taken, unless one restricts oneself to small assemblages of 200-500 pieces, such as has been done by, for example, Vaughan (1981) for the Magdalenian '0' level 10 of the Cassegros cave.

There are various ways in which a sample can be drawn, depending on the sort of question(s) one would like to ask. A first option is a random sample of retouched tools, tools showing traces of use, and debitage alike, irrespective of their size. This would provide a general view of the activities carried out at the site and an insight into the inhabitants' attitude versus stone tools. This procedure has almost never been followed and is considered unproductive for one major reason: it excludes a large amount of retouched (and used) tools from analysis, while these, by the very fact that they have been intentionally modified, were explicitly intended to be used. As such they offer the highest potential of eliciting information. Examining tiny pieces of debitage seems a waste of valuable time as there is only a small chance that they have been used[2]. The only justification for examining them is to test exactly this very assumption.

The second option is to take a weighted sample: a larger percentage from the retouched tools, a smaller from the debitage. This has the advantage that the retouched tools, which potentially contain much more information about prehistoric behaviour patterns, have a higher chance of being examined. This sampling method is exhibited by the microwear study of Swifterbant (Bienenfeld 1985, 1986). If the number of retouched tools is manageable, all of them can be included, a method exemplified by the studies presented in this volume, and previously applied by, for example Juel Jensen in her analysis of Vaenget Nord (Juel Jensen/ Brinch Petersen 1985).

Yet another manner of reducing the number of artefacts to be examined is concentrating on features, such as hearths, and to include every artefact within specified confines of such a feature. Of course this reduces the number of questions which we can ask regarding more general aspects of the site. Still, in cases where the time available for study is limited, it is a valuable method. Examples include Keeley's study of Meer (Cahen et al. 1979; Cahen/ Keeley 1980), and Moss' examination of certain hearth areas in Pincevent (Leroi-Gourhan/ Brézillon 1972).

A last category of sampling pertains to placing emphasis on one or a few specific tool categories. In this case, questions which can be answered are limited to the ones relating to aspects of form and function. A good example of such a study is Moss' comparison of burins and points from Abu

Hureyra, Syria (Moss 1983c). In this study she concludes that, although the tanged points were primarily used as projectiles, their secondary use, i.e. wood- and reed-working, corresponds with that of the burins. Such a study of the relationship between form and function can obviously be extended across sites, as exemplified by the studies concerning Swiss Neolithic hafted knives (Anderson-Gerfaud/Plisson 1986), micro-denticulates with gloss (Juel Jensen 1988b, *in press*), and Bronze Age sickles (Van Gijn 1988, *in press b*).

Because entire assemblages are being examined in this study, and because the questions asked include some regarding subsistence behaviour, a weighted sample, in which the retouched pieces were covered on a 100% basis, was used. In addition, all those artefacts with a straight edge when examined in cross-section were selected (see also *2.6.2*). This has first been proposed by Moss (1983a), and further elaborated in a comparative study of material from Pincevent, Klithi and Pont d'Ambon (Moss 1986b). Moss' experiments indicate that such edges sustain little edge damage and are therefore effective as working units. She finds this confirmed in her analysis of the debitage from Pont d'Ambon, where the curved sections tend to be unused. With respect to this latter sample she asserts that

> 'straight edges and points do seem to be reliable indicators of used pieces: out of a sample of 305, only three used pieces of debitage would have been missed if the sample had been chosen by such criteria' (Moss 1983a: 193).

Moss specifies that the edges have to be straight for a length of 2.0 cm or more. As the Hekelingen III and Leidschendam trench 4 flint artefacts are small and irregularly shaped, I also selected pieces with a straight edge between 1.0-2.0 cm. For the Beek-Molensteeg assemblage, which is characterized by a blade industry, I did use the 2.0 cm cut-off point; small debitage was generally absent anyway, as no sieving had been done.

In addition to examining all the retouched tools (i.e. retouch $\geqslant$ 1 mm and $<$ 1 mm), and all the pieces of debitage with straight sections longer than 1.0 cm (Hekelingen III and Leidschendam) or 2.0 cm (Beek-Molensteeg), I also selected the artefacts exhibiting a 'dihedral point' (Moss 1983b). Typical 'dihedral points' were generally absent in the Neolithic assemblages studied, but pointed tips, forming one end of a straight edge, occurred frequently and often showed traces of use, especially in the case of Hekelingen III. However, they were usually described as 'having a straight edge', rather than as 'pointed' artefact. Obviously, Moss' assumptions about the desirability of straight sections and pointed edges need to be tested on entire assemblages. Although she herself has attempted to do so in a article on Klithi, Pont d'Ambon and Pincevent (1986b), it clearly needs to be further investigated, as her testing still did not concern the complete assemblages. So far, her arguments are convincing and her recommendations have been modified by me only to the extent that I have also included lightly curved edges as long as they were regular: my reasoning was that such edges could be useful for shaving or scraping purposes. More details on the composition of the samples taken from the assemblages will be given in the sections pertaining to each site (*5.4.1*, *6.2.3.1*).

2.3.2 On the level of the artefact

In micro-wear studies, sampling on the level of entire assemblages has become generally accepted. When the number of artefacts comprising an assemblage is too large to deal with in its entirety, few people will nowadays select the 'goodies' only. Most archaeologists are aware that, in order to acquire a representative sample (necessary for valid statistical analysis and applicability of the results to the entire site), selection has to be done in a rigorous, pre-determined fashion.

Less accepted is the fact that microwear analysts also 'sample' the individual artefacts they examine. When functional analysis was first proposed, it was asserted that it would enable an objective assessment of tool functions and would result in the definition of functional typologies with emic relevance, instead of the intuitive, speculative functional typologies previously in vogue. The entire tool could be examined and the use-wear present would clearly show the former function. It was not fully realized that lighting conditions are never constant during the examination of an entire tool. An incident-light microscope emits light at a 90° angle to the surface studied. If this surface is slightly tilted with respect to the light beam, lighting conditions are not optimal and especially polish can easily be missed. This is particularly so, if we realize that stone tools can have a very uneven surface, epitomized in the convex retouched scraper edge. Examining such an edge is very time-consuming, as the tool has to be re-oriented every so often with respect to the light, while we scan along the edge.

Of course, all microwear analysts are aware of this to some extent and will try to examine the entire tool as best as they can. I am positive, however, that most of us, myself included, will carefully scrutinize, under optimal conditions, those parts of the tool which we consider most likely to be used, while the rest is dealt with in a more cursory way. The sections which are retouched, show edge-damage, or polish visible to the naked eye, are of course carefully examined. The proximal end of a flake, or very irregular edges, for example, are merely glanced at. Behind this differential attention lie our preconceived notions of tool use. This was very clearly demonstrated in the Tübingen blind test. Test tool no.7[a], a burin spall, had been used to incise bone. The incising was done with the distal end, while the tip was broken during use. Although the resulting wear-traces were very clear (Unrath et al. 1986: plate 41b), none of the analysts had recognized them, mainly because they had not examined that edge carefully enough; burin-spalls, in our West-European 'Upper Palaeolithic conception', are simply not used that way. The experimenters, however, worked in an Arctic setting, where burin spalls were used 'the other way around'. This example clearly illustrates the point I am trying to make: it is extremely time-consuming and, in everyday microwear work, virtually impossible to achieve optimal lighting conditions for the entire tool. We 'sample' the tool according to our pre-conceived ideas of tool use, thereby perpetuating the ruling typological notions. Moss already implicitly acknowledged that she is doing the same thing by recommending that:

> 'just before examining any archaeological piece under the microscope it is important to examine it macroscopically and to hold it in the hand as if in use. In other words, some tentative hypotheses about use are formed prior to microscopy' (Moss 1983a: 105).

Although she reassures us that other parts are examined as well, it is clear that the 'tentative hypotheses about use' will receive the most attention under the microscope.

I will dwell upon the role of microwear analysis for the resolution of typological issues later in this study (a.o. *7.2*). Here, I want to stress that perhaps microwear analysts should be explicit about their pre-conceived ideas of tool use and stop pretending that they hold an objective clue to the assessment of functional classifications. By making our 'sampling' of the individual artefacts more explicit, we can leave it to others to examine the same tools with their pre-conceived ideas.

2.4 Cleaning procedures

From the start, cleaning has been considered essential to microwear analysis. Keeley (1980) propagated the following procedure:
1. examining the piece with the naked eye and, if necessary, under the microscope for the presence of organic residue
2. wiping the implement with alcohol to remove finger grease and soaking it in warm water and detergent
3. immersing the piece in a warm 10% HCl solution and a 20-30% NaOH solution; the HCl removes mineral deposits, the NaOH organic residues
4. using an ultrasonic cleaning tank when pieces are very difficult to clean.

Later, Keeley modified the procedures: he substituted KOH for NaOH, as the latter proved to dehydrate the flint too quickly.

Due to the problems with differentiating residue and polish, not everyone agreed with the extensive cleaning procedure proposed by Keeley. With respect to archaeological tools, there is a danger of removing crucial evidence. Moreover, the series of steps is extremely time-consuming. Many researchers simplified the procedure by, for instance, only using HCl (Anderson-Gerfaud 1982; Bienenfeld 1986), or refraining from the chemical cleaning of archaeological specimens altogether. The latter position was taken because some results indicated the vulnerability of polishes to chemical attack (Plisson 1983, 1986; Plisson/ Mauger 1988). Doubts have risen as to how far one should go with chemical cleaning, not only for archaeological tools, but also for experimental ones. Although in many of the shorter reports concrete descriptions of the cleaning procedures are lacking, it can be deduced from the results and inferences, that many investigators did not use chemicals on their experimental tools (cf. Bettison 1985). This has aggravated the confusion about polish attributes because people were observing different things (Moss 1986a: 94). In my opinion Keeley is right that it is absolutely necessary to subject experimental pieces to HCl and KOH, in order to remove deposits which obscure more durable aspects of polish. The latter are in general the only indications of previous use which are preserved on archaeological tools. To achieve comparability between the archaeological assemblage and the experimental set, it is crucial to simulate to some extent the conditions to which the archaeological material was subjected.

I do believe, however, that the concentrations of HCl and KOH, which were proposed by Keeley, are unnecessarily strong and endanger the character of the more durable polishes. For the experimental pieces much weaker solvents were used on a systematic basis: a 3.6% HCl solution and a very small amount of KOH in one litre of water. This removed all plant juices, most blood stains (those which are recent (cf. note 1)) and bone collagen, while being weak enough not to attack the polishes. The HCl was applied in an ultrasonic tank in which the pieces were left 3-5 minutes; leaving them longer would heat the tools too much. In between all operations the tools were thoroughly rinsed in flowing water.

Concerning the archaeological assemblages, my opinion has changed somewhat over the years. On part of the first assemblage examined, the one of Hekelingen III, HCl was used only (*6.2.3.1*). This, however, had the effect of discolouring the stones to a bluish-green sheen. Moreover the stone-surface appeared to have dissolved slightly when examined several months later; apparently the chemical had continued to 'work'. The flint of Hekelingen III was slightly chalky and it was clear that HCl endangered such surfaces. I later realized that counteracting the effect of HCl with a base such as KOH might have solved the problem, but at the time I decided to refrain from chemical cleaning altogether. The surfaces of the stones did not seem to exhibit any traces of organic films anyhow. Yet another solution to the adverse effects of HCl is soaking the tools in water prior to treatment. In such a way the pores of the stone become filled, inhibiting penetration of HCl (H.Juel Jensen, *pers. comm.*).

As to the material from Beek-Molensteeg, all implements were cleaned chemically in the same fashion as the experimental ones (see *5.4.1*). In fact, I am quite sure that this was completely unnecessary, as the stone surfaces looked identical before and after cleaning. From a strictly scientific point of view the cleaning procedures for archaeological and experimental tools should be the same. However, I believe archaeological tools have, in most instances, been subjected to sufficient chemical cleaning in their matrix, to make both sets comparable. It is doubtful that the time invested in cleaning all archaeological tools in a systematic fashion was justified.

Apart from the initial cleaning with water and soap, and sometimes chemical cleaning, I used alcohol to remove finger-grease and grease from the clay supporting the pieces. As alcohol leaves a film when left to dry, I carefully patted (not rubbed) each piece with a paper towel[3]. Regular cleaning during examination is absolutely essential. Alcohol was chosen instead of acetone, because the fumes of the latter can be harmful to the coating of the microscope lenses.

2.5 Microscopy and photography

It has been stressed on numerous occasions that comparability between various use-wear studies can only be achieved when similar equipment is employed (Moss 1983a, 1986a; Plisson 1985a). Keeley (1980) used a Wild M20 microscope, and later on an Olympus BHM, while in France many analysts relied on Nikon equipment. It is clear that the image produced varies somewhat between the different types of microscopes, especially in the clarity, sharpness and depth of field provided.

In this research, use was made of a Nikon-Optiphot with 5x, 10x, 20x and 40x objectives, and 10x and 15x oculars. Most of the time I used 15x oculars as I preferred the 150x and 300x magnifications rather than the 100x and 200x. Filters employed included the NCB10, a polarizing filter, and the LC900. To increase contrast, frequent use was made of a green filter (GIF). The Nikon objectives have the advantage of an extremely long working distance (up to 9 mm), so that examining concavities did not present any problems. Although the microscope could switch to dark-field illumination, this option was rarely used. Keeley (1980) recommended the 5x objective for the examination of micro-scarring, but I preferred either a hand-lens (10x magnification), or, for the smaller scars, the 10x objective. Scanning the piece for the presence of polishes was done at 150x magnification. At this magnification it is still possible to examine the relationship between the polish and the edge. A magnification of 100x was found to be insufficient to detect small polish spots. The polishes were generally interpreted at 300x; a magnification of 200x often did not provide sufficient detail to warrant a statement. I find it impossible to believe that polishes can be interpreted with a magnification of 100x as some authors have claimed (e.g. Bienenfeld 1985, 1986), and I am in full agreement with Moss when she asserts that 280x (i.e. c. 300x) is the most appropriate magnification to identify polishes (Moss 1986a: 94). When sufficient detail is still lacking I have regularly switched to 400x or 560x. The latter magnification, however, is almost too detailed and one loses 'overview'.

In the following chapters polishes are described in such terms as 'rough', 'greasy', and 'domed', and it should be remembered that these descriptions pertain to the phenomena as observed at 200x or 300x. At higher magnifications spots with rough polish may suddenly seem to consist of a jumble of smooth polish spots: at different magnifications we observe different visual phenomena (Moss 1986a).

To the Nikon-Optiphot a camera and an automatic light-exposure meter could be attached. The film used was Kodak Plus X Pan, a 125 ASA film which, to increase the contrast, was upgraded to 400 ASA. When the new Kodak Professional TMAX became available, I switched to this type of film. Upgrading the film made exposure times relatively short (up to 1 second), an advantage in this sort of work, as the stone tools often move slightly out of focus due to their own weight.

Although micro-photography has greatly improved during the last decade, it is still impossible to interpret archaeological specimens solely on the basis of photographs of other analysts' experiments. A micrograph shows only one horizontal plane so various topographical features of a polish spot may be invisible because they are out of focus. Moreover, the distribution of the polish and its locational relationship to the edge are not transferable to photos. Although photomicrographs are very useful and can generally be 'recognized' by other analysts, we still cannot rely on photographic 'type-lists'.

2.6 Registration

In the early years of microwear analysis, registration has been given little attention. Odell (1977) had developed a complex registration system for the low-power approach. In the 'high-power' camp it was Vaughan (1981), who first created an explicit system. He later attempted, in collaboration with Plisson (Vaughan/ Plisson 1986), to develop a universal system.

The system used in this study has been inspired by various sources (Odell 1977; Knudson 1979; Vaughan 1981; Deckers 1985). My aim was to create a system which would be usable for a variety of assemblages and would incorporate a detailed description of form; this way it could also be used for assemblages, or parts thereof, not examined for the presence of use-wear. In addition, I wanted to make the way I arrived at a functional inference as specific as possible, by

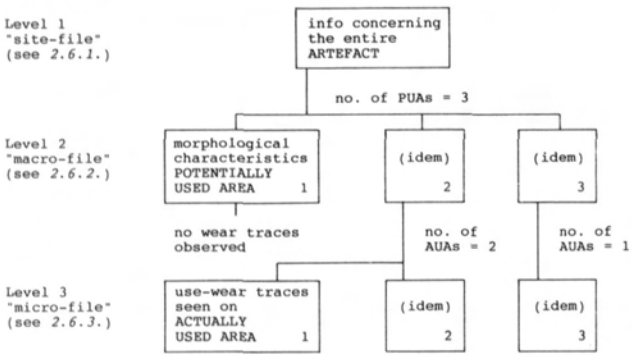


Fig. 5 The hierarchical data-base system used, displaying the three levels of analysis.

coding a complete description of the various polish attributes, aspects of micro-scarring, and striations, instead of the final conclusion only. Obviously, in order to do this, the data needed to be structured in such a way as to enable the use of a computer.

The result is a tripartite hierarchical data-base system, created in d-Base III (*fig. 5*). The first level includes variables concerning entire artefacts, pertaining to provenance within the site, typology, morphology and technology. The last variable states the number of *potentially used areas* (hereafter referred to as PUAs). PUAs are defined by the presence of retouch (both $\geqslant$ 1 mm and $<$ 1 mm), a straight section, edge-rounding or polish visible with the naked eye. The programme automatically shifts to the next file/ step if this variable scores $\geqslant$ 1. If the number of PUAs is zero, it shifts to the next artefact. The second level of information contains a morphological description of each PUA. Once defined, each PUA is microscopically examined for the presence of use-wear traces. The last variable of this file refers to whether or not the PUA has actually been used: in other words, how many *actually used areas* (referred to as AUAs) are present on a PUA. Hence, only if wear-traces are observed on a PUA (and the last entry of the PUA file scores $\geqslant$ 1), does the system shift to the third level of the hierarchy, i.e. the AUA-file in which the wear-traces are described and interpreted for contact-material and motion. For computer reasons the degree of wear is also included in the second file: if the PUA is unused, it is not necessary to descend to the third file to enter that information.

A listing of variables and attribute states (categories) can be found in appendix I. Although the system enables a complete computer analysis of morphological, technological and functional aspects, it is obvious that ambiguities always arise. These are described verbally. At the bottom of the registration sheet a drawing of ventral and dorsal aspects is present, on which the location of the use-wear-traces is indicated, as well as the spots where micro-photographs were taken. In the following I want to illustrate and discuss the variables recorded, according to the tripartite division in artefact-, PUA-, and AUA-level, i.e. 'site-', 'macro-', and 'micro-file', respectively.

2.6.1 VARIABLES RECORDED PER ARTEFACT: 'SITE-FILE'

Most of the variables described at this first level of the hierarchy are self-evident. The first variable indicates the site from which the artefact derives, the second is its individual registration number. This number was, in most cases, issued by me, since the excavations registered finds in bulk per excavation unit (square metre in the case of Hekelingen III and Leidschendam, feature in the case of Beek-Molensteeg).

COORDINATES and LAYER: variables 3, 4 and 5 deal with the artefact in the site grid system. In the assemblages discussed in this study, no exact three-dimensional locations were recorded for each artefact. In the case of the two Vlaardingen-sites, the coordinates refer to the southwest point of the square meter from which the artefact derived. With respect to the Beek-Molensteeg material, the find location of each artefact was not given in terms of coordinates, but in find numbers which correspond with certain features or points in the excavated area. The coordinates of these features and areas were subsequently determined on the excavation plan and the find numbers replaced by this two-dimensional information. No exact vertical information was available for any of the flint artefacts discussed in this study, only the layers from which the material originated.

LENGTH, WIDTH, THICKNESS and WEIGHT: length is measured from proximal to distal end; if indications as to the direction of percussion are absent, it is the longest axis which is measured. The width is taken perpendicular to the length at its maximal point, while the thickness is also a maximum measurement. Length, width and thickness were measured to 1 mm exact. All pieces were weighed to the nearest 0.1 g. For the examination of entire assemblages, this provides a good indication of the quantity of material found, more so than the number of artefacts, as this could include large amounts of tiny fragments. For individual artefacts, the weight could give a suggestion of the amount of impact they would have, as for example, with a chopping tool.

PRIMARY CLASSIFICATION: as to the distinction between blade and flake, I follow the general definition that a blade must have a length twice its width, and its lateral edges must be parallel or subparallel (Uerpman 1976). A core is an artefact on which a number of negatives can be discerned. Waste and splinters contain all artefact categories on which no point of percussion or other signs of percussion can be seen, and which do not fall in any of the other categories (other and unsure excepted). The distinction between waste and splinters is one of size: splinters are the tiny fragments less than 1 cm in length and width. The category 'other' is logically required, but, as most pieces which do not show any clear technological features are included among waste and splinters, this category is seldom used. A primary classification 'unsure' is usually restricted to those artefacts which are so extensively retouched, that it is impossible to determine whether they were produced on a blade or a flake. Categories 10-13 pertain to various types of rejuvenation flakes specific to the Bandkeramik flint technology, the distinctive features of which will be discussed in chapter 5 (*fig. 6*). A crested blade occurs when preparing a core for blade-production. Decortication flakes are the flakes showing cortex, but no further modifications.

TYPOLOGY: typology is a complex variable. As this study is not a typological one, I have tried to keep the typology as simple as possible. Most categories are based on a morphological description following the suggestions of Deckers (1985). For a discussion of typology, the reader is referred to paragraphs 5.5.5 and 6.2.5.4.

CORTEX: the amount of cortex present in an assemblage can give an indication of the quantity of raw material available and the relative distance of the raw material sources from the site: if a high percentage of artefacts displays cortex, the raw material sources are assumed to be 'nearby', since few knappers would transport entire nodules for a long distance without first preparing a core or rough-out. The different categories distinguished describe location and relative extent of the areas of the tool covered by cortex. It should be noted that all 'old' surfaces are included in this variable.

PATINA: the variable 'patina' was included as an attempt to estimate with the naked eye whether post-depositional surface modifications had affected the artefact. Categories comprise none, light, heavy, and unsure. This estimation was later assessed by microscopic analysis and described in the variable 'secondary modifications' (macro-file, see *2.6.2*). This variable can thus be regarded as a 'tentative hypothesis'. It should be stressed that the exact nature of the post-depositional surface modification is of no concern here.

POLISHED FRAGMENT: in the context of the Vlaardingen sites polished flint axes are a common occurrence. Broken axes are often used as cores. This variable takes account of the presence of artefacts with polished facets, and the extent of these facets.

DEGREE OF BURNING: as this system of registration was also designed to describe entire assemblages, the variable 'burned' was added. Obviously, burned pieces must generally be excluded from functional analysis, as even the glossiness characteristic for a brief heating can obscure use-wear traces, while artefacts which are completely fractured ('*craquelé*') can never be analyzed. Categories distinguished include unburned, glossy, red spots, *craquelé*, and unsure.

RAW MATERIAL: raw material is an important variable. Its character determines the appearance of the wear-traces (cf. *2.2.6*) and the experimental reference material should ideally come from the same source. When examining an entire assemblage, the relative percentages of the various types of raw material may suggest lines of exchange. It is also possible that certain tool-types were manufactured from a preferred material. As for the various raw material types distinguished in this study, I followed Verhart's (1983) classification for the Hekelingen III material. He differentiated four groups, the first two of which resemble flint found in the vicinity of Spiennes (Hainault, Belgium). His third group exhibits similarities to the material which can nowadays be collected from Cap Blanc Nez, close to Boulogne-sur-Mer, France. The fourth group differentiated at Hekelingen III ('790') has no counterparts as far as is known (Verhart 1983). At Leidschendam, most raw material consists of locally-available rolled pebbles, while a few pieces resemble moraine flint of northern origin. At Beek-Molensteeg, Rijckholt, Valkenburg, and 'light-grey Belgian' flint was present. Rijckholt and Rullen are sometimes difficult to distinguish from one another, and were not differentiated. The category Cap Blanc Nez was added to be able to incorporate the experimental pieces made from this raw material into the same code-list; I could not attribute them to the Hekelingen III group 3 raw material, since we do not know for certain whether the latter really derives from the Cap Blanc Nez source. The same applies to categories 13 (North Sea flint) and 14 (flint from Kristiansstad in Denmark).

GRAINSIZE: for the examination and interpretation of wear-traces, especially polish, the relative coarseness of the flint is actually more important than the exact provenance of the raw material. Polishes develop more slowly on coarse-grained flint (see *2.2.6*): tools produced from such flint will therefore more frequently be interpreted as 'unused' than fine-grained tools. The four classes of grain-size which are distinguished in this study are obviously relative and subjective. I consider chert-like varieties of flint (Valkenburg) to be coarse-grained, regular Rijckholt medium-grained, northern material fine-grained, while the class 'glossy' seldom occurs. Only when the flint is extremely homogeneous and almost translucent, is this category used. Burned material is hard to examine in terms of grain-size, and, therefore, allocated to the 'unsure' category.

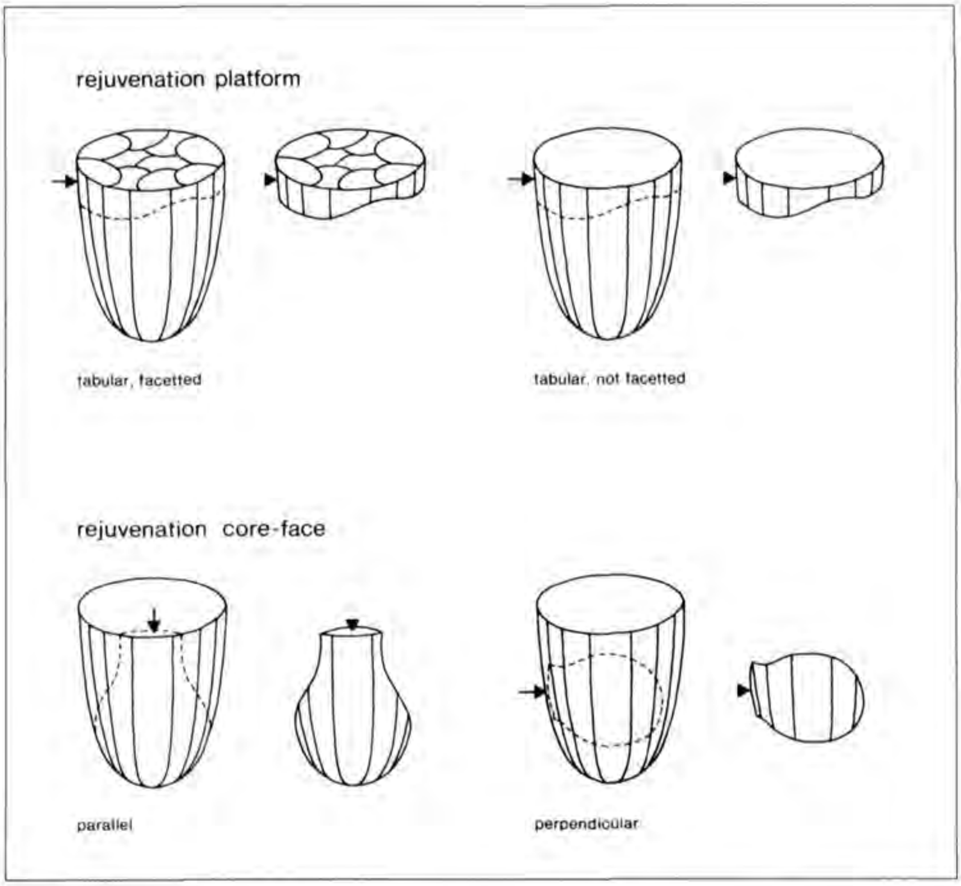


Fig. 6 Varieties of core rejuvenation flakes, characteristic for LBK flint-assemblages, coded under 'primary classification'.

FRAGMENT: there is a variety of behavioural situations for which information on breakage patterns could provide evidence, the most important of which is hafting (see *5.4.2.11*). In Mesolithic context, the relative percentages of distal, medial and proximal parts can provide valuable insight into the manufacturing process of microliths.

HAFTING: just as the variable 'patina', the evidence for 'hafting' is an hypothesis to be tested when examining the tool with the microscope. When I saw a notch, or retouch on a part of the tool which I thought might be related to facilitate a haft, this information was recorded. Traces of bitumen are less subjective. In relation to hafting, the presence of bitumen still forms a hypothesis to be tested, since such traces do not necessarily relate to hafting.

PERCUSSION[4]: differentiating between hard- and soft-hammer percussion is notoriously difficult. Blind tests have indicated that it is only possible to make such a distinction on a statistical basis: the evidence for either technique on an individual piece is seldom unequivocal. Ideally we should therefore record all variables which could indicate soft- or hard-hammer percussion and let statistics do the rest. Variables indicating hard-hammer percussion include strong undulations and pronounced bulbs of percussion (Crabtree 1972), with, on the bulb, almost invariably a scar (Beuker 1983). The platform is somewhat larger than in the case of soft-hammer percussion, because the point of impact has to lie away from the edge to avoid its crushing. In general, the section of flakes removed by hard-hammer percussion is concave (Beuker 1983), and they are larger and thicker than those flakes initiated by soft-hammer percussion. The latter exhibit less pronounced undulations and bulbs of percussion, have straighter cross-sections, and are generally thinner and more regular. Moreover, they exhibit a 'lip' on the ventral aspect (Beuker 1983). Instead of recording all these characteristics and doing a statistical analysis, it was decided to make a subjective assessment of the type of percussion on the basis of a rough evaluation of the different criteria. Tools exhibiting indications for both soft- and hard-hammer percussion were listed as 'unsure'. Artefacts lacking any indication, for instance broken fragments, were subsumed in the category 'not applicable'.

STATE DISTAL END: the state of the distal end also gives an indication of the percussion technique: hinge and step fractures are more likely to occur with hard-hammer percussion. This variable provides a further suggestion of the reduction sequence practised, i.e. whether cortex is still present and how this relates to the type of percussion used. The categories which can occur include feather, hinge, reverse hinge, and step termination, the presence of cortex on the distal facet, and the situation in which the entire butt of the core is removed along with the flake.

SURFACE PLATFORM: the surface of the platform forms yet another indication for the reduction sequence practised, and also for the technological expertise of the flint knappers. The surface can be smooth, facetted, battered, and may exhibit cortex.

DORSAL FACE PREPARATION: the final technological feature to be recorded was the way in which the dorsal face was prepared prior to the removal of the flake or blade. This feature could be an indication for idiosyncratic behaviour; it is not clear whether abrasion or micro-retouch have different advantages.

NUMBER OF NEGATIVES: the number of negatives present was only recorded in the case of cores or core-fragments[5].

NUMBER OF PUAS: a PUA is a potentially-used area. Parts of a tool are considered to be potentially-used when they exhibit one (or more) of the following phenomena: retouch ⩾ 1 mm, retouch < 1 mm, polish visible with the naked eye, a straight edge in cross-section larger than 1.0 cm (Hekelingen III, Leidschendam) or 2.0 cm (Beek-Molensteeg), a fragment of a polished flint axe surface, or a protruding point. When a PUA was present on the artefact, the system automatically shifted to the next level of the hierarchy: a morphological description of the PUA.

2.6.2. MORPHOLOGICAL DESCRIPTION OF THE PUAS: 'MACROFILE'

The preceding variables were all entered into the main 'site-file'; the number of entries into this file corresponds with the number of artefacts one examines (or, alternatively, are present in an assemblage). The next file in the hierarchy, the 'macro-file' which describes each PUA, can contain many more entries, because each tool can have more than one potentially used area. For example, a well-knapped unretouched blade with straight edges has two PUAs: its lateral sides. As soon as the site-file is concluded with an entry larger than zero in the last variable (number of PUAs) the data-entry system automatically changes to the macro-file. Here, the firsty entry is always the identification number of the piece, the second the PUA number. In this way all entries concerning one artefact can be combined across the three hierarchical levels.

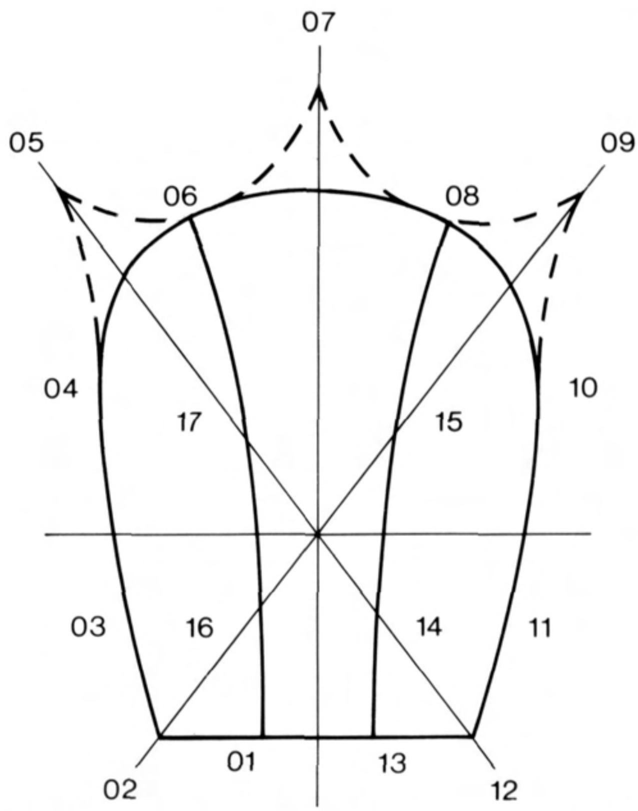


Fig. 7 System of polar coordinates used to indicate the location of PUAs and AUAs.

LOCATION OF THE PUA: a system of polar coordinates, as a way of describing the locations of features, has first been proposed by Odell (1977). Odell differentiated 32 polar coordinates. Most use-wear analysts find this system too complicated and limit themselves to four locations: distal, lateral right, proximal and lateral left. This works as long as one does not enter the information into the computer, but writes one's report from the written notes. For computer analysis a four-part division of location is too inaccurate. Therefore, I used a simplified version of Odell's scheme, including 17 polar coordinates (*fig. 7*). This system worked satisfactorily. If a PUA covered more than one polar coordinate, for example the distal end of an endscraper, it was given all necessary polar coordinate numbers in sequence (608 in the case of an endscraper).

OBSERVED PHENOMENA: this variable is important, because it determines which kind of potentially used area is present. An area is 'potentially used' when it exhibits retouch, polish visible with the naked eye, a straight edge larger than 1.0 or 2.0 cm (for the Vlaardingen and the Bandkeramik material

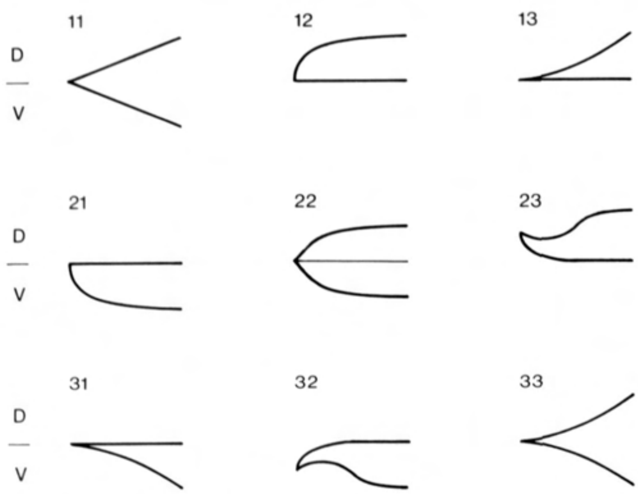


Fig. 8 Illustration of the variable 'shape of the aspect surfaces' (profile). 1 = straight, 2 = convex, 3 = concave.

respectively), a ground facet, or a protruding point. I refrain from differentiating use-retouch from intentional retouch, because the criteria are not agreed upon (cf. *2.2.1*). In this study I distinguish retouch < 1 mm (which could result from use, but which could equally plausibly be a by-product of intentional retouch, trampling or other factors), and retouch equal to, or larger than 1.0 mm. If polish was visible, as with sickle-gloss, the piece was automatically selected; the same applied to polished axe fragments. The selection criteria 'point' and 'straight edge' have already been discussed above.

EDGE ANGLE: there is much argument as to how to measure the edge angle (Dibble/Bernard 1980). The major point of disagreement is where exactly to take the measurement. It may be taken on the edge or slightly away from it, since the surfaces constituting the edge are seldom straight. A measurement away from the edge approximates the original edge angle prior to use, while a measurement on the edge reflects the intensity of use. As I was interested in the selection criteria of the users, it was necessary to know the original shape of the edge, which could then be related to the wear-traces observed on it. The angles were therefore measured 2 mm away from the edge, using a goniometer. For PUAs exhibiting large differences along their edges, an average was taken.

SHAPE OF THE ASPECT SURFACES (PROFILE): this variable describes the cross-section of the ventral and dorsal surfaces constituting an edge. For example, many convex scrapers have a flat (straight) ventral aspect and a convex dorsal surface (*fig. 8*): such an edge receives the coding 12. The possibilities include straight, concave and convex, in different combinations, with the ventral side always listed first. This variable was recorded, as it was assumed that a 11 or 13 edge would be much less stable than a 12 or 22 edge, possibly resulting in a different usage.

SHAPE OF THE EDGE: the shape of the edge, as seen from above, was recorded because it was assumed that, for example, a concave edge had different functional properties than a convex one. Cutting would seem to be much more difficult with a concave than with a convex edge. Attributes include straight, convex, concave, irregular, broken, slightly convex, and slightly concave.

OUTLINE OF THE EDGE: the variable 'shape of the edge' did not allow for the variability within an edge created by retouch, as for instance denticulation in an overall convex edge. Nor did it provide an adequate description of the different shapes of points possible. It was, therefore, decided to add a further variable describing the shape of the edge, specifically as created by retouch. The possibilities, all illustrated in figure 9, include serrated, denticulated, encoche, '*cran*', '*épaulement*', '*museau*', '*languette*', '*pédoncule*', and '*soie*', and were derived from Tixier et al. (1980: p.85, fig. 28).

FORM CROSS-SECTION: to further assess Moss' supposition that straight cross-sections are more likely to have been used than irregular, concave or convex ones, all PUAs were examined for this feature. Obviously, this meant duplication in the cases in which the PUA was already specifically selected on the basis of this observed phenomenon (i.e. in cases where all other relevant phenomena such as retouch, polish or polished axe fragment were absent). Categories include straight, convex, concave, wavy, irregular, slightly concave and unsure (*fig. 10*).

LOCATION RETOUCH: all instances in which retouch ⩾ 1 mm was observed, are described in this and the following categories. Retouch < 1 mm is described in the section of 'use-retouch' in the next hierarchical level (i.e. the micro-file). The variable 'location' includes the following attributes: ventral only, dorsal only, dorsal and ventral alternating, and dorsal and ventral bifacial.

DISTRIBUTION RETOUCH: this variable is a very subjective one and describes the spacing of the retouch scars relative to one another. The categories include overlapping, close/ regular, close/ irregular, wide/ regular, wide/ irregular, and not applicable.

WIDTH RETOUCH: the width of the retouch is measured in

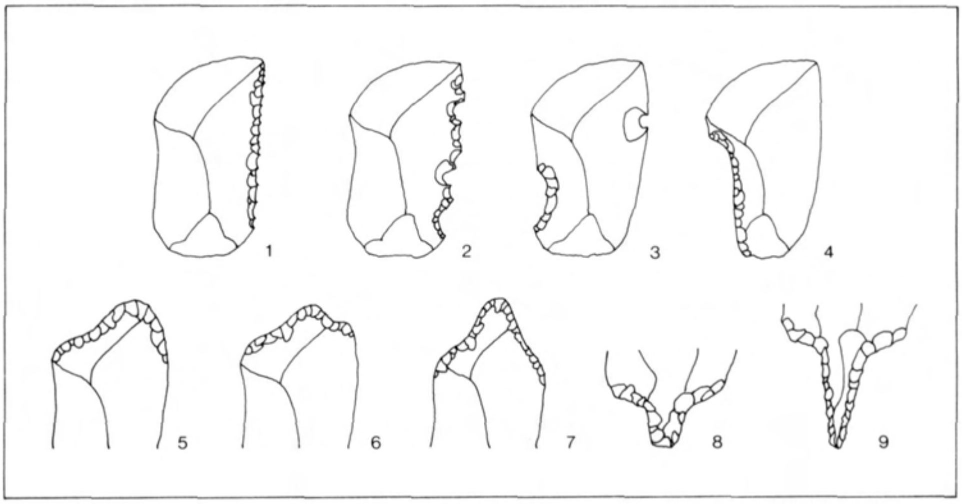


Fig. 9 Illustration of the possibilities which could be entered into the variable 'outline edge' (simplified after Tixier et al. 1980: 85, fig. 28) (see *2.6.2*). 1 = serrated, 2 = denticulated, 3 = encoche, 4 = *cran*, 5 = *épaulement*, 6 = *museau*, 7 = *languette*, 8 = *pédoncule*, 9 = *soie*.

mm (0.0-99.9 mm). In cases where a large difference existed between scar-sizes, an average was taken. The width measurement was considered to be more objective than the system proposed by Tixier et al. (1980: p.87, fig. 30). His categories 'short' and 'marginal' could refer to scar sizes 1.0-2.0 mm, 'long' scars would be 2.1-5.0 mm, 'invasive' retouch 5.1-10.0 mm, while anything larger than 1 cm would fall into the category 'covering' retouch.

FORM RETOUCH: as to the description of the morphology of the scars, opinions vary a great deal. I will not discuss the various possibilities as this would fall outside the scope of this study. I followed the propositions of the Ho-Ho committee (Hayden (ed.) 1979: 133-135). The categories differentiated include scalar well-defined, scalar vague, lamellar, half-moon, trapezoidal, square, other, and unsure. As the shape of the retouch can vary across one edge, it is possible to enter it twice.

TERMINATION RETOUCH: here too the Ho-Ho committee's suggestions were followed (Hayden (ed.) 1979: 133-135). Termination categories include step, hinge, feather, snap, other, and unsure. Again, because combinations of two termination types frequently occur, space is created in the database system to enter this characteristic twice.

SECONDARY MODIFICATIONS: the presence of post-depositional factors is generally (unless it is extremely extensive) assessed under the microscope. Logically this variable should therefore be entered into the micro-file (third hierarchical level). However, for practical reasons this was not done. If a piece exhibited extensive post-depositional surface modifications (pdsm), it was deemed not interpretable and the entire micro-file would be unnecessary. It was thus more economical to enter this information in a file which was already in operation. Categories include none (a fresh flint surface), light, medium, heavy, and burned. If a piece was interpretable, a zero was placed behind the pdsm-category, if not, a nine was added. Lightly-affected pieces were generally still interpretable, although traces resulting from meat-cutting might not be visible anymore. The interpretability of moderately-affected pieces would depend on the characteristics of the raw material. Traces of bone-working and the cutting of silicious plants would still be visible. Pieces exhibiting heavily developed post-depositional surface modifications were almost always not interpretable, nor were burned artefacts.

DEGREE OF WEAR: as for the variable 'secondary modification', the variable 'degree of wear' actually belongs to the third hierarchical level, as this aspect is also determined under the microscope. However, it is more economical to enter 'unused' pieces in this file, not having to use the micro-file for this. Moreover, some pieces were not interpretable, but nevertheless exhibited definite traces of use, such as an extremely rounded tip. These artefacts were listed as 'probably used', but otherwise not described in the micro-file. Degree of use included a series of subjective statements as to how intensive an artefact was probably employed. No attempt was made to estimate the duration of work (cf. *2.2.6*).

2.6.3 DESCRIPTION OF THE WEAR-TRACES ON THE AUAS: THE 'MICRO-FILE'

The description of the microscopically visible phenomena and the interpretation of the function of an edge (PUA) belong to the third hierarchical level, that of the AUA-file. Again this file begins with the site and the individual number, then the PUA number, and lastly the AUA number. One PUA can have more than one actually used area, when for example secondary use occurred. This implies that, when combining the site-, macro-, and micro-files into one 'combifile', the number of individuals present will equal the number of PUAs plus the number of instances in which secondary use of one PUA was evident. For example, 362 artefacts were selected for analysis in the case of Beek-Molensteeg. They yielded 619 PUAs, eight of which displayed two AUAs. When comparing variables of two different files, the combi-file is created, which contains 619 + 8 = 627 entries (i.e. PUAs). All wear categories are described in the microfile: edge-removals, edge-rounding, polish, and striations. The edge-removals (or 'use-retouch') are described according to the same variables as the retouch, the only exception being that the width is not measured in mm but in μ. I will therefore not repeat these variables here.

EDGE-ROUNDING: the rounding of the edge is very subjectively described as sharp, slightly rounded, very rounded or nibbled. First the ventral than the dorsal side is coded, resulting in for example 23 for an edge, the ventral side of which is slightly rounded and the dorsal very rounded. Such a difference suggests that the dorsal side had been the contact area.

POLISH LOCATION: the location of the polish, and the relative extent of it on both aspects, could tell us something about the tool's life history. For example, if polish is only present in very small amounts on the ventral surface of a scraper and nothing can be detected on the dorsal aspect, this could mean that the tool has been resharpened. Or, if both aspects exhibit the same width of polish, the tool could have been used for cutting purposes. The categories include the following: dorsal and ventral, but dorsal more; dorsal and ventral, but ventral more; dorsal and ventral equal; only dorsal; only ventral.

POLISH DISTRIBUTION: the distribution of the polish is closely related to the type of material worked. For instance, bone is obviously a very resistant material and causes a much more restricted distribution than contact with a softer material such as hide. In this section I will not deal with all the specifics, but refer the reader to chapter 3 for a detailed description of the distribution characteristics for each contact-material and motion. The categories which are differentiated for this variable include scintillation (or generic weak polish as Vaughan (1985a) calls it), on protruding points, reticulated, 'snow-landscape', isolated spots, thin line along edge, band along edge, band away from edge, spread, streaks of polish, greasy lustre, and other.

POLISH CONTRAST: this feature pertains not so much to a characteristic of the polish itself, as to the degree of contrast between the polished and unpolished surfaces of the artefact. If this contrast is high, it is much easier to give an interpretation of the polish. Possible attributes include great, medium and little contrast.

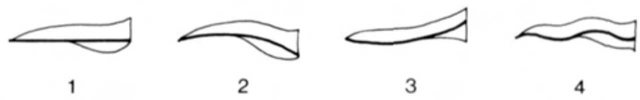


Fig. 10 Illustration of the variable 'form cross-section'. The thick-set line indicates whether the cross-section is: 1 = straight, 2 = convex, 3 = concave, 4 = irregular.

POLISH TEXTURE: the texture of the polish is also assumed to bear a close relationship to contact-material, although the overlaps are much more frequent than, for instance, in the case of polish distribution. Categories include smooth, smooth and greasy, smooth and matt, rough, rough and greasy, rough and matt, and not applicable.

POLISH BRIGHTNESS: polish brightness is yet another variable which is generally believed to be correlated with contact-material. Polish resulting from bone-working is described as very bright, while hide-working causes a dull polish. This variable differs from the variable 'polish contrast' in that it only refers to the reflectivity of the polish itself. Categories include very bright, bright and dull.

POLISH TOPOGRAPHY: in almost all publications on micro-wear analysis it is reported that specific contact-materials are associated with certain topographical characteristics: 'wood-polish' is often 'domed', 'hide-polish' is 'cratered', 'bone-polish' is 'pitted' and/ or exhibits 'comet-tails'. This variable takes account of such topographical details. Characteristics include: domed, flat, corrugated, cratered, pitted, bubbly, comet-tails, beveled, and not applicable.

POLISH WIDTH: the extent to which the polish covers the tool, perpendicular to the edge, is measured in μ. Again, I preferred this more exact measure above such descriptive categories as marginal, invasive or covering (Plisson 1985a; Vaughan 1985a). On edges exhibiting considerable variations in polish width, an average was taken. The width was measured both on the ventral and the dorsal aspect: the relative differences between the two determined the coding of the variable 'polish location'.

POLISH DIRECTIONALITY: it is often possible to discern troughs and ridges in the polish. The directionality of these features provides a good indication of the movement involved. Categories include: absent, linear perpendicular, linear parallel, linear diagonal, and random.

CONTACT-MATERIAL: the contact-material is inferred on the basis of the various polish attributes. The reader is referred to appendix I for a listing of possible contact-materials. The way I arrive at an interpretation is outlined in the last paragraph of this chapter.

DEGREE OF CERTAINTY: certain traces are rather unequivocal and the analyst can be quite sure of his/ her interpretation of contact-material. In other instances, however, traces are more ambiguous and one opts for the most likely solution, adding that the inference is an uncertain one. Obviously, for contact-material one must also include the category 'unsure', in which case the degree of certainty is 'not applicable' (see also Hurcombe 1988).

LOCATION OF STRIATIONS: the relative number of striations on both aspects determines whether the location is dorsal and ventral, but dorsal more; dorsal and ventral but ventral more; dorsal and ventral equal; only dorsal; only ventral. It involves a qualitative assessment.

DEFINITION OF STRIATIONS: this variable attempts to describe the striations in terms of their length, width and depth, all of which are assumed to relate to contact-material (Mansur-Franchomme 1983). As it is a purely qualitative description, I find it extremely difficult to be consistent in my judgement. This can be partially attributed to the fact that *real* striations (as opposed to depressions or interruptions in the polish, suggestive of being striations) seldom occur, so that consistency is hard to develop. Filled-in striations, as described by Mansur-Franchomme (1983), are more easy to differentiate.

DIRECTIONALITY OF STRIATIONS: predominant directionality of the striations is, with some practice, relatively easy to see and provides a good indication of the motion in which the tool was used. Categories include parallel, perpendicular, diagonal, random, and unsure.

INFERRED MOTION: on the basis of the location, distribution and directionality of polish and striations, and the presence and character of edge-removals, it is often possible to infer the motion in which the edge was involved. Here too, a variable 'degree of certainty' is added. Although logically clearly not a motion, hafting is also entered in this category. Because of the emphasis on PUAs and AUAs it was no problem if a PUA displayed both traces of use and of hafting. In the next paragraph the value and nature of these inferences will be discussed.

2.7 Functional inferences: possibilities and limitations

In the introductory paragraph to this chapter I have already alluded to a recent debate in microwear analysis: whether a correlation between polishes and contact-material really exists, as Keeley (1980) first suggested. Although Keeley has already discussed this problem extensively (i.e. the overlap between bone and antler, and between soaked antler and wood), doubts have accumulated as to the indicative value of polishes. More and more researchers have become aware of these ambiguities and of the fact that post-depositional surface modifications affect a substantial number of assemblages. Also, contrary to earlier claims, many post-depositional effects turned out to be not so easy to differentiate from real use-wear.

2.7.1 Blind tests

Many microwear analysts have, in the past, been subjected to a blind test, in which they were offered experimentally-used artefacts for analysis (Keeley/ Newcomer 1977; Gendel/ Pirnay 1982). The purpose of these blind tests was to monitor the capabilities of the individual microwear analyst. When such a test yielded dissatisfying results, these could easily be dismissed by attributing them to the inexperience of the microwear specialist in question.

When more and more reports appeared which questioned some of Keeley's original claims, it was decided to check the *method* and not the individual microwear analysts. In two places, London and Tübingen, a multi-analyst blind test was organized (Newcomer et al. 1986; Unrath et al. 1986). It was hoped to discover trends in the results, which could give an indication of the value of the method itself and not so much of the capabilities of individuals.

The 'London' blind test (Newcomer et al. 1986) yielded rather poor results. It should be stressed, however, that many test-tools were only briefly used, around 10 minutes. Experienced analysts know that such a short working time produces virtually no polish whatsoever, or, at most, 'generic weak polish' (the initial stage of polish formation, in which no distinctive features, suggestive of a specific contact-material, are yet present (Vaughan 1981; 1985a)). From the fact that few of the participating analysts were able to determine correctly a significant number of pieces, Newcomer et al. (1986) concluded that polishes are poorly-correlated with specific contact-materials. They attempted to corroborate this conclusion with texture-analysis of polishes (Grace et al. 1985, 1987; Grace 1989). The problems with this manner of quantifying polishes have already been outlined (see *2.2.2.2*) and will not be repeated here. Moreover, it is misleading to question an entire approach, because *one* method to quantify *one* attribute of polish failed to yield satisfactory results. Grace's texture analysis takes no account of, for instance, the distribution of the polish in relation to the edge, an attribute most analysts heavily rely on. Nevertheless, the basic criticism which Newcomer et al. (1986) raise against microwear analysis, that of overlapping polish 'types', is valid, albeit not new (cf. Keeley 1980). Especially 'wood-polish' seems to pose many problems, because of its variable appearance. Unrath et al. (1986)

mention the same difficulty, stating that wear attributes from wood can overlap, especially with those from soaked antler, but also with those from bone, and, sometimes, hide. Differentiating traces from contact with bone and antler formed yet another problem common to all blind tests published so far. Another major point of criticism which derived from the 'London' blind test was that most microwear analysts failed to separate observations from interpretations (Newcomer et al. 1986: 204). I believe this is valid as well. All too often microwear reports are limited to tables of final results and we get little insight into the way the analyst arrived at his or her conclusions.

Despite some very valid criticism, the article by Newcomer et al. (1986) has created quite a stir in the small world of microwear analysts. This is mainly due to the very polemic tone and the heavy stress they have placed on the results of the texture analysis. I think many people would agree with their concluding remarks. It is, however, the first part of the paper which has received most attention and criticism (Moss 1987a; Bamforth 1988; Hurcombe 1988; Plisson/ Van Gijn *in press*). Much of this criticism centres on the limitations and invalidity of the texture analysis.

The 'Tübingen' blind test (Unrath et al. 1986) arrived at some similar conclusions, but its tone was much more optimistic, probably partially due to the better results. Unrath et al. (1986) also draw attention to the fact that attributes can overlap between various polish-types: experimental wood-polish sometimes looks very much like soaked antler-, bone- or even fresh hide-polish. They note that the 'state' of the hide (fresh, gritty, dried, with abrasives added) causes ambiguous traces. Emphasis is placed on the fact that interpretable wear-traces do no develop on a 100% basis; softer material causes polishes to appear much more slowly than for instance contact with bone (see *2.2.6* and *3.12*).

2.7.2 Arriving at an interpretation of tool function

From the preceding discussion it should be clear that the basic issue is whether wear-traces can be *identified*, or whether there are so many uncertain factors that it is more appropriate to talk about *interpretation*. When microwear analysis started, most researchers held the opinion that an identification was possible. Now that we are becoming aware of more and more limitations, it is believed that we should no longer pretend this. Microwear analysis seems to have 'descended' to the level of most archaeological research: by a carefully-balanced line of reasoning we can arrive at an interpretation of past behaviour. In this study no mention will therefore be made of identification of tool use. Moreover, it has become clear that the strong dichotomy between high- and low-power functional analysis (i.e. micro- and macrowear studies) is not tenable. Rather it seems that all use-wear analysts emphasize different attributes of wear (see also *4.4*).

Here I would like to outline the line of reasoning followed in this study. On the basis of location and character of polish, striations and edge-rounding, an hypothesis is formulated about the function of a PUA, in terms of motion and contact-material. Taken together these are referred to as activity. The validity of this hypothesis is subsequently checked against the character and location of the edge-removals. For example, polish interpreted as being the result of contact with meat cannot be associated with heavy edge-scarring. In those cases where polish is absent or not interpretable, and provided it concerns an edge not displaying retouch ⩾ 1 mm, a functional hypothesis may be based on the character of the edge-removals alone (see *2.2.1*). The next step is asserting the functional hypothesis with respect to the morphology of the tool, such as its edge angle, curvature etc. When the morphology is considered appropriate for the presumed activity, the variables 'contact-material' and 'motion' are entered. Both are followed by a variable, called 'degree of certainty'. Actually, this variable should be called 'degree of probability': when the polish shows all or most of the attributes characteristic for a certain contact-material and motion, the probability of the functional inference is higher, but not more sure.

Upon the interpretation of the activity carried out by one PUA, we arrive at the next level of inference: the function(s) of the entire implement. In many instances, only one AUA is present on an artefact, and as a result, function of PUA and entire tool correspond. However, sometimes more than one contact-material/ motion pair (AUA) is displayed on an implement. The 'Tübingen' blind test, which involved some rather complex experiments (a.o. hafted tools and implements used twice), has made clear how difficult it is to unravel the relationship between two or more AUAs on one tool. Basically, three possibilities exist for such a situation: 1. the tool was hafted, 2. the tool was used more than once (either on the same or on different substances), 3. the various AUAs are caused by one and the same (complex) task. The inference of hafting might be complicated, but has frequently turned out to be possible (cf. *5.4.2.11* and *6.2.3.2*). The main danger seems to be mixing up the used and the hafted zone (cf. the 'Tübingen' blind test (Unrath et al. 1986)). More problematic is differentiating between situations two and three. Unless we possess rich contextual archaeological data, highly suggestive of the performance of certain tasks (see *3.1.2*), it is impossible to link two AUAs in a behaviourally meaningful way; usually, the presence of two AUAs on one implement is considered to be the reflection of two use-instances.

After having interpreted the function of the individual artefacts of an assemblage, we arrive at the third level of interpretation: what meaning can we attribute to our tables of inferred activities? There are several facets to this. Foremost, we must consider the representativity of the data in terms of pdsm visible on the tools (cf. *chapter 4*). Secondly, evidence for contact with soft materials such as meat, fresh hide, and certain green plants, may be absent under certain circumstances (see *2.2.6* and *3.12*). Next, various taphonomic processes must be taken into account. The latter are usually rather site-specific and will not be dwelt upon in this chapter. Instead, the reader is referred to the archaeological case studies and to the concluding chapter.

notes

1 Blood remains are actually not such 'short-lived' phenomena. I have found it exceedingly difficult to remove blood-stains on experimentally-knapped flint, especially when old. Loy reports blood-smears on tools of 1000 to 6000 years of age (Loy 1983: 1269).

2 Exceptions excluded, as for instance inserts for manioc rasps; these definitely need to be included when doing a wear-trace analysis in South-American context.

3 I chose to disbelieve recent reports that paper towels can inflict damage on flint objects. Quite rightly much attention has been given to the vulnerability of flint and I think that our awareness is such that flint is not anymore scattered onto tables. We should not, however, exaggerate the problem.

4 The variables percussion, state of the distal end, surface platform, and dorsal face preparation were only recorded for the Beek-Molensteeg material. These four variables were included to achieve comparability with other researchers of Bandkeramik flint technology (De Grooth 1987a).

5 For the cores and core-fragments of Beek-Molensteeg, a number of additional variables were recorded. The reader is referred to chapter 5 for further information.

3 The experiments

3.1 Introduction

Experiments have played a very important role since people became interested in the function of flint tools. In the 1890's Spurrell had already attempted to replicate the sickle-gloss he observed on Near Eastern blades, as did Curwen in the 1930's (Spurrell 1892; Curwen 1930). Semenov (1964) was, however, the first to incorporate experiments on a systematic basis into his research. Since then, every student of wear-traces starts with a series of experiments in order to become acquainted with the sort of traces that develop. In this chapter, the value of ethnographic information for the research presented here will first be outlined, as well as the role of analogies (*3.1.1*). Subsequently, the limitations and possibilities of experimental archaeology will be discussed (*3.1.2*). In paragraph 3.1.3 a description is given of the experimental procedures followed, after which the actual experiments are outlined. This last part is divided into categories of contact-material. Each section starts with some ethnographic or ethnohistorical information concerning the manner of performing certain tasks, which, it should be stressed, is not intended to be exhaustive. The search for relevant literature concentrated on North-American Indian sources because of a certain similarity in environment and subsistence between source and subject; they are also relatively numerous. To a lesser extent, ethnohistorical data of craftmanship from the Netherlands were examined. Because of time-constraints this latter effort was not carried out in an extensive systematic fashion. Where available the organization of work in terms of scheduling, division according to gender, and specialization was noted. Such detailed information on the organization and procedures of simple every-day tasks is, however, surprisingly rare, especially where it involves flint tools. After the ethnographic information follows a description of wear-traces resulting from contact with the material in question. The last section of this chapter addresses the problem of representativity (*3.12*).

3.1.1 Ethnographic information and model-building

Ethnographic information lies at the heart of an experimental programme. Although experiments which mainly serve as a simple reference are usually done in a very generalized way, because conditions have to be under control ('cutting' wood, and not the manufacture of a wooden net floater), we can learn much about the range of possible procedures from ethnographies. For example, we can obtain information on the different ways and steps in hide-processing, the desirability to soak antler before working it, or the time of the year when it is most profitable to collect a certain kind of plant. Such knowledge is generally not available in any other way. It has been demonstrated before (*2.2.6*), that an unexperienced way of carrying out experiments can be of great influence on the wear-traces which form on our tools.

Ethnographic information is not only important on the relatively simple level of procedures (resulting in an interpretation of motion and contact-material, i.e. of activity), but also for the reconstruction of tasks which were possibly carried out. Lastly, it can provide clues to build models of, for instance, the organization of subsistence tasks throughout a year (scheduling). We can obtain insight into the possibility of activities being related to each other and the manner in which they might be incorporated into the total culture. In this study, ethnographies have been used in such a way when interpreting the spectrum of inferred activities on a site in relation to other lines of evidence (*chapters 5 and 6*).

There has been much dispute about the validity of ethnographic analogies (a.o. Gould/ Watson 1982). Obviously, we can only interpret the past from our own perspective and this is of course an inductive way of reasoning. Because of the danger of imposing present-day situations upon the past, a number of rules about the use of analogies have been suggested. Firstly, it has been proposed that where continuity between past and present can be demonstrated, the analogy has more validity. These are called direct historical analogies and have played a role, for example, in Near Eastern archaeology (a.o. Kramer 1982). Another restriction which has been suggested is that analogies are more reliable if they derive from societies with an environment, subsistence base and technological expertise presumably similar to the prehistoric situation. A good example of such analogical reasoning is Clark's use of Eskimo society to interpret Star Carr (Clark 1954). In this last example, now much-critized for its simplicity, the dangers even within these restrictions are well-demonstrated.

The New Archaeologists, and especially the 'law and order' variant, have carried the argument even further. They consider the above-mentioned restrictions spurious and missing the essential point: that the use of ethnographic analogies is essentially inductive. They suggested that analogies should serve to formulate hypotheses, to be tested against the data (hypothetico-deductive method). This seems somewhat of a circular reasoning, especially because this testing is usually done only once. I would prefer the suggestion that analogies are a heuristic device. They form an illustration and, in certain cases, the best explanation for the time being. Also, we should perhaps search more for causal regularities and put less emphasis on correlations between observed features, which may be entirely coincidental. A recent approach towards a more valid and profitable use of analogies is the one proposed by Wylie (1982, 1985), who advocates a more dialectical relationship between archaeological data and explanation. More concretely, she argues for a systematic comparison, using a 'game of question-and-answer', of the archaeological configuration we want to understand and various models. These models can be derived from any possible source and are not subject to the recommendation that they must come from a similar environmental or economic context (see above). Wylie considers the archaeological data to be sufficiently powerful and independant, that they can adjust or falsify certain explanations.

3.1.2 Experiments and their role in archaeological reasoning

Experimental archaeology is a method of evaluating the plausibility of various explanations of specific, well-defined archaeological situations. As for archaeology in general, it is concerned with assessing the relationship between human behaviour and its material correlates (Ingersoll/ Macdonald 1977: XI). With much of traditional archaeology it shares an emphasis on those aspects of human behaviour considered to be most easily approached, that is technology and subsistence (i.e. Hawkes' (1954) 'first ladder of inference'), where the principle of actuality applies.

Experimental archaeology concerns a wide variety of topics (in fact all of our archaeological subject matter), everyone of which requires a different approach. The best-known experiments are the replicative ones such as flint knapping (with Crabtree as its most prominent practitioner), those assessing the efficiency of certain technological features such as silos, and those addressing questions concerning form and function. The latter experiments serve to strengthen simple formal analogies (Hodder 1982), and are pertinent to the research presented in this volume. Other approaches include the agricultural experiments at farms such as Lejre and Butser, which deal with a variety of archaeological problems, albeit almost always directed at technology or subsistence. All these examples share the fact that they involve an experiment which tests a hypothesis related to a specific problem; this means that one or more variables, which are assumed to be relevant, are controlled. It should be clear, however, that experiments can never be conclusive and cannot be considered proof, however much our hypothesis seems to be 'confirmed'. If the number of corresponding attributes between experimental and archaeological object or situation is high, then, at best, we can conclude that there is a high probability that similar causative factors operated. Obviously, it cannot be excluded that other factors had been responsible for the combination of attributes being investigated. On the other hand, experiments can certainly exclude certain possibilities and therefore narrow down the number of possible interpretations.

Coles (1973) emphasizes the need for corroborative evidence from the field of ethnography. However, I would suggest that such evidence must firstly come from the archaeological context: for example, the location in which an artefact has been found, or the association of different find-categories. Ethnographic descriptions should instead be considered as a source of inspiration. The combination of ideas derived from ethnographic sources and the archaeological context could suggest a number of possible experiments. The result of these experiments can subsequently be evaluated in the light of, for instance, the character of the wear-traces present, their distribution, or the 'efficiency' of the tool.

In use-wear analysis, experiments have mainly served as a reference. In a large collection of experimental pieces a number of variables can be controlled, and confronted with archaeological specimens. Every use-wear analyst begins by setting up such an experimental programme, which controls for variables as raw material, form of the tools, type and state of the contact-material, intensity and direction of motion; these are called generalized experiments, forming the basic reference collection. When subsequently examining an archaeological assemblage, one can recognize areas of use and often interpret the contact-material and motion (i.e. the activity) involved, because of similarities in traces between experimental and archaeological tools.

When no experimental tool in the existing reference collection displays the combination of attributes observed on the archaeological implement, additional experiments must be performed. Clues as to which activities might have taken place at a site come from the archaeological context (a.o. palaeobotanical or archaeozoological data), while ethnographic sources are a potential source of inspiration about possible procedures. An example of such a problem-oriented experiment is presented in chapter 5 and concerns the search for the activity which caused polish '23' (*5.4.2.7*). Theoretically, we should conduct such problem-oriented experiments for every artefact we cannot interpret in terms of function on the basis of the existing reference collection. We should also continue to modify these experiments until

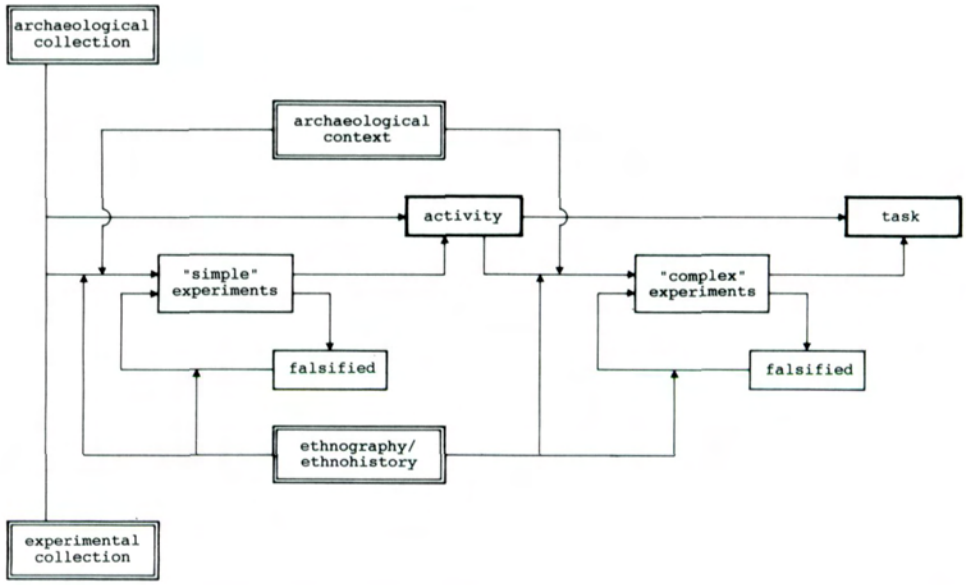


Fig. 11 Lines of reasoning in the interpretation of tool function, incorporating ethnographical or ethnohistorical information and archaeological context.

the wear-traces on experimental and archaeological tool match in every respect. In practice, this is clearly impossible because of the amount of time involved, and we are obliged to state the function of a tool as unknown. A search as described above is only worthwhile when one finds unknown but characteristic wear-traces on a group of tools from an assemblage.

Being able to interpret the activity in which a tool was used, does not necessarily mean that we have inferred the exact task which was performed. To do this, it is crucial to have corroborative evidence from the archaeological context from which the tools derive. For example, at Hekelingen III a number of tools was present with traces interpretable as being the result of bone-carving (contact-material and motion, i.e. activity). Only in combination with Maarleveld's (1985) inferences concerning bone awl and chisel manufacture, was it possible to provide an interpretation of the exact task in which these flint tools were involved (see *6.2.3.2*). Another example is drawn from the bead workshop at Kumartepe in Turkey, where flint borers have been found amidst a large quantity of shell-fragments and pre-fabs for shell beads (Calley/ Grace 1988). In such a case, the archaeological context suggests which experiments to carry out, whereas ethnoarchaeological information provides clues as to how to perform them. If the wear-traces observed on the experimental and archaeological tools exhibit sufficient similarities, we can infer with reasonable confidence, not only that the borers were used to drill shell, but that they served in the manufacture of shell beads. The first inference is limited to contact-material and motion (i.e. activity), the second specifies the task (see *fig. 11*). Usually, we do not know enough of the context to make such a detailed statement.

3.1.3 Experimental procedures

In the preceding paragraph it was outlined that a reference collection consists of two sets of experiments, the generalized and the problem-oriented ones. The first set concerns experiments which control for factors as motion, contact-material, duration and raw material type. They serve to monitor the development of the wear-traces according to these variables and as such function as a basic reference data-set. These experiments have the additional function to become accustomed to working with a flint tool, and realize its limitations and possibilities. It is also important to determine the specific morphological characteristics of edges which are the most appropriate for specific actions, something which can, at least partially, only be assessed experimentally.

The generalized experimental set includes transverse motions such as whittling, scraping and shaving, diagonal ones as splitting and carving, longitudinal actions as cutting and sawing and boring. Contact-materials include bone (fresh, soaked and dry), antler (in soaked or dry state), several species of wood (fresh, soaked and dry), hide in various states and with different additives, soft plants and cereals (together, more appropriately called herbal plants), shell, teeth, limestone, fish and meat. Duration of work varied from three minutes to five hours. Raw materials used for the experimental pieces were Rijckholt flint (both coarse- and fine-grained varieties), fine-grained moraine (northern) flint (mainly Senonian), flint from Kristiansstad (Sweden), from Cap Blanc Nez near Boulogne-sur-Mer (France), and North Sea flint recovered during dredging operations. For a description of the experiments the reader is referred to appendix II. At first, these generalized experiments were done without any practical background knowledge. As time passed, ideas, derived from ethnographic sources (mainly American Indian ones) and ethnohistory (Dutch context), were incorporated in the experimental procedures. This resulted in an increased verisimilitude. Nevertheless, there is of course no guarantee that they replicated the prehistoric way of doing things.

A small number of experiments was done with a machine devised by Prof. Dr. Ir. A. Wegener-Sleeswijk (Rijksuniversiteit Groningen) for Paula Bienenfeld (Bienenfeld 1986). This machine is capable of performing transverse and longitudinal motions on hard materials such as wood or bone, while controlling number of strokes and pressure exerted. The great advantage of such a machine is the strict control one has over various variables, specifically in the case of exerted pressure, as this factor is almost impossible to quantify when experiments are done manually. This way, one can relate these variables to questions about wear-trace formation. Obviously, it is important to address this question in a systematic, mechanised way, but as this study mainly has an archaeological rather than a methodological emphasis, it was decided to further omit the machine-driven experiments because the procedure bore too little resemblance to how we think people would have worked.

The problem of verisimilitude between the archaeological and the experimental situation becomes especially acute when it comes to skill. The most frustrating aspect of doing experiments is our lack of expertise. When addressing a specific problem, such as bone tool manufacture or bead-making, and when able to concentrate on this aspect only, it is possible to gather experience in due time. The problem with use-wear analysis is that, when we want information on entire sites, one is obliged to attempt to replicate a score of different tasks, some of which might, in prehistoric times, have been the work of specialist craftsmen. Otherwise, research is limited to questions concerning tool form and function. It goes without saying that we do a very bad job on most tasks. This became especially clear to me when I did butchering experiments in collaboration with Henk Nijland (Rijks-Instituut voor Natuurbeheer, Arnhem). Nijland is dissecting animals on a daily basis and the flint tools he used (he found them as effective as steel counterparts) displayed very few wear-traces compared to the ones I employed in the butchering process. This is clearly a matter of experience, but it has important implications for the interpretation of wear-traces on archaeological tools, especially regarding duration of use. It is misleading to infer the duration of use of archaeological artefacts on the basis of our own experiments. Instead, it would be more appropriate to infer intensity of wear, regardless of whether this is due to a longer working period or lesser skill (see also *2.2.6*). It should be remembered, however, that use-wear analysis is a very young discipline; in due time the experiments will hopefully bear more resemblance to the prehistoric situations, both in terms of procedures used and in amount of skill. When experimental collections are kept intact and stored in accessible places, it will become less and less necessary for new students in the field to perform the time-consuming generalized experiments. Instead, new researchers can immediately concentrate their efforts on specific issues and because of this specialisation, perform their experiments with greater skill.

3.1.4 Quantification of wear-attributes

In the early years of microwear analysis, little thought was given to the question of representativity of the activity-spectrum inferred from the wear-traces. Often this was taken at face-value. Not only was too little consideration paid to the effect of taphonomic processes, but it was also insufficiently realized that wear-traces do not develop on a 100% basis. Here taphonomic processes will not be dwelt upon (they will be discussed in the chapters dealing with the various sites, *chapters 5 and 6*), but rather the representativity of the wear-traces themselves. Keeley (1980) already noted that soft materials, such as meat, leave few traces, which are moreover difficult to interpret. Recently, more attention has been given to this aspect, not least because of the results of blind tests (a.o. Unrath et al. 1986). A few researchers have attempted to simply count the frequency of attributes characteristic for specific contact-materials. Vaughan (1985a) investigated a variety of materials, Van Gijn (1986a) considered traces of fish polish, and Fisher et al. (1984) analyzed arrow heads. In a recent study, Sussman (1988) has provided a system for the quantification of wear-attributes on experimentally-used quartz tools; Knuttson (1988: 65) has done the same, but in a less detailed fashion.

It was decided to contribute to the investigation of this methodological problem by counting how often attributes, considered 'typical' for certain contact-materials, developed on experimental tools. Generally speaking, the experimentally induced traces were described according to the same system as used for the archaeological ones (see *appendix I*). In appendix II the descriptions of all 301 experiments are provided. On the basis of these tables, calculations were made as to the frequency of various attributes considered to be characteristic of specific contact-materials. These results will be presented in the following pages.

3.2 Hide-working

3.2.1 Ethnographic accounts

Ethnographic descriptions of hide-processing are relatively numerous, especially for the North-American Indians.

Unfortunately, exact procedures and, especially, terminology are not always clear. No instances were found in which mention was made of the time which the various stages of hide-working involved.

A skin consists of two layers: the epidermis and the corium or dermis. The *epidermis*, the outer layer, contains the follicles from where the hairs grow. To make leather, this layer, along with the hairs, must be removed. Underneath we find the *corium*, which is the part that is tanned. It can vary in thickness depending on its anatomical location. The lower part of the corium is formed by a membrane which is sometimes referred to as the *subcutis*. It consists of fatty tissue which interferes with tanning and must therefore be removed (Stambolov 1969).

Many animals, such as deer and elk, have very little subcutaneous fat; their skins can be dried immediately without the need for extensive scraping (see for instance the Cocopa, as mentioned by Gifford (1934)). This differs from fur-bearing animals such as bears and foxes, whose skins are covered with fat and moisture when removed from the carcass. My own experiments and those of others (Brink 1978b) suggest that the removal of this fat is only possible, or in any case is greatly facilitated, when abrasives are added to absorb the moisture. After the 'fresh hide' scraping, skins are usually dried. To do so they may be staked hairside down onto the ground and exposed to the sun. Skins dried in such a way can be stored for a long time, allowing the postponement of the tanning-process. This is important because the best time to take animals for their hides is usually early autumn. This applies especially to animals such as deer, elk and caribou. Spiess points out that the caribou wintercoat is too heavy for making clothes, while the spring and summer coats are unsuitable because of shedding; during late summer the caribou skin is eaten by larvae (Spiess 1979: 30). As early autumn is exactly the time when food needs to be gathered and prepared for storage during winter, it seems likely that no time would be left to go through the tedious process of tanning the hides. Among the Copper Eskimo, processing hides is a typical winter task (Jenness 1970). Of course this schedule is different for the fur-bearing species as these are most profitably taken in winter and must be stripped from their subcutaneous fat immediately after killing.

Not all skins are preserved with the hairs attached: for making leather they have to be removed. To depilate, the skin is soaked in warm water to allow bacterial growth. Sometimes ashes or stale urine (as among the Eskimo) are added to further the process. In any case, a pH of 12 or above is needed (Stambolov 1969). After soaking, the hair is removed by scraping with a stone (Tanaina: Osgood 1937). The depilated skin must be thoroughly washed and dealkanized by, for instance, the use of animal dung.

Experiments have shown that, while the subcutis is almost impossible to remove while the hide is fresh, it can be rubbed off when the hide is dried. In fact this can easily be done with, for example, a rough sandstone (H.Plisson *pers. comm.*). Dried hides must subsequently be soaked. It requires about 2-3 days for sufficient swelling to take place to allow the penetration of the tanning agents (Stambolov 1969). Among the North-American Indians brains or liver constitute important tanning agents. After soaking, or, for that matter, when still fresh, the hide is rubbed with brains among the Tanaina (Osgood 1937), and the Plains Indians (Lowie 1954). Alternatively, the brains were dissolved in hot water, and the hide was left in this solution for some time. This practice has been reported for the Cocopa (Gifford 1934), the Surprise Valley Paiute (Kelly 1934), and the Hopi (Beaglehole 1936). Kelly notes that, if brains are put between white cloth and hung outside to dry, they can be kept for a long time. Birch bark is also reported to be able to preserve brains for an extensive period (Densmore 1928, describing Chippewa Indian hide-processing practices). It is generally assumed that the amount of brains required to tan a hide, corresponds with the size of the brains of the animal in question (Witthoft 1958). During tanning the hides are regularly 'worked', sometimes with a smooth stone as among the Plains Indians (Lowie 1954). Subsequently, the hide must be washed and dried. A softening process usually accompanies the drying. Softening is done by rubbing the skin with a rough-edged stone (Plains Indians), or by pulling the skin over a beam to loosen it while it dries (Cocopa). A well-known process is the chewing practised by Eskimo women (Balikci 1970). Sometimes fish oil is added as a softener as among the Tanaina (Osgood 1937). Much of the above refers to animal tanning agents, which are most common among American Indians. It should be stressed however that vegetal tanning, with, for instance, an extract of oak- or birch bark, is frequently used as well. It would definitely be worthwhile to investigate such methods and perform experiments with these tanning agents.

The final process to which hides may be subjected is smoking. It is often assumed that this is simply a way of colouring the hide, but it also has a tanning effect. In addition, smoking causes the hide to remain soft, irrespective of exposure to moisture, which is important, for instance, when used for mocassins (Lowie 1954).

From this description a few things can be concluded. First of all, fresh hide scrapers *per se* might not exist, because either the skin comes off clean enough for processing (apart from having to remove the subcutis), or, in the case of fresh bear and fox hides, absorbants may be added to deal with the moisture, having the additional effect of abrading the working-edge of the tool. Secondly, although scrapers are often used in the softening stage of hide-processing, i.e. as dry hide scrapers, this task can also be performed in other ways, for example by pulling the hide over a wooden beam.

Thirdly, the number and variety of tanning agents and other additives is quite considerable, and it is likely that associated wear-traces display great variability.

3.2.2 Wear-traces from hide-working

Both fresh and dry hide experiments were done. As was discussed in the preceding paragraph, this distinction is somewhat misleading, not least because fresh hides dry out during working, resulting in 'dry hide'-like wear-traces (e.g. exp. 226, 227, 230, 272). A total of 49 experiments was done with hide (see *appendix II, table 1*), involving Rijckholt, Cap Blanc Nez and northern flint. Motions included boring, cutting, scraping (with various preservative agents), and skinning. Total experimental time amounted to 24 hours and 27 minutes.

Edge-removals occurred in only five instances: three with dry leather, two with fresh elephant skin. The retouch was scalar, with a deep initiation and a hinged or feathered termination. The degree of edge-rounding was variable: moderate to heavy rounding was more frequent on scraping tools than on cutting or boring implements. There does seem to be a correlation between the dryness of the hide and the degree of edge-rounding: scraping dry hide and scraping dried-out fresh hide both produced this feature (see below). However, this observation also implies that we cannot deduce dry hide scraping as a task from a heavy rounding of the edge.

Polish developed on 32 of the 49 tools (65%). Boring resulted only once in a polish. In most cases (N = 17) the polish was distributed in a band along the edge (*figs. 12a,*

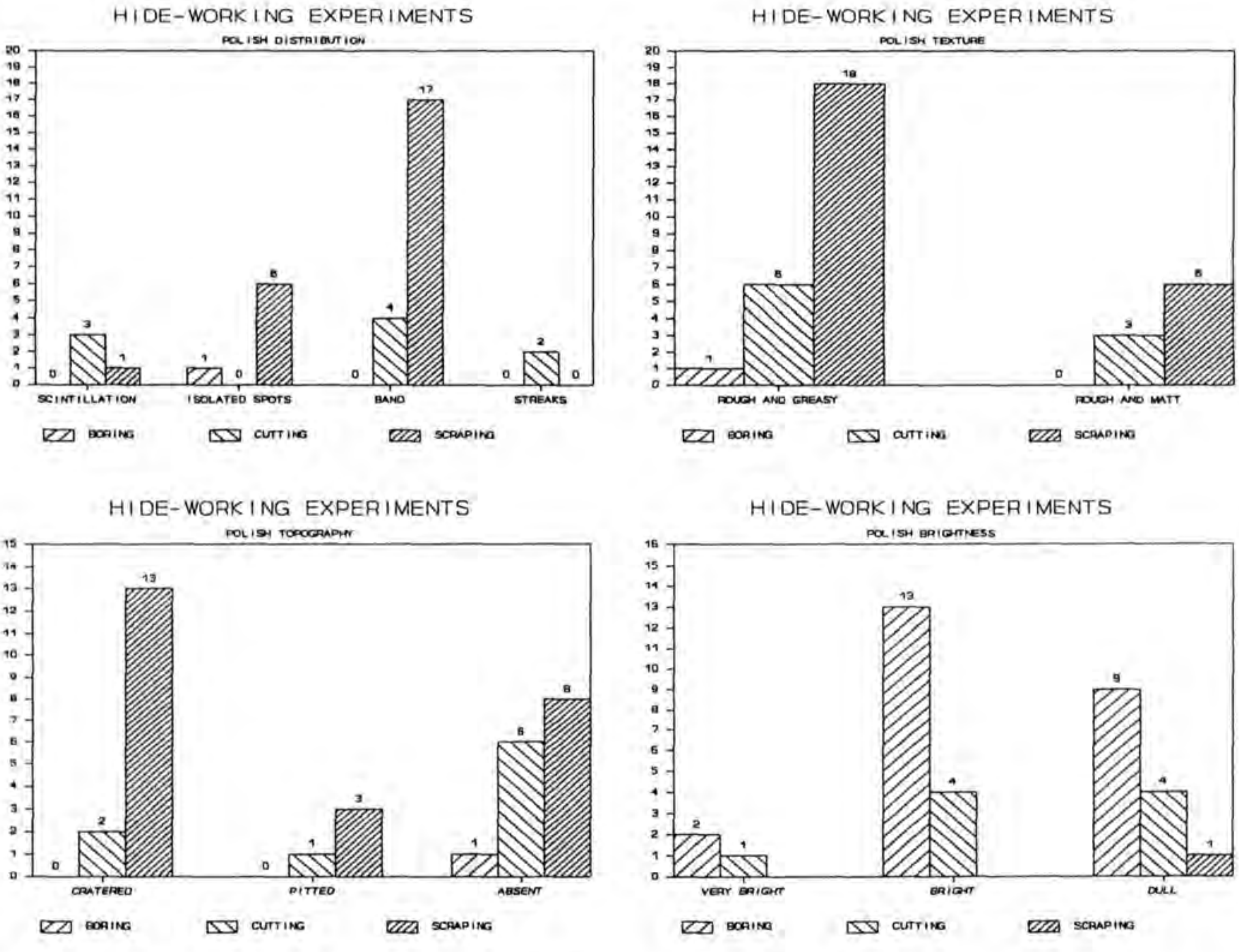
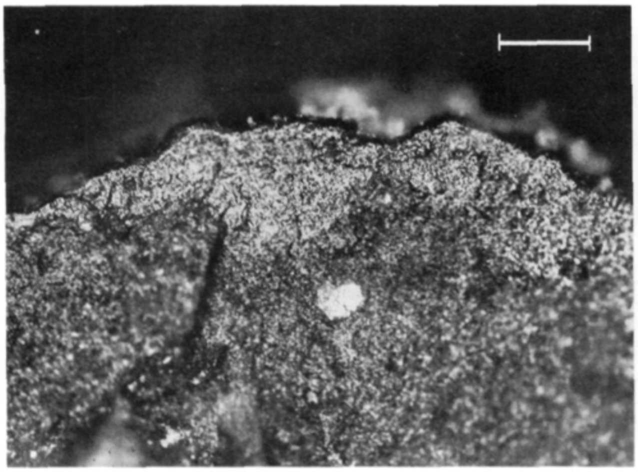


Fig. 12 Lotus graphs of polish characteristics from contact with hide. a) distribution, b) texture, c) topography, d) brightness.



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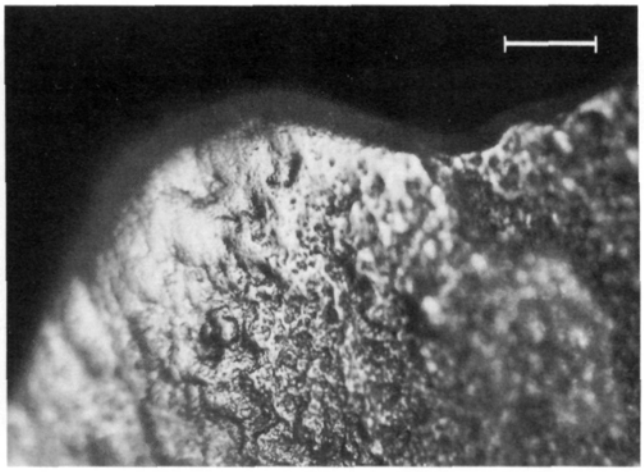

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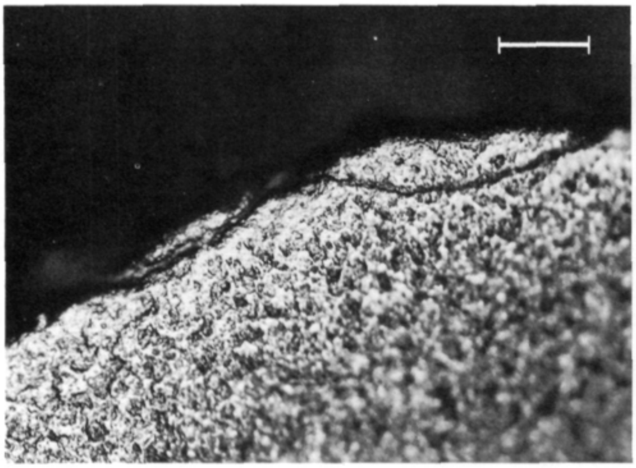

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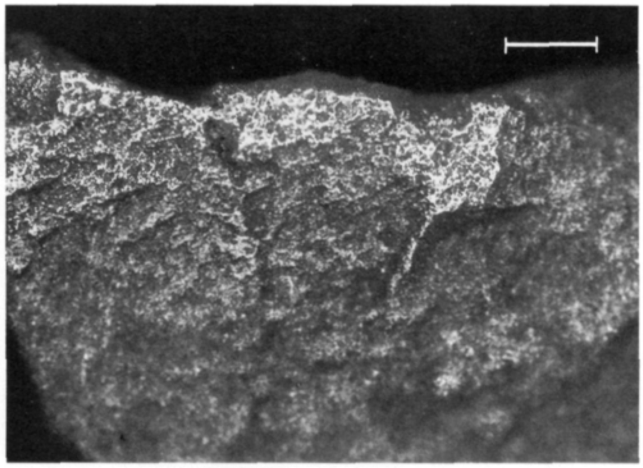

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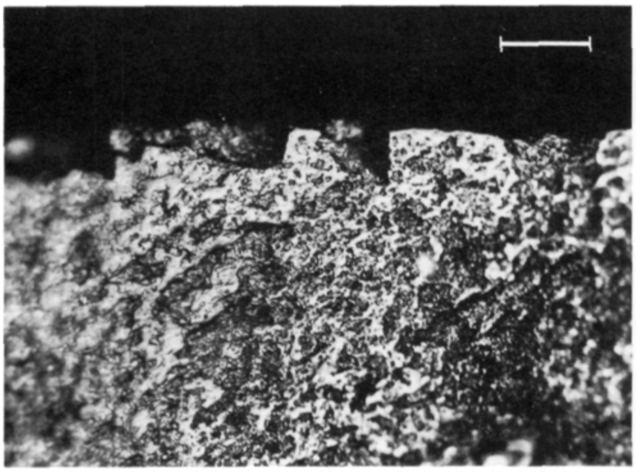

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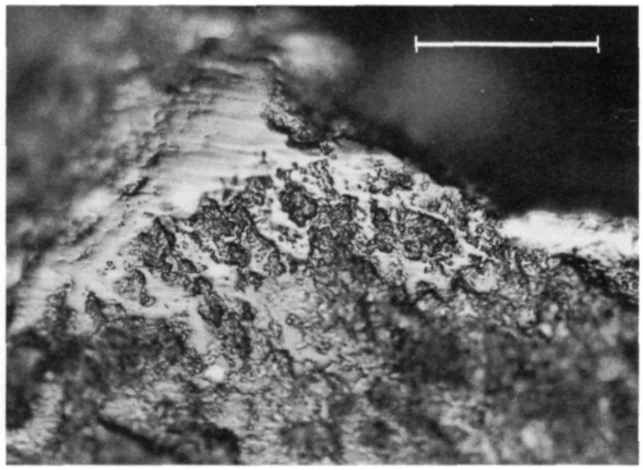


f

Fig. 13 Micrographs of experimental wear-traces. All scale bars equal 50 μ. a) characteristic band of polish from scraping fresh hide on experimental tool 100 (200x), b) polish development on experimental tool 249 used to scrape hide with powdered ochre and liver (200x), c) rough, cratered polish from contact with a drying hare-skin found on experimental tool 226 (200x), d) polish and edge-removals on experimental tool 208, used for sawing wood (200x), e) more or less reticulated distribution of wood polish on experimental tool 306, used to debark willow (200x), f) troughs in polish seen on experimental tool 55 used for whittling seasoned oak (400x).

13a); this invariably concerned scrapers. Cutting resulted in far less instances of polish; in two cases of dry leather cutting, longitudinal streaks of polish were produced (*fig. 12a*). The texture of the polish was either rough and greasy or rough and matt (*fig. 12b*), the brightness varied from intense to dull (*fig. 12d*). Fifteen tools displayed the deep craters in the polish considered to be typical for contact with hide, while four instances were described as 'pitted'. 13 tools exhibited no topographical polish characteristics (*fig. 12c*). The mean extent of the polish amounted to 483 μ (range 50-2000 μ). Striations were observed only twice.

To try to account for various additives, a series of experiments was initiated with mineral and animal tanning or preservative agents. Most remarkable were the traces resulting from scraping a hide with the addition of powdered ochre (a possible preservative) which was moistened by liver (a tanning agent) (*fig. 13b*): the polish was extremely bright but still recognizable as being from contact with hide due to the rounding of the edge and the fact that the polish followed every protrusion or indentation of the edge. Scraping with fat for softening produced a rough, greasy polish which was never well-developed, but extended far back into the piece, especially on the dorsal aspect; this was due to the fact that it was mainly the retouched aspect of the scraping-edge which was used for rubbing the grease into the skin. Unfortunately, no definitive conclusions can be drawn from these experiments because of insufficient numbers.

The above description of wear-characteristics resulting from contact with hide conforms well with observations made by other authors. The only exception concerns a series of scrapers used to remove the subcutis from fresh hare- or deer-hide; strangely enough a characteristic 'dry hide polish' developed. A band of polish, with sometimes craters or pits, was visible, following the entire contour of the edge, which displayed moderate to heavy edge-rounding (*fig. 13c*). Apparently such a hide, which is quite dry and contains only a few pieces of grease and meat (cf. the preceding paragraph), causes heavy attrition of the edge: no grease is present to protect the edge (cf. Brink 1978b). This observation confirms that, although hide as a general category is quite easy to recognize (see Unrath et al. 1986), the exact state of the hide is more difficult to infer. A large field, that of the use of vegetal tanning agents, still lies unexplored, while the role of animal tanning agents also requires some additional research.

3.3 Wood-working

3.3.1 Ethnographic accounts

Whereas ethnographic descriptions of hide-working are numerous, albeit not always as detailed as we would like them to be, accounts of wood-working are extremely scarce. Even scarcer is information about the role of stone tools in the manufacture of wooden objects. Obviously, it would have been possible to, instead, turn to the numerous ethnohistorical sources which exist on the topic of wood-working with metal tools. I refrained from doing so, firstly because of time-restrictions, and secondly because it seemed doubtful whether such an effort would pay off in terms of a better understanding of wear-traces from wood-working.

One reference to stone tools derives from the Paiute, who peeled (whittled) willows with an obsidian knife, working away from the person; splitting was done with the teeth however (Kelly 1934). The Chippewa used ash for the manufacture of sleds, as this wood is very tough (Densmore 1928), but no mention is made as to the way of manufacture. What did become clear was that stone tools did not form the sole wood-working implements, as testified by the frequent references to the use of beaver incisors as a tool for smoothing wood (Tooker 1964, referring to the Huron; Oswalt/ Van Stone 1967, reporting on the Crow Indians). Not much information could be obtained about the organization of wood-working in terms of yearround scheduling. The Paiute collected the willows during the fall, as they were too brittle in the summer; the shoots must be soaked prior to use.

3.3.2 Wear-traces from wood-working

A total of 62 wood-working experiments were performed including such motions as whittling (*fig. 14*), cutting, scraping and boring, and covering a great variety of wood species (*appendix II, table 2*). No real tasks were carried out. Types of raw material used included Rijckholt, northern flint, and Cap Blanc Nez material. Total working time amounted to 24 hours and 19 minutes.

Of the 62 experiments, 36 tools did not display any edge-removals (*fig. 13d*). Most of them had been used in a transverse motion, while one cutting tool (experiment 30.1) was probably used too briefly (6 minutes) to cause damage. If present, edge-removals varied in width from 50 μ to 700 μ. Generally, the form of the retouch was deep/ well-defined

Fig. 14 Whittling experiment on maple.

scalar, or trapezoidal, while two transversely-used implements displayed half-moon-shaped retouch. Termination varied from feather (N = 8), hinged (N = 15), to snap (N = 1). Distribution was rather varied and did not exhibit a correlation with motion. The type of wood used was of some influence on the appearance of edge-removals: a harder wood like oak is more likely to cause edge-damage than soft species like elm or poplar. Fresh wood always inflicted less damage than dry, aged wood, even when this had been soaked. It is suggested that it is not so much the duration of use, but the type of motion that determines the presence or absence of edge-removals.

Polish developed on 53 of the 62 tools (i.e. 85.5%). Distribution varied from a faint scintillation, via isolated spots, to a band along the edge, and finally, a more linked spread of polish (*fig. 15a*). A reticulated pattern, as has been reported by various authors (Keeley 1980; Moss 1983a; Plisson 1985a; Vaughan 1985a), was also observed (N = 11) (*fig. 13e*). I tend to agree with Newcomer et al. (1986) that such a pattern is dependent on the grain-structure of the raw material and not linked with working wood *per se*. Texture is usually smooth and matt (N = 43), although a few instances of a rough and matt (N = 2), or a smooth and greasy version (N = 3) also occur (*fig. 15b*). In most cases the polish was domed (N = 38) (*fig. 15c*) and very reflective (N = 30) (*fig. 15d*). Nine tools displayed no polish whatsoever. This may be the result of very short work periods (5-15 minutes). The tool of experiment 76 was used during 29

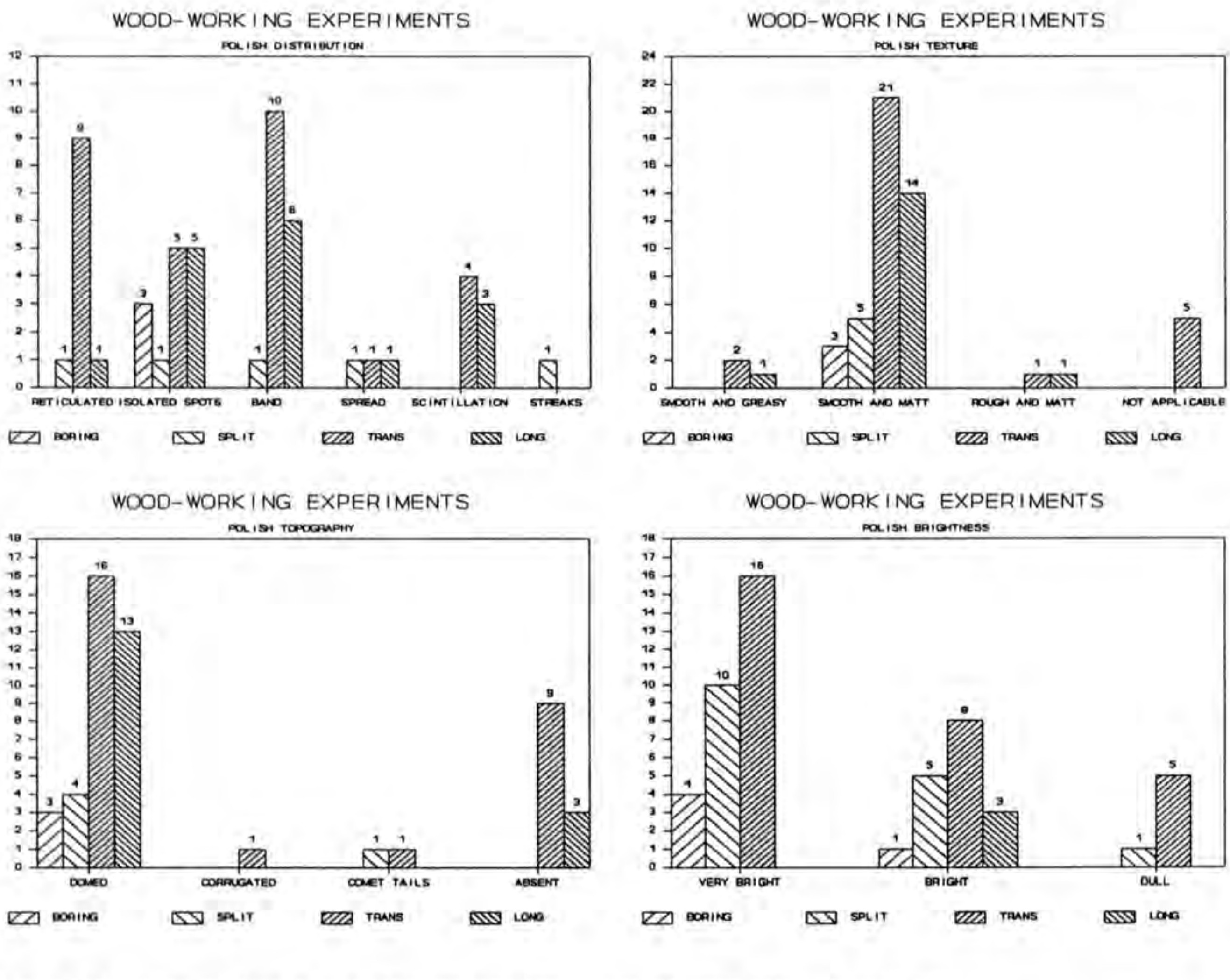


Fig. 15 Lotus graphs of polish characteristics resulting from contact with wood. split = splitting, trans = transverse, long = longitudinal, a) distribution, b) texture, c) topography, d) brightness.

minutes but displayed virtually no polish; perhaps here less pressure was exerted.

Striations are usually absent: only 13 tools exhibited deep, short and wide striae. Sometimes, as in the case of an implement used for sawing oak (experiment 55), these striae resemble the comet-tails often observed on bone-working tools (*fig. 13f*). On two whittling tools (experiments 202 and 278.2) linear distributed, matt streaks of polish were seen.

From the preceding description of wear-characteristics resulting from contact with wood it can be concluded that there is a considerable variation in traces, although a domed topography, usually considered indicative of wood, occurs frequently. Keeley (1980: 35) considered wood-polish to be quite distinctive, as did Moss (1983a: 91), although she already noted its incidental similarity to antler-polish. In blind tests, however, the identification of wood has consistently been a problem (Gendel/ Pirnay 1982; Keeley/ Newcomer 1977; Unrath et al. 1986). This might relate to the fact that the polish from wood-working forms rather slowly and therefore goes through stages of development, which vary in appearance (cf. Vaughan 1985a: 33).

3.4 Bone- and antler-working

3.4.1 Ethnographic accounts

The use of bone and antler tools is reported from a variety of contexts. The Nisean of Central California make awls, for basketry purposes, from the lower front leg of deer (Beals 1934). The Tanaina in Alaska use bone points for their fish spears (Osgood 1937). Bone splinters are employed as barbs among the Klamath Indians (Spier 1930). Many more examples can be cited, most notably from the Eskimo who, because of the lack of wood in their surroundings, made every conceivable object from bone or antler, such as bent whale bone buckets, or antler snow-goggles. However, there is, generally, a lack of information about the manufacture of such objects and the possible role of flint tools in this endeavour. It seems likely that they played an important role in the initial shaping. With respect to the finishing stage, Osgood (1937) reports that the Tanaina sharpened their awls, made of bear-bone, by rubbing them with a stone. No mention is made either of the state under which the bone or antler was most profitably worked. It is generally assumed that the bone must be fresh, or else thoroughly soaked. This conforms with the experience of the author that dried, old bone is virtually impossible to work. The same applies to antler: however, when kept wet while modifying it, antler is almost 'pulpous'.

Another aspect of bone and antler tool production which has received insufficient attention is the organization of these craft activities. By analogy to the Eskimo, it is usually taken for granted that they are performed during winter, when subsistence activities are suspended and more leisure time is available. Binford, however, has demonstrated that the same Eskimo communities produce bone or antler objects on many occasions and during all seasons (Binford 1978a; 1978b). A favourite time is, for instance, on a hunting stand while waiting for game to appear. This observation has important implications for the interpretation of site function on the basis of wear-traces present (see also *6.2.6*). Data on gender differentiation in bone or antler tool production derive solely from the Eskimo, where only men (either on hunting stands or at home) are involved in such tasks.

3.4.2 Wear-traces from bone- and antler-working

3.4.2.1 Bone

A total of 53 experiments was done involving bone as contact-material, using a variety of motions (*appendix II, table 3*). Experiments were conducted for a total of 18 hours and 22 minutes. Many represented an attempt to replicate the bone awls and chisels found in great quantities at sites attributed to the Late Neolithic Vlaardingen-group (cf. *6.2.3.2*). Some of these experiments were done by Van den Broeke and Stapert (Van den Broeke 1983). Experiments 281.1 and 281.2 formed an effort at producing a harpoon. One experiment was done with the experiment-machine (nr.21), while the remaining were generalized reference experiments, not aimed at replicating specific archaeological objects.

Traces produced by contact with bone are generally considered to be quite distinctive. Keeley differentiated a rough and a smooth polish variety, the rough kind being associated with longitudinal activities, the smooth version with transverse motions. The polish is described as being highly reflective, displaying tiny pits and having a localized distribution (Keeley 1980: 43).

The experiments reported here corroborate the results above. Scraping fresh bone results in very little edge-removals, slight edge-rounding, and in some cases (N = 7) a polish-bevel (*fig. 17a*). The polish is highly reflective (N = 8), has a smooth, almost metallic, appearance (N = 9), and exhibits comet-tails and pitting (*figs. 16b-d*). Sawing or cutting fresh bone causes much edge-damage, generally consisting of overlapping deep scalar or square scars with a stepped, hinged, or feathered termination. The associated polish, distributed in isolated spots (*fig. 16a*), is rougher and sometimes appears 'broken' (*fig. 17b*). Comet-tails are at times present (N = 6). It is likely that this roughness is due to the fact that sawing or cutting generally takes place against the grain of the bone causing attrition of the polish. Carving also results in quite heavy use-retouch, consisting of overlapping scalar scars with hinged or stepped termination. The polish is highly reflective, often metallic, smooth and almost always lined with comet-tails (in 16 of the 19 carving experiments); here too the polish appears 'broken' at times (*fig. 17c*). Wear-traces which are considered to be distinctive for bone as contact-material include a polish-bevel (Plisson

1985a), comet-tails (Vaughan 1985a: 31), and tiny pits (Keeley 1980: 43). From figure 16c it can be seen that these attributes did develop on 32 of the 50 experimental tools displaying polish (64%), suggesting that microwear traces from prehistoric use on bone cannot easily be missed.

3.4.2.2 Antler

Many reports on microwear analysis purposely do not differentiate between bone- and antler-working traces. As Keeley (1980: 56) has stressed, antler polish does not only occasionally resemble bone-, but may also look like wood-polish. Although caution is sometimes justified, antler-working traces can be quite distinctive. This means that it seems more appropriate to consider antler as a separate category. When no diagnostic features are present on the archaeological pieces, it is always possible to give an 'and/or' interpretation.

A total of 18 experiments was done with antler, covering a number of motions (*appendix II, table 4*). All of the experiments were generalized ones, i.e. not aimed at the production of a specific object. Antler was worked for six hours and 40 minutes. It should be stressed that all but two (early) experiments were performed with soaked antler, as this is extremely easy to work.

Edge-scarring occurred only on tools used in a longitudinal motion, and on one whittling implement. It featured well-defined scalar scars with a deep initiation and a hinged or feathered termination. Distribution was irregular, and its

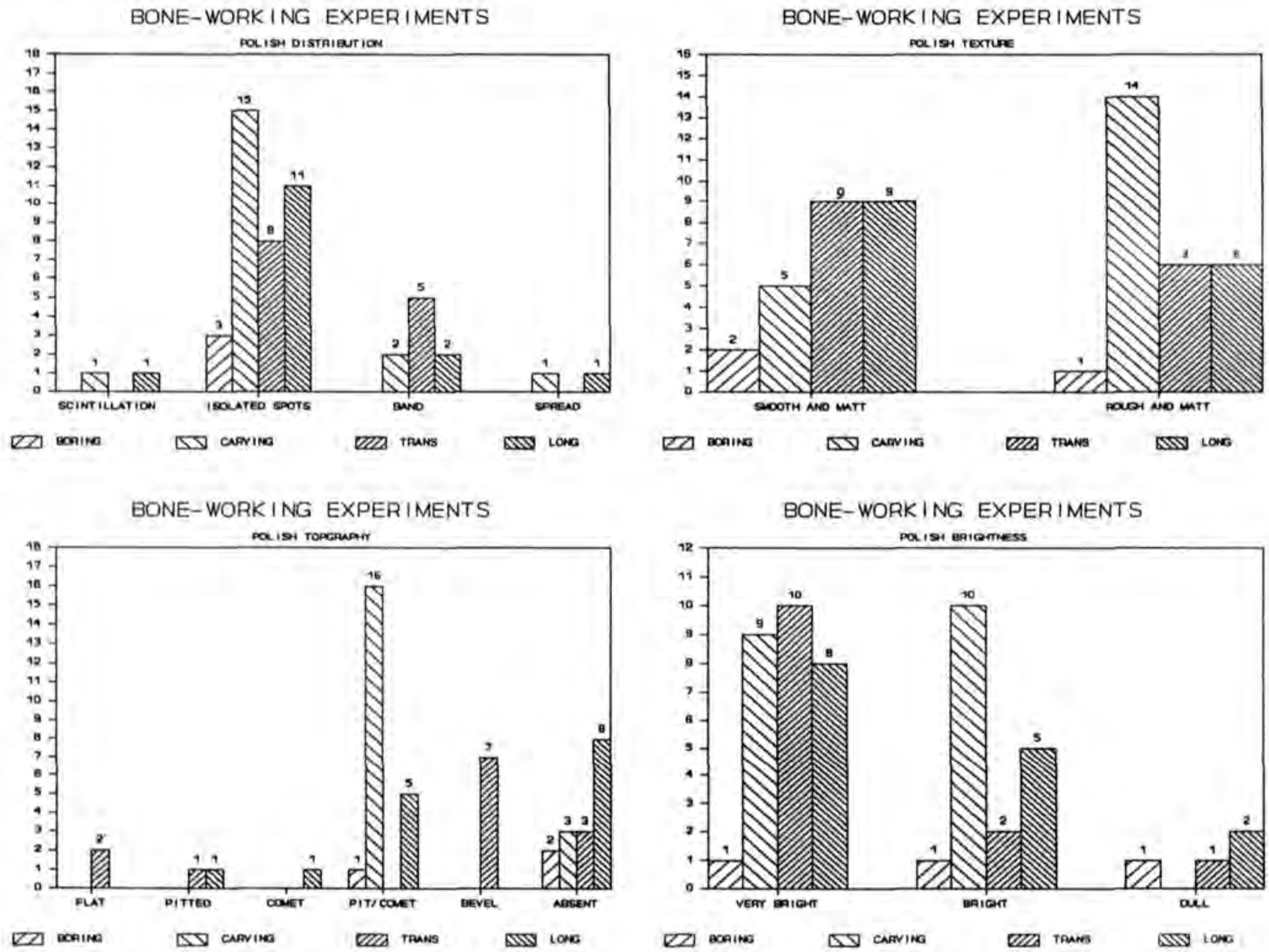


Fig. 16 Lotus graphs of polish characteristics resulting from contact with bone. trans = transverse, long = longitudinal, a) distribution, b) texture, c) topography, d) brightness.

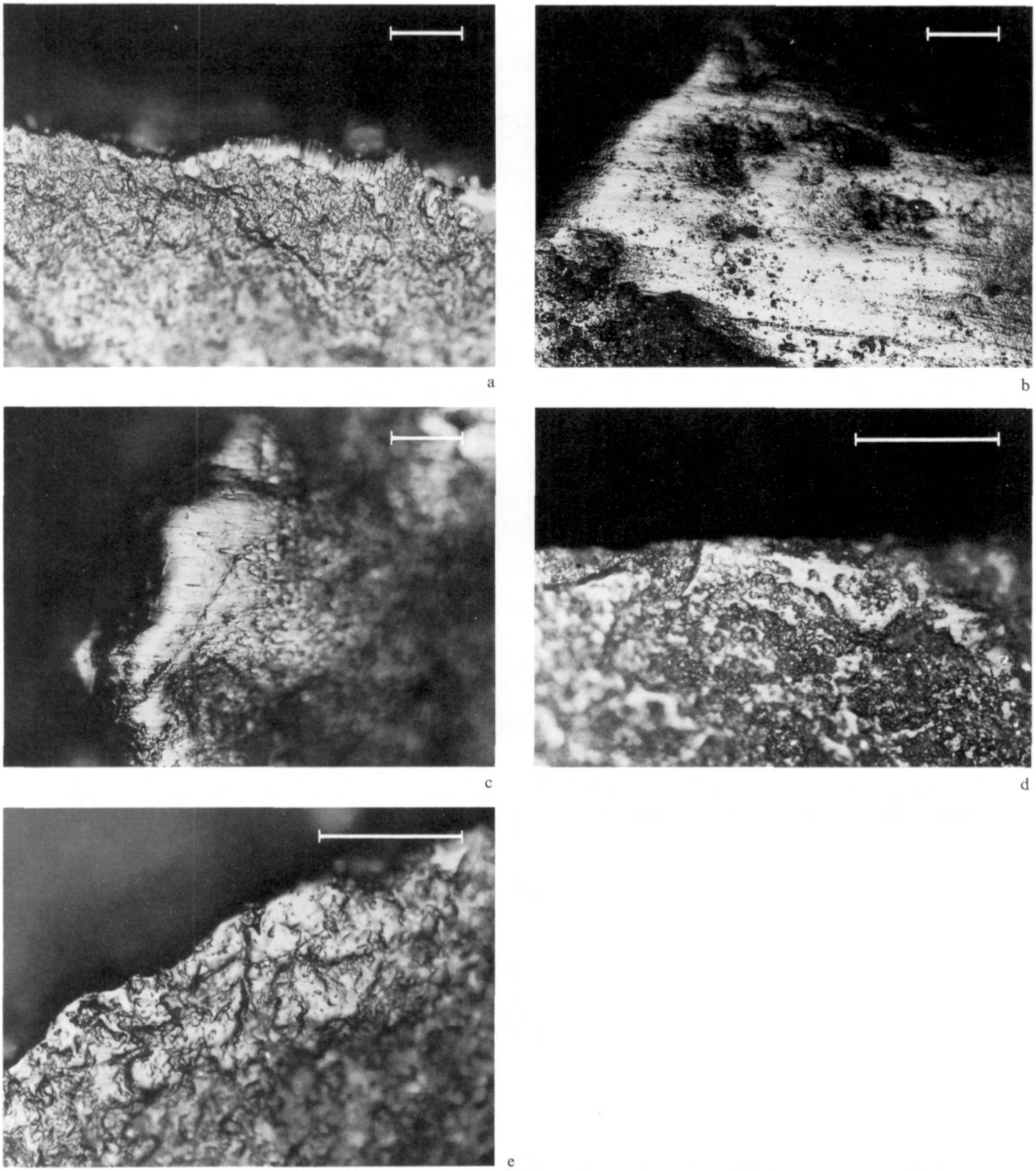


Fig. 17 Micrographs of experimental wear traces from bone-working. All scale bars equal 50 μ. a) polish bevel seen on experimental tool 220, used for scraping bone (200x), b) flat, rough polish from sawing bone (experimental tool 109, 200x), c) 'broken' polish with comet-tails on a bone-carving tool (experimental tool 56, 200x), d) flat polish resulting from sawing antler on experimental tool 170 (400x), e) polish from scraping antler seen on experimental tool 254 (400x): note the tiny pits in the polish and the latter's 'fingering' distribution.

mean width amounted to 400 μ. The degree of edge-rounding varied, but was usually minor. Polish developed on all scraping and cutting tools (N = 11), but was absent on two out of the five borers, and on an engraving implement. Experimental tool nr. 200.3, used for whittling antler, had too sharp an edge-angle for this activity: the edge-damage probably eliminated the polish. Polish characteristics are quantitatively displayed in figs. 18a-d. Longitudinal actions produced a bright to very bright polish with a flat topography (*fig. 17d*). The distinction between rough and smooth antler-polish associated with longitudinal and transverse motions respectively, as noted by Keeley (1980: 56), is not so evident on the experimental tools presented here: of the five sawing/ cutting implements, only two exhibited a rough polish (no. 210 and 277). Scraping, on the other hand, caused a smooth, matt polish in all instances, with, in two of the six cases, a domed topography; three scraping tools displayed tiny pits (*fig. 17e*). Although not presented in the graphs or tables, it seems that a 'fingering' distribution of the polish on scraper edges is very characteristic for contact with antler (*fig. 17e*; see also Keeley 1980: plate 51). The polish on scraping tools never extends far into the piece (87 μ on the average, range 20 — 150 μ). Striations have not been noted on any of the experimental implements, but directionality in polish is present on nine tools.

It is difficult to say whether antler-working can be easily

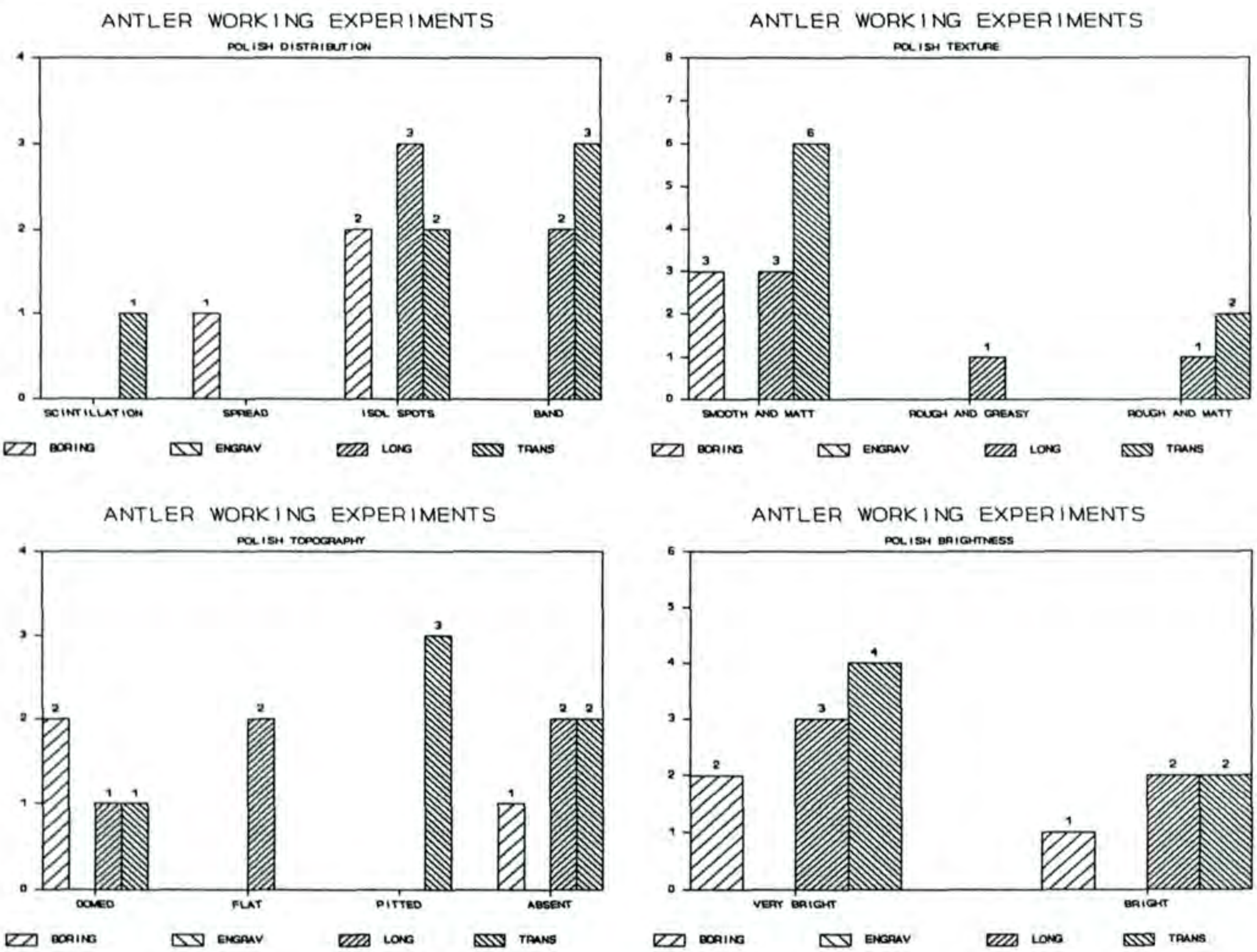


Fig. 18 Lotus graphs displaying polish characteristics on experimental antler-working tools. engra = engraving, long = longitudinal, trans = transverse, isol spots = isolated spots, a) distribution, b) texture, c) topography, d) brightness.

traced archaeologically, because this also greatly depends on the state in which the material was worked in prehistoric times. The fact that antler-polish sometimes displays a domed character (suggestive of wood), or in the case of longitudinal actions, a flat topography (resembling bone-sawing traces), gives rise to doubt. However there are tools, especially scrapers, which display the characteristic 'fingering' polish with pits, indicating that a separate category is still warranted.

3.5 Plant-working

In Neolithic context, the most important plants are the various domesticated cereals. Although the shift from the gathering of wild cereals to the cultivation of domestic varieties of these plants is difficult to pin-point, the behavioural implications in terms of tool use and organization of the work may be different. In the following pages therefore, wild and cultivated plants will be discussed separately. It should also be noted here that it would probably have been more appropriate to refer to all non-woody plant species as *herbal* plants. The indication 'soft plant', also used in this study, is confusing but has been retained because the term is employed by other use-wear analysts as well (cf. *5.4.2.4*, *5.4.2.5*).

3.5.1 Ethnographic accounts

3.5.1.1 Wild plant gathering

Much of the ethnographic material presented so far derives from North-American Indian sources. Innumerable plant species have been used by the Indians (see for instance Densmore (1928) for the Chippewa). No references for flint tools having played a role in the gathering or processing of wild plant material were found. Many plants were simply hand-picked. Keeley reports that, during a literature survey of North-American Indian sources, he has found only one example of stone tools having been used for the gathering or processing of food plants (discussion in Cauvin (ed.) 1983: 128). Based on research in the Western Desert of Australia, Hayden (1978) arrives at a similar conclusion. Tubers and roots are generally collected with a digging stick.

Instead, attention was turned towards the role of wild plants in the Dutch context, emphasizing species which might possibly be more economically collected or processed using flint blades. Turnip was selected as a root type. Although it was probably collected with a digging stick, the root might have been cut up with flint tools. Reeds were considered good roofing material, and were cut both in green and dry state. Stinging nettle (*Urtica dioica*) has of old been gathered as medicinal plant; young shoots are full of vitamins A and C, iron, calcium and many other minerals. It was also cooked as a vegetable and used for the manufacture of string and cloth. Water-hemlock is also a medicinal plant. Horse-tail (*Equisetum*) is traditionally applied for polishing pans in Dutch farmsteads (B.Decker *pers.comm.*), probably because of its highly silicious stems[1]. The leaves of cat's-tail (*Lythrum*) form good matting material, while the tubers are rich in carbohydrates and protein. Moor grass (*Molinia*) was, in former days, often used for making bee-hives.

One cultivated plant, flax (*Linum usitatissimum*), is dealt with here as well, because its stems do not contain silica. As only one experiment was performed involving this plantspecies, a category 'non-silicious domesticated plants' was not warranted. Instead, it is discussed in the section on non-silicious wild plants (*3.5.2.1*). Flax cannot be cut: it must be pulled out of the ground. Only in the subsequent processing of this crop could flint tools have played a role (*fig. 19*).

Obviously, many more wild plants could have been of great value to prehistoric man. However, when experimenting it became clear that, in terms of wear development, two groups could be differentiated: silicious plants such as reeds, wild grasses, horse-tails, cat's-tails and, to a lesser extent, stinging nettle, versus all the other 'green' plants. While the former produced a reflective polish, the latter did not cause any distinctive damage. Although the number of experiments involving wild plants could be extended, this would probably not have added much new information. Scheduling collecting activities obviously varies per species: springtime is the period to harvest herbs and several other green 'leaf'-plants, while during autumn various fruits, berries and nuts should be gathered. January is the most appropriate time to cut reeds for roofing; even now this is still the time when this activity is carried out, aided at times by the presence of ice.

3.5.1.2 Cereal-harvesting

For the most part, ethnographic information concerning the harvesting of domesticated cereals derives from the Near East. Here, flint sickles played a very important role. How-

Fig. 19 The loosening of the inner flax fibres from the rotten outer skin; an obtuse-angled tool is used to break and remove the outer layer.

ever, none have been observed in operation, since metal counterparts are used nowadays. Direct or indirect evidence for hafting is usually present on the archaeological sickle blades so that the overall shape of prehistoric sickles can be reconstructed (cf. Stordeur 1987). These reconstructions suggest that the archaeological sickles might have been used in a similar fashion as their metal counterparts.

The main issue is actually how far down the stem the grain was cut. Three options have been suggested. A first possibility is that the stems were cut or broken just below the ears (Reynolds 1981; Anderson-Gerfaud 1988) (*fig. 20*). This can nowadays still be observed in northern Syria, where young girls enter the fields to pick the green ears (cf. film presented by Dominique Vaughan during the symposium 'The exploitation of plants in prehistory', held in Jalès, France in June 1988). A second option implies that the stems were cut a little below the ear (*fig. 21*), somewhere

Fig. 22 Barley field at the experimental farm at Lejre, Denmark. Note the variable height of the ears and the large amounts of weeds present.

Fig. 20 Breaking off, with the aid of a flint tool, the cereal ears from their stems.

Fig. 21 Harvesting barley with a composite sickle somewhere half-way the stems.

Fig. 23 Reaping barley close to the ground in a 'modern' field, with the aid of a crescent-shaped sickle.

halfway. My own experiments would suggest that this is not a very practical procedure in fields where the stems do not attain roughly the same height (*fig. 22*). One has to cut further down to be sure to collect all the ears, including those of lesser height. This method yields straw of variable length, which is less useful for purposes such as roofing. The third option is cutting just above the ground surface (*fig. 23*). This has the advantage of leaving a stubble-field on which animals can graze while manuring the field at the same time. Leaving the straw attached to the ear also facilitates the removal of the kernels during threshing, thereby protecting the grains from being squashed. However, this harvesting method also implies the loss of possible roofing material. It has been suggested that reaping close to the ground would be too physically demanding for the harvesters, but this seems to be a western imposition and should not automatically be assumed correct. Alternatively, it is possible to uproot the entire stalk, but this is only done for barley (Hillman 1981). Van der Kooij (1976) mentions that this method is used when stems stand wide apart. It is also believed that the presence of soil particles might be a hindrance for threshing.

As to the organization of the work in Northwestern Europe, the harvest would have occurred in late summer, the exact period depending on latitude. Probably everyone available was needed, allowing little time for other activities during that period. Obviously, the fields had to be tended during the spring and early summer, but this concerns less-concentrated efforts than the actual harvesting.

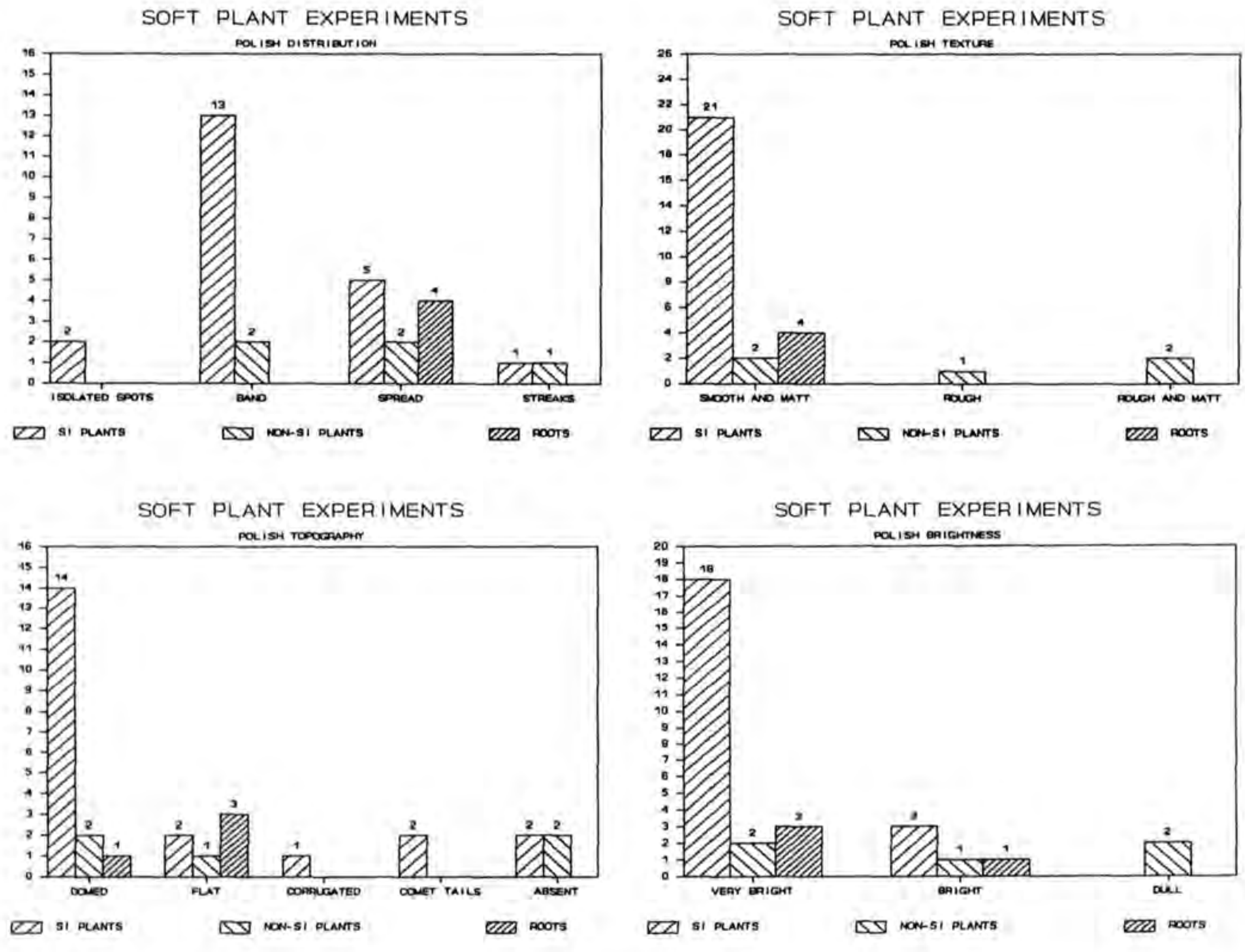


Fig. 24 Lotus graphs displaying polish characteristics on experimental tools used on soft plants other than cereals. si = silicious, a) distribution, b) texture, c) topography, d) brightness.

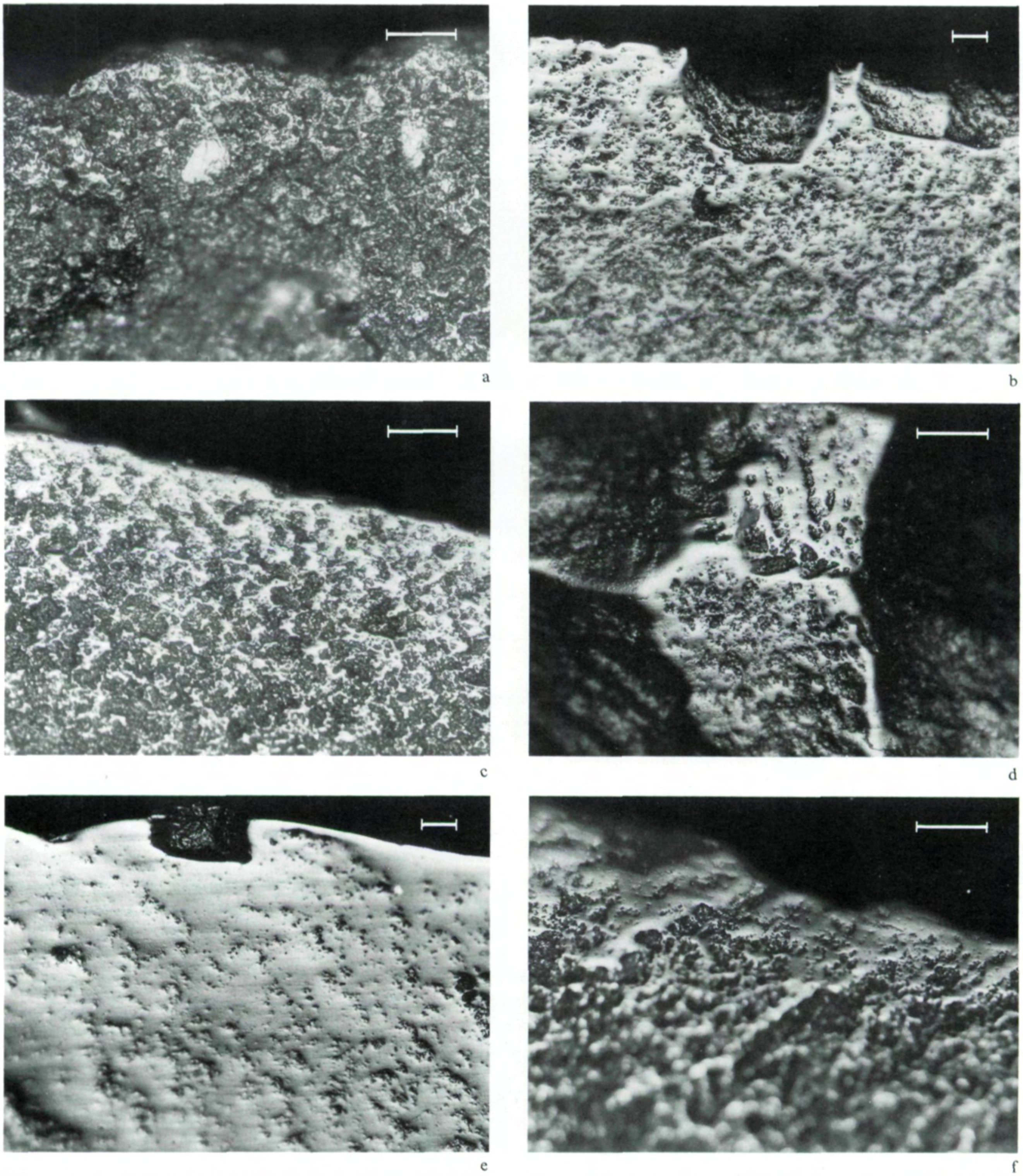


Fig. 25 Micrographs of wear-traces on experimental soft plant-processing and cereal harvesting tools. All scale bars equal 50 μ. a) polish and edge-rounding from working putrefied flax in perpendicular fashion (experimental tool 326, 200x), b) polish from cutting reeds (experimental tool 183, 100x), c) narrow band of polish resulting from cutting grass with experimental tool 186 (200x), d) domed polish on experimental tool 234 after 90 minutes of reaping barley (200x), e) well-developed polish on experimental tool 238 after 4.5 hours of reaping barley (100x), f) polish from reaping emmer (experimental tool 120, 200x).

3.5.2 Wear-traces

3.5.2.1 Wear-traces from cutting wild plants

A total of 35 experiments was performed with cutting various soft plants (*appendix II, table 5*). The total time worked amounted to 16 hours and 57 minutes. Three categories of wild plants were differentiated: silicious wild plants (a.o. reeds, wild grasses, cat's tail), non-silicious 'green' plants (a.o. celery, cabbage), and roots (turnip). Frequencies of various polish characteristics are depicted in fig. 24a-d.

Four experiments were done using turnip as an example for the gathering of root crops. The resulting polish, covering a large area of the tool, was smooth and matt in texture. Edge-damage was scalar with feathered or hinged terminations. The great extent of the polish is probably due to the presence of soil on the turnip. Non-silicious 'green' plants and vegetables such as celery, cabbage or green ('pasture') grasses did not cause any polish, edge-removals or even edge-rounding. Water-hemlock (experiment 310) produced some, albeit rather minimal, wear which would clearly not be interpretable on archaeological tools. Stinging nettles contain some silica in their 'stinging hairs', and produce a very narrow band of dull polish. The experiment with flax (nr. 326) involved the breaking of putrefied stems to loosen the inner fibres (*fig. 19*). Some light edge-rounding occurred, as well as some scalar edge-damage (*fig. 25a*). The polish was distributed in 'streaks', rather bright, smooth and matt in texture, and exhibiting a clear directionality.

Cutting silicious wild plants produced only slight edge-rounding. Micro-scarring occurred on the implements used on cat's-tail (experiments 314 and 315) because of the very tough stem of this plant: the retouch is half-moon in shape with snapped termination. The extensive use-retouch on these tools might explain the lack of a well-developed band of highly reflective polish. Remarkably enough, comet-tails are present in the polish on one of these two tools (experiment 315), implying that the development of this feature is associated with resistant, hard contact-materials as a general category, rather than just with bone (cf. *3.4.2.1*). The other occurrence of edge-scarring was on dry reed cutting tools (experiments 41, 280 and 288); here it concerned scalar scars with a feather termination, irregularly spaced. The experiments with horse-tail and fresh reeds only produced slight edge-rounding and a well-defined band of highly reflective, almost 'fluid' polish, matt and smooth in texture, with a domed topography (*fig. 25b*). No striations were observed on any of the plant-working tools, although the polish frequently displayed directionality. Grasses also caused a very well-defined band of polish (*fig. 25c*). In general, this band is much narrower than the ones produced by thicker stemmed species. One exception forms experiment 280, a dry reed cutting implement, which displays a metallic, narrow band of polish, only 300 μ wide. Such a metallic appearance of the polish seems to be confined to tools used on dry reed.

It can be concluded that finding (and interpreting) wear-traces from non-silicious fresh plants is virtually impossible in archaeological context. This would imply that, assuming such plants were collected with the aid of flint tools (which is by no means a necessity), these activities will remain archaeologically invisible (unless botanical evidence is present). As far as the silicious wild plants are concerned, traces produced by them are very evident, and post-depositional surface modifications will have to be extremely severe to cause such traces to be uninterpretable. Traces from cutting grass might disappear a little faster, because of their somewhat narrower width.

3.5.2.2 Wear-traces from reaping domesticated cereals

A total of 21 experiments with reaping cereals was performed (*appendix II, table 6*). Species included barley, emmer, bread wheat and oats. The total harvesting time amounted to 45 hours and 38 minutes. The time worked varied from 30-300 minutes. Two experiments, one with a composite sickle, were done on a weed-infested barley field at the experimental station at Lejre, Denmark (*figs. 21, 22*). In three other cases a retouched cresent-shaped sickle was employed (see also Van Gijn 1988) (*fig. 23*). In six experiments the flint implements were hafted with a mixture of resin and bee-wax[2].

Use-retouch developed on only six tools; in all instances it concerned feather-shaped scars with a hinged termination, irregularly and widely spaced, extending inwards to a maximum of 200 μ. The edge-rounding varied and seemed to be related to the duration of work, as well as to the relative coarseness of the flint. The polish is distributed in a band of at least 0.5 cm width (*fig. 26a*). The polish itself is highly reflective (*fig. 26d*), matt and smooth (*fig. 26b*), and displaying a clear directionality parallel to the edge. Those tools briefly used (i.e. with a less heavily developed polish) display a rather domed topography (*fig. 25d*), while on the tools displaying an outspread distribution, the topography seems flat (*figs. 25e, 26c*). Striations developed only in five examples; for the most part it concerned shallow striations.

The traces described here generally conform with those reported by other authors. No evidence was found for differences in the character of the polishes from barley and emmer (*fig. 25f*). It is suggested, however, that it is possible, at least experimentally, to differentiate between polishes from cutting reeds and those from reaping domesticated cereals, in the sense that the former have a 'wet', fluid-like appearance (even in the case of a well-developed polish (*fig. 25b*)), while the latter have a somewhat rougher and flatter polish.

Recently, claims have been made that it is possible to differentiate between harvesting wild and cultivated cereals (Korobkova 1981; Unger-Hamilton 1985, 1988). In archaeological context it has frequently been observed that sickle-

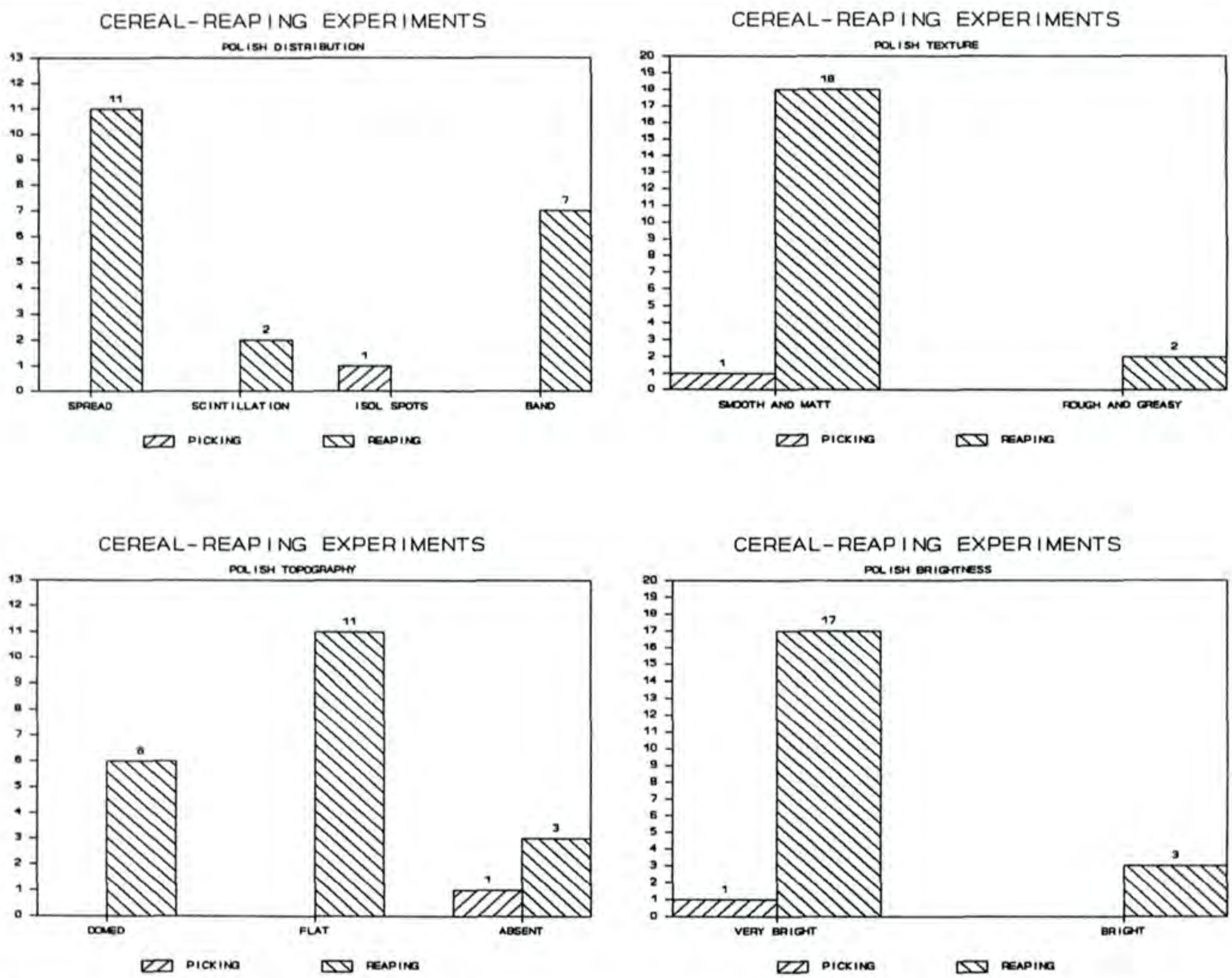


Fig. 26 Lotus graphs of polish characteristics on experimental cereal harvesting tools. a) distribution, b) texture, c) topography, d) brightness.

sheen has a very rough and striated appearance. Unger-Hamilton has done experiments with both wild and domesticated grain: the former caused a smooth, the latter a rough polish variety. She explains this by the fact that cultivated fields are ploughed and weeded, causing disturbance of the soil, particles of which may be deposited on the stems. Flint sickle blades would be scratched by these soil particles. The large majority of the cereal-harvesting experiments reported here were done on weeded, ploughed fields, but the polish never displayed this strange rough and striated appearance. Juel Jensen has postulated a more likely explanation for the striated appearance of archaeological sickle blades. She hypothesized that the roughness is due to large amounts of weeds in the fields. This was corroborated experimentally on a weed-infested field at Lejre, Denmark (H.Juel Jensen *pers. comm.*). My own experiments at Lejre did not produce a striated polish, probably because of their relatively short duration (*fig. 27a*).

3.6 Butchering and meat-cutting

3.6.1 Ethnographic accounts

Ethnographic data on the use of flint implements in butchering are virtually non-existent. The Copper Eskimo are reported to scrape off the meat and tendons from a caribou skin, using a stone knife (Jenness 1970). Sinew is a sought-after article, as it provides excellent thread for sewing,

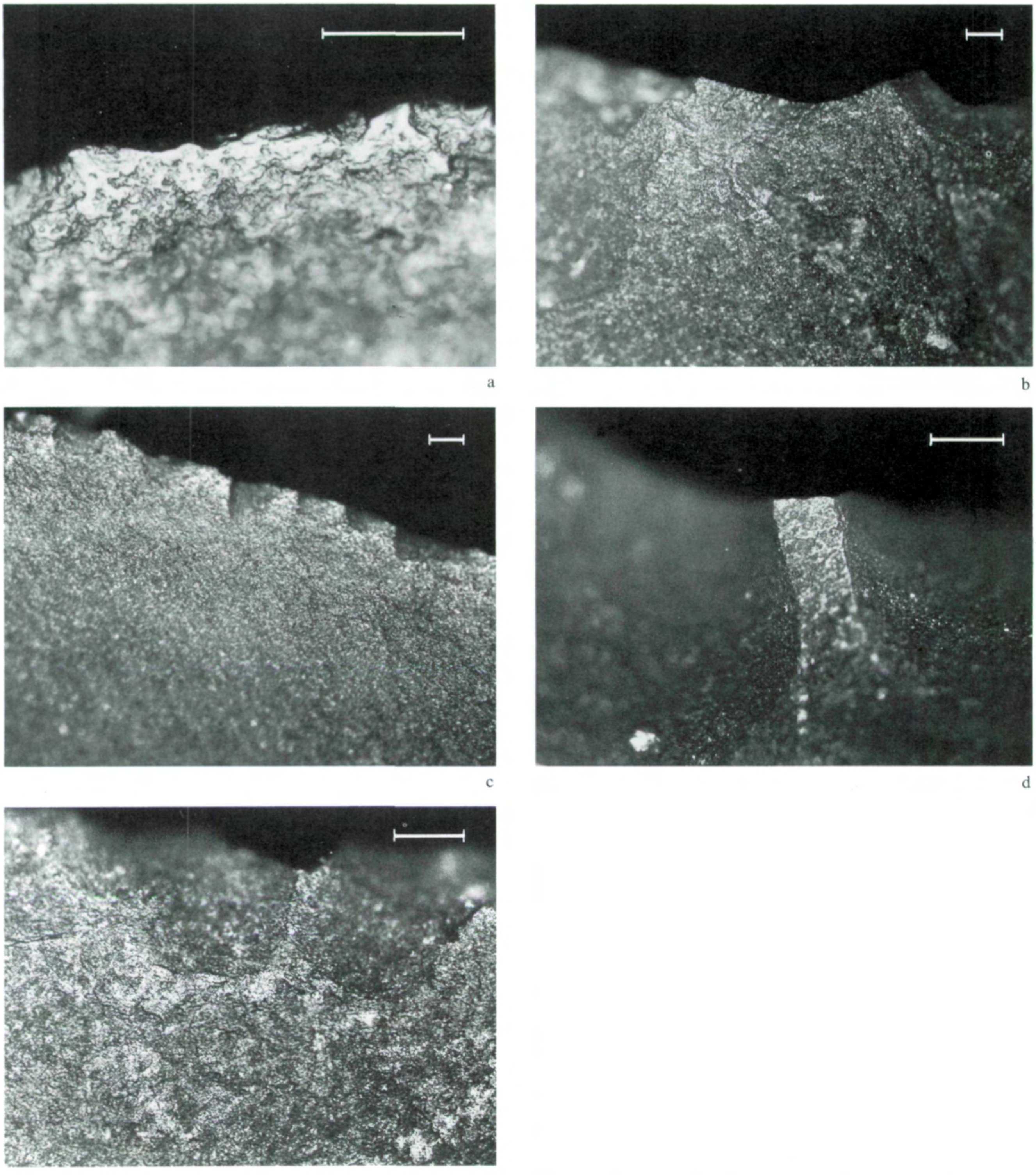


Fig. 27 Micrographs of experimental wear traces. All scale bars equal 50 μ. a) polish on experimental tool 318a used for harvesting weed-infested barley (400x) (see also *fig. 21*), b) edge-damage and faint polish on experimental tool 224 used for butchering a roe-deer (100x), c) scalar scars from cutting sturgeon-skin (experimental tool 184, 100x), d) 'bone' polish from cutting fish (experimental tool 194, 200x), e) linear streaks from scaling fish (experimental tool 193, 200x).

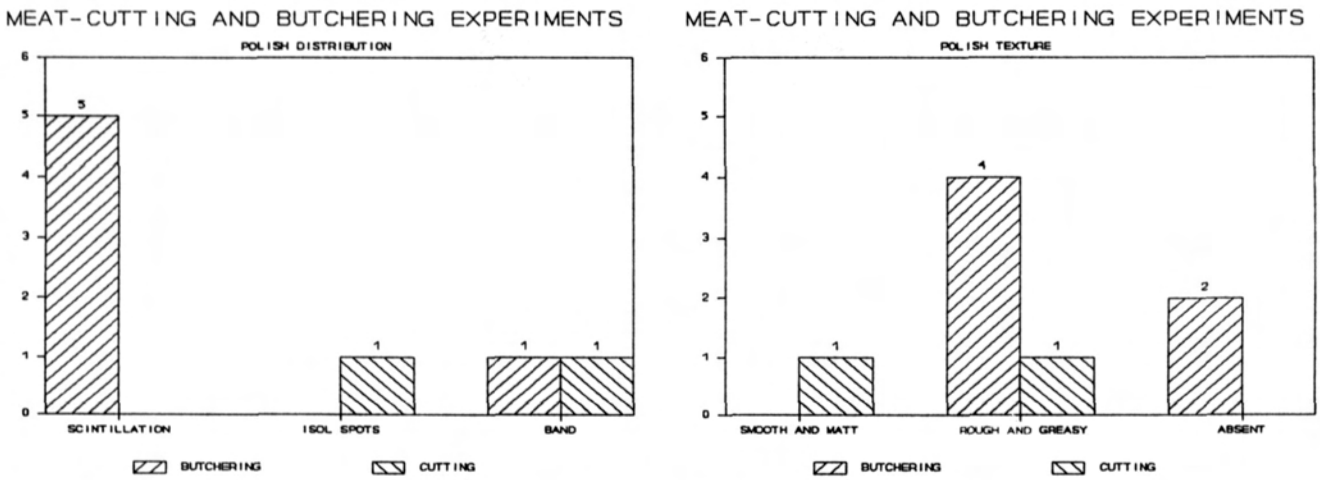


Fig. 28 Lotus graphs of polish characteristics on meat-cutting and butchering tools. a) distribution, b) texture.

snares and lashings (Osgood 1937, referring to the Tanaina). Most American Indian people customarily dry strips of meat for later storage; some pounded the dried meat to mix with berries (Densmore 1928). Butchering commonly seems to occur in the vicinity of the kill-site (Beaglehole 1936), unless it concerns small game.

Most of the information concerning the techniques and organization of butchering derives from ethnoarchaeological sources (Binford 1978a, 1983; Frison 1978, 1979), or from recent experiments (Patterson 1975, 1976; Walker 1978; Jones 1980; Odell 1980a). The latter were generally concerned with edge-characteristics most suitable for the task and with the examination of the resulting macroscopic wear-traces (see *3.6.2*).

3.6.2 Wear-traces from butchering and meat-cutting

A total of eight butchering and four meat-cutting experiments was performed (*Appendix II, table 7*), involving five hours and 13 minutes of work. Five butchering experiments involved roe-deer, two concerned fox, and one involved badger. In four experiments edge-scarring occurred, always scalar, and in three cases with a feathered termination (*fig. 27b*). There does seem to be a correlation between duration of work and the occurrence of scarring, although the tool of exp. 58, used longer than any other experimental piece, displayed none. However, this piece had not come into any contact with bone, contrary to exp. 53, exhibiting the most extensive use-retouch. Edge-rounding was moderate at most. Polish developed in six experiments, generally confined to a faint scintillation (*fig. 28a*). It concerned a rough and greasy lustre in appearance (*fig. 28b*), seldom displaying directionality, and lacking topographical characteristics. In some cases minute spots of 'bone-polish' were present. Striations were absent.

The meat-cutting experiments showed traces of use in only two cases. In experiment 164, used to cut meat off bone, it concerned bone-polish (bright, smooth and matt, with clear directionality), while the invasive retouch present is probably due to bone contact as well. The other tool displayed a band of rough, greasy, relatively bright polish; some small scalar, feathered scars were present. This tool was used for 45 minutes on meat with a lot of tough fat. The remaining two meat-cutting tools exhibited no traces of use whatsoever.

Traces from butchering, and especially meat-cutting, have been a source of much debate among wear-analysts. Keeley maintained that meat-polish was quite distinctive, because of its pronounced greasy lustre (Keeley 1980: 53). He observed a general smoothing of the stone's microtopography, with few striations. Keeley differentiated between fresh hide- and meat-polish, as did Moss (1983a). Anderson-Gerfaud (1981) and Vaughan (1985a) do not distinguish these two groups, the latter asserting that both only caused a generic weak polish (Vaughan 1985a: 38). Instead, Vaughan considered butchering-traces as a separate category, because of the bone-contact involved. As far as fresh hide-cutting (skinning) is concerned, I do agree that these traces are comparable with those caused by meat. However, this is definitely not the case with scraping fresh hides. In this study therefore, meat-cutting, skinning and butchering were kept in the same category.

While skinning and meat-cutting produced traces of wear which would seldom be visible archaeologically, butchering traces can be quite distinctive. Although it is very possible to butcher an animal without touching bone (Patterson 1981; H.Nijland *pers.comm.*), in most instances a characteristic pattern of small scalar scars occurs, sometimes associated with isolated spots of bone-polish or some weakly developed lustre. Still, an expert butcher does not have to damage the tool very much. This implies that, contrary to some claims (Odell 1980a), only one cutting implement is generally necessary to dissect, for instance, a roe deer (H.Nijland *pers.comm.*). Patterson (1976) arrives at the same conclusion. To conclude, meat-cutting tools and, to a lesser extent, butchering implements will be severely underrated in archaeological wear-trace reports.

3.7 Fish

3.7.1 Ethnographic accounts

A lot of information is available about fishing procedures among the American Indians (see, for instance, Rostlund 1952; Stewart 1977). Of interest to the present study, however, is only if and how the fish was processed. When fish was caught for winter storage, some form of cleaning was always practised before the product was smoked or dried. Most Northwest Coast Indian tribes slit open the salmon, removed the entrails, and cut off the head. In the case of big, fat fish, they also cut the fillets for greater thinness (Spier 1930; Stewart 1977). To perform these operations, they sometimes made use of bone knives ('herring-knives'), slate knives (Stewart 1977: 155) or, occasionally, mussel shells. It is likely that also flint tools were employed in fish cleaning. Although cleaning is necessary when it concerns large quantities of fish to be processed for storage, there are however many instances in which no cleaning was practised. Osgood (1937) reports that the Tanaina buried silver salmon in the permafrost, using alternating layers of fish, fish-eggs (their saltiness acting as a preservative), and grass. The Huron buried fish in mud or hung it up, without removing the viscera; the resulting product was considered to be a good seasoning for the soup (Rostlund 1952).

As to the organization of the work, it is apparent that in almost all instances in which seasonal runs of anadromous fish were exploited, this was done in an organized fashion. Anadromous fish, such as salmon or sturgeon, are the only species that lend themselves to large-scale preservation for winter storage, because they can be caught in enormous quantities. In order to catch the shoals, facilities such as traps or weirs were constructed. These can be considered tended facilities (*sensu* Oswalt 1976), because it is necessary to regularly check whether or not the runs have arrived. This is the reason why specific expeditions were organized at the time of the runs. Camp was set up close to the weirs or traps (Osgood 1937; Balicki 1970). The Huron, basically an agricultural people, built fish-cabins of bark (having two fireplaces) on the islands to which they went to fish (Tooker 1964). The fish was gutted on the spot and hung to dry on racks (Trigger 1969). Other people are also reported to process the fish close to the catch-site (cf. Nelson 1973, reporting on the Kutchin, or Osgood 1937 on the Tanaina).

It is apparent that even agriculturally-based people such as the Huron organized fishing expeditions. After the harvest, in autumn, it was worthwhile to go through the trouble of freeing labour, travelling, and building specific fishing cabins (Tooker 1964; Trigger 1969). This observation is particularly relevant when we examine the site of Hekelingen III (*6.2*).

3.7.2 Wear-traces from fish

In a previous paper (Van Gijn 1986a) the character of the wear-traces resulting from contact with fish have been extensively discussed. Here a summary will suffice (*fig. 29a-d*). A total of 27 experiments was performed with various species of fish (*appendix II, table 8*). Total working time amounted to nine hours and 53 minutes. Edge-rounding never exceeded the stage of moderate. Use-retouch developed in 20 cases, and was mostly closely distributed (*fig. 27c*). The form of the retouch was somewhat variable, with trapezoidal or square shapes mainly associated with longitudinal movements on bony fish with resistant scales, such as bream (exp. 5 and 7). Lasting polish (as compared to 'residue', see Van Gijn 1986a) was visible on 18 tools. In nine instances it concerned a very bright, smooth and matt polish, indistinguishable from bone-polish and displaying comet-tails (*fig. 27d*); this occurred on experimental tools which had been used in a longitudinal fashion. On seven tools (in four cases in combination with bone-polish) did the characteristic linear streaks of polish develop (*fig. 27e*); these occur mostly when removing hard and resistant scales such as those of rudd. Only once was a greasy scintillation ('meat-polish-like') visible.

These results lead to the conclusion that the processing of fish is largely invisible from the point of view of use-wear analysis. Certainly, fish-processing tools can be hidden among the tools interpreted as butchering implements, or among bone-working tools. Only the linear streaks of polish seem to be characteristic for fish-processing, but they are exclusively associated with scaling and are absent when scaling soft-scaled fishes, such as pike. Although they can be differentiated in experimental context, in archaeological context these linear streaks of polish might be difficult to separate from the MLITS which develop on projectiles (see below).

3.8 Projectiles

3.8.1 Ethnographic accounts

Ethnographic accounts are not specific about the relationship between the shape of an arrow head and, for instance, the animal species hunted. Therefore most information

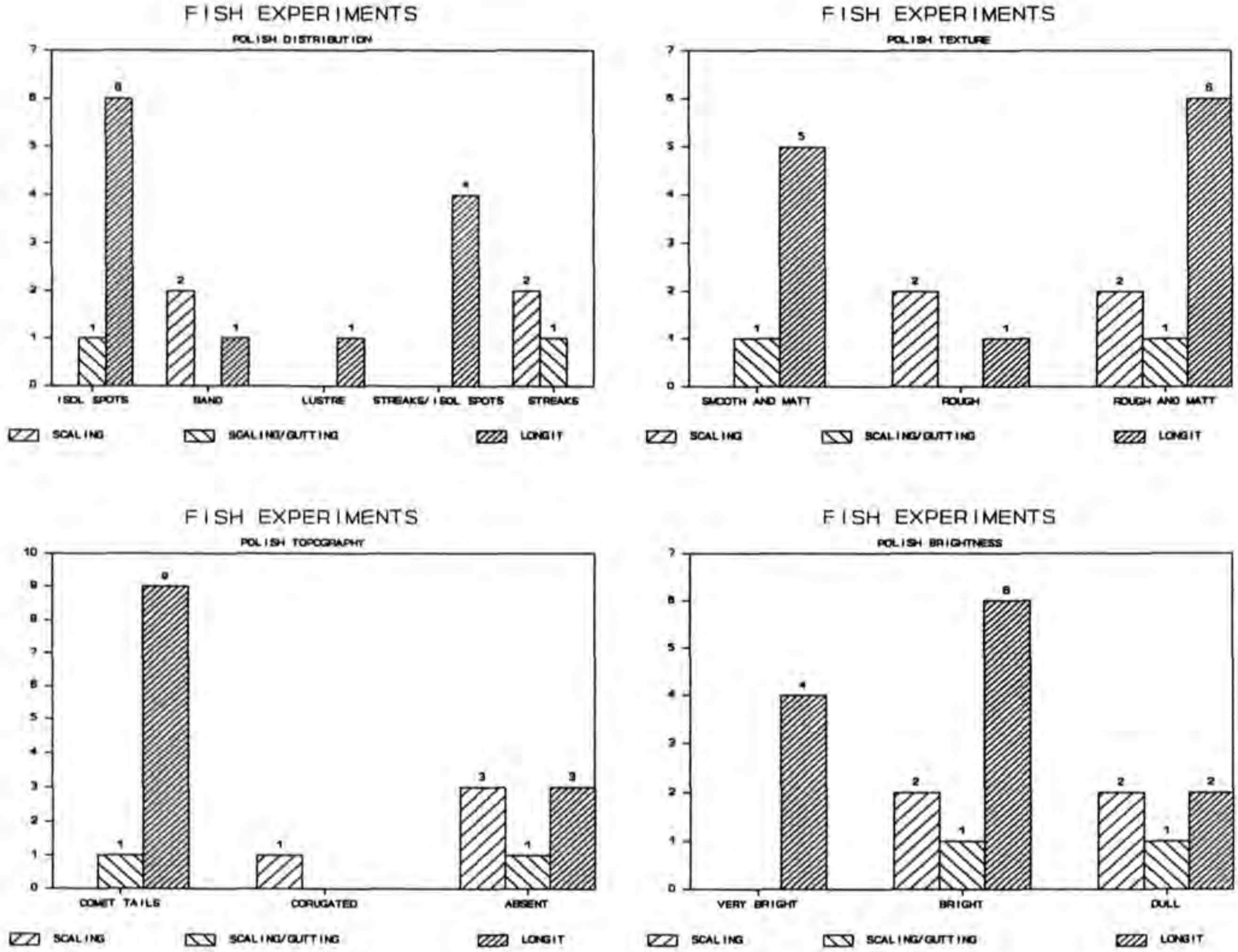


Fig. 29 Lotus graphs of polish characteristics on experimental fish-processing tools. isol spots = isolated spots, str/isol spots = streaks + isolated spots, longit. = longitudinal, a) distribution, b) texture, c) topography, d) brightness.

comes from recent experimentation (a.o. Fisher et al. 1984; Odell/ Cowan 1986) and will be discussed in the next paragraph.

3.8.2 WEAR-TRACES FROM THE USE OF PROJECTILES

In cooperation with Drs. Jaap Beuker (Drents Museum, Assen), a total of 11 transverse arrow heads were shot at a dead roe-deer hung up between two trees beside a leaf covered sand road (*fig. 30*). The bow used was a 48 lbs modern type. All arrow heads, manufactured by Beuker from either very fine-grained northern flint or Rijckholt material, were shot only once. Two arrow heads could not be retrieved (*appendix II, table 9*). After the experiment, the roe-deer was butchered by Henk Nijland (Rijks-Instituut voor Natuurbeheer, Arnhem) to determine the precise trajectories of the arrow heads inside the body. In this way we hoped to find out whether the arrow heads had come into contact with bone. On two of the nine tools no damage was visible (22%). The remaining (78%) showed impact fractures of half-moon shape with deep initiation and feather termination. Six tools (67%) displayed the characteristic linear streaks of polish (MLITS) (*fig. 31a*), running parallel to the direction of impact.

These results coincide with previous reports about experimentally-induced wear-traces on arrow heads (Fisher et al. 1984; Odell/ Cowan 1986). Fisher et al. (1984) mention that on 66% of the transverse arrow heads microwear-traces (i.e. linear streaks of polish) developed, while 61% of the used Brommian points displayed this feature. However, they note a much lower number of instances (41%) in which macro-traces (i.e. fractures) were present. Odell and Cowan (1986: 204, table 1) report a 100% occurrence of macroscopic damage on the tip. These results indicate that with relatively little effort a possible previous use as projectile point can be ascertained in at least 66% of the cases.

Fig. 30 Shooting transverse arrow heads at a dead roe-deer.

3.9 Pottery

3.9.1 Ethnographic accounts

In Neolithic contexts, one of the contact-materials that has to be considered is pottery. It is conceivable that stone tools were used during the manufacturing process, for instance for scraping the inside of a pot after the clay had partially

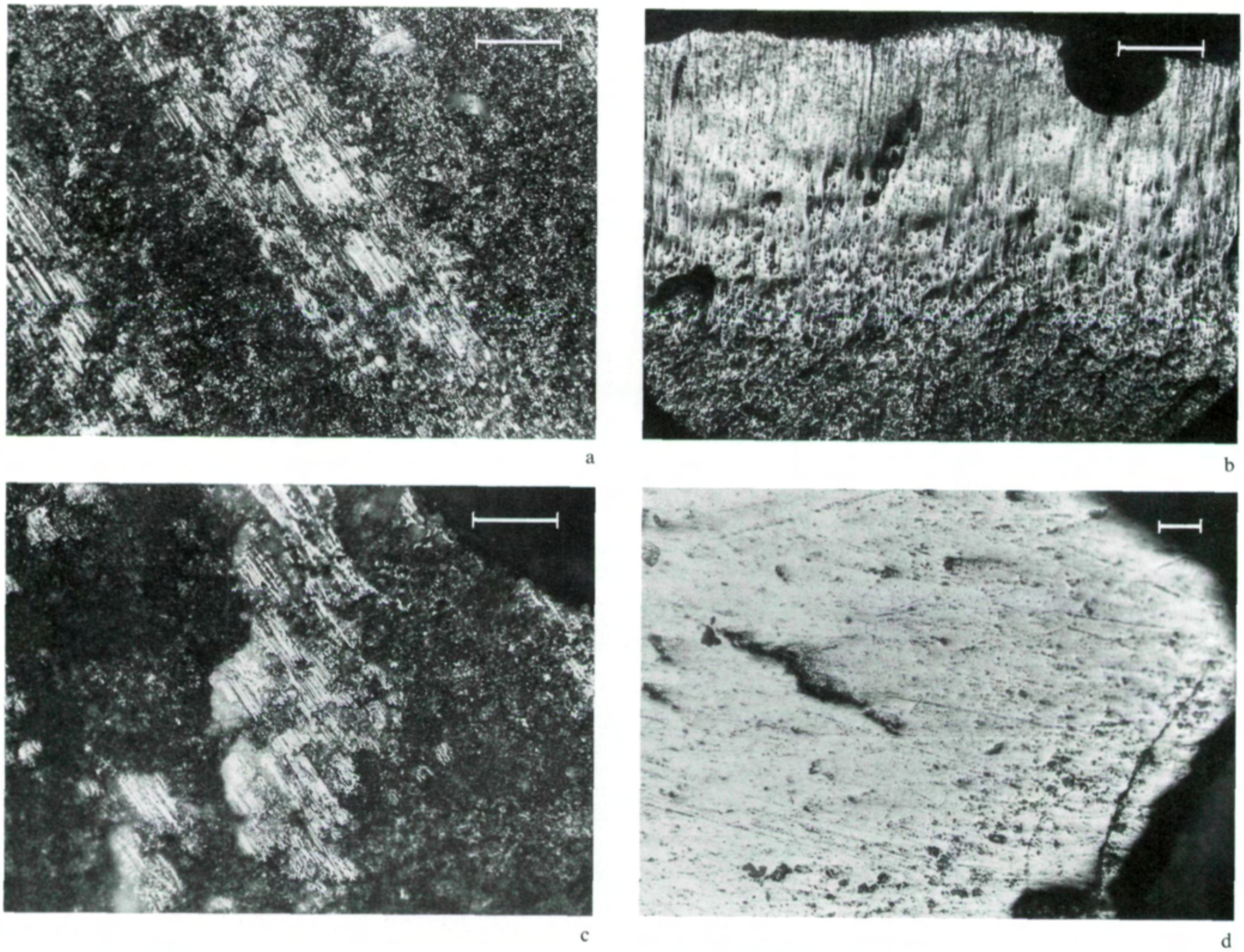


Fig. 31 Micrographs of experimental wear-traces. All scale bars equal 50 μ. a) microscopic linear streaks of polish (MLIT) resulting from use as projectile on experimental tool 129 (200x), b) polish on experimental tool 199 employed for scraping dried clay (200x), c) wear-traces on experimental tool 78 used for cutting limestone (200x), d) well-developed polish resulting from cutting sods, observed on experimental tool 182 (100x).

dried, or for decoration. It is also possible that flint borers were employed for repairing baked pottery. Hardly any ethnographic examples of the use of flint for pottery making were found. The Cocopa in California are reported to have used an unhafted stone blade, or a clam or oyster shell, to shape a pottery vessel (Gifford 1934). In general, ribs of sheep or pigs are said to perform that function. No instances were found of the use of flint borers for the repair of baked vessels.

3.9.2 Wear-traces from pottery

Six scraping and two boring experiments were done, involving a total of three hours and five minutes of work (*appendix II, table 10*). The scraping experiments all involved dry clay, either untempered or tempered in various ways. In two cases a retouched edge was used, but this was clearly unsuitable as the retouch scratched the clay surface too much: an unretouched obtusely-angled blade was much more appropriate. On all six tools a heavily rounded edge developed, as well as a highly reflective polish, extending far back into the piece. The polish was distributed in a wide band (*figs. 31b, 32a*), had a rough and matt texture, a corrugated topography, and a directionality perpendicular to the edge. In six instances the polish was very bright (*fig. 32b*). In the cases with quartz- or chamotte-tempered clay, deep, long, and wide striations developed. Only once (exp. 199) did use-retouch occur, probably due to the acute angle of the working-edge. The two boring experiments did not cause a similar heavy edge-rounding, perhaps because both implements were only used briefly. A rather dull, rough, matt polish developed on protruding points. On the tool employed for boring chamotte-tempered baked clay, some edge-damage occurred.

With respect to the scraping of dried, unbaked vessels, it does seem that characteristic wear-traces are produced on a 100% basis after a relatively short period of time. The boring of baked vessels seems more problematic in terms of the development of wear-attributes: although both tools were only briefly used, it is doubtful whether the polish would have increased, as edge-damage would have eliminated the polish spots.

3.10 Stone, shell and teeth

3.10.1 Ethnographic accounts

Many people use soft stone, shell or teeth ornaments. It is likely that flint tools often played a role in their manufacture. Again, however, reports on the process of manufacture are extremely rare. Among the Surprise Valley Payute, pipes were made of soft stone, and obsidian blades were used to scrape out the cavity (Kelly 1934). It is also assumed that flint tools were used for sawing soft stone or shell, but no ethnographic accounts were found on this matter.

3.10.2 Wear-traces from stone, shell and teeth

Only one experiment (*appendix II, table 11*) was performed on soft stone: a slab of limestone was cut for seven minutes, resulting in severe edge-damage (overlapping, hinged scars), and isolated spots of polish. Striations also developed (*fig. 31c*). Clearly, it is not possible to base conclusions on only one experiment; it is intented to direct more experiments towards working with various types of stones in the future. The same applies to the category teeth; with this material only one experiment was done as well. Edge-removals had a square or trapezoidal shape, and stepped terminations: the polish was rough and matt, distributed on the protruding parts of the implement, and displaying clear directionality.

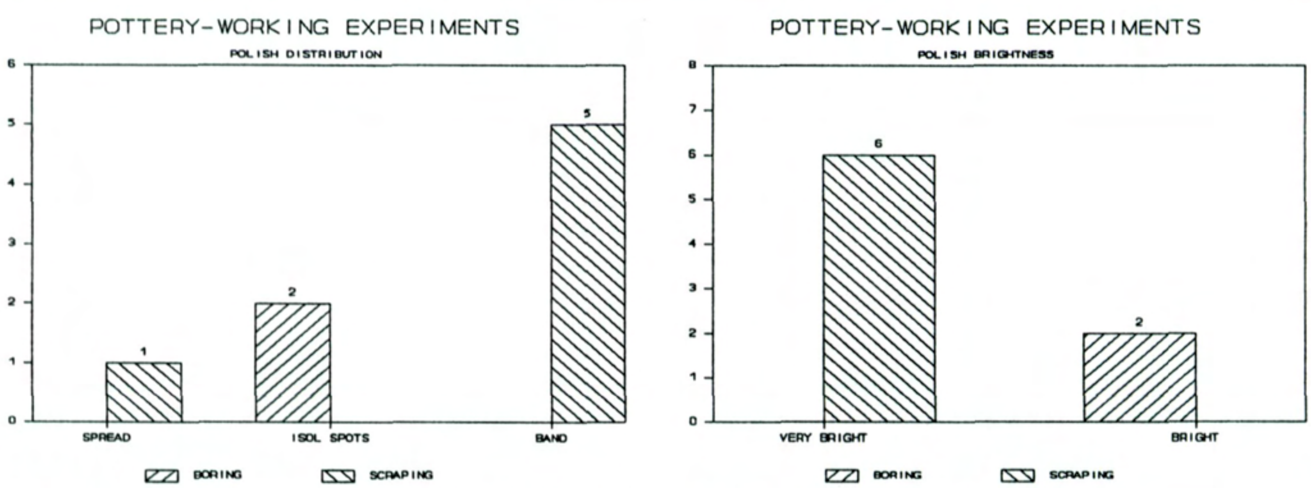


Fig. 32 Lotus graphs displaying polish characteristics from working pottery. a) distribution, b) polish brightness.

More experiments were performed with shell, mostly concerning a boring motion. Edge-scarring was frequent; of three implements the entire tip broke off, on the others square or trapezoidal stepped scars occurred. The polish was never extensive, localized as it was on protruding points (*figs. 33a, 33b*), while striations were not observed.

3.11 Soil

3.11.1 Ethnographic accounts

Soil as contact-material is somewhat ambiguous. There are many ways in which flint implements can come into contact with soil without an intentional (human) action being responsible, such as in the case of soil remnants on a root being cut (see *3.5.2.1*), putting the implement down on the ground, or simply post-depositional contact. Here, the concern is with soil as an intentional contact-material, i.e. during hoeing and sod-cutting. Californian Indians are known to have employed obsidian hoes (R.Whallon *pers. comm.*). Ethnographic parallels for the use of flint tools for cutting sods have not been found.

3.11.2 Wear-traces from soil

Only five experiments involved soil (*appendix II, table 12*). Four concerned sod-cutting experiments performed to test the suitability of crescent-shaped sickles for this purpose (cf. Van Gijn 1988, *in press b*). The fifth tool was used for hoeing. A total of 220 minutes of work is represented. Very little use-retouch occurred, while edge-rounding was extensive. Polish developed quickly; in all cases it displayed a spread-out distribution, a matt, rough texture, a flat topography, and extreme brightness (*fig. 31d*). Examined with the naked eye this polish clearly resembles 'sickle-gloss' (Van Gijn 1988, *in press b*). Striations were long and narrow, with varying depth and a random or parallel directionality. As the wear-traces on all five tools were identical, no graphs were made.

3.12 Counting experimental wear-attributes

In the preceding pages the various wear-attributes, as they occur on the experimental tools, were presented. It is apparent that characteristics deemed unique for a certain contact-material do not always develop. For example, a cratered (or sometimes pitted) topography is commonly associated with hide, but was only present on 20 out of the 49 tools. Characteristic 'wood-polish' is supposed to be domed: a mere 38 of the 53 tools with polish displayed this feature (of 62 experimental tools). 'Bone-polish' has comet-tails and/or pits or, in the case of scraping-tools, a bevel; 32 of the 53 implements showed one or more of these features. Of the harder contact-materials, 'antler-polish' especially lacks distinctive attributes which would differentiate it from 'wood'- or 'bone-polish'. As far as the more yielding contact-materials are concerned, the absence of distinctive wear-traces is even more evident. If we exclude the experiments with turnip (which actually mainly involved contact with the sandy root-surface), non-silicious soft plants rarely produce polish or use-retouch. If damage occurs, it is non-distinctive. The same applies to contact with meat. Silicious plants however, whether it be wild species or domesticated cereals, produce a very distinctive polish within a short time with a spread-out distribution. Impact damage on projectile points is quite distinctive and develops frequently. Too few experiments were done with other categories of materials to allow conclusions to be drawn.

Looking at the results in a slightly different way, cross-tables were made of contact-material and motion, noting

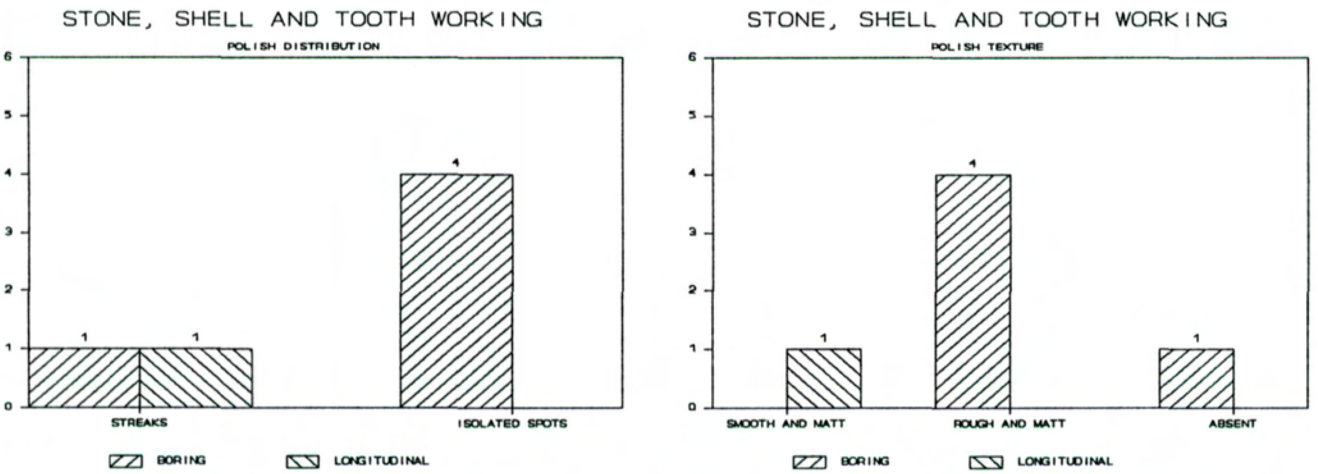


Fig. 33 Lotus graphs of polish on experimental implements employed on stone, shell or tooth. a) distribution, b) texture.

Table 1 Experimental tools: frequency of the occurrence of polish according to contact-material and motion. * concerns carving bone, ** includes the four experiments with turnip, involving extensive contact with the soil particles adhering to the root's surface.

	longitudinal		transverse		boring		other		total	
		%		%		%		%		%
hide	9/15	60	22/28	70	1/6	17	–	–	32/49	65
wood	16/17	94	29/35	83	3/3	100	5/7	71	53/62	86
bone	15/15	100	13/15	87	3/4	75	19/19	100*	50/53	94
antler	5/5	100	6/7	86	3/5	60	0/1	0	14/18	78
silicious wild plant	22/23	96	–	–	–	–	1/1	100	23/24	96
non-silicious wild plant	6/10	60**	1/1	100	–	–	–	–	7/11	64
cereals	20/20	100	–	–	–	–	1/1	100	21/21	100
butchering	6/8	75	–	–	–	–	–	–	6/8	75
meat	2/4	50	–	–	–	–	–	–	2/4	50
fish	12/16	75	4/5	80	–	–	2/6	33	18/27	67
projectile	–	–	–	–	–	–	6/9	67	6/9	67
pottery	–	–	6/6	100			2/2	100	8/8	100
shell/stone	1/3	33	–	–	5/8	63	–	–	6/11	55
soil	4/4	100	–	–	–	–	1/1	100	5/5	100

Table 2 Experimental tools: frequency of the occurrence of edge-removals according to contact-material and motion.

	longitudinal		transverse		boring		other		total	
		%		%		%		%		%
hide	4/15	27	0/28	0	1/6	17	–	–	5/49	10
wood	15/17	88	11/35	31	0/3	0	0/7	0	26/62	42
bone	14/15	93	4/15	27	0/4	0	17/19	90	35/53	66
antler	5/5	100	1/ 7	14	0/5	0	0/1	0	6/18	33
silicious wild plant	7/23	30	–	–	–	–	0/1	0	7/24	29
non-silicious wild plant	3/10	30	1/1	100	–	–	–	–	4/11	6
cereals	6/21	28	–	–	–	–	–	–	6/21	29
butchering	4/8	50	–	–	–	–	–	–	4/8	50
meat	2/4	50	–	–	–	–	–	–	2/4	50
fish	15/16	94	3/5	60	–	–	2/6	34	20/27	74
projectile	–	–	–	–	–	–	7/9	78	7/9	78
pottery	–	–	1/6	17	1/2	50	–	–	2/8	25
shell/stone	3/3	100	–	–	4/8	50	–	–	7/11	64
soil	0/4	0	–	–	–	–	0/1	0	0/5	0

presence or absence of polish (*table 1*) and edge-removals (*table 2*). No table was made for the presence of striations as these occurred rarely, with the exception of longitudinal motions on wood: this resulted in striae on 8 of the 17 implements used in this fashion.

If we examine table 1 it can be seen that polish (whether it displays particular characteristics or not) is present on a very large percentage of the used implements. Cereals, soil and pottery even cause polish on a 100% basis. Silicious wild plants, such as reeds, and bone score also very high: in 96% and 94% of the cases, respectively, a polish developed. The rather low score of hide (65%), commonly regarded to develop microwear-traces relatively quickly, and of a quite diagnostic nature, needs some explanation. Included in this score are experiments with modern leather, which in most instances was dyed; this material caused polish in only five of the 11 cases. If we omit these present-day 'pollutive' experiments, the frequency of the occurrence of hide-polish increases to 71%. Antler and butchering also score c. 70%, while wood produces polish in 86% of the experiments. MLITS on projectile points developed on 67% of the tools. The rather high percentage of polish occurrences on soft plants is due to the inclusion of the experiments with turnip, which actually mainly involved contact with soil. If we omit these four implements, the score drops dramatically to 20%. The 50% for meat is also too high, as experiment 164 is included, which involved contact with bone; omitting this implement produces a score of 25% for meat. However, the numbers involved here are so low, that quantitative comparisons are meaningless. Fish produced traces in more cases, 67%, but this is complicated by the fact that this concerns 'bone-polish' in most cases, while traces really characteristic of contact with fish occurred on only 26% of the tools. In the case of the shell/ stone/ teeth-category, the relatively low score of polish occurrences (55%) is due to the removal of polish by use-retouch.

Percentages of the occurrence of use-retouch produce a different picture (*table 2*). Hide scores extremely low: only 10% of the tools display scarring. Plants score around 30%; the high score for non-silicious plants is due to the experiments with turnip, which has a very resistant skin. The 50% score of meat is due to the inclusion of experiment 164 (see above).

The low score for pottery can be attributed to the fact that it concerned dried (not baked) material. Projectile points display impact scars on 78% of the implements. Rather surprising are the relatively low total scores for bone, wood and antler (66%, 42% and 33% respectively). However, if we examine the percentages per motion, it is clear that longitudinal motions scored extremely high for these three materials (93% for bone, 88% for wood, and 100% for antler). In contrast, transverse motions scored extremely low, especially for antler (14%); such motions are commonly carried out parallel with the grain, while the used tool edge is more stable due to retouch and a steep edge angle.

The results described here conform generally with the unfortunately rather few instances in which experimental results are quantified (Fisher et al. 1984; Vaughan 1985a). The relatively more frequent development of polish, when compared to the occurrence of use-retouch, is somewhat surprising. The low-power approach seems, considering the infrequent occurrence of scarring on some experimental tools, to be potentially missing used tools, especially if compared with the high score of polishes. However, it should be stressed that this polish is not always distinctive or well-developed and could thus be easily missed or misinterpreted on archaeological implements. This is especially the case, because polish is more vulnerable and can be more easily modified, even after relatively minor chemical or mechanical attack. I would think, therefore, that the instances in which used pieces would be missed in archaeological assemblages could be about equal for both approaches. Certainly, softer materials such as meat and non-silicious plants will be under-represented in both low- and high-power analyses (Shea 1988: 71). From tables 1 and 2 it can be seen that in certain cases polish development is strong, with edge-scarring being absent (i.e. hide), while in other instances the opposite is observed (i.e. stone, shell, teeth). The most profitable avenue of approach would thus be a combination of low- and high-power analyses.

notes

1 In fact *Equisetum*, or scoring-rush as it is called, is reported to have been used by the Klamath to smooth wooden arrow shafts (Spier 1930: 195). Carpenters in Denmark used it to finish furniture (H.Juel Jensen *pers.comm.*).

2 A mixture of resin and bee-wax works well, but the relative amounts needed from the two components depend on the weather. When the work is carried out in hot temperatures, more resin is needed for better adherence. In cold weather, one has to add more wax to improve the flexibility which prevents the flint inserts from breaking out of the haft.

4 Post-depositional surface modifications

4.1 Introduction

It is to be expected that, since flint artefacts sustain a variety of damage from many contact materials, they are also subject to modifications from 'natural' causes, such as compaction of the soil, soil creep, water transport etc. Keeley fully realized this problem, and he formulated the following criteria:

'for an assemblage to be suitable for microwear analysis, the majority of its implements must be in extremely fresh condition, that is, unaffected by any form of natural abrasion. This condition is best fulfilled by only studying collections from archaeological deposits judged to be in primary context' (Keeley 1980: 84).

However, Keeley himself had to discard a large percentage of the assemblages he was studying (see *4.3*), even though the material was considered to derive from primary contexts. It became apparent that many assemblages had to be rejected. More disturbing was the fact that natural abrasion even occurred on assemblages which seemed in fresh condition when examined with the naked eye, such as Etiolles (Plisson 1985a) and Kolhorn (author's determination, not published). Even concerning assemblages generally considered to be in sufficiently good condition for high-power microwear study, the analysts frequently had to conclude that all tools displayed a sheen (Mansur-Franchomme 1983: 188), or, as Moss has formulated it,

'the analysis of the first 50-100 pieces in any microwear study using high magnification will be distorted by the necessity of growing accustomed to the post-depositional alterations unique for each site' (Moss 1983a: 144).

Upon microscopic examination, most assemblages yield some uninterpretable artefacts; the presence of sheen can vary within a site and even on one and the same implement. Rarely were archaeological polishes observed which exactly matched experimental traces:

'Il est aisé de produire expérimentalement des traces d'usage 'typiques', semblables à celles qui ont été décrites et illustrées par L.H. Keeley et d'autres chercheurs. Il est rare, en revanche, d'observer des polis aussi classiques lors de l'examen de pièces préhistoriques' (Gysels/ Cahen 1982: 221).

Plisson has been engaged in an extensive experimental programme to try to replicate secondary modifications and account for the factors responsible for their development. Plisson's experiments covered the aspects of the problem most easily addressed, and it did not seem useful to duplicate them, especially since they were extensively published (Plisson 1983a, 1985a, 1986; Plisson/ Mauger 1988). Extending upon Plisson's experiments requires detailed knowledge of surface-chemistry which is beyond this author's competence. Instead, a literature search was initiated to get an overview of the conditions under which analysts report their assemblages to be affected by surface modifications (see *4.3*).

4.2 Post-depositional surface modifications: a wide range of phenomena

4.2.1 Introduction

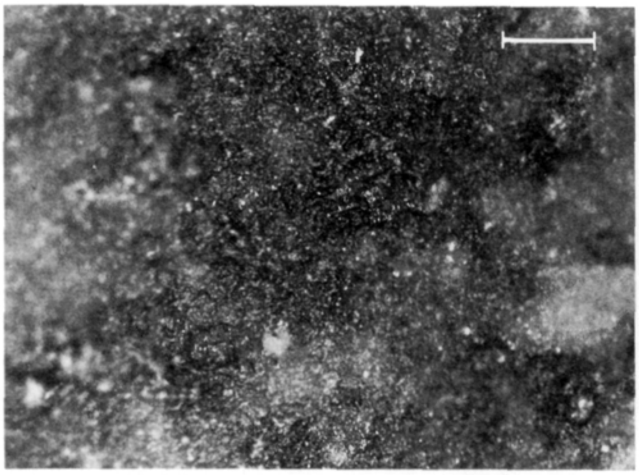
Patination must be one of the most confusing 'dustbin' concepts in lithic studies. In high-power use-wear analysis the term is sometimes used for any modification which hampers a possible functional interpretation. In this section an overview will be given of the various phenomena, and the experiments or other investigations which have been done to shed light on their origin, including the research which was done in this field by the author.

4.2.2 Chemical alterations

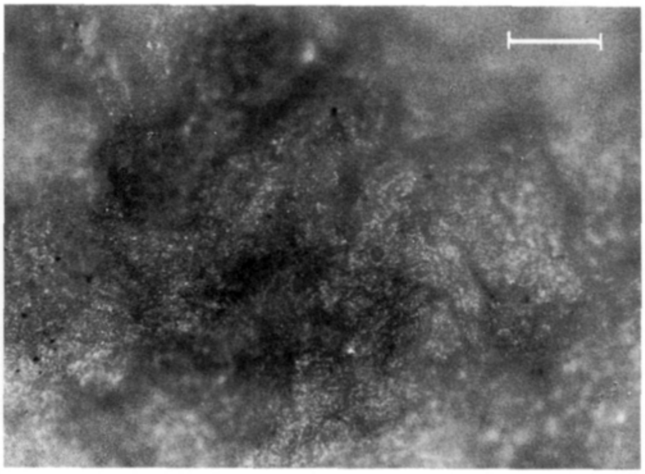
4.2.2.1 White or bluish patina

White patina has been described by a number of people (a.o. Schmalz 1960; Stapert 1976). The term refers to a thin layer of whitish colouration covering (part of) the tool. Schmalz (1960) describes the surface of white patinated flint as being 'sugary', highly porous, and reflecting light to all directions. As to its origin, most authors agree that alkaline environments induce white patina; Rottländer (1975a) mentions a pH of 10.0 or higher. Both Schmalz (1960) and Plisson (1985a) have experimented with various alkaline solutions and were able to reproduce white or bluish patina in a relatively short time. Characteristic for patinated flint is a slight weight loss. This is often attributed to a dehydration of water present in the pores between the quartz crystals, but it appears that the latter also dissolve themselves (Schmalz 1960).

A film of patination with a 'sugary' surface has also been observed on many of the flints from the Middle Palaeolithic site of Belvédère, the Netherlands (Van Gijn 1989). One



a



b

Fig. 34 Surface of a tool from Belvédère site K: a) immediately upon excavation (200x), b) the same tool after a few minutes of exposure to light and air (200x).

phenomenon, observed at site K, must be mentioned here. From site K a large number of flakes was retrieved, all displaying a dark-grey colour similar to fresh Rijckholt flint. However, after some time (varying between two days and a few months) the implements attained the creamy, light-yellow colour (white patina) characteristic for much of the previously excavated Belvédère material. A microscope was set up adjacent to the excavation trench to enable the examination of the 'fresh' flints as soon as they were recovered. For the first two minutes the flint surface of the site K implements indeed looked in mint condition under the microscope, with no sign of the 'sugary' surface (*fig. 34a*); however, the dissolution of the surface occurred after a short while (2-3 minutes), but this could not be observed with the naked eye, as the creamy colour did not appear till later. Apparently, even though the flint seemed to be fresh, the soil-matrix evidently had already altered the structure of the stone in such a way that exposure to light, or desiccation, caused a catalyzation leading to the dissolution of the surface (fig. 34b). This suggests that water plays a crucial role, something which has been argued before (Andersen/ Whitlow 1983). The process of dissolution is not reversible, but can be stopped by immediately putting the implements in water and storing them in a dark place (Van Gijn 1989: 127). The fact that the process is irreversible would indicate that it is not free water present in the pores that disappears, but water-groups bound into the chemical structure of the flint. Rottländer stresses that

'light gives the energy to split off water even from a chemical bondage' (Rottländer 1975b: 56).

Hopefully, it will be possible to extend the research into the patination process on the Belvédère material during future excavations.

White patina also seems to develop on flint which is exposed to the sun for extended periods of time, especially in hot climates with large daily temperature amplitudes. During a survey of flint knapping sites on Long Island, Antigua (West-Indies), it was noted that the side of the flint facing upwards frequently displayed white patination, while the opposite aspect was still fresh (Verpoorte/ Van Gijn *in prep.*). It seems unlikely that an alkaline matrix would have been responsible for the patination process, because the stone-surface lying in the soil was still fresh. Texier (1981) notes that at Khor a Qatar (Tunesia) all small debitage has disappeared from the surface of the site, while larger artefacts have been heavily patinated; under the surface of the ground the implements are however still fresh. He attributes this to the alternating phases of desiccation during the hot days and the formation of dew on the pieces in the early mornings. The dew could initiate the dissolution of the quartz crystals under certain conditions (Texier 1981: 167), eventually leading to the total disintegration of the smaller artefacts.

To conclude, it would appear that white patination can occur under different circumstances. First of all, it develops in alkaline environments, secondly, it seems that desiccation and exposure to the elements (a combined effect of sun, dew and temperature differences) can play a role.

4.2.2.2 Colour patina

Colour patinas are generally explained as being a deposit of various minerals present in the groundwater. Already patinated surfaces are more prone to this, due to their increased porosity (Schmalz 1960: 49). An alternative hypothesis is provided by Rottländer (1975a: 109), who suggests that it can also be the result of iron, already present in the flint, oxydizing at the surface. Yet another suggestion is that peat can cause a black or yellowish-brown colour patina. Although most artefacts with colour patina display a waxy texture, some remain dull despite the change in colour. It is perhaps this last phenomenon which is referred to as 'staining' in the archaeological literature (Frame 1986: 354; Dumont 1988: 34).

4.2.2.3 Gloss patina and other sheens

Rottländer has done extensive research into the somewhat elusive phenomenon of gloss patina. It concerns a more or less uniform sheen over the surface of the flint; some variability may be present on one and the same artefact. When examined with a scanning-electron microscope the surface appears smoothed (Rottländer 1975b: fig. 6). Rottländer argues that under the influence of plant juices, the protrusions of the flint are dissolved into a silicious gel, which then flows to the lower-lying parts of the surface, resulting in a smoothed, polished surface. The formation of gloss patina occurs especially in acidic environments such as peat layers, with pH 4 or less (Rottländer 1975a, 1975b). Because gloss patina does not develop uniformly over the tool, depending as it does on very localized groundwater circulation, the phenomenon can be quite confusing for the use-wear analyst. For example, one transverse arrow head from the Bronze Age site of Oldeboorn (Friesland) was initially interpreted as displaying meat-, and wood-/soft plant-polish. However, upon analysis with the SEM, the surface turned out to be smoothed and polished, and quite unlike the original flint surface (*fig. 35*) (Van Gijn 1983: 65).

In reports on high-power use-wear analysis one frequently encounters the term 'soil-sheen'. Unfortunately, this term has rarely been defined. I would suppose that at least part of the observed post-depositional surface modifications subsumed under the category 'soil-sheen' actually concerns instances of gloss patina. Stapert (1976: 14) discusses yet another, possibly related, natural modification, i.e. the rounding of ridges and edges. He considers this rounding to be due to solution, caused by the tools having lain in the soil for a long period. According to Stapert it is seldom seen on Mesolithic or younger flints. However, high-power analyses indicate that at least some solution of edges and ridges also occurs on assemblages from more recent times than the Palaeolithic.

A last observation pertaining to 'miscellaneous sheens', whether they be referred to as soil sheen, solution phenomena or weakly developed gloss patina, concerns the flint assemblage from Belvédère site J, which is currently under study. This assemblage, dated to the Weichselian, displays virtually no white patination nor rounding of edges or ridges. Invariably, however, one side of the artefacts exhibits a sheen which is visible with the naked eye. Presumably, the shiny aspect is the one which has been facing upwards and has been exposed for an extended period of time. The

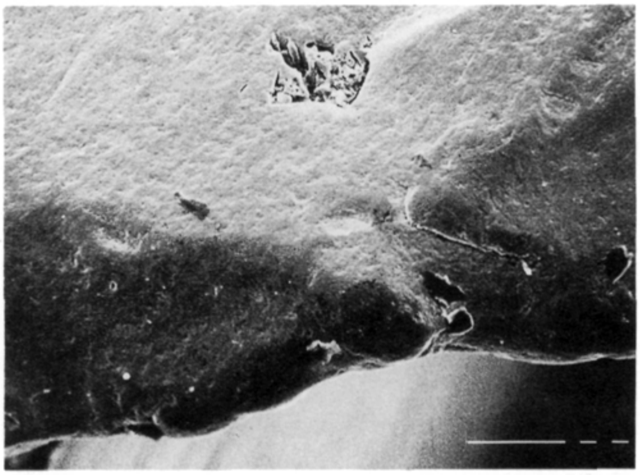


Fig. 35 SEM photograph of an artefact with gloss patina from Oldeboorn, the Netherlands (160x).

influence of light alone does not seem to have been responsible, as this is reported to cause a 'dull gray patination' (Rottländer 1975b: 56). No scratches were visible microscopically, suggesting that abrasion was not the causative factor. However, it is suggested that the sheen is due to the polishing by extremely fine loess-particles being blown by the wind; the very fine grain-size of these particles could have caused a uniform sheen, instead of abrasion scratches. This example shows again how complicated the question of 'soil sheen' is.

4.2.2.4 Friction gloss

Frequently during use-wear analysis so-called 'bright spots' have been observed on artefacts. Their origin is not clear at present. It is possible that friction gloss is a solution phenomenon. It has also been suggested that it is caused by the banging of artefacts against each other (Shepherd 1972), or by hafting (Moss 1987b) (see also *chapter 6, note 2*). Stapert (1976: 30) reports one instance of a patch of friction gloss being interpretable as evidence for hafting. In high-power use-wear analysis these spots are generally not inhibiting a functional interpretation as their distribution is quite localised.

4.2.3 MECHANICAL ALTERATIONS

4.2.3.1 Trampling

Several experiments have been performed to replicate the effect of trampling on the surface of the flint (Tringham et al. 1974; Flenniken/ Haggerty 1979). Generally it is assumed that trampling causes edge-scarring, and the experiments done so far have therefore emphasised this aspect of wear. Tringham et al. (1974: 192) maintain that the edge-damage inflicted by trampling was randomly distributed along the circumference of the artefact and located unifacially only.

This conclusion has been challenged by other investigators. Flenniken and Haggerty report that 37% of 428 trampled unmodified flakes was damaged; some of the scarred flakes (N = 56, i.e. 13% of the total) could even be mistaken for intentionally retouched, 'typological' artefacts (Flenniken/Haggerty 1979: 211). These authors deny that edge-damage from use can be unequivocally differentiated from the unintentional effects of trampling. They state that

> 'the most conclusive result of our experiment was that, as one would expect, no polish occurred on any of the trampled material. We believe that polish is the only definite indicator of aboriginal flake use' (Flenniken/ Haggerty 1979: 213).

I believe that this last remark has to be modified slightly. Various experiments have shown that a kind of 'polish' does occur as a result of trampling. It concerns an undifferentiated 'sheen', which does not obscure (at least in its initial stages) well-developed polishes from contact with bone, silicious plants or dry hide, but does mask vaguer polishes such as those from meat, fresh hide, and initial wood-polish.

It seems therefore that trampling by the inhabitants of an occupation area, or, for that matter, 'settling' of the soil (due to solifluction, soil creep or simply compaction), does indeed modify the surface of the artefacts to a considerable extent. It is not only abrasion which occurs, but also edge-damage and, in extreme conditions such as peri-glacial environments, the development of deep scratches, pressure cones and cryoturbation retouch (Stapert 1976).

4.2.3.2 Post-excavation damage

Damage inflicted on tools during excavation, find-processing, or during further analysis, has been the subject of some discussion (Wylie 1974; Gero 1978; Plisson 1985b). Vigorous sieving on a metal screen produces edge-damage as well as 'metal-polish', i.e. bright, coloured streaks. This latter feature is irremovable, but fortunately very easy to distinguish from use-polish. However, some caution should be exercised with sieving. Certainly it would be advisable to avoid metal contact as much as possible.

The cleaning of implements constitutes another occasion when artefacts may be damaged. Rubbing off adhering sediments from flint artefacts is a normal cleaning procedure, but unfortunately it is very detrimental to polishes, as it inflicts a mechanical 'soil sheen' on the surface. Brushing off the sediments with a toothbrush has the same effect, even under running water. The brushing itself (with a nylon toothbrush), if done on a clean surface, does not seem to affect the surface (Levi Sala 1988). Best is cleaning the artefacts under running water with as little rubbing as possible. Numbering with ink and nail-polish does not cause lasting damage, but such marks can form a nuisance to analysis (hence, have to be removed), if placed for instance along the ventral aspect of a scraper edge.

Chemical cleaning of implements prior to examination by microscope is also known to cause changes, not only to the appearance of polishes, but, in due course, also to the flint itself. Plisson and Mauger (1988) have extensively described the changes resulting from the use of various chemicals, and I will not reiterate their points here. However, it is clear that we should not use NaOH, due to its desiccating effect on the flint. In addition, contrary to what some researchers believe (cf. Plisson 1985a), but in agreement with others (Mansur-Franchomme 1983), it is suggested that caution is also warranted with the use of HCl. If its application is not followed by a thorough rinsing with tap water, and if it is not neutralized with e.g. KOH, its use can cause a bluish sheen on the flints (as happened with some of the Hekelingen III flints), or else a yellow colouration (cf. Van Gijn 1989). As has been mentioned before (see *2.4*), this effect can be avoided by first soaking the implements in water (H.Juel Jensen *pers.comm.*).

Contact between flint artefacts, whether due to their being stored together in large bags, or refitting attempts, causes quite substantial alterations. They include extensive edge-damage, which sometimes removes existing polish, friction-gloss, linear streaks of polish, and slight rounding of the edges and ridges. It is quite understandable that it is impossible to individually bag in plastic every single tiny piece of debitage. However, considering the already enormous amount of time, money and effort put into excavation, it should not be too much to ask to put all retouched implements, blades, and preferably also larger flakes, into separate plastic bags. As far as refitting is concerned, it would be best to leave such attempts until wear-trace analysis has been performed. Stone might seem resilient, it is, in its own way, as fragile as pottery. In addition, the scattering of large bags of flint onto tables causes extensive edge-damage, friction-gloss etc. It would therefore be advisable to perform a wear-trace analysis prior to an assemblage's 'degradation' to study-collection. A final stage during which flint implements can sustain damage, is during the microscopic analysis itself. Various authors have noted that repeated handling produces a 'meat-polish' (Plisson 1985a: 100; Unrath et al. 1986).

4.2.4 Discussion

From the preceding paragraphs it can be concluded that the number of factors which can be harmful to a piece of flint is substantial. As far as post-depositional surface modifications, such as patination and abrasion, are concerned, the situation is rather confusing at present. As Keeley (1980: 29) already noted, microwear analysts have the tendency to subsume under 'patination' a wide variety of phenomena, the causes of which are still very poorly understood.

4.3 Inventory of occurrences of pdsm in archaeological assemblages

Use-wear analysts have done a considerable number of experiments to replicate various post-depositional surface modifications (Plisson 1985a; Levi Sala 1986, 1988; Plisson/ Mauger 1988), and non-archaeologists such as Rottländer (1975a, 1975b) have tried to shed light on their origins. However, it seems we are still far from being able to predict when assemblages are suitable for microwear analysis.

It was therefore decided that it might be useful to look back upon the results so far obtained by various microwear analyses. It was hoped that, by doing so, regularities might appear which could direct further research into the origins of post-depositional surface modifications. This survey concentrates on research done on West European flint material, as it proved very difficult to acquire an overview of the more obscure references from the United States or Japan. Consequently, the more accessible publications reporting on 'remote areas', such as Koobi Fora (Keeley/ Toth 1981) or Patagonia (Mansur-Franchomme 1984), have also been excluded. Still, I am sure I will have overlooked several references pertaining to the study area.

Factors which are generally considered to be important for the question of natural alterations include the date of the assemblage and the matrix and/or geological condition in which the material was deposited. As most authors have not specified the exact character of the post-depositional surface modifications they observed, table 3 only lists whether or not mention was made of such phenomena (+ or -). In principle, the column 'number of pieces studied' (no st) only includes the implements which were actually examined microscopically. This means that it represents a sample of the total assemblage (the exact number of artefacts, from which the sample was drawn, was often not provided), which was usually selected according to the criterion of freshness. Thus, the percentage of pieces with alterations concerns the implements which, although they looked fresh with the naked eye, appeared to be modified after examination with the microscope. The actual percentage of pieces affected might therefore have been much higher than listed under the column % pdsm in table 3. However, in some cases (i.e. all sites reported in Beyries 1987, and those indicated by *), the numbers studied were unclear and the amounts listed concern the total assemblages. It should be stressed that, due to inconsistencies in the various texts, or to confusion on my part about the numbers provided, some quantities can be misrepresented.

From table 3 it can be observed that the age of the artefacts, and hence the amount of time they have been in their matrix, to some extent does have influence on the quality of the material. Lower and Middle Palaeolithic assemblages invariably seem to display surface modifications of some sort; white patina (by whatever influence it is caused) is most frequently reported. For later periods the situation varies considerably. Magdalenian assemblages are usually in good condition for microwear analysis, with the exception of Etiolles[1]; Plisson (1985a) mentions some sheen on implements from Pincevent, habitation 1, as well. The single category of artefacts which consistently displays only few alterations concerns LBK assemblages. At Darion, Couture de la Chaussée (Blicquy), Liège Place Saint-Lambert, Beek-Molensteeg, Elsloo, Langweiler 8, and Laurenzberg 7, implements are reported to be generally in excellent condition. In contrast, many Middle and Late Neolithic assemblages display quite heavy sheen, while Bronze Age flint from Oldeboorn shows gloss patina. It seems therefore that, apart from the very old assemblages which invariably are somewhat altered, age is not a determining factor anymore from Upper Palaeolithic times onwards.

The substance of the matrix does not appear to be a causal factor, with the possible exception of sand. All assemblages from a sandy matrix are reported to display at least some modifications; Upper Palaeolithic sites in Denmark and Mesolithic sites in the Netherlands, which are in both cases usually located on sand ridges, have consistently been rejected for microwear analysis (H.Juel Jensen *pers. comm.*; observations of the author).

One factor which was believed to be of influence, the pH of the matrix (cf. Rottländer 1975a, 1975b), is so seldom accounted for as to be rather useless for this inventory. Table 4 presents the few instances this feature has been mentioned. The values show neutral or slightly alkaline conditions to have prevailed, but from all five sites patination has been reported. Rottländer suggests an alkalinity of pH $\geqslant$ 10 for white patina to develop and an acidity of pH = 3.5-4.0 for gloss patina formation. The fact that none of the sites fulfills either of these conditions and nevertheless all of them produced assemblages with surface modifications, suggests that other factors played a more important role.

4.4 Conclusion

The picture which emerges from the preceding paragraphs is a pretty negative one: it seems that extremely few assemblages are so well-preserved for microwear analysis to offer representative results. The number of factors which can alter the surface of flints is considerable indeed. Although the Magdalenian assemblages from the Paris Basin are generally in relatively good condition, they do display modifications to some extent, despite the fact that they were quickly covered by sedimentary deposits. The only assemblages which are consistently reported to be in mint condition, are the ones from the loess, dating from the Bandkeramik period. These implements for the most part derive from pits, i.e. dumps. The above-described categories of assemblages represent the two circumstances in which microwear analysis yields the most satisfactory results: 1) material from dumps

Table 3 Assemblages studied (using the high-power method) for the presence of traces of use, indicating percentages of post-depositional surface modifications.

site	date	pdsm	no st	%pdsm	wear-traces	matrix	geol.sit.	publication
Clacton-Golf course	Clact.	+	312	20	butchering	marl, gravel	riverine	Keeley 1980
Swanscombe	Clact.	+	267	75	most used	loam	riverine	Keeley 1980
Hoxne	Acheul.	+	408	29	wood, hide	silt	riverine	Keeley 1980
Arcy-sur-Cure/Renne	Mid.Pal.	+	227	79	wood	variable	cave	Beyries 1987
Corbehem	Mid.Pal.	+	1767	96	wood	loess	open air	Beyries 1987
Grotte Vaufrey VIII	Mid.Pal.	+	?	?	wood	sand, gravel	cave	Beyries 1987
Combe-Grenal III	Mid.Pal.	+	558	79	wood	?	cave	Beyries 1987
Pie-Lombard	Mid.Pal.	+	316	96	no traces	clay	cave	Beyries 1987
Marillac X	Mid.Pal.	+	626	87	wood	clay, chalk	cave	Beyries 1987
Pech de l'Azé 1	Mid.Pal.	+	47	?	wood	sand	abri	Anderson-Gerfaud 1981
Pech de l'Azé 4	Mid.Pal.	+	113	?	wood	sand	abri	Anderson-Gerfaud 1981
Corbiac	Mid.Pal.	+	62	?	wood	sand	open air	Anderson-Gerfaud 1981
Biache St.Vaast	Mid.Pal.	–	?	?	wood	fine fluv.	riverine	Beyries 1988
Belvédère IV	Mid.Pal.	+	55	87	butchering	fine fluv.	riverine	Van Gijn 1989
Paglicci Cave	Mid.Pal.	?	296	?	meat	variable	cave	Donahue 1985
La Cotte	Mid.Pal.	+	367	42	hide, wood	loessic	cave	Frame 1986
Mesvin IV	Mid.Pal.	+	27	?	diverse	coarse river	riverine	Gysels/ Cahen 1982
Verberie	Magdal.	–	192	–	meat, hide	sandy loam	open air	Symens 1986
Verberie	Magdal.	–	43	–	diverse	sandy loam	open air	Audouze et al. 1981
Pincevent 1	Magdal.	+	218	–	diverse	silt	open air	Plisson 1985a
Pincevent 36	Magdal.	–	121	–	diverse	silt	open air	Moss 1983a
Cassegros 10	Magdal.	+	532	18	dry hide	?	cave	Vaughan 1985a
Andernach 2	Magdal.	?	262	?	diverse	loess	open air	Vaughan 1985b
Andernach	Magdal.	–	191	–	meat, hide	loess	open air	Plisson 1985a
Zigeunerfels	Magdal.	–	410	–	animal subst.	?	cave	Vaughan 1985b
La Tourasse	Azilian	+	95	18	diverse	?	abri	Plisson 1982
Pont d'Ambon	Azilian	+	475*	?	diverse	silt, grav,	abri	Moss 1983a
Oldeholtwolde	Hamburg	–	218	–	diverse	sand	open air	Moss 1988
Meer	Tjonger	+	257	25	diverse	sand	open air	Cahen et al. 1979; Keeley 1978
Star Carr	E.Mesol.	+	156*	–	diverse	clay, peat	open air	Dumont 1988
Mt.Sandel	E.Mesol.	+	273*	–	diverse	?	?	Dumont 1988
Vaenget Nord	Konge-mose	+	846	26	diverse	clay	open air	Juel Jensen/ Brinch Petersen 1985
Ageröd V	Konge-mose	+	90	16	diverse	sand	open air	Juel Jensen 1982, 1984
Elsloo	LBK	+	104	14	diverse	loess	open air	Schreurs 1989
Beek-Molensteeg	LBK	+	349	17	diverse	loess	open air	Van Gijn, this volume
Langweiler 8/ Laurenzberg 7	LBK	–	378	–	diverse	loess	open air	Vaughan 1985b
Darion	LBK	–	1992	0.8	diverse	loess	open air	Caspar 1988
Liège Pl.St.Lambert	LBK	–	143	–	diverse	loess	open air	Caspar/ Gysels 1984
Couture d.l.Chaussée	Blicquy	–	215	–	diverse	loess	open air	Cahen/ Gysels 1983
Ringkloster	Ertebølle	–	63	–	hide, wood	peat	open air	Juel Jensen 1982
Ertebølle	Ertebølle	–	100	–	diverse	sand	open air	Juel Jensen 1982
Swifterbant S51	5300 BP	–	223	–	diverse	clay	riverine	Bienenfeld 1986
Swifterbant S4	5300 BP	+	80	7	diverse	clay	riverine	Bienenfeld 1986
Swifterbant S2	5300 BP	?	127	?	diverse	clay	riverine	Bienenfeld 1986
Hazendonk 1	5300 BP	+	17	29	diverse	sand	sanddune	Bienenfeld 1986
Hazendonk 2	5100 BP	+	14	21	diverse	sand	sanddune	Bienenfeld 1986
Hazendonk 3	4900 BP	+	106	12	diverse	sand	sanddune	Bienenfeld 1986
Siggeneben Süd	5000 BP	+	47	32	diverse	sand, gravel	open air	Schulte im Walde/ Strzoda 1985
Gassel	4900 BP	+	95	18	diverse	sand	open air	Bienenfeld 1986, 1988
Hazendonk-VL.1a	4700 BP	–	4	–	diverse	sand	sanddune	Bienenfeld 1986
Hazendonk-VL.1b	4400 BP	+	41	–	diverse	sand	sanddune	Bienenfeld 1986
Hekelingen III	4300 BP	+	337	37	diverse	silt	riverine	Van Gijn, this volume
Leidschendam 4	4300 BP	+	73	56	diverse	sand	open air	Van Gijn, this volume
Sarup	4300 BP	+	161	13	wood, hide	sand	open air	Jeppesen 1984
Oldeboorn	3700 BP	+	101	18	diverse	sand, peat	open air	Van Gijn 1983

Table 4 pH values reported for various sites.

Site	pH	publication
Arjoune (Syria)	7.0	Unger Hamilton 1988
Pincevent habit.1 (France)	8.35-8.60	Plisson 1985a
Belvédère site G (Holland)	8.6	Van Gijn 1989
Belvédère site C (Holland)	6.0-6.5	Van Gijn 1989
Hekelingen III (Holland)	5.9-7.4	Van Gijn, this volume

and 2) assemblages deposited in a place rarely frequented by people (i.e. no trampling) and very quickly (in a matter of years) covered by sediments. The latter instance, a rare occurrence, also provides a very good chance of finding activity areas. However, it seems that such a situation, in which a place is soon deserted, not to be visited again, exemplifies only a very small segment of the human activity spectrum: it excludes permanent settlements, base-camps, and even stations occupied every year to exploit a specific resource. Moreover, the assemblages from the Paris Basin are not consistently in fresh condition, indicating that other factors are of influence as well.

Dumps, where microwear traces stand the best chance of preservation, are unfortunately not ideal in terms of the reconstruction of past behaviour. It concerns secondary deposits which may or may not bear a relationship to activities carried out nearby. A large sample from the pits at the LBK site of Darion was subjected to microwear analysis, but no evidence of differentiation between the content of these pits was found (Caspar 1988); the same pertained to Elsloo (Schreurs 1989). This may mean that 'everyone was living the same life', and one can be tempted to draw far-reaching conclusions about the egalitarian nature of these settlements. However, this is an interpretation we must be cautious with because of the very fact that we can be dealing with predominantly secondary deposits.

The supposition that a microwear analysis can produce representative results only in the two situations described above, does not mean that wear analysis is useless in other instances. Also in those cases wear-traces can be observed, but they will be confined to those which are very distinct and resistant to chemical and/or mechanical attack, i.e. the ones caused by silicious plants, bone, dry hide, and perhaps wood. Although the outcome will not be representative, interesting data can nevertheless be obtained (cf. *6.2*). For those assemblages which we are inclined to reject for microwear analysis, I would argue that it is necessary to broaden our methodology and include explicitly low-power techniques in our approach. Obviously, this is only possible when we can be relatively certain that no or little post-depositional edge-damage has taken place. It is unwise to continue to reject important assemblages because of post-depositional surface modifications. Instead, there should be change in our tactics, emphazising different aspects of wear according to the possibilities inherent in each assemblage. By using the low-power approach in those cases in which polishes and striations have disappeared or become invisible, the possibilities of use-wear analysis can be extended. Clearly, the level of inference will be somewhat lower for assemblages only studied by stereo-microscopy (but cf. Shea 1988), and confined to statements about relative hardness of contact-materials, but such information is still valuable. If we do not adapt our techniques to the preservation-state of the assemblage to be studied, we might even run out of suitable assemblages and/or interesting archaeological problems to solve.

note

1 Etoiles is not included in this table, because it was rejected for analysis (Plisson 1985a).

5 The Linearbandkeramik site of Beek-Molensteeg

5.1 Introduction

The Dutch Linearbandkeramik (LBK) sites are situated in the loess-belt which extends from the Rhine in the east to the southwestern part of Belgium in the west (Bakels 1987: fig. 2). The settlements in this area represent the most northwestern extension of the LBK culture. The Dutch LBK sites, and also the ones of the nearby Aldenhovener Platte in West-Germany, were first inhabited around 5400 BC, and the occupation lasted until about 4900 BC (calibrated ^{14}C). Almost all the LBK settlements are located on loess-covered plateaus, in the vicinity of a stream and surrounded by woodland. Usually, several sites are grouped together into clusters (Bakels 1982). One such cluster is that of the Graetheide, of which Beek-Molensteeg forms a part (*fig. 36*). Nearby lie the Heeswater cluster, across the Meuse in southwestern direction, and the Merzbach cluster, c. 30 km to the southeast (Lüning 1982). As of now 27 sites have been located within the Graetheide cluster, although at times it is difficult to separate one site from the next: along some of the streams one continuous row of settlement remains is present.

From the extensive excavations at Sittard (Modderman 1958-1959), Stein (Modderman 1970), Elsloo (Modderman 1970) and Geleen (Waterbolk 1958-1959), we know a great deal about the Dutch LBK in terms of settlement organization (Bakels 1982), house form (Modderman 1970), economy (Bakels 1978) and pottery typology (Modderman 1985). De Grooth is presently carrying out an extensive analysis of the flint technology (De Grooth 1986, 1987a, 1987b), while Van de Velde's stimulating research of the Elsloo cemetery has provided insight into LBK social organization (Van de Velde 1979). Much is also known from neighbouring areas, as exemplified by the Aldenhovener Platte project (a.o. Lüning 1982), the Aisne Valley project (a.o. Ilett et al. 1982) and the work in Hesbaye (a.o. Cahen 1984). Generally speaking, what appears is an amazing uniformity in many aspects across these various regions, although specialists stress that regional differences do exist.

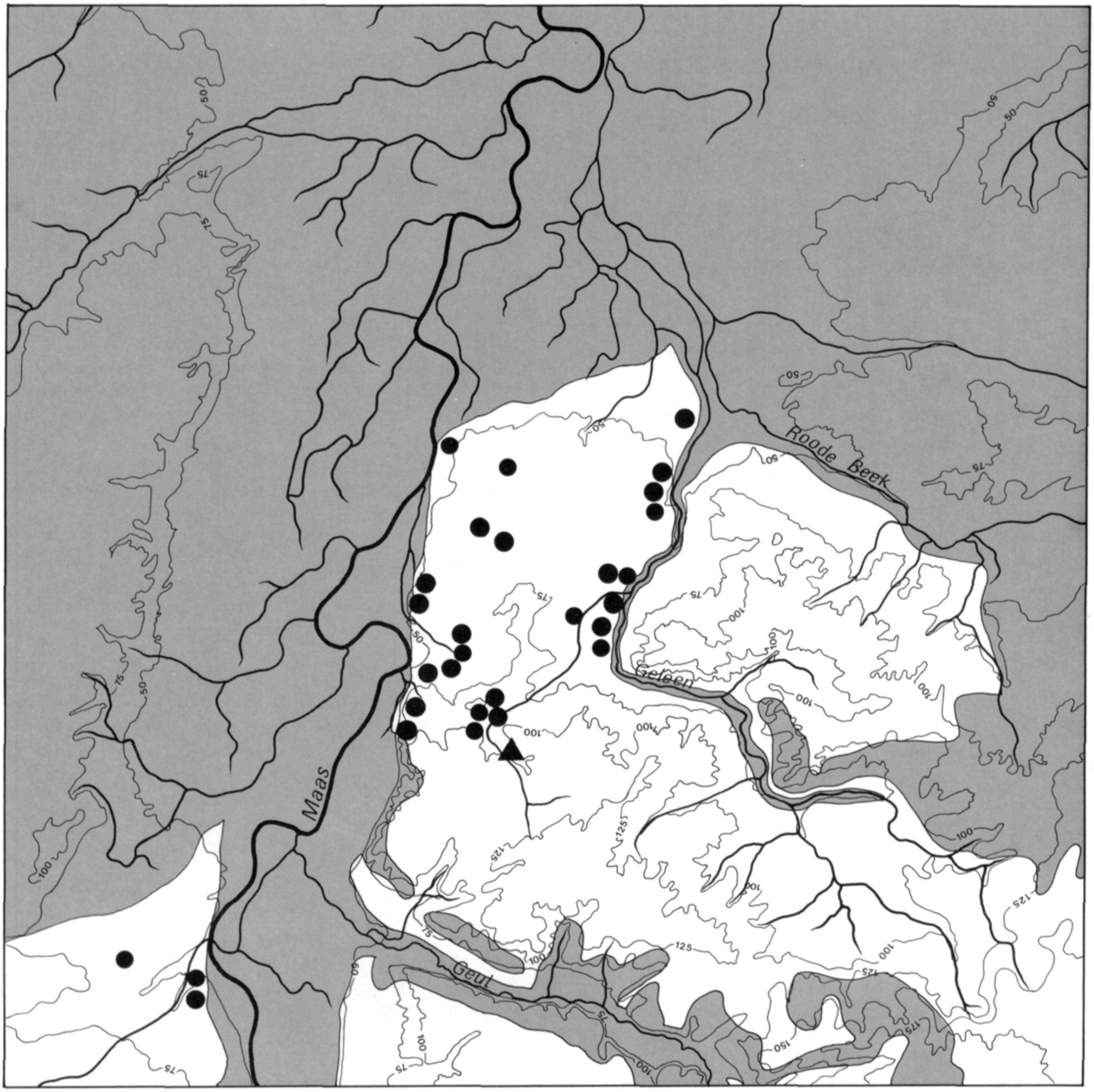
5.1.1 Site location and excavation history

The site of Beek-Molensteeg is situated on a gently-sloping small plateau on the highest terrace of the Meuse river (*fig. 37*). To the west, there is a steep, densely wooded drop towards the valley of the Keutelbeek, while in eastern direction the area is defined by a slight elevation, east of which no finds have been collected (*fig. 38*). To the north, the presence of an orchard makes it impossible to do fieldwalking. For many years, amateurs have been very actively collecting in the area, most of their material being attributable to the LBK culture. The largest collections are those of Mr. J.Aussems and Ir. H.van Veen. Both have recorded the approximate location of their finds, and it is clear that the area yielding finds extends all the way from the steep drop towards the Keutelbeek to the slight incline in the east. Artefacts, albeit only a few, have also been reported just south of the Molenpad. Figure 38 shows the inferred size of the settlement, with the highest density of finds located within the circled area (P. Mennens *pers.comm.*). The total area which delivered material during fieldwalking is roughly 8 hectares; the size of the LBK settlement itself might have been smaller however.

The reason for starting an excavation was the fact that the farmer using the terrain had been digging trenches for grass storage, and required more of them. From one of these trenches a group of finds was retrieved which suggested the presence of a pit, such as is often located adjacent to LBK houses. By excavating part of the terrain, it would be possible to simultaneously provide the farmer with a safe area to dig his trenches, whilst verifying the assumption that it concerned a LBK site.

A rescue excavation took place from May 24th — June 8th 1979, under the direction of the IPL, H. Groenendijk having the daily supervision. Members of the Heemkunde Vereniging Beek took part in the project. A total of 450 m² was excavated, which represented only c. 0.5% of the approximated extent of the settlement (but see above). The examined area was located at the fringe of the settlement, close to the drop towards the Keutelbeek, but within the area which had yielded most artefacts during fieldwalking (*fig. 38*).

The top-soil was removed by backhoe, after which the surface was further cleaned and deepened by shovel. The location of the finds was measured two-dimensionally, or, during the deepening of a further 10-15 cm, collected in 2 x 2 m squares. The first level (*fig. 39a*) provided a great deal of finds, but no recognizable features. Groenendijk attri-



löss ● linearbandkeramik sites ▲ Beek-Molensteeg

Fig. 36 The loess plateau in southern Limburg with the LBK-sites of the Graetheide-cluster. Beek-Molensteeg is indicated by a triangle (after Bakels 1978: fig. 2).

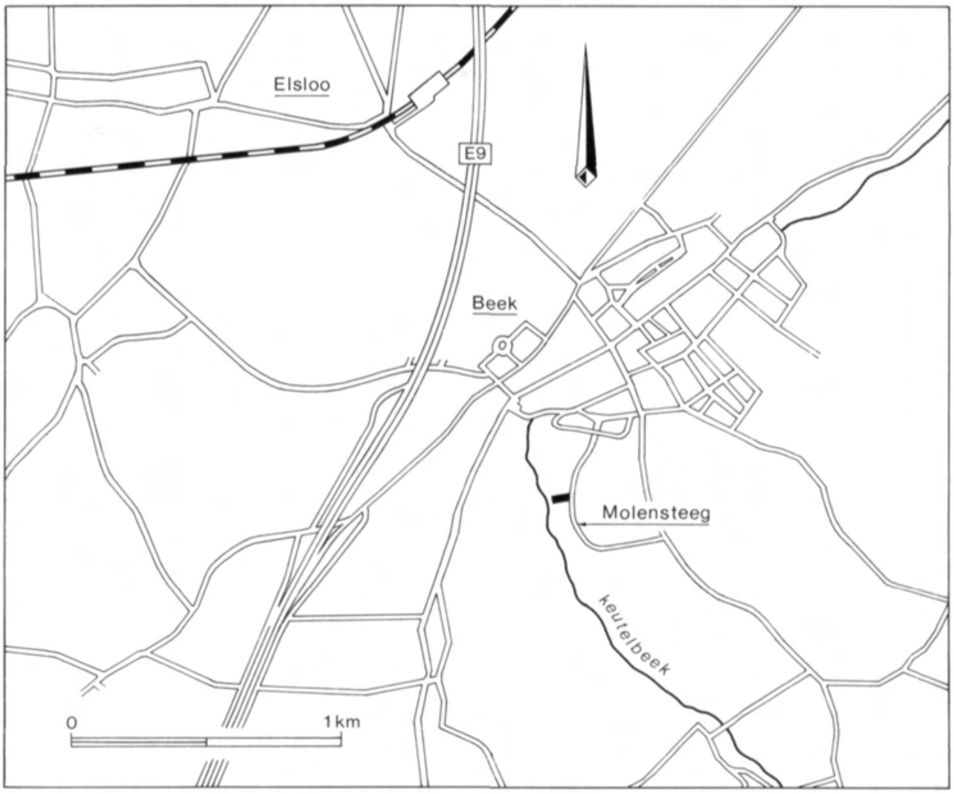


Fig. 37 Location of the site Beek-Molensteeg.

Fig. 38 Aerial photograph of the area of Beek-Molensteeg. Indicated are the excavated trench, and the probable boundary of the site as indicated by surface finds. The heavy line indicates the highest concentration of finds.

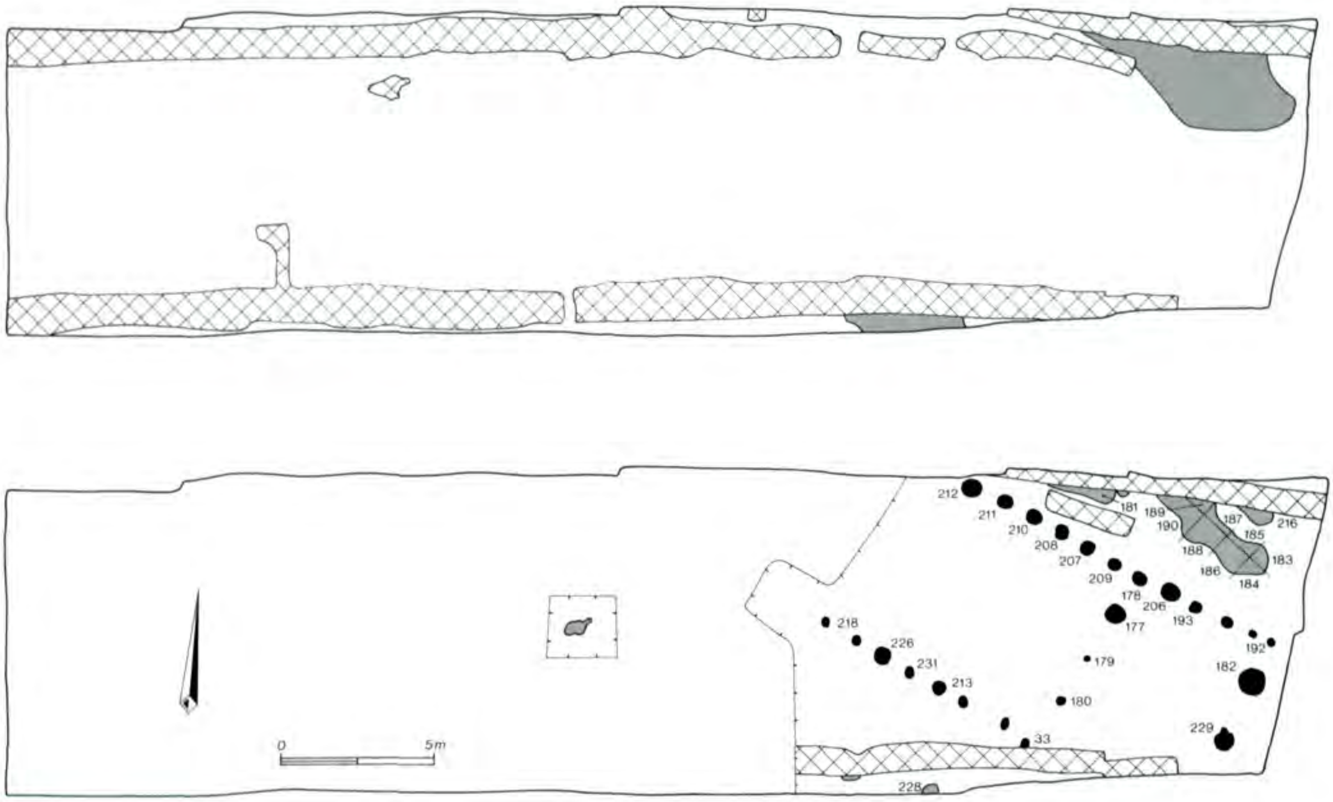


Fig. 39 Beek-Molensteeg: excavation plan. a) first level, b) second level.

butes this to the extensive homogenization which takes places in the loess, especially under orchards (Groenendijk 1980, 1989). Many artefacts relating to the original living surfaces must have been 'worked' downwards. However, it should be mentioned that, apart from the area close to the drop towards the Keutelbeek, very little erosion has taken place (Groenendijk 1980, 1989). Excavation of the second level (*fig. 39b*) produced one rubbish pit and a series of postholes indicating a house plan; finds were more confined to the features in this level. The house is oriented northwest-southeast. It seems most likely that the fragment of the house excavated, concerns the middle part. This section is often considered as the living area of the extended family and the focus of domestic life (Coudart 1987). Its width measures 6.40 m, slightly above the general mean of 5.50 — 6.00 m for the LBK houses. This suggests that the structure might have been a 'Grossbau' (Groenendijk 1980).

Apart from a great number of flints, finds included pottery, ten fragments of grinding stones, two adzes (Bakels 1987), some whetstone-fragments and two fragments of haematite. Botanical samples were taken from various levels and quadrants within the rubbish pit (Bakels/ Rousselle 1985: fig. 2). Analysis indicated the presence of emmer wheat (*Triticum dicoccum*) and possibly einkorn (*Triticum monococcum*). Remains of other cultivated plants, such as barley, flax or peas, were absent (Bakels/ Rousselle 1985: 43). The pottery, found in considerable quantity, provides the only means to date the site, as no ^{14}C dates are available. It is apparent that the decorated pottery is consistent, for the most part, with Modderman's phase IId (Modderman 1970: 199; Groenendijk 1989: fig. 4), i.e. the last phase of the Dutch Linearbandkeramik (c. 4200-4050 bc, conventional ^{14}C dates). The pit situated to the north of the house mainly yielded phase IId pottery, elsewhere a few sherds attributable to phase IIc were present. If we examine the material collected by the amateur archaeologists or that in the Heemkunde Museum of Beek, the same picture emerges: decorative motives on these sherds are all attributable to phase IId and, to a lesser extent, to phase IIc. Groenendijk suggests that this small plateau, situated at the periphery of the Graetheide cluster, was only occupied towards the end of the LBK period. The location of the site in relation to water-supply is not very suitable due to the steep drop towards the Keutelbeek (Groenendijk 1989).

It should be mentioned that there is some evidence for human occupation during periods other than the Linearbandkeramik. Among the amateur collections some small cores and scrapers, all produced from a very translucent, greasy-looking, light-yellow coloured flint, suggest an earlier use of the site during the Mesolithic. There are also some tools which are possibly attributable to the Michelsberg culture, but it is not entirely clear whether they derive from exactly the same location. A Middle or Late Neolithic polished axe was recovered during the excavation, and two similar but broken specimens were found during fieldwalking, together with some undiagnostic polished axe-fragments. Finally, sherds dating from the Middle or Late Iron Age have been found.

5.1.2 Objectives

There were several reasons for selecting the Beek-Molensteeg flint assemblage for use-wear analysis. Among its attractions were its manageable size, the fact that the exact provenance of the artefacts was known, and the good preservation of the material. Initially, it was assumed to be a short-lived, relatively homogeneous site. Beek-Molensteeg is the only Dutch LBK settlement situated on the highest terrace of the Meuse. This feature, and the fact that it was supposed to be a small site, led to the postulation that it might have had a special function in the regional settlement pattern. This would be interesting to examine from a lithic point of view. However, it is now clear that the site is much larger than expected, nor should we attribute much significance to its location on the highest Meuse terrace, as its general setting is very much like that of other LBK settlements (Bakels 1978, 1982). In addition, Beek-Molensteeg was the second site (after Beek-Kerkeveld, see De Grooth 1987a) where large amounts of Valkenburg flint had been recovered. De Grooth's research on the technological features of both Rijckholt and Valkenburg flint showed that the reduction sequence was the same for both types of raw material. It was decided to examine whether the two varieties of flint were also used in similar ways. No use-wear analysis had been done on Dutch LBK flint, although several Belgian assemblages have been, or are being examined, such as Liège Place Saint-Lambert and Darion (Cahen et al. 1986; Caspar 1988). Vaughan examined a small number of tools from Langweiler 8 and Laurenzberg 7 on the Aldenhovener Platte, West-Germany (Vaughan 1985b). Although the Beek-Molensteeg assemblage is admittedly small and forms part of a much larger settlement (and thus might not be fully representative), it should provide the opportunity to see whether the range of activities inferred was comparable with those of Darion and Langweiler 8. This might demonstrate whether the same uniformity prevailed, not only in the flint reduction sequences, but also in the pattern of flint use.

5.1.3 Methods and sampling procedure

It was agreed with Groenendijk that I would not only carry out a use-wear analysis of a sample of the flint assemblage, but would also examine it for technological features and make an inventory of the various tool types present. This chapter can therefore be considered a final publication of the flint assemblage of Beek-Molensteeg, an abbreviated version of which will appear in the site report (Groenendijk/Van Gijn *in prep.*). Taking this more general approach had implications for the registration system, making it different from the one previously used for the examination of the Vlaardingen assemblages (see *chapter 6*). In the 'site-file' a number of variables, pertaining to technological aspects of LBK flint-working, were added. They were derived from De Grooth (M.de Grooth *pers.comm.*). The total assemblage included 1704 flint artefacts, 362 of which exhibited one or more features which could relate to use, such as intentional retouch (i.e. retouch $\geqslant$ 1 mm), retouch $<$ 1 mm, polish visible with the naked eye, or an edge with a straight cross-section $\geqslant$ 2 cm. These 362 artefacts were selected for use-wear analysis and yielded a total of 619 PUAs (Potentially Used Areas).

As the present study attempts to deal with the Beek-Molensteeg assemblage in an integral fashion, it was decided also to examine the material collected by the amateurs prior to, and after the excavation. An additional advantage of including this material is that it offered the possibility of assessing the representativity of the excavated material in terms of dating (see *5.1.1*). The largest collection is the one of Ir. H. Van Veen, while Mr. J. Aussems also owns a considerable number of artefacts. Lastly, the Heemkunde Museum in Beek has some pieces in its possession. It is very likely that many other local amateurs have retrieved material from the site, but it was decided that an exhaustive search would require too much time and effort in relation to the amount of information these small collections would offer. The three collections mentioned above were all examined for percentages of raw material present (especially concerning Valkenburg flint), and for the range of tool types. In addition, attention was paid to possibly intrusive elements, such as Mesolithic and Middle or Late Neolithic flints.

5.2 The flint technology

5.2.1 Introduction

Interest in the reduction sequences which lead to the final products is a relatively recent development. Until about 20 years ago the morphology and style of a flint artefact were the main concern. Crabtree, an amateur archaeologist living near rich flint sources in Idaho (USA), was one of the first to draw attention to the importance of technological features visible on prehistoric flint artefacts, and what these could tell us about human decision-making. Crabtree was an extremely gifted flint-knapper (Crabtree 1972, 1974), and his work has inspired many others to start experimental flint knapping (Plew et al. 1985). Later, this led to yet another field of expertise: refitting of flint assemblages (Cahen et al. 1979; Cziesla 1986; Roebroeks/ Hennekens *in press*). By reconstructing the original nodules from the multitude of flint artefacts, the various steps in the reduction process become visible. Also, 'missing' artefacts can shed light on questions regarding exploitation and transport of raw material (Roebroeks et al. 1988).

In this study no attempt has been made to either replicate the reduction sequence experimentally, or to refit the assemblage. This was due, above all, to the fact that the Bandkeramik reduction sequence has been studied in great detail both in Dutch Limburg (De Grooth 1987a, 1987b) and in the surrounding areas (Cahen 1984; Löhr et al. 1977). The picture that emerges is one of great homogeneity in the technology practised across the Lower-Rhine area. To duplicate these studies would be pointless.

As a consequence, the analysis of the technological aspects of the Beek-Molensteeg flint assemblage will be limited to a description of the various technological attributes. Following De Grooth (1987a), use will be made of Collins' (1975) heuristic flow diagram to characterize the various steps in the reduction sequence.

Collins differentiates the following five main steps: acquisition of raw material, core-preparation, primary trimming, shaping, and maintenance/ modification (Collins 1975: fig. 1). Each step produces a characteristic product group composed of waste and objects meant for either immediate use or further modification. Obviously, the excavated area is so small that it is dangerous to automatically extrapolate the following observations to the entire site.

5.2.2 The acquisition of raw material

As in all other LBK sites of the Graetheide cluster, Rijckholt flint is the most commonly employed raw material, representing 80.4% of the total number of flint artefacts at Beek-Molensteeg (*table 5*) (in terms of weight Rijckholt flint represents 20.6 kg of the total of 29.0 kg recovered, or 71.0%). Rijckholt flint derives from the ubiquitous Gulpen Formation. It has a medium-fine grain-size and a mottled appearance, with colours varying from light-grey and greyish-blue to blue-black. Characteristically, the flint is dotted with lightly-coloured specks. Coarse-grained varieties exist, which are of a homogeneous light-grey colour. Often coarse-grained patches are present within otherwise medium- or fine-grained nodules.

It is not clear where exactly the flint has been collected. The nearest source are the gravel beds of the Meuse, but, as this flint was heavily battered, it was seldom used (De Grooth 1987a). Probably the Rijckholt flint was gathered in an area south of the river Geul. Nodules could easily have been collected here from the hill-slopes, as they would weather out from the surface. The fact that the cortex is not 'Bergfrisch' would support this hypothesis. As of now no evidence exists for deliberate open-cast extraction sites (Bakels 1978). Deep-mining of flint is not to appear until later. The distance from Beek-Molensteeg to the chalk area of southwest Limburg is approximately 10-15 km, a distance which could easily be covered in a day.

Most Graetheide sites were almost exclusively dependent on Rijckholt flint. The Younger LBK site of Beek-Kerkeveld was the first to yield large quantities of Valkenburg flint (De Grooth 1987a), Beek-Molensteeg was the second. Valkenburg flint originates from the Lower Maastricht Formation, the Valkenburg Chalks (Felder 1975). It can be gathered from various locations near the village of Valkenburg (Felder 1975; Marichal 1983), but also occurs close to Beek (F.Brounen *pers.comm.*). It is generally much coarser-grained than Rijckholt flint, although just underneath the cortex it can be quite fine-grained. It is available in pipe-shaped or platy nodules, which can be gathered from hill-slopes. Its colour is described by Felder (1975) as being grey to greyish-blue, but in the archaeological context (also in Beek-Molensteeg) a light-brown to beige variety predominates. Valkenburg flint represents 10.5% of the number of artefacts (by weight: 6.9 kg of the total of 29.0 kg, i.e. 23.8%). It is noticeable that the mean size of the Valkenburg artefacts greatly exceeds the one of the implements produced from other types of flint.

The third variety of raw material which is represented in the Beek-Molensteeg assemblage is a fine-grained homogeneous flint of a yellowish-grey colour, displaying innumerable tiny white dots. This type of flint is represented by 56 artefacts, or 3.3% of the total. For the most part, the artefacts are small. It probably concerns what is generally referred to as light-grey Belgian flint (Löhr et al. 1977), described as having a homogeneous colour, with shiny fractures. One of the sources of light-grey Belgian material is Dommartin (Cahen et al. 1986). The flint exhibits no cortex and cores are alltogether lacking, suggesting transport of prefabs or perhaps even of finished products. The presence of these 'foreign' elements supports the observation that towards the Younger LBK a small percentage of non-local flints begins to appear in the assemblages (Löhr et al. 1977; De Grooth 1987a). Löhr et al. note that this phenomenon coincides with the construction of the oldest defensive earthworks (Löhr et al. 1977). They propose that the flint would not have been obtained by organizing expeditions, or by down-the-line exchange, but rather by formalized exchange-networks. Although De Grooth (1987b: 215) mentions the possibility that the exotic flint is the result of reciprocal gifts, she seems to prefer the hypothesis that these pieces

Table 5 Beek-Molensteeg: raw material types present with mean length, width, thickness and weight of the artefacts.

	N	%	mean length (cm)	mean width (cm)	mean thickness (cm)	mean weight (g)	total weight (kg)
Rijckholt	1370	80.4	3.5	2.5	0.8	15.0	20.6
Valkenburg	179	10.5	5.0	3.8	1.3	38.3	6.9
light-grey Belgian	56	3.3	3.0	2.1	0.6	6.3	0.4
rolled material	9	0.5	2.2	1.6	0.8	5.0	0.0
other	8	0.5	3.3	2.2	1.2	16.5	0.1
uncertain	82	4.8	3.2	2.2	1.0	12.1	1.0
total	1704	100	3.4	2.4	1.0	15.5	29.0

reflect the existence of a supralocal mode of production, ascribable to a strain on the procurement of raw material (De Grooth 1987a). It is argued here, however, that non-local flint such as light-grey Belgian is present in such minute quantities as to be economically insignificant, suggesting that this material forms part of a symbolic exchange system to further ties of friendship between, presumably, independent social units (for example between the Graetheide cluster and the nearby Heeswater cluster around Rosmeer). The situation is somewhat different for the appearance of Valkenburg flint in the Younger LBK; this raw material certainly had economic significance and might point to a possible strain on the more easily accessible outcrops of Rijckholt flint. However, Valkenburg material cannot be considered a non-local flint; it can be collected nearby and, therefore, it is not necessary to postulate exchange-networks.

The fourth type of raw material includes nine pieces with an extremely rolled cortex, produced from small pebbles. Presumably the pebbles derive from the gravel beds of the river Meuse. The category 'other' includes all miscellaneous flints, which did not resemble any of the known raw material types, nor were sufficiently homogeneous in character to form a group. Burned or heavily patinated artefacts were subsumed under 'uncertain/ unsure'.

The relative percentages of Rijckholt and Valkenburg flint within the excavated assemblage are corroborated by the frequency counts of the raw material gathered during field-walking. Aussems' collection included 11.5% Valkenburg flint, Van Veen's had 12.9%.

The spatial distribution of the three prominent material types displays no differences. As can be expected, all three distribution patterns show a strong tendency to cluster in the rubbish pit, although this is slightly more so with Valkenburg material.

5.2.3 Core-preparation and primary trimming

Because such a small area of the site has been excavated, it is difficult to tell whether the initial testing of the nodules was done prior to transport to the site or afterwards. The first option is generally postulated when the flint source is located at some distance from the settlement. De Grooth (1987a) has been able to demonstrate, on the basis of her study of Beek-Kerkeveld, that unworked blocks and nodules were transported to the site; some were discarded after only one or two flakes had been removed, presumably for testing the quality of the nodule. At Beek-Molensteeg no large unmodified nodules were found, suggesting that selection and testing in this case was done at the location of collection. This applies both to the Rijckholt and the Valkenburg material. Nevertheless, as I have stressed before, the presence of tested and discarded nodules elsewhere at the site cannot be excluded, so the conclusion must remain tentative for the time being.

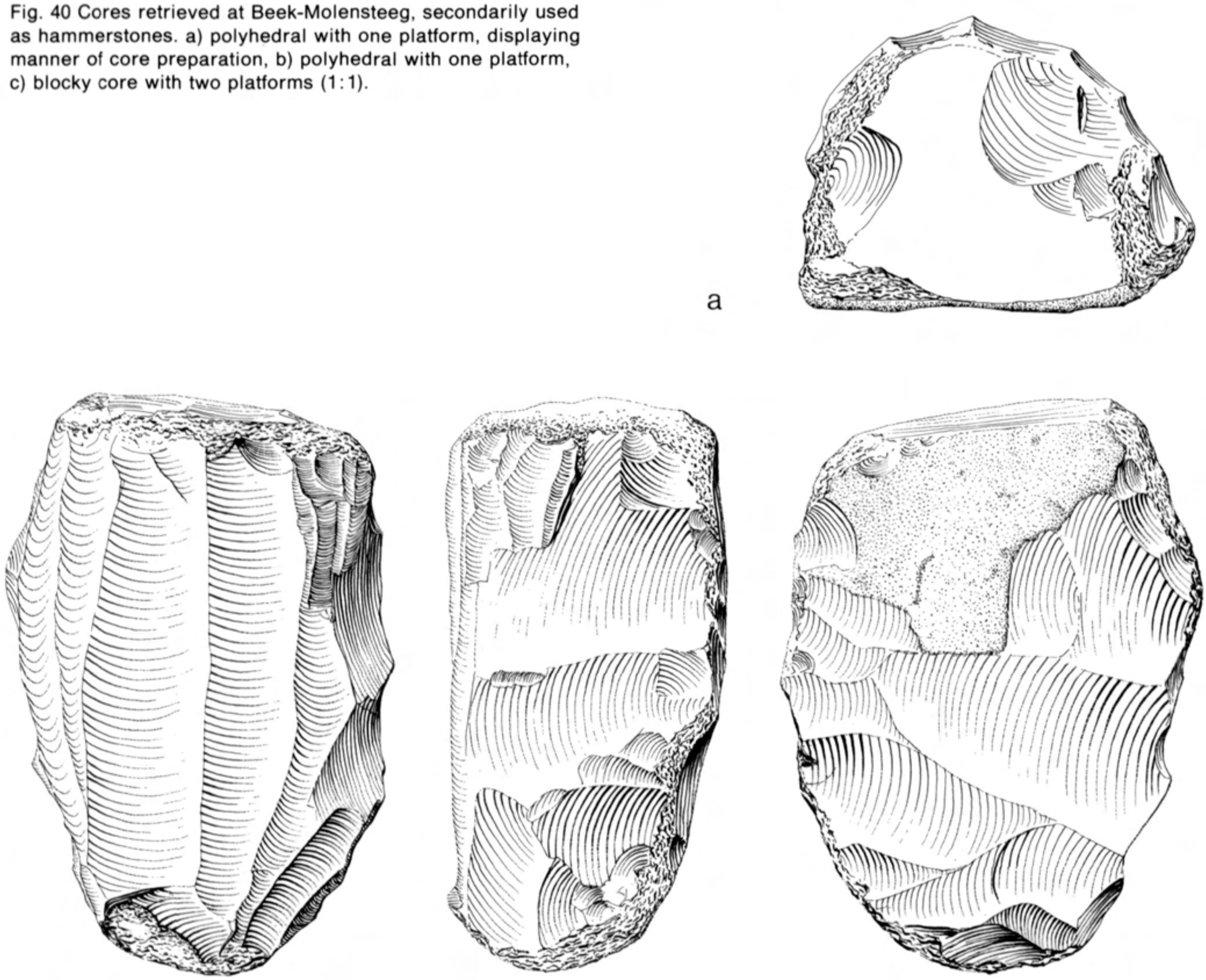
There is definite evidence, however, for primary trimming to have been done at the site itself. Generally, it is assumed that the larger the distance between raw material source area and habitation site, the more trimming is done prior to transportation (Gramley 1980). Although the source area for Rijckholt flint is a considerable distance away (i.e. 10-15 km), the large number of decortication flakes indicates that much of the initial reduction was done at the site. The number of Rijckholt decortication flakes amounts to 187 (13.6%), while 44.0% of the 1370 Rijckholt artefacts exhibit cortex to various degrees.

With respect to the Valkenburg flint it was observed that 47.5% of the 179 pieces exhibit cortex, whereas 22 (12.3%) are classified as decortication flakes. The source of this flint variety is located, however, somewhat nearer to the settlement, approximately 8 km away or possibly less.

As no refitting was done, not much can be said about the exact preparation of the cores. Most decortication flakes (52.0%) exhibit a heavily-developed bulb of percussion and other indications of removal by hard-hammer percussion. Only seven crested blades are present, three of which exhibited cortex, suggesting they were created in the primary trimming phase. There is no evidence of primary tablets, removed to create a platform.

Apart from the decortication flakes, which are obviously attributable to the primary trimming phase, it is unclear how many of the cortex-less flakes were also produced in this stage of the reduction-sequence. Flakes display a higher incidence of evidence for hard-hammer percussion, presence

Fig. 40 Cores retrieved at Beek-Molensteeg, secondarily used as hammerstones. a) polyhedral with one platform, displaying manner of core preparation, b) polyhedral with one platform, c) blocky core with two platforms (1:1).



of cortex, and hinged distal ends, than blades. As hard-hammer percussion seems to be predominantly used in the primary trimming (De Grooth 1987a), many of these flakes might indeed have been produced during this stage.

Spatial distribution of the decortication flakes displays a regular pattern across the area of the rubbish pit and the interior of the house.

5.2.4 Further reduction and shaping

After the initial trimming and preparing of a face and a platform on the core, further reduction could proceed. Many of the flakes were probably created in the trimming phase, while blades were produced during the subsequent systematic reduction of the cores. The cores are, for the most part, of a polyhedral shape (N = 19) with one platform (*figs. 40a, 40b*). Nine cores were of a more blocky shape with two opposite platforms (*fig. 40c*). Both of these types are blade-cores, most of which can be considered exhausted, and show evidence for a considerable production. Four artefacts were classified as flake-cores, five as exhausted flake-cores. Lastly, one core could not be attributed to any of these groups. The average number of negatives for all cores amounts to 14.6. Average length of the blade-cores is 7.0 cm, of the flake-cores 4.9 cm (*table 6*).

The method of reduction seems to have been the same for Rijckholt and Valkenburg flint. For both types of raw mate-

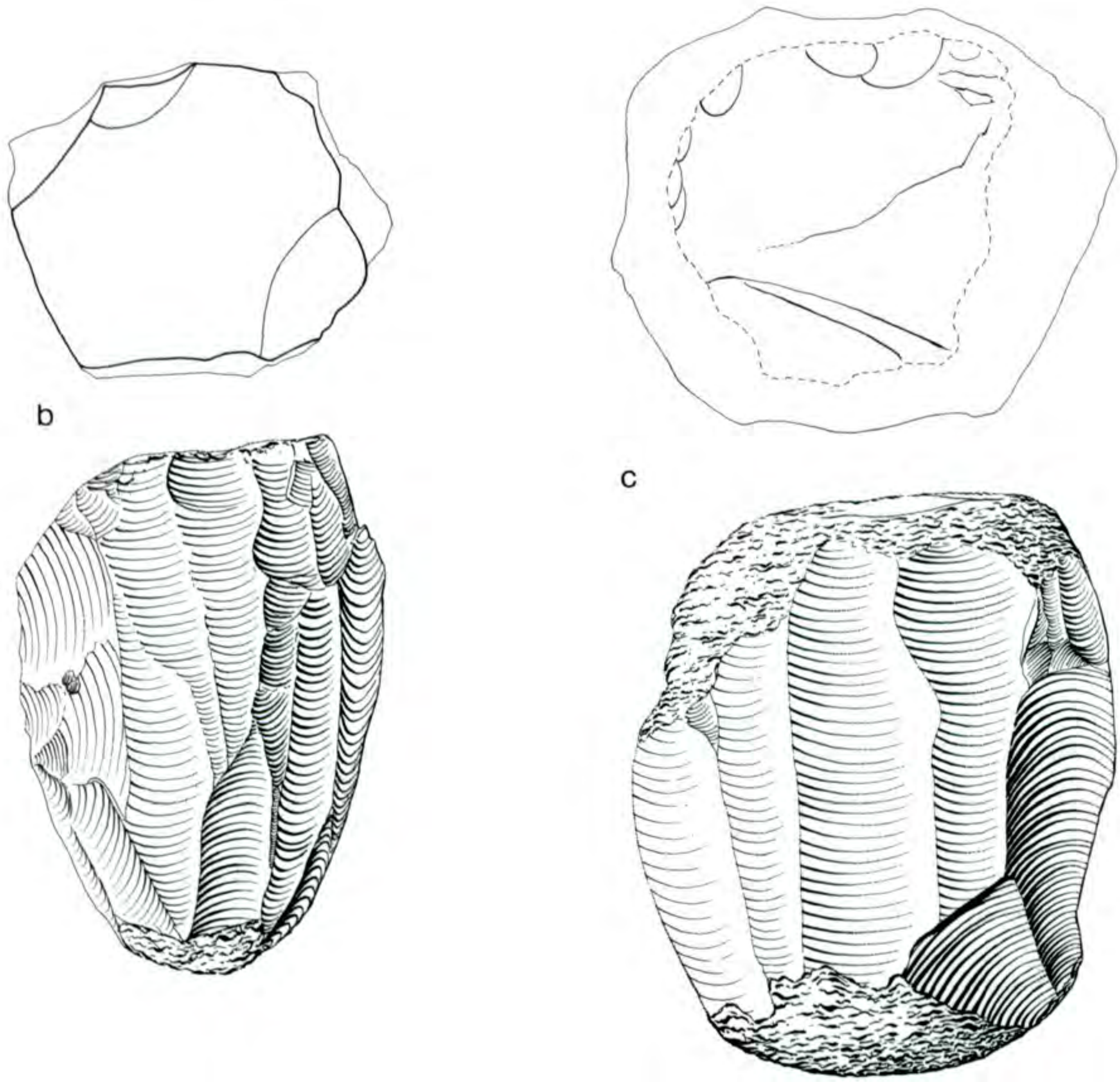


Table 6 Beek-Molensteeg: morphological characteristics of different types of cores present.

	N	mean length (cm)	mean weight (g)	Rijckholt	Valkenburg	face rejuvenation	platform rejuvenation	average no. of negatives
polyhedral blade core	19	7.0	173.6	16	3	2	4	16.4
blade core with two platforms	9	6.9	307.4	9	–	2	–	15.4
flake core	4	5.0	126.7	4	–	–	–	11.3
exhausted flake core	5	4.7	111.8	5	–	–	–	16.0
uncertain	1	7.9	116.6	1	–	–	–	14.0
total	38	6.3	147.2	35	3	4	4	14.6

Table 7 Beek-Molensteeg: number of potentially used areas (PUAs) on artefacts, differentiated by the raw material they are produced of. *0 PUAs = artefacts not selected for use-wear analysis.

number PUAs	Rijckholt	Valkenburg	light-grey Belgian	rolled material	other	unsure	total
0*	1087 (79.3%)	125 (69.8%)	43 (76.8%)	9	8	71	1343
1	105 (7.7%)	20 (11.2%)	5 (8.9%)	–	–	2	132
2	157 (11.5%)	33 (18.4%)	5 (8.9%)	–	–	7	203
3	21 (1.5%)	1 (0.6%)	3 (5.4%)	–	–	2	26
total	1370	179	56	9	8	82	1704

Table 8 Beek-Molensteeg: number of potentially used areas (PUAs) on blades and flakes. *0 PUAs = artefacts not selected for use-wear analysis. The categories blades and flakes presented here, do not include specialized specimens as core-rejuvenation or decortication flakes and crested blades.

number PUAs	blades	flakes	total
0*	237 (49.2%)	598 (91.6%)	835
1	66 (13.7%)	33 (5.1%)	99
2	164 (34.0%)	18 (2.8%)	182
3	15 (3.1%)	4 (0.6%)	19
total	482 (100 %)	653 (100 %)	1135

Table 9 Beek-Molensteeg: metrical attributes of the core-rejuvenation pieces.

rejuvenation pieces	N	mean length (cm)	mean width (cm)	mean thickness (cm)	Rijckholt	Valkenburg	other/ unsure
facetted tablet	46	6.3	5.6	2.0	31	14	1
smooth tablet	29	6.3	5.7	2.4	16	13	–
axial flank	30	6.5	5.0	1.7	17	11	2
lateral flank	8	6.2	5.1	2.0	7	1	–
total	113				71	39	3

Table 10 Beek-Molensteeg: various attributes of cores used as hammerstones (N = 23). RH = Rijckholt, VB = Valkenburg, grain size: 1 = coarse, 2 = medium, 3 = fine.

	mean length (cm)	mean width (cm)	mean weight (g)	raw material RH	VB	grain-size 1	2	3	total
polyhedral blade core	7.1	5.1	208.9	11	2	2	6	5	13
blade core with two platforms	7.6	6.5	384.7	6	–	–	5	1	6
flake core	6.9	8.7	375.2	6	–	–	2	–	2
exhausted flake core	4.1	6.3	152.9	2	–	–	1	1	2
total	6.4	6.7	280.4	21	2	2	14	7	23

rial the surface platform is in c. 40% of the cases smooth and in c. 15% facetted. Unfortunately, on two-thirds of the pieces it was difficult to determine in which way the dorsal face was prepared prior to removal. On those for which such identification was possible, micro-retouching was observed more frequently than abrasion, in both assemblages. There does seem to be a slight difference in the mode of percussion practised: Valkenburg material exhibits a slightly higher frequency of hard-hammer percussion (50.5%), and also of hinged distal ends (14.0%), than Rijckholt material (43.3% and 11.1% respectively). This is probably due to the larger size of the Valkenburg nodules used and their coarser grain. Artefacts made on Valkenburg flint did yield a slightly higher frequency of potentially used areas, than the ones made on Rijckholt (*table 7*). It is likely that this can also be attributed to the greater size of the nodules and the consequent longer cutting edges of flakes and blades.

Blades were obviously the preferred blanks. This is indicated first of all by the relatively large number of blade-cores present (28 of the 38, or 73.7%), but also by the fact that blades yielded comparatively more potentially used areas (PUAs) than flakes (*table 8*). Moreover, a higher percentage of blades was subsequently modified: 58 blades (12.0% of the total of 482) show retouch versus only 30 flakes (4.6% of the total of 653). Obviously, other primary categories were also shaped into tools, such as some of the decortication flakes (11 of the 225, or 4.9%). The morphology of the final products will be dealt with elsewhere in this chapter. Here it suffices to say that most retouched tools display steep, unifacial retouch, such as is exhibited on the end-scrapers. Invasive retouch is absent, as is a bifacial location.

5.2.5 Maintenance and modification

Beek-Molensteeg has yielded the same characteristic core-rejuvenation pieces as other LBK assemblages. When the flaking-angle became too obtuse and could no longer be amended by small-scale retouch of the platform, the entire platform was removed by hard-hammer percussion. These large flakes are called tablets; they can be smooth (*fig. 41a*) or facetted (*figs. 41b, 41c*). In the latter case it is likely that we are dealing with a primary platform, the facetting being the result of removing the cortex and shaping the platform. Tablets with a smooth dorsal surface can very well be secondary platforms, the smooth surface having been created by the earlier removal of a (facetted) tablet. The tablets are generally about 2 cm thick, although maximum values can be much higher: 4.1 cm for the facetted tablets, 5.9 cm for one of the smooth-surfaced ones (*table 9*). Besides improving the striking angle, tablets can also remove hinge-fractures and irregularities in the upper part of the core. A disadvantage of this technique is the great waste of raw material, since the blades struck after this operation will be about 2 cm shorter. Evidence for the removal of a tablet was also observed on four polyhedral cores (*table 6*).

Another technique to rejuvenate an unworkable core is the removal of a part of the core-face (see *fig. 6*). This may be done when hinge- or step-fractures on the core-face impede further production. The core-face was removed from the platform (axial flank) (*fig. 42*), or from the side of the core (lateral flank) (*fig. 43*), in both cases by hard-hammer percussion. Two polyhedral and two blocky cores displayed signs of face-rejuvenation (*table 6*).

As no refitting was done, it was impossible to reconstruct rejuvenation stages. De Grooth has demonstrated that one of the nodules from Beek-Kerkeveld showed six rejuvenation phases (De Grooth 1987a). This suggests that, although the rejuvenation techniques meant a waste of raw material, a good core was exploited to a maximum.

As in other Bandkeramik assemblages, exhausted cores were often used as hammerstones. Traces of battering were observed on 23 cores (*figs. 40a-c*). Both Rijckholt and Valkenburg cores were employed as such. The type of core usually selected for this purpose was the polyhedral one (N = 13), although blade-cores with two opposite platforms were chosen as well (N = 6). The size of the hammerstones varies a great deal (for example, the range of their weight is 57.6-675.7 g). It is remarkable that cores of good quality raw material (the fine-grained Rijckholt ones (N = 5)) were much further reduced, before being discarded for production and included among the hammerstones. Their mean weight (it concerns exclusively polyhedral cores) is only 106.5 g, considerably lower than the average weight of all polyhedral cores (208.9 g), or the average for all hammerstones (280.4 g) (*table 10*). In addition, three cores and one tablet (*fig. 41a*) displayed traces of battering which were not extensive enough to attribute them unequivocally to intentional use as hammerstones.

The spatial patterning of the rejuvenation pieces was similar to almost all the distributions of the various attributes, namely a cluster at the rubbish pit and its surroundings, with only a few pieces located within the house area or immediately outside it.

Collins' (1975) last stage is the use of the products. This aspect will be discussed in detail later in this chapter (*5.4*).

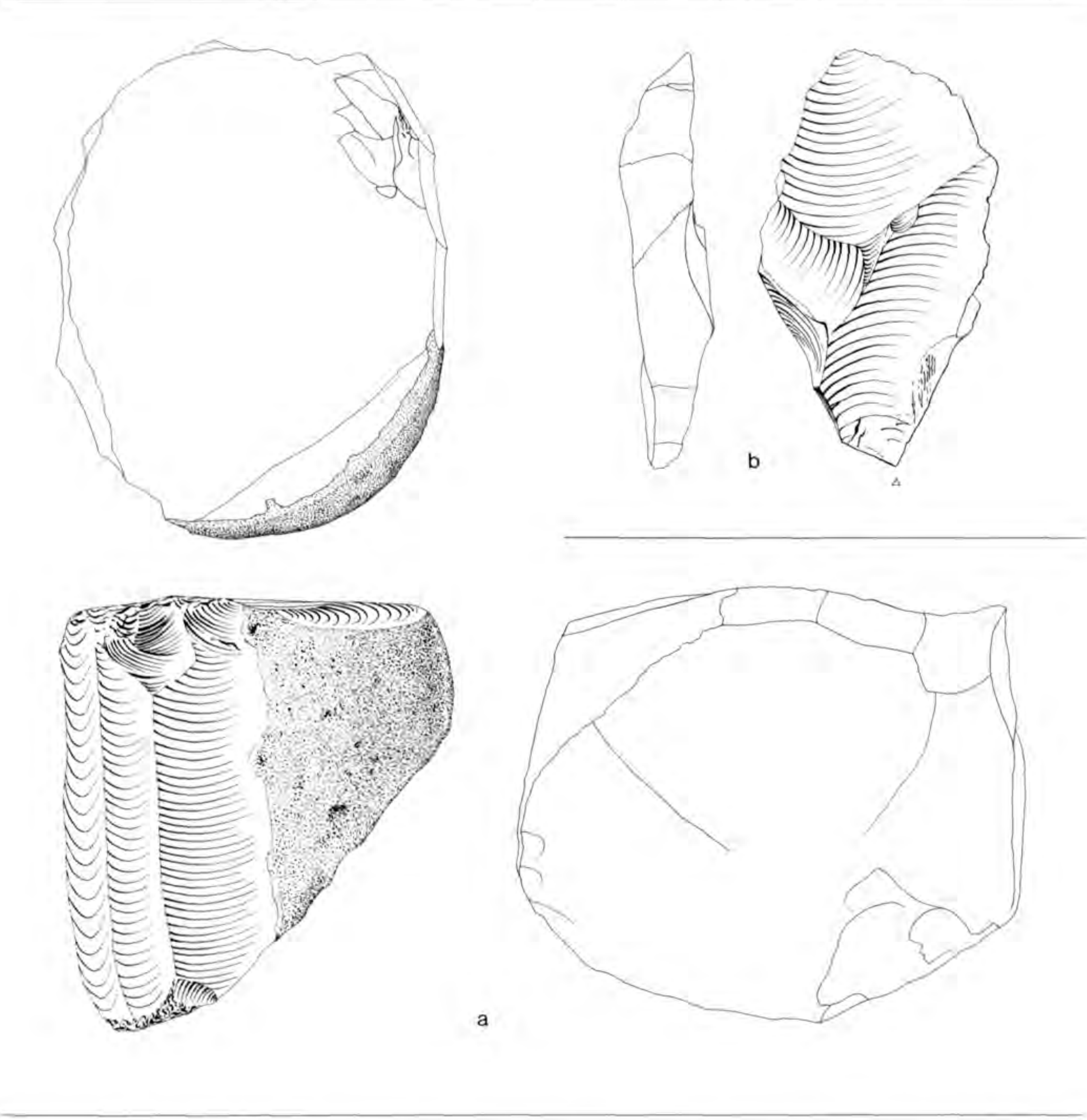
5.3 Tool typology

5.3.1 Introduction

In contrast to Middle and Late Neolithic flint assemblages, LBK lithic complexes have often formed an object of study. Many of the Belgian assemblages have received attention (Cahen/ Van Berg 1979; Ulrix-Closset/ Rousselle 1982; Cahen et al. 1986), while Löhr, Zimmermann and Hahn (1977) have published a lengthy study of the Langweiler 8 flint assemblage. Most of the classifications used by these authors are quite simple and straightforward. Bohmers and

Table 11 Beek-Molensteeg: tool types present.

unretouched blades	409
unretouched flakes	860
unretouched waste	200
blades with retouch < 1 mm	64
blades with retouch ⩾ 1 mm	31
flakes with retouch < 1 mm	11
flakes with retouch ⩾ 1 mm	5
endscraper-on-blade	25
endscraper-on-flake	13
convex scrapers	12
multiple scraper-on-blade	1
multiple scraper-on-flake	3
composite tool-on-flake	1
encoches	7
waste with retouch	2
transverse arrow heads	1
points	2
LBK points	3
borers	1
truncated blades	8
quartiers d'orange	3
unsure	4
cores	38
total	1704



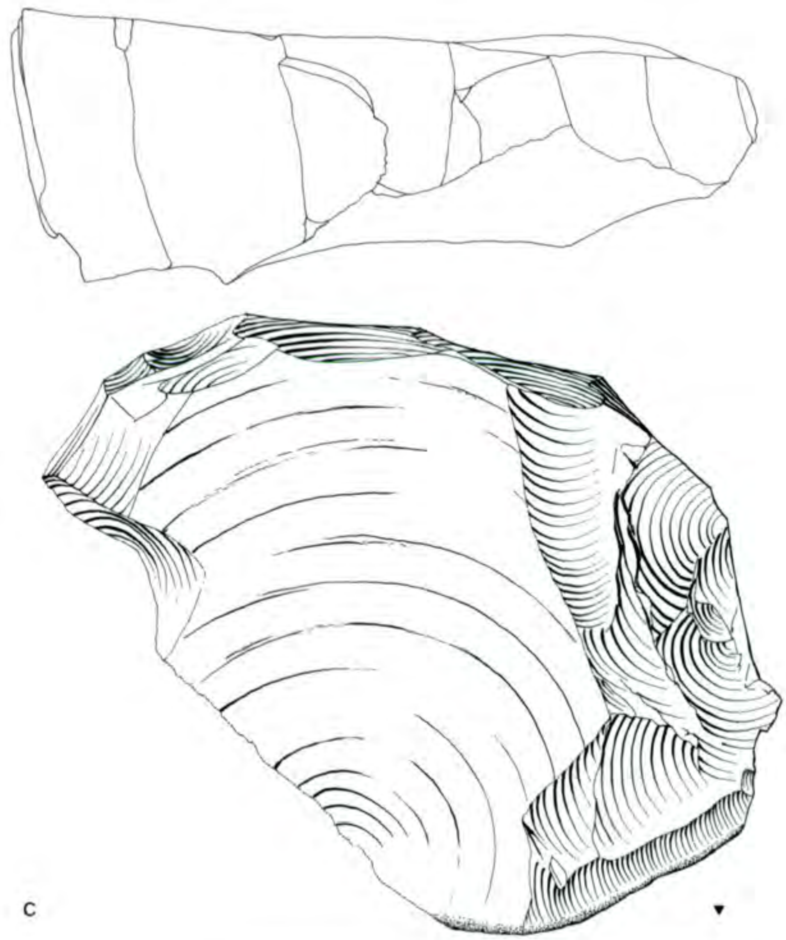
Bruijn (1958-1959) have studied the Dutch LBK assemblages, for which Newell (1970) later developed a much more detailed classification. The latter's proposals have, however, evoked much criticism (cf. Löhr et al. 1977) and have never been adopted. With respect to the Beek-Molensteeg assemblage, a simple classification was opted for, mainly because a detailed typological analysis was by no means the objective of this study.

5.3.2 TOOL TYPES PRESENT

The types of implements encountered in the Beek-Molensteeg assemblage are very similar to those found elsewhere (*table 11*).

SCRAPERS: the most common tool type is the scraper (*figs. 44a-d*). The majority (N = 25) of the scraping edges was created on the distal ends of blades. In addition, several

Fig. 41 Tablets retrieved at Beek-Molensteeg with a) smooth surface, b, c) facetted surface (1:1).



endscrapers produced on flakes were present (N = 13). Some flakes displayed continuous retouch on more than one edge of their circumference; these were classified as convex scrapers (N = 12). Lastly, four artefacts exhibited retouch on more than one convex edge; the areas with retouch were, however, separated by unmodified stretches. Such tools were called multiple scrapers.

BORERS: only one borer, produced on a flake, was identified in the assemblage. Reamers were absent. Although borers never constitute a large percentage in LBK assemblages, the one of Beek-Molensteeg seems to be extremely low.

TRUNCATED BLADES: eight blades exhibited steep scalar retouch along their distal end, with a feather or hinge termination. Although they are not reported as such for the Aldenhovener Platte (Löhr et al. 1977), they are a regular occurrence in Belgium. Cahen and Van Berg (1979) report 25 truncated blades from Blicquy, and they are also present at the site of Staberg near Rosmeer (Ulrix-Closset/ Rousselle 1982).

POINTS: a total of six points was present in the assemblage, amongst which a transverse arrow head, and three artefacts which could be classified as typical LBK points. The latter have a triangular shape (*figs. 46g, 46h*).

QUARTIERS D'ORANGE: it has generally been assumed that this tool type is absent in Dutch LBK assemblages (Newell 1970; De Grooth 1987a). However, Beek-Molensteeg has yielded at least one (*fig. 48c*). *Quartiers d'orange* have a triangular or rectangular cross-section, and one longitudinal edge with a 70°-90° angle, obtained by the intersection of two previous removals; their backs display extensive retouch. Two Beek-Molensteeg artefacts matched these requirements in all respects, with the exception of the retouched back (*figs. 48a, 48b*). These tools are more appropriately called '*débitage-en-frite*' (J.Pelegrin *pers.comm.*). Since all three tools display so

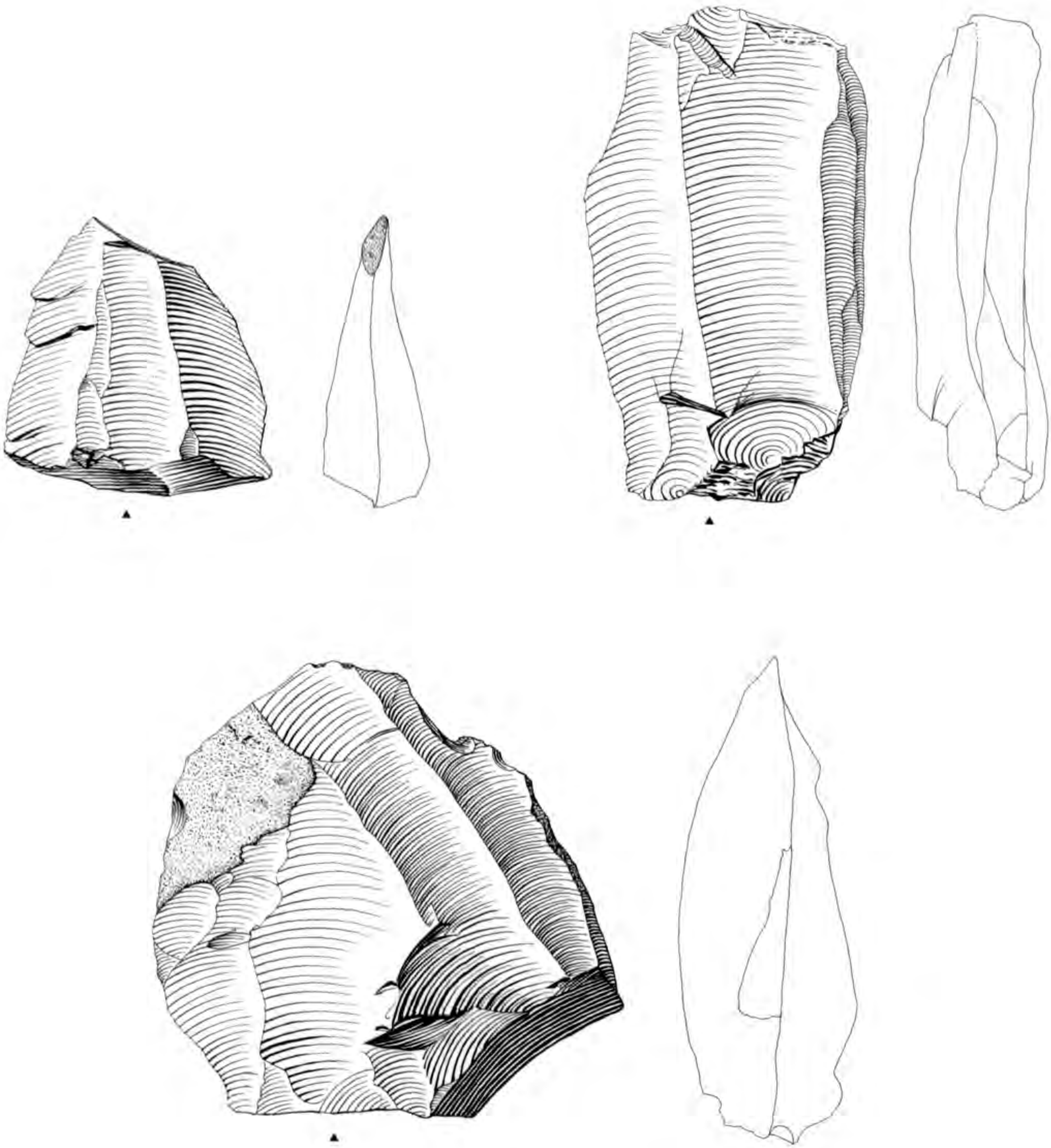


Fig. 42 Core-face rejuvenation pieces from Beek-Molensteeg: axial flanks (1:1).

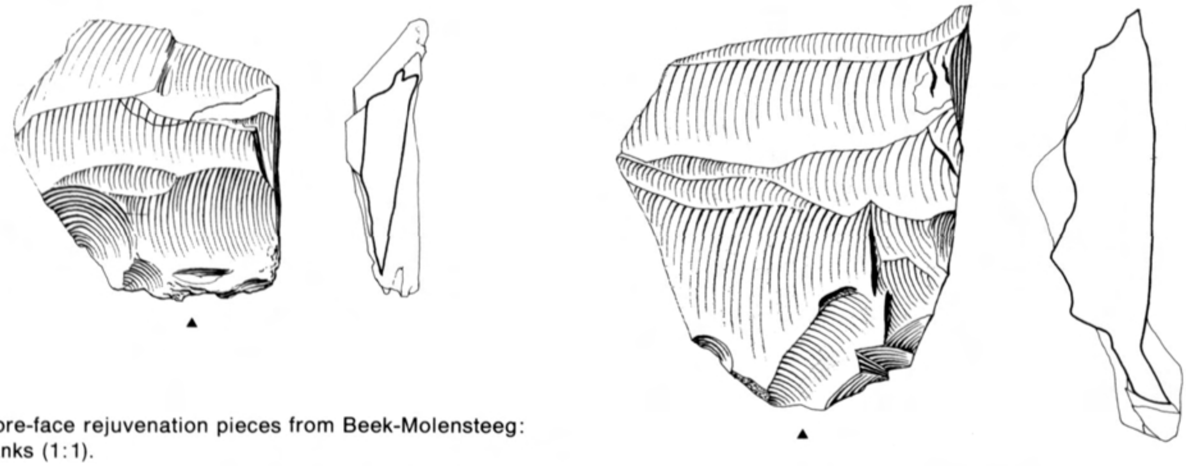


Fig. 43 Core-face rejuvenation pieces from Beek-Molensteeg: lateral flanks (1:1).

much similarity in their morphology and function (see *5.4.2.7*), they were retained as one category.

ENCOCHES AND DENTICULATES: seven tools exhibited an *encoche*. Denticulates were classified as absent in the Beek-Molensteeg assemblage, but this might be due to a different perception as to what should be included in this tool type. De Grooth (1987a) does not report them either.

RETOUCHED BLADES: in addition to endscrapers-on-blade and truncated blades, 31 blades exhibited retouch extending 1 mm or more over the piece. Usually the retouch is located on one of the lateral sides. Moreover, 64 blades displayed retouch of less than 1 mm in width. Two blades were of special interest in that the proximal end had been intentionally narrowed by retouch, probably to facilitate hafting, leaving the functional edges unmodified (*figs. 44f, 46c*).

RETOUCHED FLAKES: five straight edges of flakes were retouched along their lateral or proximal borders. In addition, 11 flakes displayed retouch of less than 1 mm.

RETOUCHED WASTE: two implements without bulb of percussion, or other indication of impact, were retouched. One had a concave, and one a convex working edge.

HAMMERSTONES: 23 of the 38 cores were secondarily used as hammerstones (*figs. 40a-e*). This category concerned, for the most part, polyhedral cores of fine- or medium-grained varieties of Rijckholt flint. The fine-grained Rijckholt cores were further reduced (see also *5.2.5*).

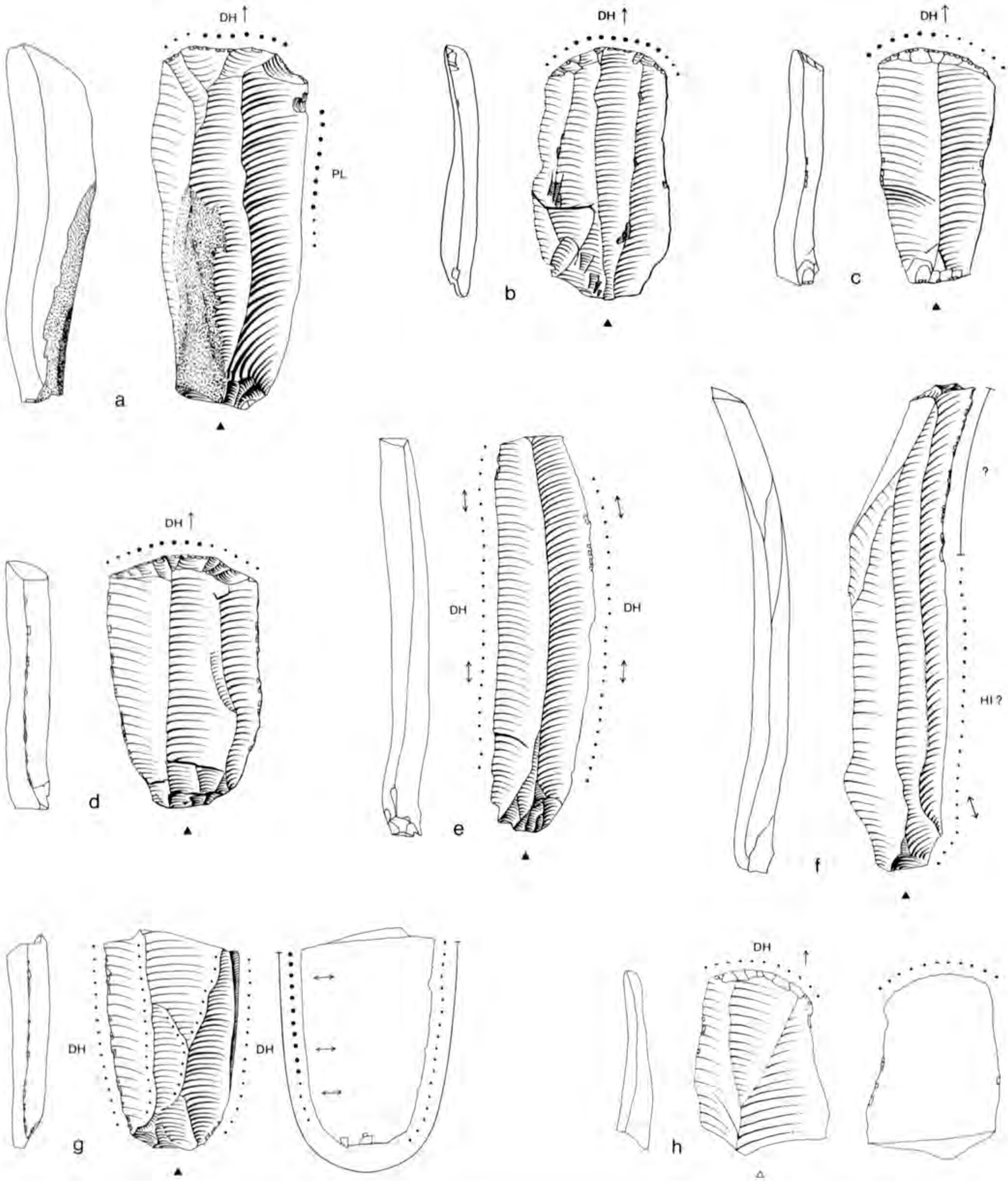
The amateur collections and the material present in the Heemkunde Museum of Beek showed a similar range of tool types. Aussems possessed (as of May 1988) four endscrapers-on-blade and four sickle blades, the museum owned one triangular LBK point, three endscrapers-on-blade, one convex scraper and six retouched flakes. During various surveys, Van Veen retrieved four sickle blades, 12 endscrapers-on-blade, one retouched flake and one retouched blade. From a small-scale rescue-excavation just adjacent to the IPL trench, Van Veen found an additional three sickle blades, six endscrapers-on-blade, four endscrapers-on-flake, one truncated blade, three retouched blades, and two *quartiers d'orange*.

Spatial analysis of the various types revealed that, again, most tools were confined to the space of the rubbish pit and its immediate surroundings. Only convex scrapers-on-flake and one endscraper-on-blade were located outside this area.

5.4 The functional analysis

5.4.1 SAMPLING AND METHODS

The sampling of the Beek-Molensteeg assemblage was executed in a manner which was essentially identical to the one outlined in paragraph 2.3. All retouched tools were examined, apart from those which had been removed by backhoe and had ended upon the dump, only to be found later when their exact provenance could no longer be reconstructed. A total of 114 tools with retouch $\geqslant$ 1 mm was examined, as well as 74 implements displaying retouch $<$ 1 mm. Additionally, all artefacts exhibiting an edge which was straight or slightly convex/ concave in cross-section were examined. The artefacts had to display such a regular edge for a length of 2 cm or more (see *2.3* for a discussion of this feature). As blades, which have straight parallel edges, are numerous in LBK assemblages, these sampling criteria resulted in 174 artefacts to be examined. All in all, a total of 362 artefacts,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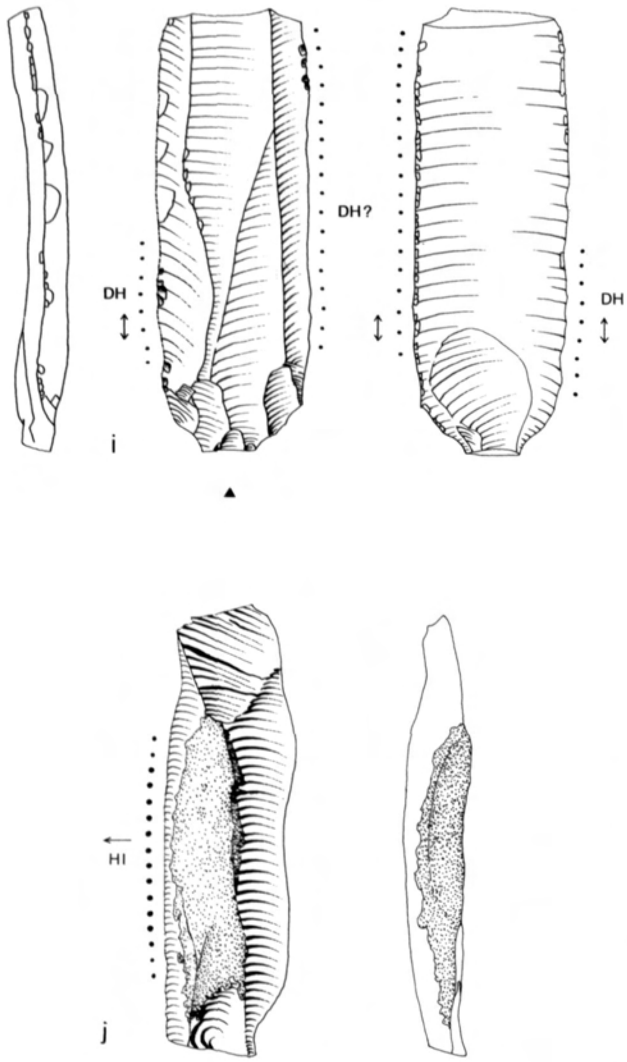


Fig. 44 Beek-Molensteeg: hide-working tools. a-d) endscrapers on blades (BMO1, BMO77, BMO24 and BMO71), e) tool BMO38 used for cutting hide, f) possibly hafted blade BMO28, g) proximal end of a blade which was probably hafted (BMO9), h) endscraper with typical breakage-pattern (BMO42), i-j) blades (BMO45, BMO206) (1:1).

having 619 PUAs, was studied for traces of use.

Cleaning methods were basically the same as those proposed by Keeley (1980). Firstly, all pieces were put in a weak HCl-solution in an ultrasonic cleaning tank for about 3 minutes. They were then thoroughly rinsed in tap water, after which they were left to soak in a KOH-solution for 1-3 minutes. Lastly, they were rinsed again with tap water. Alcohol was used to remove finger grease and other impurities.

Post-depositional surface modifications, probably mainly due to abrasion, were present, but not nearly as extensive as in the Vlaardingen-assemblages (see *6.2.3*). From a total of 619 PUAs, 121 were not interpretable; in five cases this was caused by light burning, not noticed when the artefacts were selected for the use-wear sample. From the remaining edges which were not interpretable, a large number (N = 48) derived from the topsoil. In addition, there were those PUAs which displayed traces of use, but were otherwise not interpretable; they were listed as 'probably used', and no wear-traces were described in the 'micro-file'. The number of fresh Rijckholt and Valkenburg pieces is large, 81.7% and 88.8% of the total number of PUAs, respectively. The light-grey Belgian material posed more problems: 11 of the 24 PUAs exhibited too much sheen to allow an interpretation. This might be due to the natural translucency of this material and its fine grain-size. The total number of interpretable PUAs amounts to 492 (i.e. 78.5% of all PUAs) (see also *table 27*).

5.4.2 Activities inferred

Although only a very small portion of the site has been excavated, a wide range of activities is represented in the spectrum reconstructed by use-wear analysis. In the following paragraphs the various activities inferred will be discussed. Before doing so, it is perhaps worthwhile to recapitulate the various analytical steps taken. From 1704 artefacts, comprising the Beek-Molensteeg assemblage, 362 were selected for analysis, 114 of which concerned 'intentionally' (i.e. retouch $\geqslant$ 1 mm) retouched tools. These 362 implements yielded 619 potentially used areas (PUAs), on which 149 actually used areas (AUAs) were observed. Eight PUAs displayed two used zones, indicating that only 141 PUAs exhibit traces of use. If we look at the entire tools, it turns out that 54 of the 114 retouched implements show interpretable wear-traces. In the following paragraphs, consecutively all contact-materials will be discussed. In addition, two 'motions' are also treated as 'activity inferred': 'projectile' and 'hafting'. With respect to projectile points, it is almost never possible to infer anything about the object into which the implement was shot. Hafting clearly is not a real 'motion'; the rationale behind its inclusion in this category has been outlined elsewhere (cf. *2.6.3*). Table 12 provides an overview of inferred contact-materials and motions.

5.4.2.1 Hide-working

The contact-material most frequently represented in the assemblage of Beek-Molensteeg is hide. Out of the 149 actually used areas (there can be more than one AUA per tool and even per PUA), 54 exhibit extensive edge rounding and a clearly defined band of polish, which could be attri-

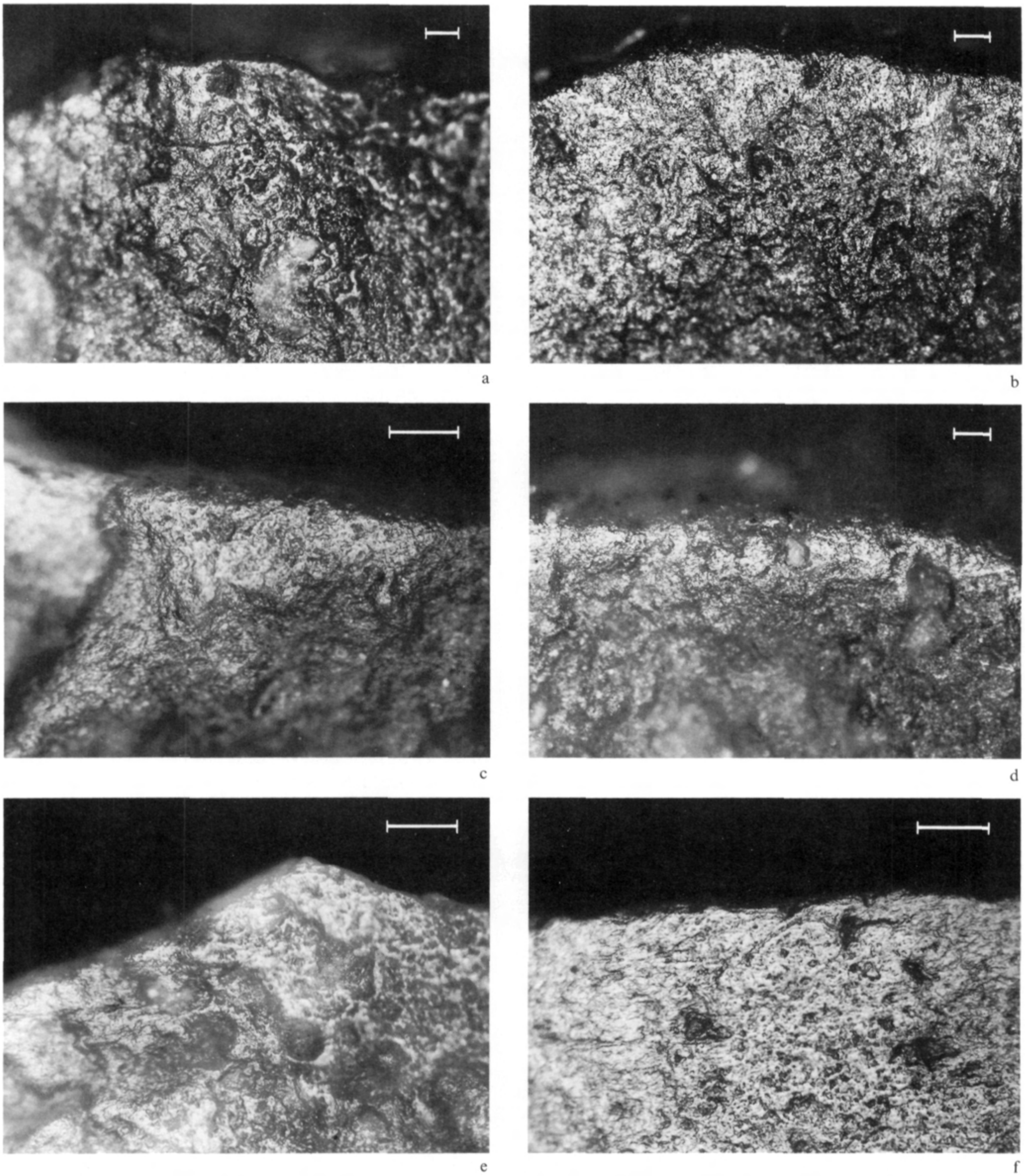


Fig. 45 Beek-Molensteeg: micrographs of traces interpreted as being from contact with hide, observed on the tools depicted in fig. 44. All scale bars equal 50 μ. a) BMO1 (100x), b) BMO77 (100x), c) BMO24 (200x), d) BMO71 (100x), e) BMO45 (200x), f) BMO38 (200x).

Table 12 Beek-Molensteeg: inferred motion and contact-material by actually used area (AUA).

	transverse	scraping	whittling	cutting	carving	splitting	boring	projectile	hafting	unsure	total
hide	1	26	–	22	–	–	1	–	3	1	54
wood	1	9	7	–	1	–	–	–	–	5	23
wood/bone/antler	–	1	–	1	1	–	–	–	1	–	4
soft plant	3	1	–	5	–	1	–	–	–	3	13
cereals	–	–	–	9	–	–	–	–	–	–	9
meat	–	–	–	1	–	–	–	–	–	1	2
'23'	6	–	–	–	–	–	–	–	–	–	6
hard material	–	–	–	2	–	–	–	–	–	–	2
soft material	–	2	–	2	–	–	–	–	–	–	4
unknown	1	2	–	4	–	–	1	3	7	14	32
total	12	41	7	46	2	1	2	3	11	24	149

buted to hide; these inferences were generally 'certain'. However, the state of the hide, i.e. dry, wet or fresh, is more difficult to ascertain, as is the interpretion of the character of possible additives such as ochre or abrasives. Some tools exhibited a band of polish with a more greasy, 'wet' appearance, suggesting that the hide worked was fresh or wet/moist (N = 7). The majority of the tools, however, displayed a matt polish with craters in it, and quite a few striations, indicating that the hide was dry (N = 29). Of the remainder (N = 18) of the AUAs with evidence for hide-working, traces were more ambiguous and no statement could be made as to the condition of the worked hide.

With respect to motions, both scraping (N = 26) (*figs. 45a-d*) and cutting (N = 22) (*figs. 45e, 45f*) have been attested. Three tools exhibit traces of hide-polish distributed in such a way that hafting has been inferred (*fig. 44g*), one was used in a piercing fashion, while in another case the motion involved is unsure. The correlation between tool type and motion was quite strong (see paragraph 5 of this chapter), the majority of the endscrapers and convex scrapers indeed having been used for scraping (*figs. 44a-d*). The cutting of hides was generally performed with unretouched blades (*figs. 44e, 44i, 44j*).

Hide-working has also been demonstrated in previous microwear analyses of LBK material. Vaughan, in his analysis of the Langweiler 8 and Laurenzberg 7 material, mentions that 41% of the used zones indicated contact with dry hide (Vaughan 1985b: 328). Unfortunately, Vaughan does not differentiate between the various motions involved in hide-working. Caspar, in a preliminary article on the microwear analysis of the Belgian site of Darion, lists that 156 implements displayed hide-polish, i.e. 60% of the tools exhibiting traces of wear (Caspar 1985: 66). In contrast to the Beek-Molensteeg analysis, where about an equal number of hide-working tools was employed in scraping and cutting motions, Caspar notes that 82.8% of the hide-working zones was used in a transverse motion versus 15.8% in a longitudinal movement. He also finds only a very minute percentage (1.4%) of hide-boring zones (Caspar 1985: 66). Another LBK site on which a functional analysis was performed is Place Saint-Lambert in Liège. Here Caspar and Gysels (1984) found that only 26 out of the 181 (14.36%) analysed tools exhibited traces attributable to hide-working (Caspar/ Gysels 1984: 207), a surprisingly low percentage. Lastly, the site of Blicquy-Couture de la Chaussée has been the object of functional analysis. Here, 29% of the tools was used on hide (Cahen et al. 1986: 73).

From the functional analysis of the above mentioned sites, and the present one of Beek-Molensteeg, it can be concluded that the processing of hides is very well-represented in the westernmost extension of the LBK. In a previous chapter (see *3.2*) the difficulties of interpreting hide-working traces were outlined. Although attributing traces of wear to the general category of 'hide' posed no problems (Unrath et al. 1986), interpreting the state of the hide and identifying the precise step in the transformation from raw hide to a more lasting product, is clearly much more difficult. To solve this problem a long-term research programme is required, replicating all the various steps, and including an enormous number of variables. In the hide-processing experiments presented in this study (see *3.2.2*) emphasis was placed on tanning with various animal substances, such as brains, liver or fat, while in LBK context one would expect vegetable tanning to have been employed instead. Obviously, this gap in the experimental programme should be addressed in the near future.

Whatever the exact procedures and the role of the hide-working tools in the process, it is clear that the working of hides was a major activity in LBK settlements. Given the character of the wear-traces, more indicative of 'dry' hide, it can also be argued that it is not so much the initial cleaning of fresh hides which took place, but the further processing of already clean hides. At LBK sites, evidence for hide-processing activities comes from 'slit-like' pits which are hypothesized to be tanning pits (Van de Velde 1973). Such pits were found at a.o. Hienheim (Van de Velde 1973;

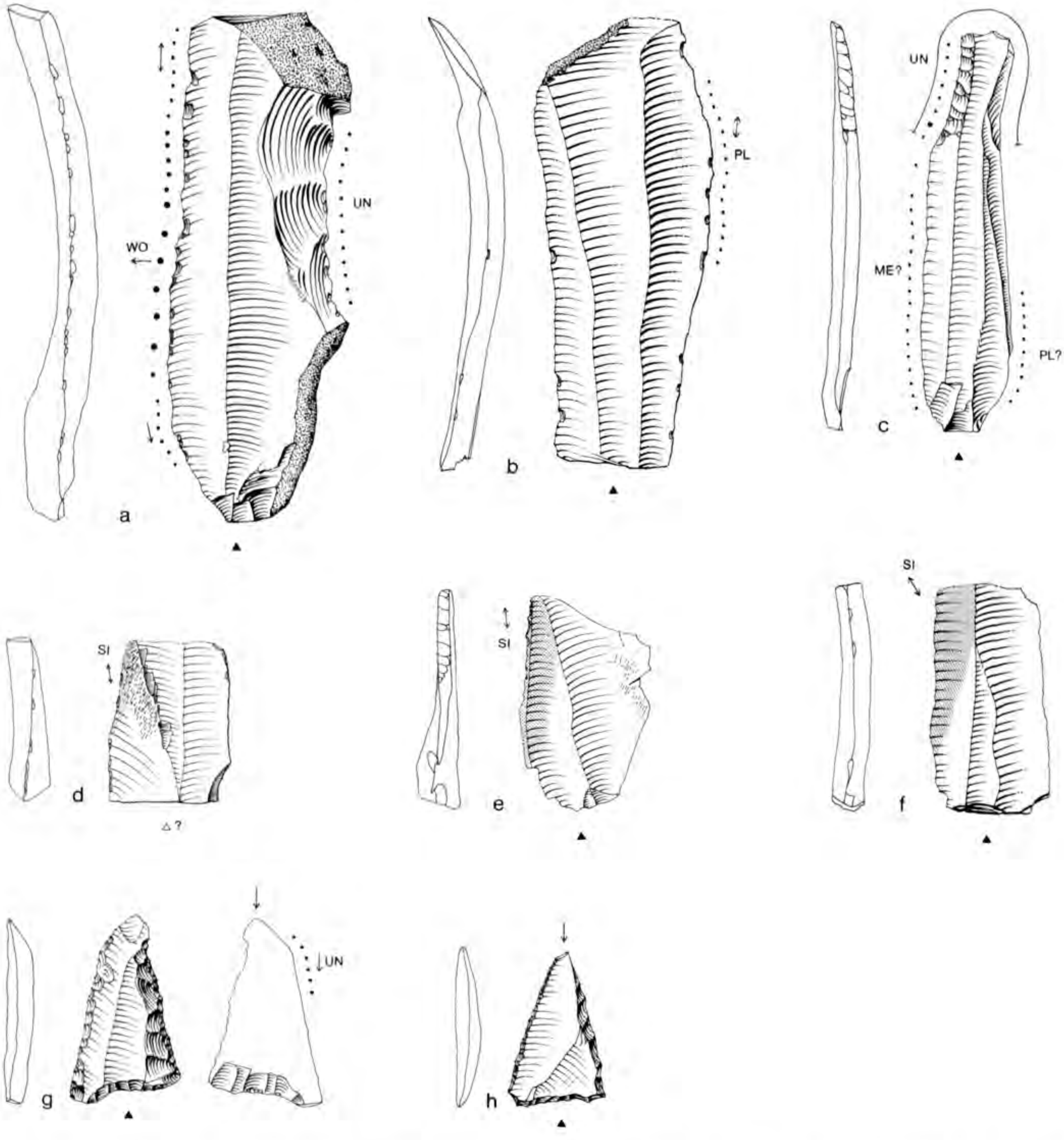


Fig. 46 Beek-Molensteeg: implements with traces of use. a) wood-working traces on BMO65, b) BMO34 probably used for cutting soft plants, c) possibly hafted blade for multiple uses (BMO23), d-f) sickle blades (BMO19, BMO18, BMO6), g-h) LBK projectile points with impact fractures (BMO110, BMO81) (1:1).

Modderman 1986), Lindenthal (Buttler/ Haberey 1936, cited in Van de Velde 1973) and Monrepos (Paret 1910, cited in Van de Velde 1973). Although Van de Velde's interpretation of these pits is not without controversy (cf. Gronenborn 1989), it is worth further investigation. Among the first aspects to be considered is, for instance, the spatial distribution of these pits. As tanning is an enterprise producing unpleasant smells, the pits are more likely to occur at the fringes of the settlement. There is plenty of ethnographic support for such a separate activity area. Also, the pits are likely to cluster, instead of being randomly distributed throughout the settlement. Returning to the flint tools, the high percentage of hide-working implements might indicate that hide-working is an 'on-site' activity; the implements must have been utilised during a stage in the hide-softening which could take place anywhere in the settlement. I consider it less likely that the presence of these implements must be attributed to retooling within the settlement. The main argument against this, is the presence of distal ends of hide-scrapers which apparently broke from their hafts during use (see *5.4.2.11*). This also implies that we should not attribute too much significance to the high percentage of hide-working tools, as equally important activities might have taken place 'off-site', with loss or discard of implements taking place elsewhere.

5.4.2.2 Wood-working

The second activity represented in the Beek-Molensteeg flint assemblage is the working of wood. A total of 23 AUAs exhibited traces indicative of wood as a contact-material (15.4% of the used zones). Surprisingly, none of these zones was used in a cutting motion, nor was boring represented. Nine edges were used for scraping, one for carving, seven for whittling (*figs. 46a, 47a*), and one in a transverse motion. Lastly, the motion of five zones could not be ascertained. The polish present on the tools was smooth, domed, and linked up at the edge. The edge was slightly rounded and, especially in the case of the whittling tools, also scarred by edge-damage. The whittling tools were generally quite large (6.4 cm in length versus a mean of 3.4 cm for the total assemblage). Some of the endscrapers were used on wood, but generally wood-working was performed with tools not clearly attributable to a standardised type (see paragraph 5, this chapter). The degree of wear exhibited by the wood-working tools varies from light to heavy.

As with the evidence for hide-working, wood-working has also been attested for in previous microwear analyses of LBK material. Langweiler 8 and Laurenzberg 7 yielded a very low score of 3% wood-working tools (Vaughan 1985b: 328), while the Belgian sites provided a picture slightly more similar to the Beek-Molensteeg results: Darion yielded 28 wood-working tools out of a total of 260 used artefacts (Cahen et al. 1986: 56), and at Place Saint-Lambert in Liège 30 of the 143 pieces examined (i.e. 21%) were identified as wood-working implements (Caspar/ Gysels 1984: 200). Blicquy-Couture de la Chaussée, however, showed a higher percentage: 31.3% had evidence for wood-working (Cahen et al. 1986: 73). It is not clear whether this concerns 31.3% of the pieces analysed or of the used pieces.

The presence of wood-working tools among LBK flint assemblages should come as no surprise. The environment in which the LBK people settled was wooded, and it is likely that wood did not only provide building material for the large houses, but also the raw material for a score of minor tools and utensils. The macroscopically visible gloss on the cutting edges of stone adzes has often been attributed to wood-working (Bakels 1987); recently this has been confirmed by use-wear analysis (Drobniewicz 1988). It is very probable that the adzes were employed in the felling of the trees and for other coarse wood-work (Dohrn-Ihmig 1979-1980). The flint tools presented here probably reflect the minor craft activities, performed in or near the houses, involving wood as a worked material (i.e. the manufacture of wooden objects and utensils).

5.4.2.3 Wood-/ bone-/ antler-working

Four used zones fall into this category. None of them exhibited traces which could be interpreted as resulting from contact with bone. One scraper displayed a 'deposit'-like polish, which could possibly be attributed to contact with antler (interpretation 'uncertain'). On three tools a domed, very bright, smooth polish was observed, suggestive of contact with wood. However, comet-tails were present within the polish, an attribute generally associated with bone-working. The most likely interpretation seems to be that a rather hard variety of wood was involved. This inference is supported by some experiments resulting in the same combination of attributes (cf. *3.3.2*). Motions which were inferred, included longitudinal (N = 1), carving (N = 1), scraping (N = 1), and hafting (N = 1, interpretation 'uncertain').

Evidence for bone- and antler-working is conspicuously absent in other LBK assemblages as well. Vaughan reports for the Aldenhovener Platte that only 2% of the used zones showed traces resulting from contact with bone (Vaughan 1985b: 328). In Darion only three out of a total of 260 used pieces were utilized on bone, while the Place Saint-Lambert yielded none at all (Cahen et al. 1986: 55-56). Bruijn macroscopically studied flint artefacts from several Dutch LBK sites and arrived at the conclusion that the scrapers must have been used on coarser hard-wood or bone, considering the gloss they exhibit (Bruijn 1958-1959: 219). Although Modderman still adheres to Bruijn's opinion, even stating that wood- and bone-working played a very important role in LBK economy (Modderman 1985: 69), recent research arrives at a different conclusion. Wood-working

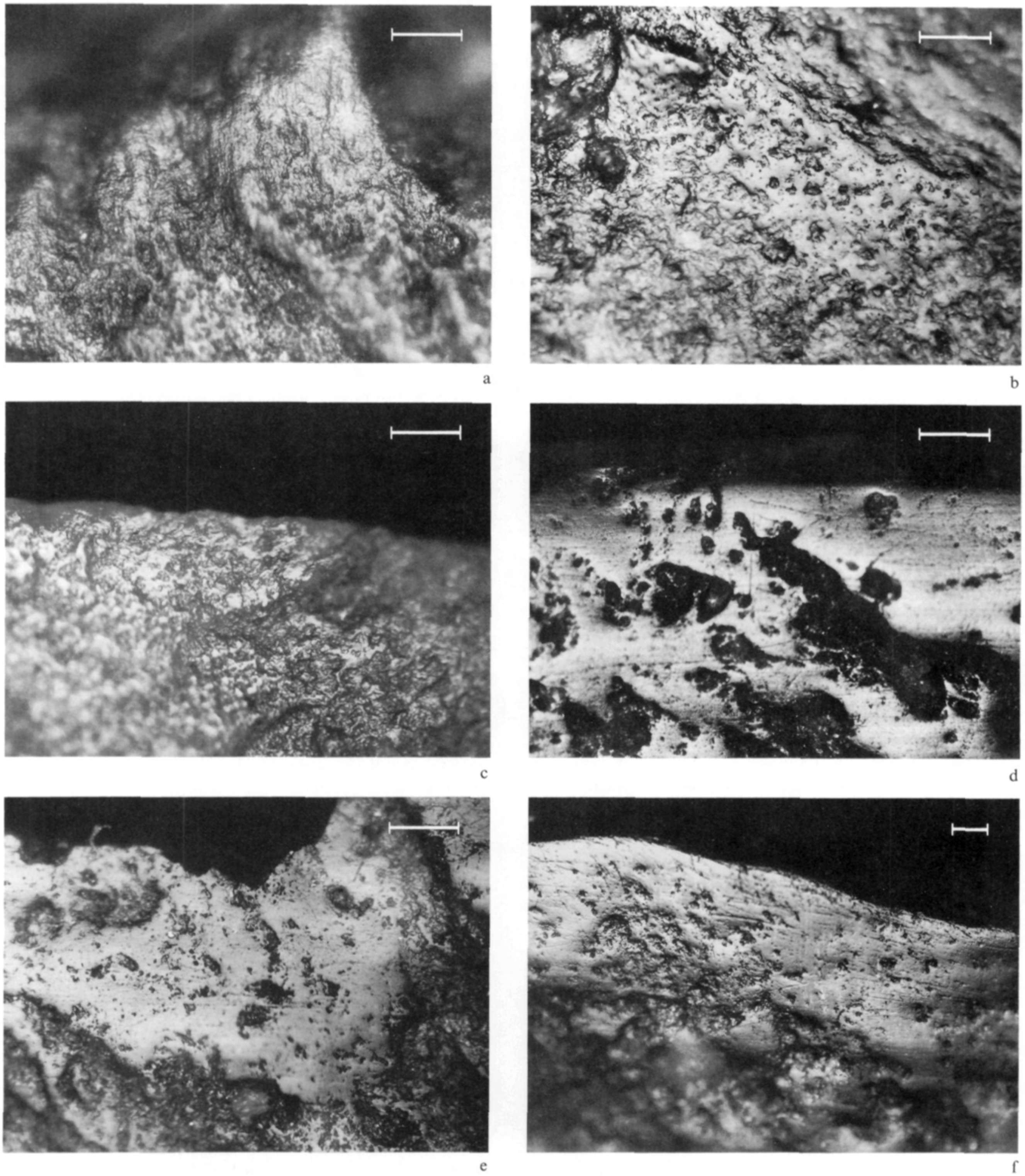


Fig. 47 Beek-Molensteeg: micrographs of the artefacts depicted in fig. 46. All scale bars equal 50 μ. a) BMO65 (200x), b) BMO34 (200x), c) BMO23 (200x), d) BMO6 (200x), e) BMO19 (200x), f) BMO18 (100x).

was indeed important, but evidence for bone-working seems virtually lacking, at least on the flint tools.

5.4.2.4 *Processing of soft plants excluding cereals*

Soft plants form another category of contact-material for which evidence is available. In the present study cereals are not included in this category. As was already demonstrated in chapter 3, soft plant species can be divided into two groups: the plants that contain silica in their stems, leaves or roots, and those that do not. Contact with silicious plants such as reeds, wild grasses and sedges produces a smooth and highly reflective polish, while the damage caused by non-silicious plants is much less conspicious. In the case of 12 PUAs a somewhat dull, smooth polish was observed suggesting non-silicious soft plants as contact-material (*figs. 47b, 47c*). This inference was corroborated by the fact that the edges on which this polish was located had sharp angles, and had hardly or no edge-damage (*figs. 46b, 46c*). Striations were absent, although directionality was generally visible within the polish. Two types of motions were represented: four transverse and five longitudinal ones, while three used edges could not be interpreted in terms of this variable. One *quartier d'orange* (*fig. 48a*) displayed evidence for having been used to split silicious plant. The polish was not striated, but extremely smooth and undulating, highly reflective, and located on a tip of the tool in such a way as to suggest a splitting motion. Interestingly enough, this tool was produced from light-grey Belgian flint, and had four zones of use, suggesting that this piece was heavily curated. It is very probable that more plant-working tools are present in the sample, the wear-traces of which are not detectable.

Unfortunately, in some reports on functional analysis of LBK flints the distinction between non-silicious and silicious plants is not always made, nor are cereals always differentiated. Vaughan, in his interpretation of the Langweiler 8 and Laurenzberg 7 material lists that of the used zones 4% indicates use on reeds, 38% use on soft plants (Vaughan 1985b: 328). Why he makes this distinction is not evident, nor is it apparent whether this latter category also includes tools for harvesting cereals.

It is not at all clear what sort of plants were worked with the Beek-Molensteeg tools. In one case the traces were present on what was originally probably a hafted blade, in conjunction with other traces such as from meat. It might very well be that we are dealing here with a multipurpose 'kitchen' knife employed during the preparation of meals (*fig. 46c*). It should be noted that this particular implement was made from light-grey Belgian flint. In other instances, single-type uses are represented: in the case of transverse movements these are suggestive of craft activities such as the shredding of plant fibres, a.o. for making clothes. The tools used in longitudinal movement might have functioned to neatly section plants stems, and probably not for harvesting, because gathering plants is generally far more easy by hand-picking, especially when the stands are dispersed (cf. *3.5.1.1*). As has been stated before, polishes characteristic for specific plant species have yet to be found (cf. *3.5.2.1*). Until more specific experimentation has taken place, or additional botanical information becomes available, it would be inprudent to speculate about the plant species involved.

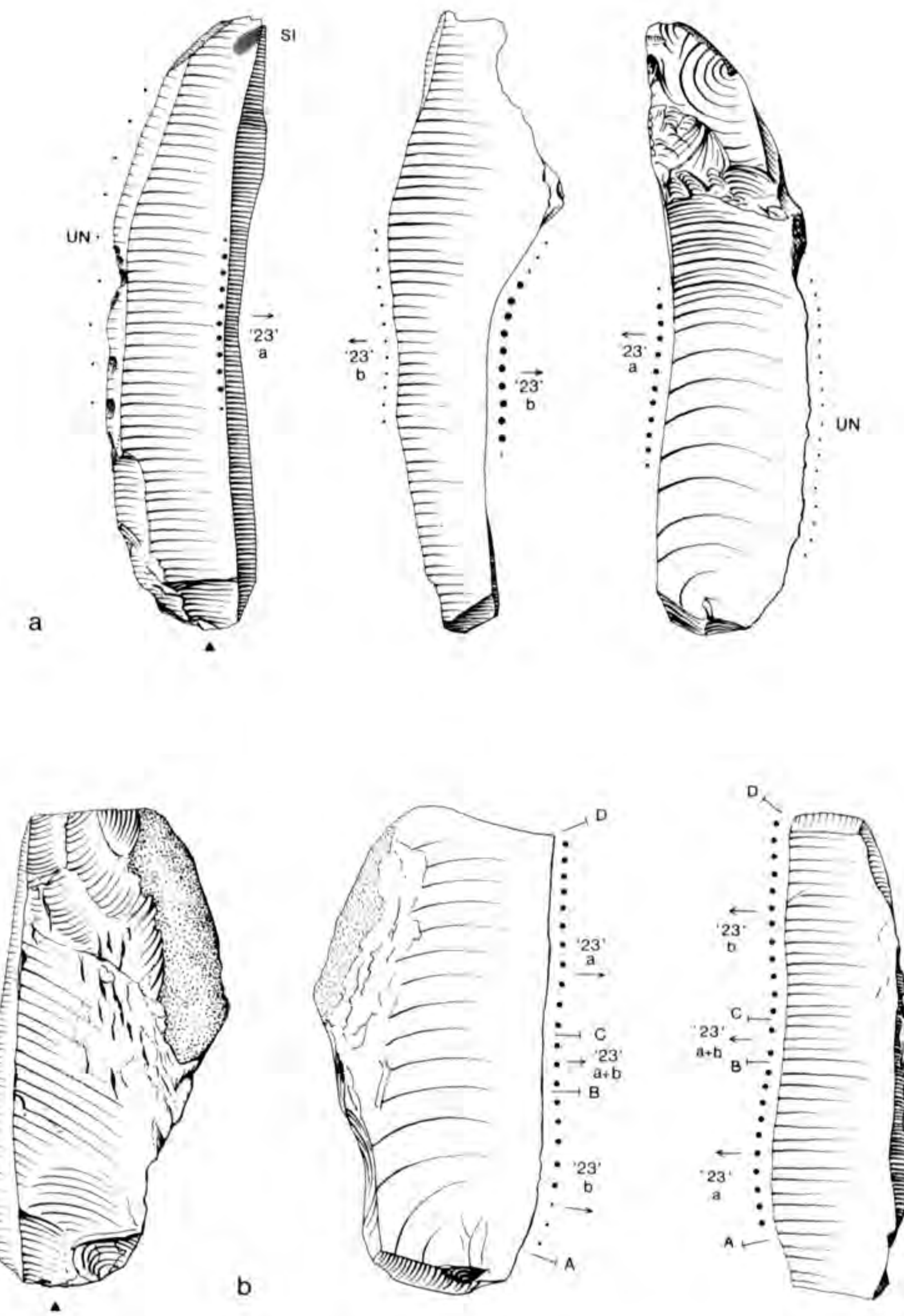
5.4.2.5 *Reaping of cereals*

So-called sickle-gloss was present on nine used zones (AUAs), all of them employed in a longitudinal movement. The polish, visible with the naked eye as a lustrous band on the tool edge, was very rough and cratered when viewed under the microscope. Striations were numerous, while there were occasional examples of edge-removals. Usually, unretouched blades or blade-fragments displayed the above-described combination of wear-traces (*fig. 46d-f*).

In addition to the sickle blades retrieved from the IPL excavation, a further three examples were excavated by Van Veen just adjacent to the trench, while four more were present in his and Aussems' collections. From these additional seven sickle blades, two were produced from Valkenburg flint.

It is generally assumed that the polish visible on the sickle blades is due to the reaping of cereals. The polish, however, which was obtained on experimental sickles used to harvest barley, emmer and bread wheat, did not resemble the archaeological polish. While the experimental polish was extremely smooth and highly reflective, with few striations, the archaeological sheen was rough, less reflective and scarred by innumerable striations (*figs. 47d-f*). The same discrepancy had been noted by Juel Jensen (1988b, *in press*). She has, however, been able to reproduce the archaeological version when harvesting a field infested with weeds at the experimental farm in Lejre, Denmark. Juel Jensen concludes that the striations must have been caused by contact with weeds (Juel Jensen 1988b, *in press*). An attempt was made to duplicate her experiment during the summer of 1988 in Lejre. Although this time the field contained more weeds than in previous years (observation H.Juel Jensen) (*fig. 22*), the polish observed on the two tools used (cf. *3.5.2.2*) was nevertheless smooth and highly reflective with few if any striations (*fig. 27a*); in fact the polish was similar to the sheen obtained on modern, 'clean' fields. This discrepancy between Juel Jensen's and my own results may be attributable to the fact that the former used her tool for 7 hours, while the author's tools were only employed for 2.5 hours. In a more linked stage of polish development, striations might appear, due to the fact that a polished surface is less hard than an unpolished one (Witthoft 1967).

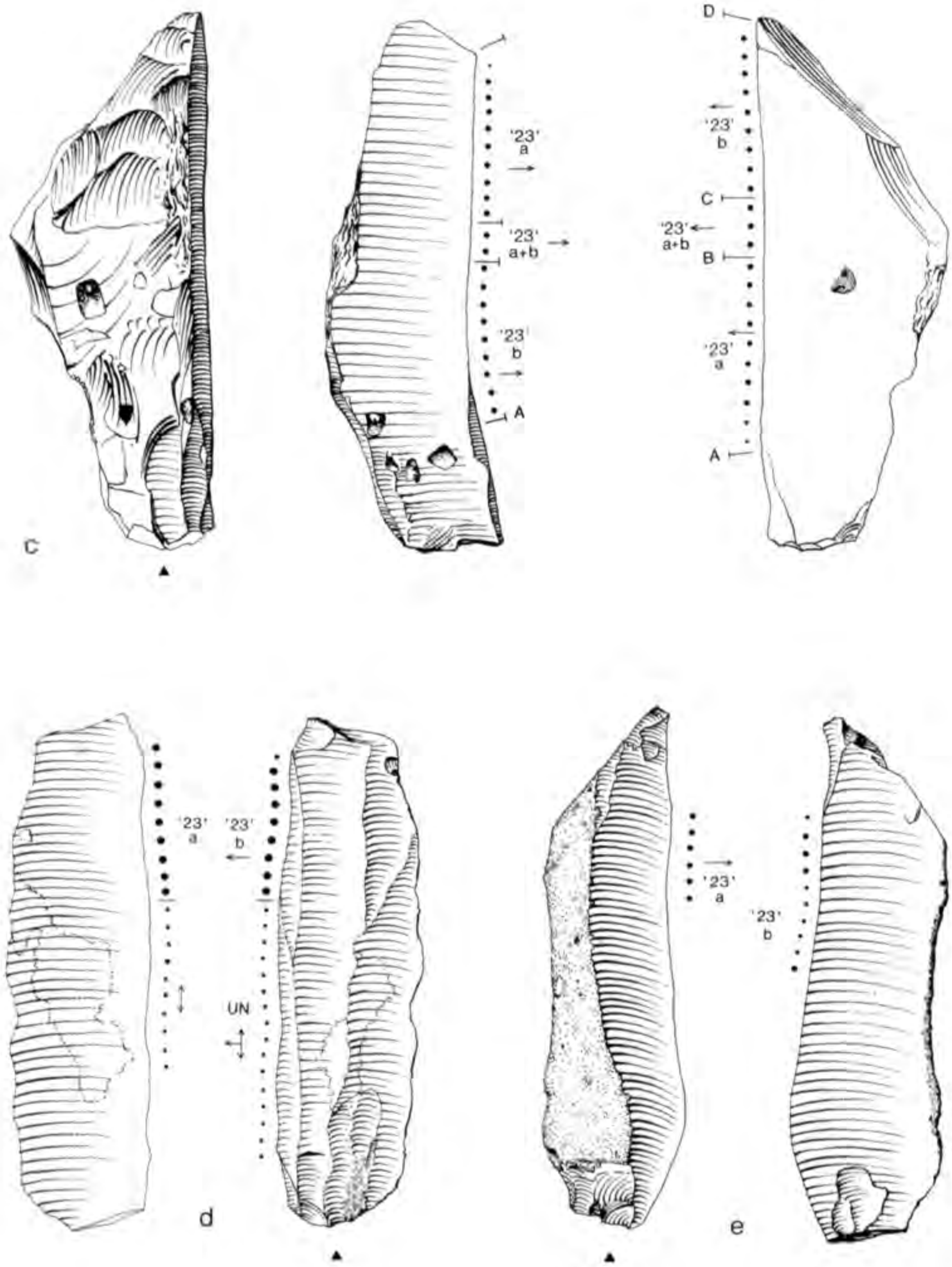
The 'weed' hypothesis described above is supported by palaeobotanical evidence from various LBK sites indicating the presence of weeds among the carbonised grains from the



rubbish pits (Bakels/ Rousselle 1985). Moreover, evidence exists, for instance at Aubechies, that weed plants harvested along with the grain were at least 50 cm high (Bakels/ Rousselle 1985: 50). The latter authors make a further remark which is of relevance to the question of the amount of weeds in the LBK fields: both weed species which thrive when the grain is sown in autumn (winterwheat), and those which prosper if the grain is sown in spring, are present in the samples. Bakels and Rousselle (1985: 55) argue that it is likely that the grain has been sown in spring in fields which were not totally cleaned of the previous autumn's weed species. This suggests that the amount of weed among the crops might have been considerable.

The exact interpretation of the sickle blades continues to

Fig. 48 Beek-Molensteeg: quartiers d'orange (a-c) and two blades (d, e) on which polish '23' was observed. a) BMO125, b) BMO90, c) BMO109, d) BMO264, e) BMO319 (1:1).



be somewhat of a problem. Although experimental and archaeological wear-traces do not match in the sense that the latter are characterised by striations, it is nevertheless likely that the implements were used for harvesting cereals. An explanation for the presence of striations is still required; the 'weed-hypothesis' proposed by Juel Jensen is attractive in this respect (see also *3.5.2.2*), and it would be very worthwhile to continue experimentation in this direction.

Hafting traces, in the form of small spots of bone- or wood-polish from friction, were absent on the sickle blades. This supports the assumption that an adhesive was used to fix the blades and blade-fragments; in such a way movement of the flint within its haft was severely restricted and no damage could occur (cf. Keeley 1982). In one instance, tool

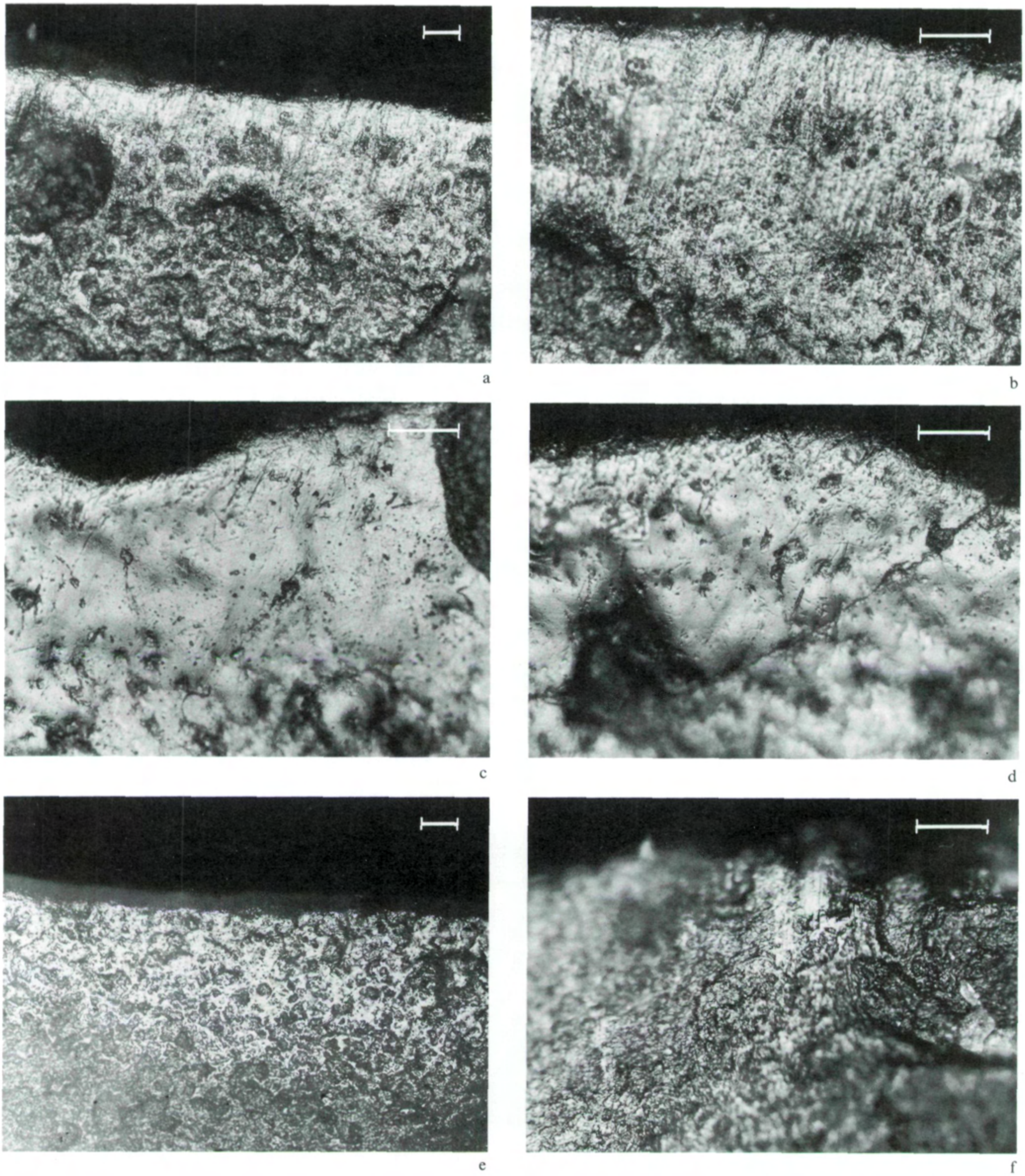


Fig. 49 Beek-Molensteeg: wear-traces observed on the artefacts depicted in fig. 48. All scale bars equal 50 μ. a) 'hide-like polish' ('23') displayed by artefact BMO90 (100x), b) idem (200x), c) smoothly polished aspect ('23b') seen on BMO90 (200x), d) view on the relationship between rough ('23a') and smooth polish ('23b') on same edge of BMO90 (200x), e) band of '23b' on BMO125 (100x), f) BMO9 displaying friction gloss interpreted as being from hafting (200x).

BMO6 (*fig. 46f*), tiny specks of a black material are present on the edge opposite the one displaying sickle-sheen; it could be that these specks are remnants of a fixative. The distribution of the polished areas, covering a triangular section of the edge (*figs. 46d-f*), suggests that they were fixed in sequence in a lunar-shaped haft, with each segment slightly oblique, leaving only a triangular part protruding from the haft. Frank (1983) has done harvesting experiments with replicas of a similar type of tool (the Karanovo-type) and arrives at the conclusion that the hafting is quite effective. This is supported by my own experiments (*chapter 3, note 2*).

One question which needs addressing is how much harvesting time the polish observed on the sickle blades represents. Experiments with cereal-harvesting indicate that sickle-gloss develops slowly. I would estimate that the gloss visible on the archaeological specimens is the result of at least 10 hours work. It would be an interesting endeavour to compare the number of sickle blades between sites. We should not forget, however, that the LBK sickles seem to have been composite tools, similar to the Karanovo one, so a group of blades represents one tool. Moreover, absolute numbers are not very illuminating, since from each site a different percentage has been excavated, while colluvial processes vary. In addition, loss of sickle blade-fragments on the fields seems very likely, and so retooling activities may have taken place there as well, in order to replace lost fragments.

5.4.2.6 Cutting meat

Only two tools show evidence for contact with meat (*fig. 46c*). It is very likely that a much higher number of the artefacts were used for cutting meat, but traces are lacking, because the grain size of Rijckholt, and certainly of Valkenburg flint is usually too coarse to enable the development of wear. In chapter 3 the difficulties with the interpretation of this material have already been outlined (*3.6*).

5.4.2.7 Polish '23': an unresolved transverse motion

On all of the *quartiers d'orange* (N = 3) and on two blades (*figs. 48a-e*), a very strange combination of polish attributes was found. One aspect of the used zone exhibits a very smooth, almost 'snowfield'-like, highly reflective polish, somewhat reminiscent of reed or well-developed antler-polish (*figs. 49c-e*). The polish has a perpendicular directionality and extends about 400 μ into the piece. Striations are absent, as is edge-damage, but the edge is very rounded. The other aspect of the tools displays a totally different polish: rough, matt and covered with striations oriented perpendicular to the edge (*figs. 49a, 49b*). The two polish versions are certainly correlated and caused by one activity involving a transverse motion. Definite proof of this is provided by the tool BMO109 (*fig. 48c*), the distal part of the edge exhibiting the rough version on the ventral and the smooth polish on the dorsal aspect, while the proximal part shows the pattern reversed. This tool has thus been used twice on the same edge, and was turned around between the two use-instances. Another interesting tool is BMO125, actually not a *quartier d'orange* but *débitage en frite*, made of light-grey Belgian flint. This piece possessed two unretouched edges with angles of c. 85°, both of which displayed polish '23'. It should be mentioned that in four of the six cases this polish was located on a zone with an edge angle of 70°-90°; only tool BMO319 had an edge angle of 60°. In all cases the edges were unretouched and very slightly concave when viewed from above. The polish was invariably limited to about 2.5 cm along the edge. No traces suggestive of hafting could be located. It is likely that these tools were held in the hand during use.

This polish has first been described by Keeley (1977) who examined a few tools from Hienheim (Bavaria, West-Germany), one of which exhibited the same combination of rough and smooth polish. It concerns a complete blade of tabular flint with a length of 7.8 cm and a width of 1.4 cm. On one unretouched edge, with an edge angle of 68°, a stretch of polish of c. 2.5 cm is visible (M.de Grooth *pers. comm.*). Keeley argues that this combination of traces could be caused by dehairing wet hides with the addition of mud. He supports this suggestion with an ethnographic example of North-American Indians, but has not experimentally tested his idea. He assumes that the aspect with the rough polish is the surface coming into contact with the hide, while the smooth polish is caused by the mud-particles (Keeley 1977: 71). Caspar, in his analysis of Belgian LBK sites, has found exactly the same wear pattern as described above on almost all the *quartiers d'orange* he has examined. He supports Keeley's dehairing hypothesis as to their function (Cahen et al. 1986: 47).

Although Keeley's arguments sound reasonable enough and could theoretically explain the character of the two polish versions, it is not convincing for one major reason: the well-defined distribution of the polish along the edge and its limitation to a stretch of 1.5 - 2.5 cm, does not conform with the properties of the assumed contact-material, i.e. wet hide. A wet hide which has to be dehaired does not have a circumscribed shape and will never cause a restricted polish distribution as is observed on the archaeological tools. The actual contact-material must have possessed a well-defined, fixed shape, and contact must have been limited to c. 2 cm. Wooden branches seem a likely possibility, but all experiments done so far yield nothing like the traces described above, but just 'ordinary wood-polishes'. So far the search for the 'culprit' has not been successful. As this polish appears at such geographically-separated sites as Hienheim and Darion, it seems that the activity it represents forms an integral part of the 'LBK complex'. One material which then immediately comes to mind is flax (*Linum usitatissimum*), which makes its entry in LBK context (Bakels 1978; Bakels/ Rousselle 1985). Traditional Dutch and Belgian flax-processing tools and their application, as indicated by ethnohistorical sources (De Wilde 1984; Van Iersel 1985), do not bear much similarity to the *quartiers d'orange* and the way in which they seem to have been used. Nevertheless, one experiment was performed loosening the inner flax fibres from the putrefied outer stems. The rotting process was induced by leaving the flax in water for a few days. With the blunt edge of an experimental *quartier d'orange* I attempted to break and remove the outer skin, without damaging the inner flax fibres (*fig. 19*). The tool worked well and, if the bundles worked at any one time did not exceed a thickness of ± 2 cm, contact was indeed confined to only part of the working edge. Unfortunately, the resulting wear-traces (*fig. 25a*) did not bear any resemblance to the archaeological ones, apart from producing a similarly rounded edge.

Another material category which was investigated is formed by bramble-branches. These are reported to be extremely suitable for the manufacture of beehives, because they cause harmful insects to stay away (B.Decker *pers.comm.*). In the Netherlands most beehives are made of this material. The thorns and bark are removed by pulling the branch over a sharp edge. An experiment was performed to test this but the resulting wear-traces, again, did not match the archaeological ones. Obviously, the options are not exhausted by flax and bramble-branches. Other possibilities, which have not yet been investigated, include softening strips of bark or strips of skin. To conclude, the search for the contact-material responsible for polish '23' is still continuing.

5.4.2.8 The use of projectile points

Three instances of bending fractures were encountered: these traces are commonly assumed to derive from impact, and a use as projectile points can be inferred (see *3.8.2*). The tools in question are too small to be spear points. Typologically, in all three cases it concerned LBK points (*figs. 46g, 46h*). The contact-material involved could not be inferred; no polish was visible.

5.4.2.9 Working hard and soft material

In certain cases it was impossible to give a specific interpretation of contact-material, but whether it concerned a soft or hard material could still be assessed on the basis of the presence or absence of edge-removals in conjunction with shape and edge angle of the used zone. Four zones were used on soft material (two scraping, two cutting), two on a hard substance (both longitudinal).

5.4.2.10 Working unknown material

Quite a large percentage (N = 32, or 21.5%) of the used zones could not be interpreted as to contact-material involved. Motions included transverse actions (N = 3), longitudinal movements (N = 4), instances of hafting (N = 7), projectile (N = 3), boring (N = 1), and 'unsure' (N = 14).

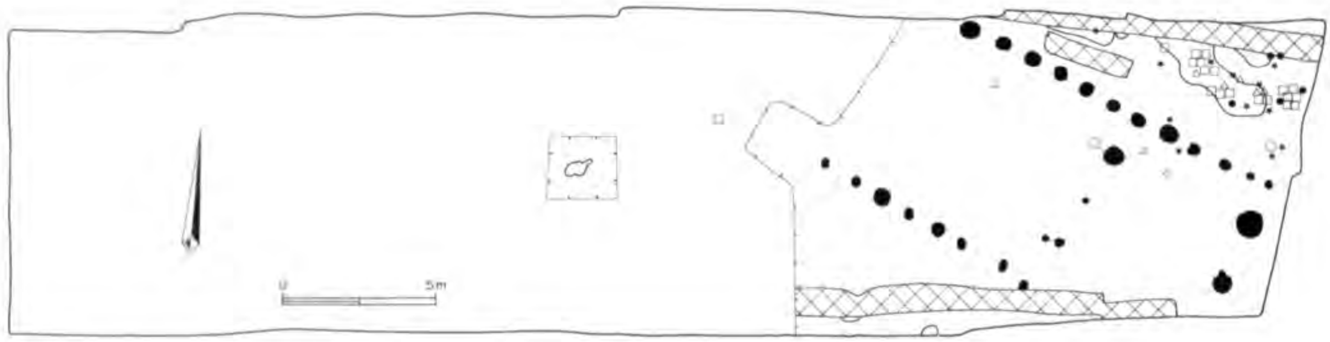
5.4.2.11 Hafting

Traces of hafting in the form of polish spots were observed on 11 PUAs. Hide was the contact-material in three cases inferred, in one instance it was wood/ bone/ antler, and on the remaining seven PUAs 'unsure'. Hafting as possible 'motion' was inferred from the location, direction and kind of the wear-traces (*fig. 49f*) in relation to the general shape of the tool. The three tools with traces interpreted as resulting from hide-working (*fig. 44g*) were all endscrapers produced on blades, with their proximal half probably inserted into a haft. Caspar (1985: 69) has observed a comparable distribution of hide-polish on tools from Darion and suggests that the hide-polish is due to the insertion of a strip of raw hide between the flint tool and its haft[1]. Such a strip also facilitates the retooling (*sensu* Keeley 1982: 799) of the haft. The idea that the endscrapers were hafted is supported by the presence of four distal ends of such scrapers, all displaying evidence for hide-working (*fig. 44h*). These pieces, as well as one proximal end with polish (*fig. 44g*), exhibit a smooth break with a lip. Most likely, such breaks can be attributed to an excess of pressure on a hafted endscraper. Strangely enough, however, the pressure leading to the break must have been excerted on the dorsal, retouched aspect: this might suggest that the scrapers were used in a pushing motion (away from the worker) while holding the tool at a high angle.

Indirect evidence of hafting is also present on sickle blades. These tools display a well-defined triangular polished surface on one edge (*figs. 46d-f*), while on the opposite edge no traces are present. It is possible that this latter edge was fixed into the haft by means of an adhesive, perhaps resin. This would seem to be confirmed by the presence of tiny black specks of deposit on tool BMO6, which might be the remnants of such a material. Experiments have indicated that such a hafting procedure leaves few, if any, traces of wear on the flint tool (Keeley 1982), and without doubt there were many more hafted implements than we have evidence for.

5.4.3 Spatial distribution

Like the spatial distribution of the various tool types, most used pieces concentrate in the rubbish pit and its surrounding area. A few artefacts are located within the house, with hardly any outside this area. All wood- and plant-working tools centre on the rubbish pit (*fig. 50*). Only the hide-working tools (*fig. 51*) have a slightly wider distribution. Assuming that this patterning reflects primary discard of implements, this might perhaps indicate that hide-working activities are located outside the house, with tools being discarded on the



□ wood • soft plants ▫ cereals • polish '23'

Fig. 50 Spatial distribution of the soft plant-processing, cereal-harvesting, and wood-working implements from Beek-Molensteeg. Also depicted is the number of instances of polish '23' (one sickle blade and two PUAs with wood-working traces are not illustrated as they were found on the dump).

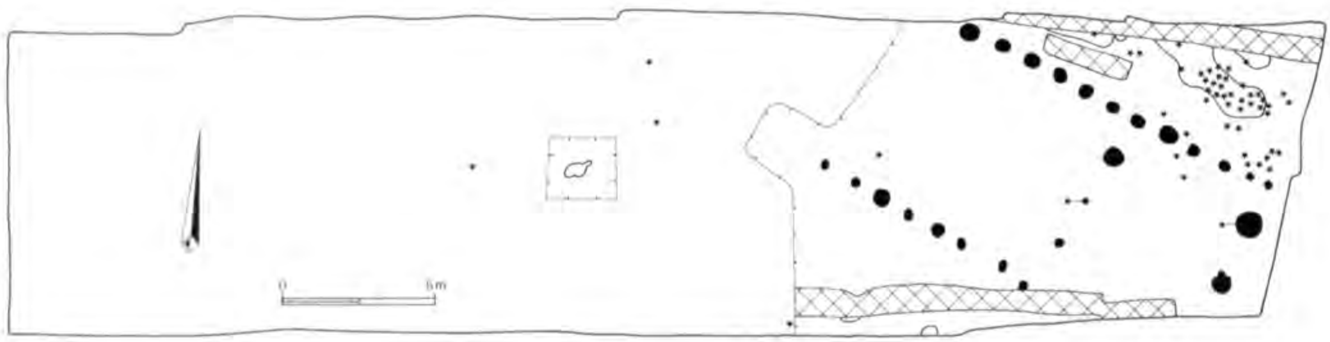
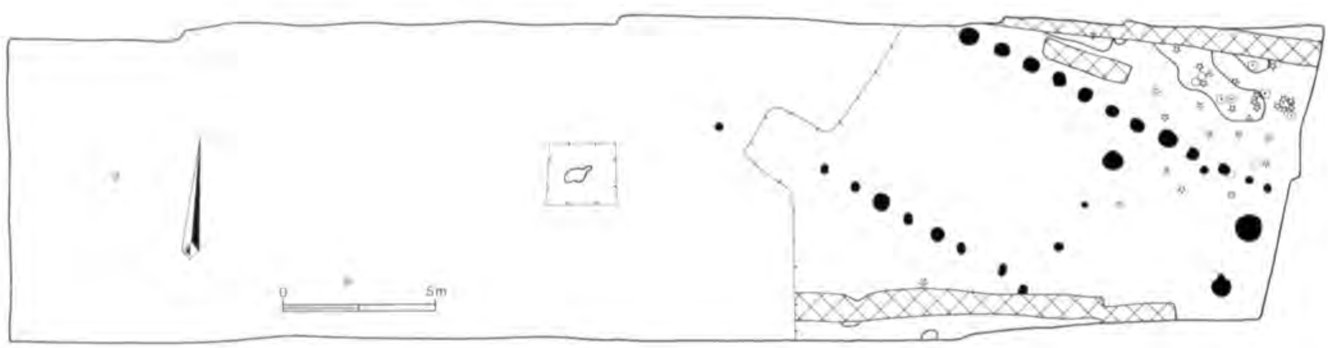


Fig. 51 Spatial distribution of the hide-working tools from Beek-Molensteeg.



○ bone/wood/antler • meat ◎ soft material ◎ hard material ✳ unknown material △ projectile

Fig. 52 Spatial distribution of the tools with miscellaneous traces from Beek-Molensteeg. One PUA with traces indicative of contact with a soft material and one with traces of unknown origin were found on the dump.

Table 13 Beek-Molensteeg: edge-angle, divided into classes, versus inferred motion by actually used area (AUA).

	<20°	20-39°	40-59°	60-79°	80-99°	≥100°	total
transverse	–	2	2	5	3	–	12
scraping	–	2	7	16	16	–	41
whittling	–	3	3	1	–	–	7
cutting/sawing	–	17	25	3	1	–	46
carving	–	1	1	–	–	–	2
splitting	–	–	–	–	1	–	1
boring/piercing	2	–	–	–	–	–	2
projectile	3	–	–	–	–	–	3
hafting	–	3	8	–	–	–	11
unsure	–	7	7	7	3	–	24
total	5	35	53	32	24	–	149

Table 14 Beek-Molensteeg: edge-angle, divided into classes, versus inferred contact-material by actually used area (AUA).

	<20°	20-39°	40-59°	60-79°	80-99°	≥100°	total
hide	1	9	19	14	11	–	54
wood	–	3	9	6	5	–	23
wood/bone/antler	–	1	2	1	–	–	4
soft plant	–	7	5	–	1	–	13
cereals	–	5	3	–	1	–	9
meat	–	–	2	–	–	–	2
'23'	–	–	–	3	3	–	6
hard material	–	1	1	–	–	–	2
soft material	–	1	2	–	1	–	4
unknown	4	8	10	8	2	–	32
total	5	35	53	32	24	–	149

Table 15 Beek-Molensteeg: edge-angle, divided into classes, versus inferred intensity of wear by potentially used area (PUA).

	<20°	20-39°	40-59°	60-79°	80-99°	≥100°	total
no traces	1	144 (64.0%)	139 (61.0%)	40 (40.0%)	18 (27.2%)	1	343
lightly	1	6 (2.7%)	4 (1.8%)	9 (9.0%)	5 (7.6%)	–	25
medium	–	4 (1.8%)	9 (3.9%)	7 (7.0%)	5 (7.6%)	–	25
heavily	–	14 (6.2%)	21 (9.2%)	10 (10.0%)	5 (7.6%)	–	50
resharpened	–	1 (0.4%)	–	–	5 (7.6%)	–	6
probably used	–	7 (3.1%)	5 (2.1%)	4 (4.0%)	1 (1.5%)	–	17
not interpretable	–	40 (17.8%)	33 (14.5%)	24 (24.0%)	23 (23.8%)	1	121
unsure	4	9 (4.0%)	17 (7.5%)	6 (6.0%)	4 (6.1%)	–	40
total	6	225 (100 %)	228 (100 %)	100 (100 %)	66 (100 %)	2	627

Table 16 Beek-Molensteeg: relationship between shape of the edge versus inferred motion per actually used area (AUA).

	straight	convex	concave	pointed	irregular	total
transverse	6	3	–	–	3	12
scraping	8	32	–	–	1	41
whittling	5	1	1	–	–	7
cutting/sawing	23	13	2	–	8	46
carving	2	–	–	–	–	2
splitting	1	–	–	–	–	1
boring/piercing	–	–	–	2	–	2
projectile	–	–	1	2	–	3
hafting	7	2	2	–	–	11
unsure	7	11	5	–	1	24
total	59	62	11	4	13	149

Table 17 Beek-Molensteeg: relationship between shape of the edge and inferred contact-material per actually used area (AUA).

	straight	convex	concave	pointed	irregular	total
hide	18	29	–	1	6	54
wood	6	11	3	–	3	23
wood/bone/antler	1	1	1	–	1	4
soft plant	8	3	2	–	–	13
cereals	6	1	–	–	2	9
meat	1	–	1	–	–	2
'23'	5	1	–	–	–	6
hard material	2	–	–	–	–	2
soft material	1	3	–	–	–	4
unknown	11	13	4	3	1	32
total	59	62	11	4	13	149

Table 18 Beek-Molensteeg: intensity of wear versus shape of the edge by potentially used area (PUA).

	straight	convex	concave	pointed	irregular	total
no traces	175 (15.5%)	71 (45.5%)	58 (61.0%)	1	38	343
lightly worn	1 (2.3%)	11 (7.1%)	3 (3.2%)	1	3	25
medium worn	13 (4.4%)	10 (6.4%)	2 (2.1%)	–	–	25
heavily worn	23 (7.7%)	21 (13.5%)	2 (2.1%)	–	4	50
resharpened	1 (0.3%)	3 (1.9%)	–	–	2	6
probably used	10 (3.4%)	5 (3.2%)	–	–	2	17
not interpretable	56 (18.7%)	20 (12.8%)	27 (28.4%)	–	18	121
unsure	14 (4.7%)	15 (9.6%)	3 (3.2%)	3	5	40
total	299 (100 %)	156 (100 %)	95 (100 %)	5	72	627

spot instead of being dumped in a pit after completion of the task. This could, however, only be tested if a much larger area had been excavated. Figure 52 depicts the distribution of the inferred activities other than those mentioned above.

5.5 Aspects of tool form and function

The relationship between the general shape of a tool and its typology and function, is one of the first questions which was addressed by microwear analysis (Odell 1981; Vaughan 1985b; Juel Jensen 1988a). A great number of type categories had been based on simple analogies with present-day tool types. When microwear analysis was first developed, many lithic analists were excited about the possibility this technique offered to test the validity of many of these typological classifications. In this paragraph the relationship between certain morphological attributes of individual working edges will first be examined. Subsequently, the functional homogeneity of tool types will be discussed (*5.5.5*). Lastly, the question will be addressed whether artefacts made of Rijckholt material and those made of Valkenburg flint display the same pattern of use (*5.5.6*).

5.5.1 Edge angle

The first aspect of the tool form which was investigated concerned edge angle. A clear relationship could be demonstrated between edge angle and motion (*table 13*). Leaving aside the categories with less entries and concentrating on scraping and cutting, it can be seen that the majority of the cutting tools have edges smaller than 60°, while most scraping edges score 60° or more. A correlation between edge angle groups and motion such as has been suggested by Wilmsen (1968) is not in evidence here.

In general, hide-working implements possess a variety of edge angles, with a slight emphasis on higher edge angles. This can be explained by the fact that hide-processing involved both longitudinal and transverse motions (see *table 14*). Tools for soft plant-processing and cereal-harvesting generally have smaller edge angles, which is not surprising, as they are mostly used in a cutting motion. Wood-working tools exhibit a variety of edges. These results indicate that caution is needed when inferring tool function on the basis of edge angle measurements (cf. Wilmsen 1968; Tainter 1979).

A third category examined in relation to edge angle was degree of wear exhibited by the tools (*table 15*). Edge angles smaller than 20° or larger than 100° are rarely represented among the PUAs; if present, they turn out to be seldom used. The other categories of edge angle do not show any differences.

5.5.2 Shape of the edge

The second morphological attribute studied was the shape of the edge when seen from above (convex, concave, straight). As might be expected, straight edges were used for longitudinal motions while slightly convex and convex edges

Table 19 Beek-Molensteeg: inferred motion versus shape of the aspect surfaces (profile) by actually used area (AUA). 1 = straight; 2 = convex; 3 = concave; first code = ventral; second code = dorsal.

	11	12	13	21	22	23	31	32	total
transverse	10	1	1	–	–	–	–	–	12
scraping	6	21	–	1	–	1	1	11	41
whittling	5	–	1	1	–	–	–	–	7
cutting/sawing	41	3	1	–	–	–	–	1	46
carving	2	–	–	–	–	–	–	–	2
splitting	1	–	–	–	–	–	–	–	1
boring/piercing	–	2	–	–	–	–	–	–	2
projectile	1	1	–	–	1	–	–	–	3
hafting	10	–	1	–	–	–	–	–	11
unsure	13	7	2	1	–	–	–	1	24
total	89	35	6	3	1	1	1	13	149

Table 20 Beek-Molensteeg: inferred contact-material versus shape of the aspect surfaces (profile) by actually used area (AUA). 1 = straight; 2 = convex; 3 = concave; first code = ventral; second code = dorsal.

	11	12	13	21	22	23	31	32	total
hide	27	18	–	–	–	1	–	8	54
wood	9	7	1	3	–	–	–	3	23
wood/bone/antler	3	–	–	–	–	–	–	1	4
soft plant	11	–	2	–	–	–	–	–	13
cereals	7	1	1	–	–	–	–	–	9
meat	2	–	–	–	–	–	–	–	2
'23'	6	–	–	–	1	–	–	–	7
hard material	2	–	–	–	–	–	–	–	2
soft material	3	1	–	–	–	–	–	–	4
unknown	19	8	2	–	1	–	1	1	32
total	89	35	6	3	1	1	1	13	149

Table 21 Beek-Molensteeg: intensity of wear versus shape of the aspect surfaces by potentially used area (PUA).

	11	12	13	21	22	23	31	32	33	total
no traces	272	37	16	10	1	1	2	4	–	343
lightly worn	12	6	2	3	–	–	–	2	–	25
medium worn	15	7	–	–	–	1	–	2	–	25
heavily worn	34	9	1	–	–	–	–	6	–	50
resharpened	–	5	–	–	–	–	–	1	–	6
probably used	11	3	1	1	–	–	–	1	–	17
not interpretable	74	37	4	4	1	–	–	–	1	121
unsure	25	8	3	–	1	–	1	2	–	40
total	443	112	27	18	3	2	3	18	1	627

were employed for scraping (*table 16*). It can also be seen from this table that straight edges were more versatile and were deemed appropriate for a variety of motions.

The relationship between contact-material and shape of the edge is less evident (*table 17*). Straight and slightly convex edges were employed on a number of different materials, although there does seem to have been a slight preference for straight edges when it comes to the cutting of plants.

The last aspect considered in respect to the shape of the edge, is degree of wear (*table 18*). Here the number of observations is much larger as it concerns all potentially used areas (PUAs). The percentage of PUAs with no traces is about equal for all the different edge shapes, with the possible exception of the convex edges which show a somewhat higher incidence of use. It must be stressed that this variable might be influenced to a certain extent by the sampling technique used, as highly irregular edge shapes might correlate with irregular cross-sections of the working edge; it will be remembered that the regularity of the cross-section was one of the criteria for the selection of 'potentially used areas'.

5.5.3 Shape of the aspect surfaces

A third morphological attribute which was examined concerns the shape of the ventral and dorsal surfaces composing the edge, i.e. the profile of the edge. When the plane of the ventral surface is straight, an entry of 1 is given. When the opposing dorsal side is convex, the PUA scores 12 (see *fig. 8*). Again we can observe a very strong relationship between the morphology of the tool edge and the inferred motion (*table 19*), since this variable is to some extent correlated with (and hence duplicates the results of) the variable edge angle.

Edges with both a straight ventral and a straight dorsal surface have been employed for cutting purposes and general transverse motions, while the edges with a straight or concave ventral and a convex dorsal side (categories 12 and 32) were considered more suitable for scraping. If we examine inferred contact-material in terms of this morphological variable, it can be seen that the '11' tools are more versatile, with all contact-materials being represented (*table 20*). The '12' and '32' tools are limited to hide- and wood-working.

As to degree of wear, the '11', '12' and '32' edges show a higher frequency of heavy use. The percentage of 'unused' zones is about equal for all categories (*table 21*).

Table 22 Beek-Molensteeg: simplified typology versus motion inferred by actually used area (AUA).

	transverse	scraping	whittling	cutting	carving	splitting	boring	projectile	hafting	unsure	total
unretouched blades	6	4	1	16	–	–	–	–	2	6	35
unretouched flakes	–	–	–	2	–	–	–	–	–	–	2
unretouched waste	–	–	–	1	–	–	1	–	–	–	2
retouched blades	1	3	5	25	2	–	–	–	2	9	47
retouched flakes	–	1	1	–	–	–	–	–	–	2	4
endscrapers-on-blade	–	18	–	–	–	–	–	–	4	1	23
endscrapers-on-flake	–	11	–	1	–	–	–	–	3	1	16
convex scrapers	1	4	–	–	–	–	–	–	–	2	7
multiple scrapers	–	–	–	–	–	–	–	–	–	1	1
quartiers d'orange	4	–	–	–	–	1	–	–	–	1	6
truncated blades	–	–	–	1	–	–	–	–	–	–	1
points	–	–	–	–	–	–	1	–	–	1	2
LBK points	–	–	–	–	–	–	–	3	–	–	3
total	12	41	7	46	2	1	2	3	11	24	149

Table 23 Beek-Molensteeg: simplified typological classification versus inferred contact-material by actually used area (AUA).

	hide	wood	wood/bone antler	soft plant	cereals	meat	'23'	hard material	soft material	unknown	total
unretouched blades	11	2	–	7	2	1	2	–	2	8	35
unretouched flakes	2	–	–	–	–	–	–	–	–	–	2
unretouched waste	2	–	–	–	–	–	–	–	–	–	2
retouched blades	14	11	3	3	7	1	–	2	1	5	47
retouched flakes	1	1	–	–	–	–	–	–	–	2	4
endscrapers-on-blade	13	4	–	1	–	–	–	–	1	4	23
endscrapers-on-flake	10	1	1	–	–	–	–	–	–	4	16
convex scrapers	1	4	–	–	–	–	–	–	–	2	7
multiple scrapers	–	–	–	–	–	–	–	–	–	1	1
quartiers d'orange	1	–	–	–	–	–	4	–	–	1	6
truncated blades	–	–	–	1	–	–	–	–	–	–	1
points	–	–	–	–	–	–	–	–	–	2	2
LBK points	–	–	–	–	–	–	–	–	–	3	3
total	54	23	4	13	9	2	6	2	4	32	149

Table 24 Beek-Molensteeg: simplified typology versus inferred intensity of wear by potentially used area (PUA).

	no traces	lightly worn	medium worn	heavily worn	resharpened	probably used	not interpretable	unsure	total
unretouched blades	177	9	3	11	–	3	34	12	249
unretouched flakes	34	–	–	2	–	–	5	–	41
unretouched waste	3	1	–	–	–	–	5	1	10
retouched blades	77	4	10	21	1	10	42	8	173
retouched flakes	23	5	3	–	–	2	15	4	52
retouched waste	–	–	–	–	–	–	2	–	2
endscrapers-on-flake	–	1	4	7	1	1	1	3	18
endscrapers-on-blade	13	2	3	8	4	1	5	6	42
quartiers d'orange	–	3	2	1	–	–	–	–	6
transverse arrowheads	–	–	–	–	–	–	3	–	3
truncated blades	10	–	–	–	–	–	5	1	16
borers	2	–	–	–	–	–	–	–	2
points	2	–	–	–	–	–	–	2	4
LBK points	2	–	–	–	–	–	4	3	9
total	343	25	25	50	6	17	121	40	627

5.5.4 Form of the cross-section

The form of the cross-section of potentially used areas (PUAs) forms the last morphological attribute studied. Obviously, this variable formed one of the selection criteria for the sample of PUAs and should actually not figure in this analysis. However, it was decided to examine the results to verify the assumption that this variable is important to identify whether or not an edge is considered usable. It can be observed that edges with a straight cross-section are indeed the most versatile, having been used for a variety of motions. Edges with an overhanging convex edge are suitable for scraping and for general transverse motions, while concave cross-sections functioned as cutting tools, but were inappropriate for any other motion. As to the relationship with inferred contact-material, it turns out that straight edges again are the most versatile, having been used on all categories represented. It is not surprising that convex edges, being less suitable for longitudinal motions, do not exhibit wear-traces attributable to plant- and meat-processing.

As to the relationship of form of the cross-section and degree of wear, it appears that, although straight edges might be the most versatile, they are not significantly frequent nor, for that matter, are they heavily worn. Convex edges exhibit slightly more instances of (heavy) use. This is not so surprising when we remember that most convex edges are intentionally retouched ones (i.e. scraper edges) and, as such, are intended to be used. Since the focus of LBK lithic technology was the production of blades, the occurrence of straight edges is of course frequent: by far not all of these edges were selected for use. It would actually have been more appropriate to examine the form of the cross-section only for edges (PUAs) selected on the basis of the presence of retouch.

5.5.5 Tool type

So far in this section on the relationship between tool form and function the emphasis has been on the morphological characteristics of individual working edges. Obviously, there can be several of such edges on one tool. Now, it will be examined whether specific tool types have consistently been used for certain activities. As the variable 'typology' (cf. *chapter 2* and *appendix I*) offers too many categories, the number of possibilities was reduced to fourteen (*tables 22-24*).

The relationship between the motion involved and the tool type is quite evident (*table 22*): all but one 'endscraper' displaying traces of use were employed as scrapers. In this regard there does not seem to be any difference between the function of 'endscrapers-on-flake' versus 'endscrapers-on-blade'. On seven lateral edges of endscrapers hafting traces were observed. *Quartiers d'orange* were used in a transverse motion, and points of the LBK type were indeed used as projectiles, affirming the typological notion. Blades constitute a generalized tool, although they display a strong tendency to be used in longitudinal fashion.

With respect to contact-material (*table 23*), a correlation can be observed between 'endscrapers' and hide. Blades exhibit evidence for a variety of contact substances, while the other tool types are not represented in sufficient numbers to warrant a statement. Only the *quartiers d'orange* consistently display the same mysterious '23'-polish. However, this type of wear is present on every edge with the same morphological characteristics as the functional edge of the *quartiers*, regardless of the tool type on which it is present.

Table 24, depicting the relationship between the degree of wear and the general tool types, reveals that retouched tools are more frequently used than unretouched ones, something which is to be expected. Nevertheless, especially unretouched blades quite often exhibit signs of use. *Quartiers d'orange*, the effective edges of which are also unretouched, are invariably used, while only three endscrapers lacked traces of wear. It must be stressed again that the fact that no traces of use were observed does not necessarily mean that the pieces were not used, as wear does not develop on a 100% basis (see also *3.12*).

5.5.6 Raw material

One of the objectives of the functional study of the Beek-Molensteeg flint assemblage was to determine whether patterns of use are similar for tools made from Rijckholt and those made from Valkenburg flint. Despite the fact that raw material is not a morphological aspect of artefacts, it does have technological implications and hence may indirectly influence tool form.

No differences can be observed in the variety of motions carried out by tools made of Rijckholt, Valkenburg or light-grey Belgian flint (*table 25*). Where minor differences do exist, this can be attributed to distortion due to the small numbers present. The same pertains to contact-material, although in this case the high number of hide-working traces on Valkenburg flint must be noted (*table 26*). When the intensity of wear displayed by the artefacts from the three categories of raw material are observed (*table 27*), the high incidence of Valkenburg PUAs with no traces (73.0%) is remarkable, as is the low incidence of PUAs without traces of use (29.2%) on light-grey Belgian flint. This last observation may be considered an indication that light-grey Belgian flint was valued more highly than the two local flint varieties.

5.5.7 Discussion

The preceding pages show that there is indeed a relationship between the morphology of an edge and the motion executed. All four morphological attributes examined, edge angle, shape of the edge, shape of the aspect surfaces, and form of the cross-section, differed according to whether a longitudinal or a transverse motion had been carried out.

Table 25 Beek-Molensteeg: raw material type versus inferred motion by actually used area (AUA).

	Rijckholt	Valkenburg	light-grey Belgian	other/unsure	total
transverse	10 (8.2%)	–	2 (22.2%)	–	12
scraping	35 (28.7%)	4 (33.3%)	–	2 (33.3%)	41
whittling	6 (4.9%)	1 (8.3%)	–	–	7
cutting/sawing	37 (30.3%)	4 (33.3%)	4 (44.4%)	1 (16.6%)	46
carving	2 (1.6%)	–	–	–	2
splitting	–	–	1 (11.1%)	–	1
boring/piercing	2 (1.6%)	–	–	–	2
projectile	2 (1.6%)	–	1 (11.1%)	–	3
hafting	9 (7.4%)	1 (8.3%)	–	1 (16.6%)	11
unknown	19 (15.6%)	2 (16.6%)	1 (11.1%)	2 (33.3%)	24
total	122 (100 %)	12 (100 %)	9 (100 %)	6 (100 %)	149

Table 26 Beek-Molensteeg: raw material type versus inferred contact-material by actually used area (AUA).

	Rijckholt	Valkenburg	light-grey Belgian	other/unsure	total
hide	43 (35.2%)	7 (58.3%)	2	2	54
wood	21 (17.2%)	1 (8.3%)	–	1	23
wood/bone/antler	4 (3.3%)	–	–	–	4
soft plant	11 (9.1%)	–	2	–	13
cereals	7 (5.7%)	2 (16.7%)	–	–	9
meat	2 (1.6%)	–	–	–	2
'23'	4 (3.3%)	–	2	–	6
hard material	1 (0.8%)	–	1	–	2
soft material	4 (3.3%)	–	–	–	4
unknown	25 (20.5%)	2 (16.7%)	2	3	32
total	122 (100 %)	12 (100 %)	9 (100 %)	6 (100 %)	149

Table 27 Beek-Molensteeg: raw material type versus inferred intensity of wear by potentially used area (PUA).

	Rijckholt	Valkenburg	light-grey Belgian	other/unsure	total
no traces	267 (54.4%)	65 (73.0%)	7 (29.2%)	4	343
lightly worn	18 (3.7%)	2 (2.4%)	1 (4.2%)	4	25
medium worn	21 (4.3%)	2 (2.4%)	1 (4.2%)	1	25
heavily worn	45 (9.2%)	2 (2.4%)	2 (8.3%)	1	50
resharpened	3 (0.6%)	2 (2.4%)	–	1	6
probably used	15 (3.1%)	2 (2.4%)	–	–	17
not interpretable	90 (18.3%)	10 (11.2%)	11 (45.8%)	10	121
unsure	32 (6.5%)	4 (4.5%)	2 (8.3%)	2	40
total	491 (100 %)	89 (100 %)	24 (100 %)	23 (100 %)	627

However, further subdivisions could not be made. Such a correlation was less evident for contact-material. Only in cases where the latter was associated with motion (hide = scraping), did such a relationship exist.

Some of the tool types appear to be standardized in terms of their morphological attributes. Consequently, at least some types, in particular the endscrapers, *quartiers d'orange* and LBK points, display a strong correlation with a specific motion. Furthermore, endscrapers, whether produced on blades or on flakes, and *quartiers d'orange* also correlate with specific contact-materials, i.e. hide and polish '23', respectively.

On the other hand, blades, both retouched and unmodified, constitute a generalized tool for most longitudinal activities, on various contact-materials. Referring to them as 'knives' is therefore not totally inappropriate from a functional point of view. They also exhibit traces of multiple use, further corroborating the conclusion that they should be regarded as a multiple-purpose tool, akin to our modern kitchen or pocket-knife.

5.6 Conclusion

It will be clear that the analysis of the flint material from the Younger LBK site Beek-Molensteeg provided relatively little new information. In terms of the raw materials exploited, the site confirms the scenario of small quantities of finished products, made from exotic raw material types, appearing in Younger LBK assemblages. It also illustrates the beginning of the exploitation of Valkenburg flint during this period (see Löhr et al. 1977; De Grooth 1987a). It might indeed have been the case that the availability of the more accessible sources of Rijckholt flint was strained. Clearly, however, the supply of Rijckholt material was not exhausted at that time as grand-scale exploitation was only to begin during the later Michelsberg period. Michelsberg exploitation of Rijckholt flint constituted mining, a technological innovation which was evidently outside the bounds of the LBK culture. Instead, people apparently turned their attention toward the exploitation of Valkenburg flint, which could also be collected from colluvial deposits. Beek-Molensteeg is the second Younger LBK site, after Beek-Kerkeveld (De Grooth 1987a), yielding large quantities of this raw material. In contrast, the small number of exotic flints cannot have formed a substitute or additional source to the presumably dwindling supply of easily accessible Rijckholt flint. The numbers of such flints at Beek-Molensteeg are too small for people to be directly dependent on it for their regular supply. It seems more likely that these exotic flints functioned in a social manner, for example in maintaining relationships with distant acquaintances in the context of which the flint could be a token of this interaction. The absence of exotic cores, rejuvenation pieces and cortex makes it likely that the artefacts were indeed transported as finished tools, as De Grooth (1987a) also assumes for Elsloo's younger phases. It should be stressed that the perception as to what constitutes an appropriate tool is clearly similar across these interactive networks, as is suggested by the presence of a *quartier d'orange* produced on light-grey Belgian flint (*fig. 48a*).

The technological features exhibited in the Beek-Molensteeg assemblage conform entirely with those observed elsewhere in the vicinity (Löhr et al. 1977; Cahen et al. 1986; De Grooth 1987a). The characteristic rejuvenation pieces are represented, both the platform and the core-face varieties. The typological range is also very similar, although here minor differences exist. These mainly concern types which are difficult to define in terms of specific attributes, or are rather variable in appearance, such as splintered pieces, denticulates etc. So-called regional variation is probably more a matter of definition than an actual absence of certain tool types. The presence of *quartiers d'orange* at Beek-Molensteeg, hitherto assumed to be absent in Dutch LBK assemblages, testifies to this point of view. It should be noted here that upon re-examination of part of the Elsloo assemblage this tool type also turns out to be present at this site (Schreurs 1989; J. Flamman *pers.comm.*).

Lastly, the same uniformity apparently also prevails in the range of activities carried out within the settlement. The presence of heavily-rounded scraping and cutting implements testifies to the processing of hides at this site. If we look at it in a purely quantitative manner, hide-working constituted the most important activity, but we should take into consideration the high visibility of such traces (see *3.12*), as well as the fact that these tools are likely to have been used and discarded 'on-site' (see *5.4.2.1*). The second most important activity was wood-working, presumably concerning the manufacture and repair of small wooden objects and utensils. In the Beek-Molensteeg collection, no evidence was found for bone- or antler-working, confirming the conclusions of other LBK assemblages. Cereals were apparently reaped with flint sickle blades, as testified by the occurrence of nine PUAs with a highly lustrous sheen; the polish was very heavily striated, possibly pointing to the presence of numerous weeds in the LBK fields (but see the discussion in paragraphs *3.5.2.2* and *5.4.2.5*). Twelve potentially used edges display traces interpreted as being the result of contact with soft plants; it can be suggested that these tools were used in craft-activities. Most remarkable was the mysterious polish '23' on three *quartiers d'orange* and two blades (see *5.4.2.7*). It is not yet clear which task this polish represents. The tools were without doubt used in a transverse motion on a substance with a width circumscribed to c. 2 cm. The polish was found on every artefact characterized by an unretouched edge of c. 6-7 cm in length, of great regularity, and an edge angle between 70 and 90°. It can be argued that the task carried out by these working edges constituted an integral part of the LBK cultural pattern, as such tools were found in almost every LBK assemblage so far studied for wear-traces (i.e. Hienheim, Beek-Molensteeg, Elsloo, Darion), whereas they have not been encountered in any other flint assemblage.

Rather remarkable is the very low frequency at which the Beek-Molensteeg artefacts show evidence of use. Of the 114 retouched tools only 54 display wear. If we examine potentially used areas, it is striking that only 141 of the 619 (i.e. 22.8%) PUAs bear use-wear traces, yielding 149 AUAs. Such few indications of use would suggest that the refuse-pit and the area around it contained a lot of knapping waste; refitting might possibly elucidate this further. If we look at used PUAs by raw material, it can be concluded that Valkenburg PUAs display considerably less evidence of use than the ones of Rijckholt flint (13.5% vs. 25.3%), while, at the other hand, PUAs on light-grey Belgian flint were employed more frequently (37.5%). The low percentage of used Valkenburg material might be explained by assuming that this type of flint included a lot of knapping debris: it showed a higher spatial clustering in the pit than the other raw material types. The low incidence of use of Valkenburg flint does question the gravity of the presumed strain on raw material (i.e. of the more accessible Rijckholt flint). The intensive wear of PUAs on exotic flint, i.e. light-grey Belgian, suggests that this material was highly valued and possibly curated. The different flint types did not seem to be associated with specific activities.

A rather strong correlation is present between certain aspects of tool form and motion. Edge angle seems to be the most pertinent morphological feature in this respect, although the relationship was confined to the pairs 'blunt edge = scraping' and 'acute edge = cutting'. When examining the functional integrity of types, it becomes apparent that endscrapers were mostly used for scraping hide, *quartiers d'orange* always displayed polish '23', points were indeed used as projectiles, while blades constituted a general purpose tool.

The apparent uniformity in all aspects of flint use across the Lower Rhine Basin (and possibly beyond), implies that continued research of this type is not likely to enlarge the general picture or to reveal much new information. A functional analysis, which requires such a lot of time, seems especially unrewarding, considering the strong correlation between tool form and function. A use-wear analysis can only be justified when very specific problems are addressed concerning activity loci or internal organization, i.e. intra-site variability. For instance, a relevant question for a site which is 'completely' excavated, is whether every domestic unit really participated in hide-processing, as the present data seem to suggest. Or, to put it differently, use-wear analysis can provide a clue to intra-site specialisation. The technological analysis of the flint assemblage from Elsloo indicates that a domestic mode of production predominated; every household knapped for its own needs. However, in addition, during every occupation phase there seems to be one house with a larger amount of flint waste, especially rejuvenation pieces, than the others (De Grooth 1987a). De Grooth concludes that this house might have been inhabited by an ad-hoc specialist in knapping, who produced not only for his own household, but occasionally also for other families within the settlement. To test this hypothesis, a use-wear analysis of a carefully selected sample from the pits of various houses is now being undertaken by students of the IPL. It is predicted that the flint deriving from these 'specialists houses' should exhibit fewer instances of use.

Although such detailed research concerning a single settlement is very interesting, I believe that it is useful to approach the LBK on a more theoretical plane. Much is known about Bandkeramik settlement and economy, but in my opinion the most intriguing question concerning this culture is left unanswered, and worse, is seldom theorized about: how could this uniformity be maintained across such a large region and over such a long period. This uniformity in itself is in support of the hypothesis that the LBK cultural complex was introduced not so much by diffusion, but by actual immigrants (colonists). Considering the fact that the LBK immigrants had to adapt themselves to different settings, interacting with different neighbours, it is particularly remarkable that such little diversification took place. It seems that it is along these lines that research on LBK needs to proceed, rather than collecting more detailed information, only confirming what has been found numerous times before.

note

1 One experiment with inserting a strip of moist raw hide between a bone haft and flint suggests, however, that this method of hafting does not work, since the hide contracts around the flint as it dries (J. Flamman, *pers.comm.* 1989).

6 The Late Neolithic Vlaardingen sites

6.1 The Vlaardingen-group

6.1.1 General introduction

The sites of the Vlaardingen-culture are confined to the Rhine/ Meuse delta and date from circa 4700-4100 BP, conventional ^{14}C-dates. Because of its specifically coastal distribution (cf. Zandwerven, Vlaardingen, Hekelingen I) the culture was initially referred to as 'Coastal Neolithic' (Modderman 1953: 10). It was only after the type site of Vlaardingen had been excavated in 1961 that the various assemblages were designated as belonging to the Vlaardingen-group (cf. Louwe Kooijmans 1983a: 65).

Up to now c. 25 sites have been found (*fig. 53*). They are located in four different environmental zones:
1. on coastal barriers (Haamstede, Voorschoten, Leidschendam)
2. on levees along creeks in the freshwater tidal zone (Vlaardingen, Hekelingen)
3. in the peat area on riverdunes (Hazendonk)
4. in the area of river-clay deposits on stream levees (Ewijk)

The Vlaardingen-group (VL) has been subdivided chronologically into phases 1a, 1b, 2a and 2b on the basis of the pottery (Louwe Kooijmans 1976). The West Group of the Funnel Beaker culture (TRB), in the northeast of the Netherlands, is roughly contemporaneous but there is little evidence of mutual interaction (Louwe Kooijmans 1983a: 58). Both VL and TRB are contemporaneous with the Seine-Oise-Marne culture (SOM); the northernmost SOM sites are located in the Belgian Ardennes and Hainault. Strangely enough the area between SOM and VL seems to be archaeologically rather sterile (see Louwe Kooijmans 1983a: fig. 1): just a few isolated finds are known. It is only in Limburg, in the valley of the Meuse, that we encounter a few sites, such as Koningsbosch, Kraaienberg and Stein, which are contemporaneous with VL and closely related in terms of the material found there. Louwe Kooijmans (1983a) has suggested that these sites could be termed the Stein-group. Later VL occupation phases are synchronous with the Protruding Foot Beaker culture (PFB); the relationship between these two entities is not yet entirely clear.

Characteristic of VL pottery assemblages are the large thick-walled vessels, stone-gritted and often with perforations under the rim or knobs. Collared flasks and clay discs are common finds. Bone awls and chisels are present in considerable numbers. The flint assemblages are typified by transverse, leaf-shaped and tanged arrow heads, borers, scrapers and polished axes with oval cross-section (Van Regteren Altena et al. 1962-1963). The only convincing house plan derives from Haamstede; it measures approximately 5 x 10 m and has a rectangular shape. House plans have also been reported for Vlaardingen (Glasbergen et al. 1961: 57, 1967: 103) and Leidschendam (Glasbergen et al. 1967: 100), but the cluster of postholes from which these plans were derived could also be interpreted differently.

6.1.2 Subsistence economy

One of the questions preoccupying Dutch archaeologists concerned with the Neolithic is the degree to which the people were fully sedentary and dependent on agriculture and animal husbandry for their subsistence. In the Early Neolithic, during which the Bandkeramik farmers had settled in Limburg (c. 6400 BP), ample evidence exists that a hunter-gatherer lifestyle continued in the north and west of The Netherlands. One example from the Late Mesolithic is the Leien-Wartena complex (Newell 1970). It is also beyond doubt that the transition to sedentary farming was completed by the time of the Early or Middle Bronze Age. However, for the intervening period the picture, especially for the coastal area, is not yet entirely clear.

A number of models have been proposed to explain the transition from hunter-gathering to farming. Zvelebil (1986: 8-10) has provided an outline of the various models regarding this typical archaeological problem. He differentiates between two basic approaches. Firstly, knowledge is supposed to have been the limiting factor: as soon as hunter-gatherers became aware of the advantages of this 'superior' mode of subsistence, they switched over. Secondly, there is an approach based on imbalances between population and resources. Within this framework several variations have been put forward. One idea is that environmental factors, such as desiccation, might have induced people to change to a farming way of life. Another variation is the idea that population growth forced people to farming (Cohen 1977).

The idea that knowledge might have formed the limiting factor can be dismissed on several grounds. Firstly, it has become clear that the basic assumption underlying this model, of farming being a 'superior' mode of subsistence, is

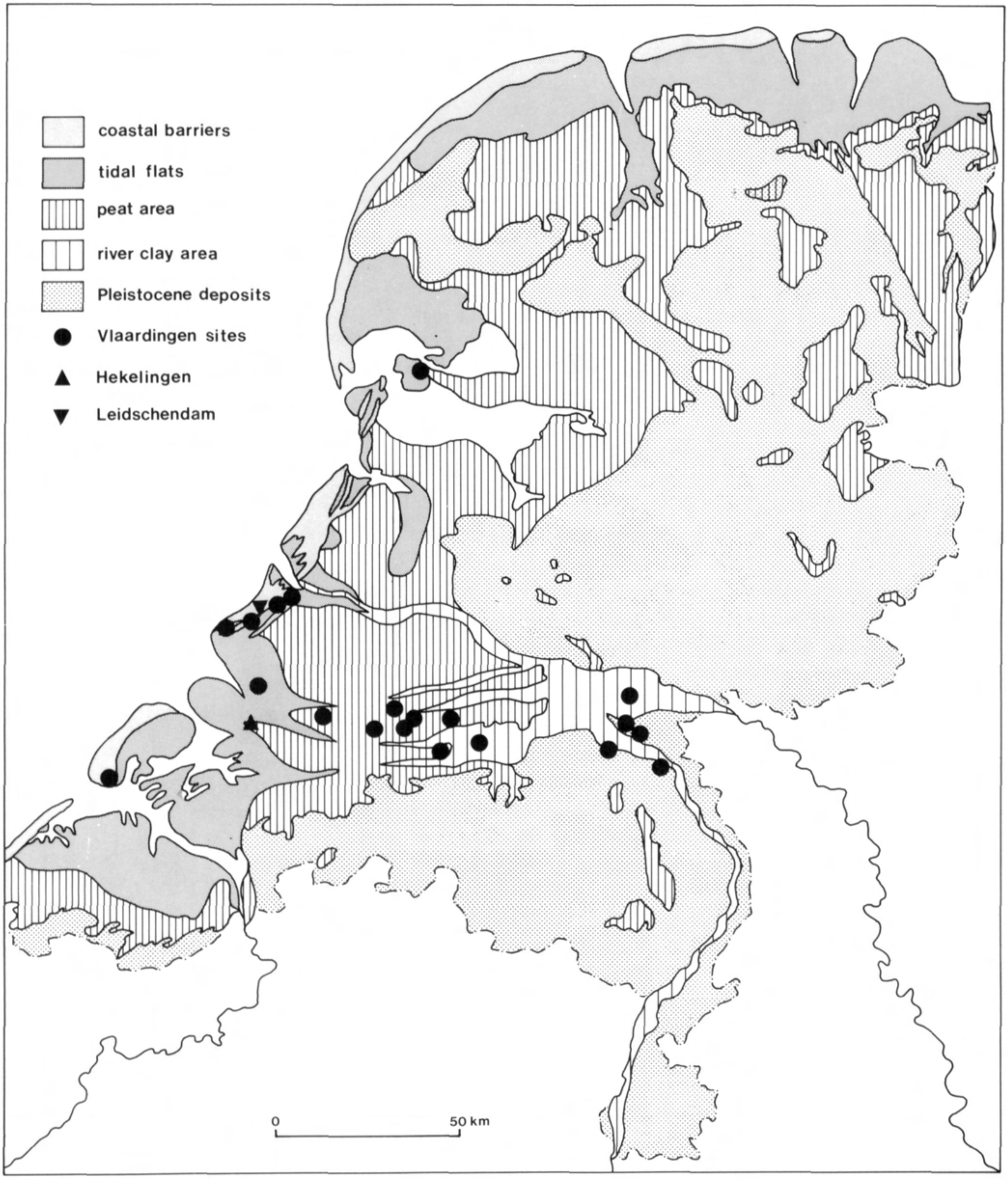


Fig. 53 Location of VL-sites in relation to the geomorphological situation (drawing L.B.M. Verhart).

not valid (cf. the affluent hunter-gatherer (Lee/ DeVore 1968)). Moreover, archaeological and ethnographic evidence shows that both modes of subsistence existed alongside each other for extended periods of time; hunter-gatherers must have known of agriculture, especially because they habitually travel long distances. The second general model, of an imbalance between population and resources, embodies the danger of environmental determinism. Recently, a somewhat attenuated version has been proposed, implying three phases: during the 'availability phase' only foraging is relied upon, in the 'substitution phase' foraging and farming exist alongside each other, while in the 'consolidation phase' farming becomes the main mode of subsistence with foraging losing its economic importance (Zvelebil/ Rowley-Conwy 1984; Zvelebil 1986: fig. 3). This model is quite attractive because it offers a continuum of possible 'poses' with which to describe variability in settlements; it unfortunately does not provide an explanation for the differential change from foraging to farming.

The VL sites can be examined in the light of this issue. We can assume that knowledge about agriculture and animal husbandry was available throughout the Netherlands by the Late Neolithic. In fact some of the VL settlements, those located on the coastal dunes and in the riverine area, reveal evidence of the cultivation of domesticated cereals (Groenman-van Waateringe et al. 1968; Asmussen/ Moree 1987). The same pertains to some of the partially contemporary PFB sites to the north, Kolhorn and Aartswoud (Pals 1983). However, several VL sites are not so easy to interpret: it is far from clear whether agriculture was practised in the freshwater tidal zone or on the riverdunes in the peat area.

Coastal and riparian environments are generally considered to be very productive because of their high biomass. This is especially true of the western coasts of Europe and the America's, where a warm gulf-stream has a moderating effect on the temperature, while seasonal variability is relatively great. Enough food can be obtained by fishing, hunting and gathering, while many of the products can be stored, albeit with some effort due to the prevailing humidity. Consequently, coastal populations are generally considered to be affluent societies (cf. the Indians of the Northwest Coast of America); an archaeological example is provided by the Danish Ertebølle culture. It is often assumed that farming was simply not 'necessary' (Zvelebil/ Rowley-Conwy 1984).

Perhaps the VL sites in the peat- and freshwater tidal zone represent the remains of pockets of such hunter-gatherer-fisher communities. A second possibility (suggested by the presence of bones of domesticated cattle and pigs (see *6.2.1*)) is that it concerned more or less permanent inhabitations of pastorally oriented peoples, who also relied on hunting and gathering; the saltmarshes to the south provided excellent grazing. Lastly, the sites in question could have been bases of exploitation, subsidiary to farming settlements which needed resources specific to these wet environments. Such agricultural settlements might include VL settlements on the dune ridges, e.g. Leidschendam, or riverine sites such as Ewijk. Yet another possibility form the sites of the Stein-group or sites possibly situated to the south on the saltmarshes of Zeeland, where permanent inhabitation might have been possible, analogous to the siting of the PFB settlements of Kolhorn and Aartswoud (see also Louwe Kooijmans 1986, 1987).

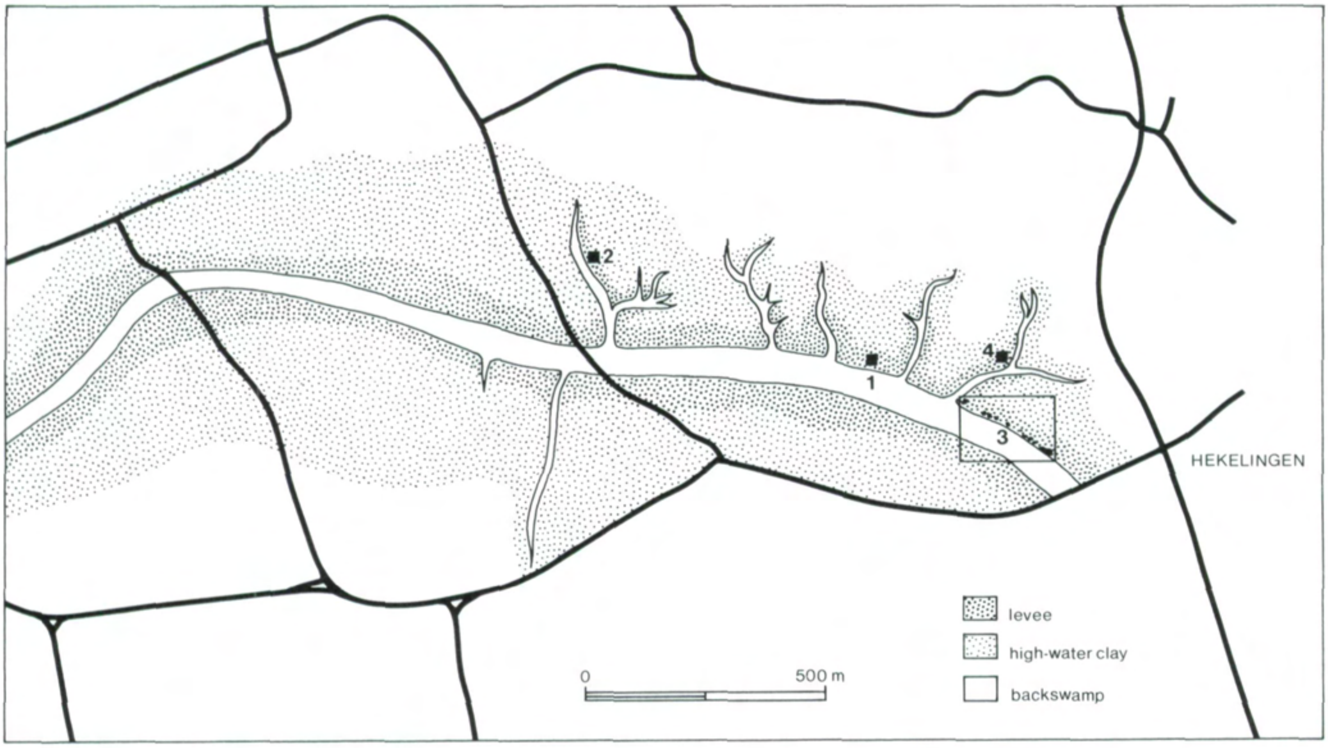
6.1.3 Objectives

In this chapter I will try to shed some light on this problem. My intention was to compare assemblages deriving from all four different environmental zones in which the VL group was present. Paula Bienenfeld had already examined the material from Hazendonk, located in the peat area (Bienenfeld 1986). As well as Middle Neolithic habitation traces, Hazendonk yielded material from all VL phases but VL-2a. As Hazendonk is the only VL site excavated so far in this zone, it was decided to include Bienenfeld's results. The fluviatile depositional zone is not covered because a preliminary study of the material from Ewijk revealed that, unfortunately, the post-depositional surface modifications were too extensive to allow a microwear analysis. Ewijk represents the only site which was, albeit as a 'by-product' of research aimed at the retrieval of Iron Age and Roman remains, excavated in the area of the river-clay deposits. My emphasis was therefore put on the freshwater tidal zone, on the edge of which the site of Hekelingen III was located; the material retrieved here seemed suitable for functional analysis. As a comparison, the flint from the site of Leidschendam, situated on a coastal dune, was also examined. As this assemblage was affected by abrasion, I looked for additional material from this environmental zone, but the flint from the recently excavated site of Voorschoten (Van Veen 1989) displays the same abrasion problem. Consequently, the present chapter will present the results of the analysis of Hekelingen III and Leidschendam. In the conclusion to this chapter I will compare these two sites and the VL levels of Hazendonk.

6.2 Hekelingen III

6.2.1 Introduction and research goals

The site Hekelingen III is situated just south of Spijkenisse in the Vriesland polder. The settlement spreads across the northern levee of a c. 50 m wide freshwater tidal stream and forms a continuation of Hekelingen I, part of which was excavated in 1950 (Modderman 1953) (*fig. 54a*). Together, these sites extend over a distance of 600 m, 200 m of which had to be excavated because of building activities. On the levee, which was c. 20 m wide, a number of find concentrations could be distinguished, hereafter referred to as



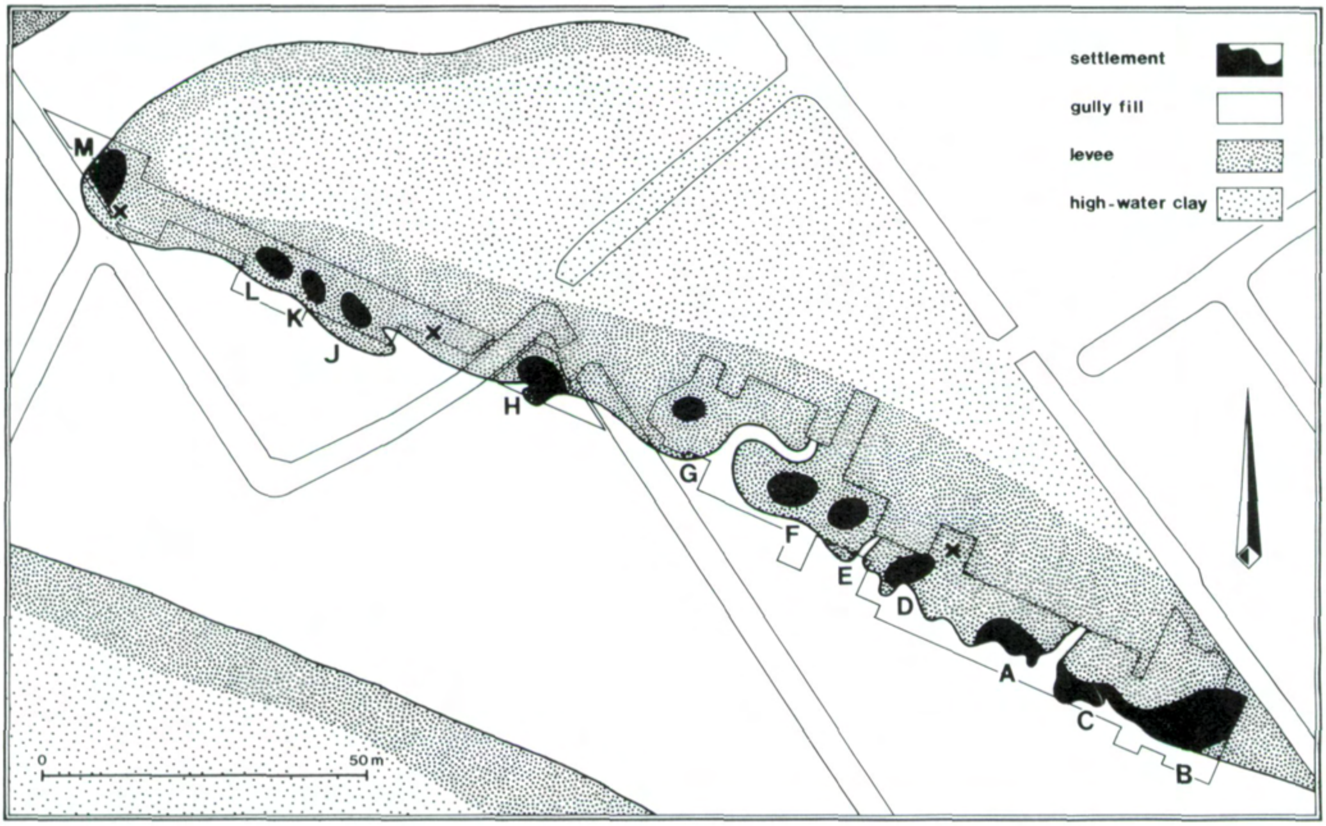


Fig. 54 a) *Location of Hekelingen III in relation to the tidal creeks and backswamps. Hekelingen I, II and IV are shown as well.* b) *location of the archaeological units excavated in Hekelingen III; the excavation trench, following the edge of the levee, is also indicated.*

archaeological units (*fig. 54b*). The salvage operation was carried out from April-October 1980 under the direction of Prof. Dr. L.P. Louwe Kooijmans and Dr. P. van de Velde. During the subsequent building activities another small site, Hekelingen II, was encountered closeby which could not be properly investigated. In addition, during a survey of the area, a fourth, very small site, called Hekelingen IV, was located just north of Hekelingen III on the levee of a small tributary of the main creek; this site was not investigated further (*fig. 54a*). To the south of Hekelingen III, on the opposite bank of the main creek no evidence for human habitation was found (Louwe Kooijmans/ Van de Velde 1980).

The Vriesland polder is unique in that the estuarine landscape formed during the Calais IV transgression phase (see below) lies close to the present-day surface, is undisturbed by subsequent erosion and has not been covered by a thick clay-deposit. The prehistoric landscape consisted of a major freshwater stream of c. 50 m wide and a number of small tributary creeks all lined by levees. Behind the levees lay the backswamp zone, in parts of which peat was growing, while elsewhere an open marsh was present. The system formed part of the delta of the Meuse. To the south, saltmarshes predominated, in what is now the province of Zeeland. Jagerman (1982) has done a geomorphological study of the area; the following description of the stratigraphy is based on his work. Louwe Kooijmans and Van de Velde have combined the geological stratigraphy with the archaeological remains.

Underlying the deposits on which habitation took place, are the saltmarsh deposits of the Calais III transgressive phase. These sediments are cut by the creek and levee system of Calais IV age. Two levee deposits can be differentiated. On the first levee deposit (Calais IV1a), consisting of sandy clay/ clayey fine sand, the archaeological units of Hekelingen III phase 1 are located: A1, B1, C1 and M1. The creek was still active during this period and it is probable that sedimentation occurred during occupation because the material from these sites is well preserved compared with the finds attributed to later phases (L.P.Louwe Kooijmans *pers. comm.*) This sedimentation phase is followed by a period of erosion, during which the creek eroded extensive tracts of the levee, causing some archaeological material to end up in creek deposits, as in unit A1g. Subsequently, sedimentation of the second levee deposit (Calais IVa2) and of the greater part of the channel fill took place. On this second levee, which is more clayey, are found the archaeological units attributed to phase 3: B3, C3, D3, E3, F3 and M3.

Phases 1 and 3 are stratigraphically clearly defined habitation phases (*fig. 55*). Between the erosion and subsequent second sedimentation stage, but stratigraphically somewhat higher than units A1, B1, C1 and M1, are located units H2 and I2, attributed to Hekelingen III phase 2. Since B1 is dated quite late in phase 1, and B3 early in phase 3, only marginally separated from each other by the second levee sediment, and because H2 is synchronous with this latter deposit, Louwe Kooijmans (*in prep.*) assumes a continuous,

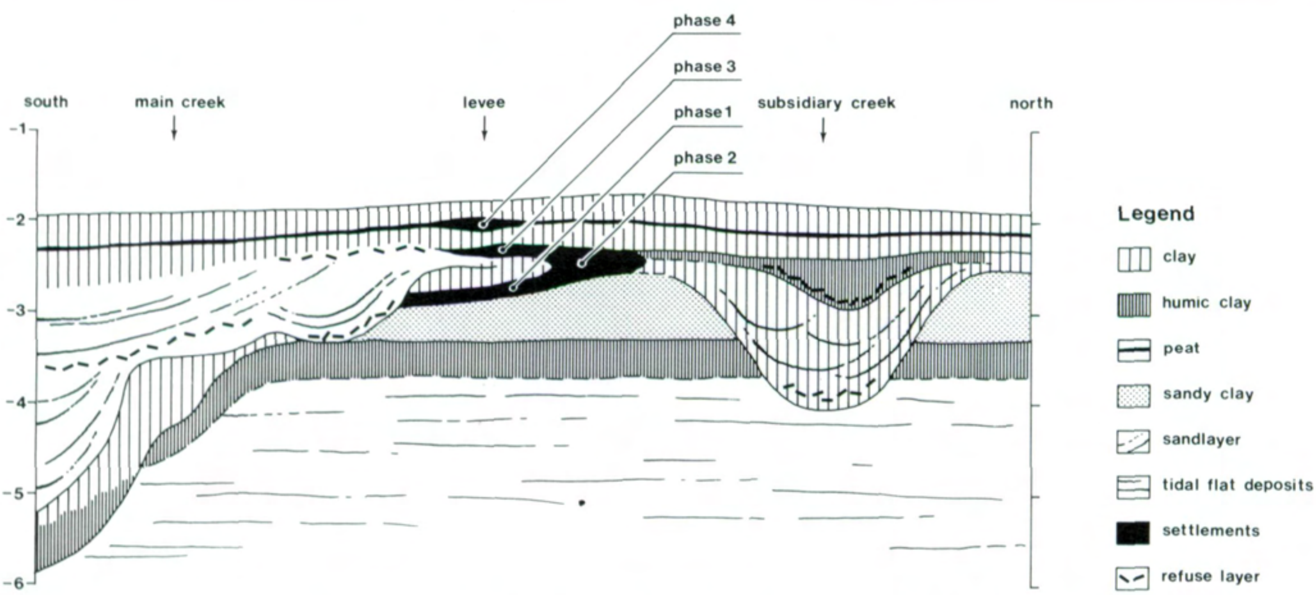


Fig. 55 Schematized profile across the levee and the main creek, indicating vertical position of the four occupation phases.

but shifting occupation. These three habitation phases all yield material belonging to the VL group. Overlying these deposits is the third and final levee sediment, on which Late Bell Beaker material has been encountered (phase 4). The prehistoric occupation levels were formerly sealed by a thick peat deposit of which only a thin band has remained, and on top of this a still extant clay cover.

The above sequence is supported by ^{14}C dates. During excavation a large number of samples could be taken, especially from phases 1 and 3 (Louwe Kooijmans 1985: 100). A total of 8 samples was selected for analysis: two from both phase 1 and 3, one sample each from phases 2 and 4, and one from each of the two creek fills, respectively. Table 28 shows the results. It reveals that the duration of the VL occupation can be estimated at between 200 and 450 years, in VL-1b and VL-2a. It seems that occupation was continuous and that no significant gaps in habitation occurred (Louwe Kooijmans *in prep.*).

A number of studies have attempted to elucidate the environment which prevailed during the period of occupation. Analysis of the wood remains has demonstrated that along the edge of the stream a vegetation of alder (*Alnus*) predominated, while somewhat higher up on the levee ash (*Fraxinus*) was present (Casparie/ Suwijn, *pers.comm.*). On the highest sections of the levee maple (*Acer*), hazel (*Corylus*), prunus (*Prunus*) and hawthorn (*Crataegus*) were attested. No traces of oak (*Quercus*) were found with the exception of five oak posts, belonging to a special funerary structure, which were probably imported (Hoogland 1985). In the backswamp behind the levee willow (*Salix*) and alder predominated. The picture gleaned from the pollen analysis is slightly different: a *Corylus/ Quercus* stand would have been growing on top of the levee, while a eutrophic alder carr would have been present in the backswamps (Bakels 1986, 1988).

The wild fauna living in this setting included red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*) and wild boar (*Sus scrofa*). Beaver (*Castor fiber*) thrived in this humid environment. Freshwater fishes such as pike (*Esox lucius*) and roach (*Rutilus rutilus*) dominated, whereas sturgeon (*Acipenser sturio*) came to the area to spawn. Lastly, mullet (*Lisa ramada*) was available, a saltwater fish which occasionally visits freshwater streams in the summer (Prummel 1987).

Hunting formed an important component of the subsistence pattern of the inhabitants of Hekelingen III. Red deer was the major game animal. Small fur-bearing animals were captured as well, such as pine marten (*Martes martes*), otter (*Lutra lutra*) and beaver. Other game animals included wild boar, and brown bear (*Ursus arctos*). A few remains of grey seal (*Halichoerus grypus*) indicate that sea mammals were also taken, probably when stranded. Sturgeon, at the other hand, seemed to have been exploited to a considerable

Table 28 Hekelingen III: habitation phases with ^{14}C dates (after Louwe Kooijmans, *in prep.*).

phase	C14 BP	cal. B.C. minimum	cal. B.C. maximum	cultural affiliation
4	3865 ± 30	2525 – 2400	2550 – 2300	BB
3	4150 – 4050	2900 – 2800	2900 – 2650	VL 2a
2	4200 – 4150	c. 2925	c. 2925	VL 1b
1	4300 – 4200	3000 – 2950	3100 – 2950	VL 1b

extent. In addition to hunting and fishing, the inhabitants of Hekelingen III reared both pigs and, to a lesser extent, cattle (Prummel 1987). However, pollen analysis has shown that stinging nettle and onions were present on the levees, suggesting cattle had not been grazing there else these plants would have been eaten (Bakels 1986). An alternative grazing location would have been the saltmarshes of Zeeland.

The gathering of wild plants formed a significant contribution to the diet. Charred apples, hazelnuts and acorns were eaten; the acorns might have been collected elsewhere as the analysis of wood remains indicates oak to be absent (Bakels 1988: 160). Water nuts (*Trapa natans*) were also consumed. The people also had access to agricultural products. Remains of linseed (*Linum usitatissimum*), naked barley (*Hordeum vulgare* var. *nudum*) and emmer wheat (*Triticum dicoccum*) have been found; most of these seeds had been charred. Nevertheless, it is assumed that none of these crops were grown locally; although some chaff and rachis fragments have been encountered, this does not automatically imply local cropping (Bakels 1988). Unthreshed grain could have been taken along, with the advantage that seeds still enclosed by their glumes preserve better (Hillman 1981). Bakels (1988: 161) asserts that an important argument for the absence of agricultural fields at Hekelingen III would be the lack of space; assuming a group size of 15 persons (Louwe Kooijmans 1983b, 1985: 101) a levee of c. 500 m would be needed for the fields. Such an extensive clearance is not evident in the pollen diagram.

One unresolved problem is whether Hekelingen III could have been inhabited on a yearround basis, or reflects multiple short-term occupancies. There is evidence for occupancy during September in the form of water nuts, acorns and apples. The very few remains of hibernating birds indicate winter residence. Human presence during the winter months is also suggested by the fact that fur-bearing animals were captured; furs are at their prime in this season[1]. The sturgeon remains point to a late spring or early summer occupation when this anadromous fish swims up the creeks to spawn in the backswamps. So far no unequivocal evidence has been found for species which can only be exploited during early spring and late summer. The fact that human occupation during most of the seasons can be attested for, obviously does not mean that we can conclude yearround inhabitation. This is much more difficult to document and probably requires a combination of all possible avenues of research.

The use-wear analysis of the flint tools attempted to answer several such questions. A primary aim was to assess the character of the domestic craft activities carried out. It is often assumed that time-consuming activities such as bone- or hide-working were not carried out in a place where one resided only for a brief period of time. In this way the use-wear analysis could perhaps contribute to the question of duration of occupancy. Secondly, the role of flint tools in various subsistence tasks such as butchering, cereal-harvesting, plant procurement or fishing had to be ascertained. A third aim was to assess the variability between the various archaeological units through time and to search for the presence of activity areas. Lastly, the relationship between morphological aspects of artefacts, and the manner in which they were used, would be examined.

6.2.2 The flint technology

The morphology of the flint artefacts of Hekelingen III has been described by Verhart (1983) who paid special attention to the nature and possible source of the raw material from which the artefacts were produced, as well as technological aspects. The study of the Hekelingen III material is therefore limited to a functional analysis.

Verhart (1983) has been able to differentiate three main groups of raw material. The first type is of a mottled grey colour and fine-grained, supposedly originating from the vicinity of Spiennes in Hainault, Belgium. Most of the polished axes were made of this material. We find no blanks or prefabs for these axes, so it is likely that they arrived on the site as finished tools, probably in unbroken state. One axe exhibits an impact fracture, suggesting accidental damage during use. Such breakages formed excellent platforms which were used, without any modification, to produce flakes. Raw material type 1 predominates in the units attributed to Hekelingen III phase 1.

Although the second type of raw material shows some superficial similarities to the flint from Rijckholt in Limburg, the Netherlands, Verhart also seeks its origin in Hainault. It possessed a brownish-black color with tiny white specks, a fine grain size and sometimes coarser-grained grey inclusions. This material was brought into the site in the form of nodules. A few polished axe-fragments derive from this variety of flint.

A third type of raw material, not occurring during phase 1, is seen predominately in the units attributed to phase 3. It has a black color, a fine grain size, and sometimes a greasy appearance, and resembles most closely some flint samples from Boulognes-Sur-Mer, France. There are no axe fragments of this material. A fourth type was also present in small quantities; its origin probably lies in southern direction as well, but could not be specified further (Verhart 1983).

The question of whether or not there was ample access to raw material is difficult to answer. Certainly all of it had to be imported since natural occurrances of such good quality flint were not available nearby. In contrast with Leidschendam for example, local rolled flint was rarely used in Hekelingen III. The rather inefficient way of reducing the cores suggests that there was probably no lack of suitable material. I will deal with this problem in somewhat more detail in paragraph 7 of this chapter.

Cores (N = 49) are found on nodules or on broken polished axes. Because all the flint had to be imported, it is unlikely that large nodules were transported without pretreatment. This assumption is corroborated by the fact that the artefacts showed little cortex. Refitting-efforts produced virtually no joints, with the exception of some between units D, E and F, indicating their probable contemporaneity (Verhart, *in press*). This suggests that either only a small percentage of the implements was discarded at the site (i.e. was excavated), and/or that flint products were brought into the site in (semi-)finished form. Some flint was apparently knapped at the site, but the extent to which this took place is a little difficult to ascertain since no sieving was done during the excavation; the smaller fractions of debitage, had they been present, are therefore easily missed.

The cores possess a very irregular shape, the platforms are spaced haphazardly and platform preparation appears to be a rare phenomenon. This absence of planning and preparation results in a large number of hinge fractures inhibiting further reduction. Although the discarded cores are still quite sizable, closer examination of them reveals that there was indeed a good reason for discard: most have such an obtuse angle between platform and core-face that it would be impossible to produce any more flakes. Only after considerable modification could these cores be made productive again. Evidently the inhabitants of Hekelingen III chose not to undertake such work, either because they lacked the skill or because enough raw material was available to make it necessary to do so.

With regards to finished artefacts, it should be mentioned that a slight discrepancy sometimes exists in the number of retouched tools and of artefacts showing 'use-retouch' reported by Verhart and myself. This relates to disagreement at times as to whether certain edge-removals should be interpreted as use-retouch or as accidental breakages. Occasionally, there was also some difference of opinion over whether or not a certain artefact constituted a retouched tool. This confusion may seem incomprehensible to those who are not familiar with the character of Dutch Late Neolithic flint assemblages, which generally display very poor workmanship while standardized types are often lacking. Hekelingen III is a good example of such an assemblage. A standardized blade technology did not form part of the repertoire: it is clear that they were content with flakes, on the basis of which in fact all tools needed could be produced.

6.2.3 The functional analysis

6.2.3.1 Methods used and composition of the sample

The excavation procedure determined to a certain extent the composition of the sample. The site of Hekelingen III was excavated in the following manner: first, a backhoe was used to remove the soil overlying the first archaeological level and subsequent intervening sterile clay layers. Archaeological levels were excavated by shovel; finds were recorded in 1 x 1 m squares and collected by hand. No sieving was done because of the clayey matrix and the short time available. Basis for the sample taken for use-wear analysis formed the counts Verhart (1983) had made of the flint. Only those archaeological units which had yielded at least 10 modified artefacts were selected: A1, A1-creek (A1g), B1, M1, H2, B3, D3, E3, F3 (*table 29*), giving a total of 1011 artefacts.

Table 29 Hekelingen III: composition of the sample.

unit	total flint	total weight (g)	number of artefacts examined	number of retouched tools	total interpretable AUAs
M1	138	821	53	24	22
A1	132	1003	34	20	18
A1g	210	809	64	40	36
B1	145	818	42	21	28
H2	88	568	40	15	26
B3	86	439	36	11	16
D3	63	354	22	9	7
E3	53	1234	15	6	5
F3	96	324	33	14	7
total	1011	6391	337	160	165

From the total of 1011 artefacts, 337 were selected for analysis (33.3%), yielding 449 potentially used areas (PUAs). These PUAs include retouched edges (i.e. retouch ⩾ 1 mm), edges exhibiting 'use-retouch' (i.e. retouch < 1 mm), areas showing polish visible with the naked eye, points, and edges with a straight cross-section ⩾ 1.0 cm. Of the 449 PUAs, only 159 could be interpreted in terms of contact-material and motion, while 85 PUAs displayed no traces. This means that a mere 244 PUAs, or 54.3%, were interpretable, yielding 165 AUAs. The remainder possess secondary modifications, which prevent interpretation of tool use; several of these uninterpretable edges nevertheless were very probably used. Mean length of the examined

Table 30 Hekelingen III: raw material categories with the degree of wear (percentages, according to PUA). The discrepancy in number of PUAs in this table (455 instead of 449) is due to the computer registration. The additional six PUAs are from those tools displaying more than one AUA per PUA.

	type 1	type 2	type 3	type '790'	not applicable	unsure	total
no traces	54 (18.6%)	23 (31.5%)	4 (8.7%)	2 (22.2%)	2 (9.5%)	–	85
used	59 (20.3%)	12 (16.4%)	12 (26.0%)	1 (11.1%)	2 (9.5%)	1 (6.7%)	87
possibly used	38 (13.1%)	5 (6.8%)	5 (10.9%)	3 (33.3%)	3 (14.3%)	–	54
not interpretable	81 (27.8%)	26 (35.6%)	21 (45.7%)	2 (22.2%)	10 (47.6%)	12 (80.0%)	152
unsure	59 (20.3%)	7 (9.6%)	4 (8.7%)	1 (11.1%)	4 (19.0%)	2 (13.3%)	77
total	291	73	46	9	21	15	455

Table 31 Hekelingen III: inferred motion and contact-material by actually used area (AUA).

	scraping	whittling	cutting	carving	splitting	boring	projectile	hafting	unsure	total
hide	22	–	7	–	–	3	–	4	5	41
soft plant	–	–	3	–	6	–	–	6	1	16
wood	3	6	9	1	–	1	–	–	1	21
wood/bone/antler	1	–	–	–	–	1	–	–	2	4
bone	4	–	12	9	–	2	–	–	–	27
antler	2	–	1	1	–	–	–	–	4	8
soft stone	–	–	–	–	–	1	–	–	–	1
shell	–	–	–	–	–	1	–	–	–	1
hard material	2	–	4	–	–	1	–	–	3	10
soft material	3	–	–	–	–	3	–	–	8	14
unknown	3	–	1	–	–	4	3	2	9	22
total	40	6	37	11	6	17	3	12	33	165

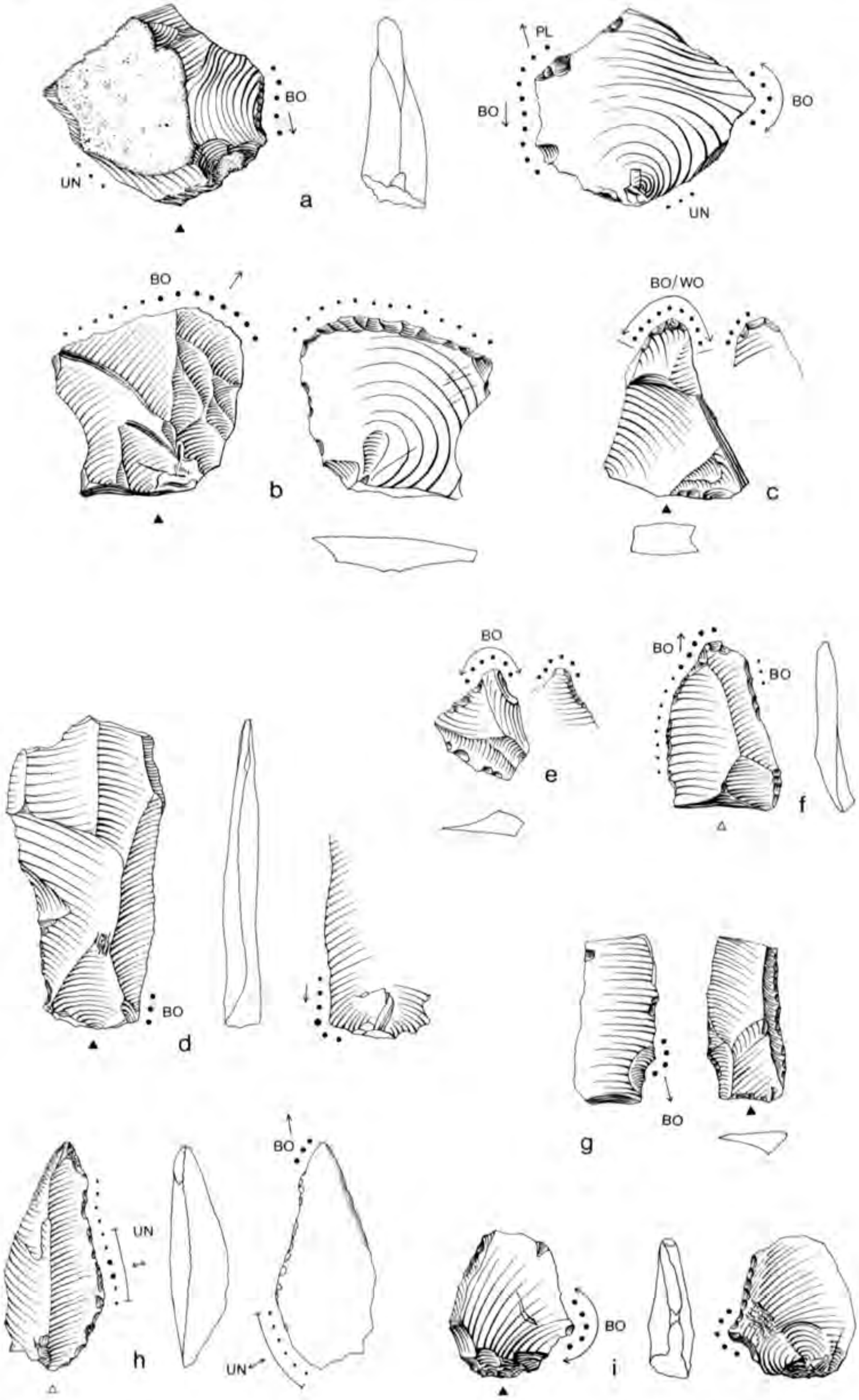


Fig. 56 Bone-working implements from Hekelingen III. a) B3/15 used for carving and boring, b) D3/3 used for scraping, c) borer B1/13, d) B3/18 used for carving, e) A1g/10 used for boring, f) A1/23 used for carving, g) M1/5 used for carving, h) B1/24 used for carving, possibly also displaying traces of having been hafted, i) E3/3 used for boring (1:1).

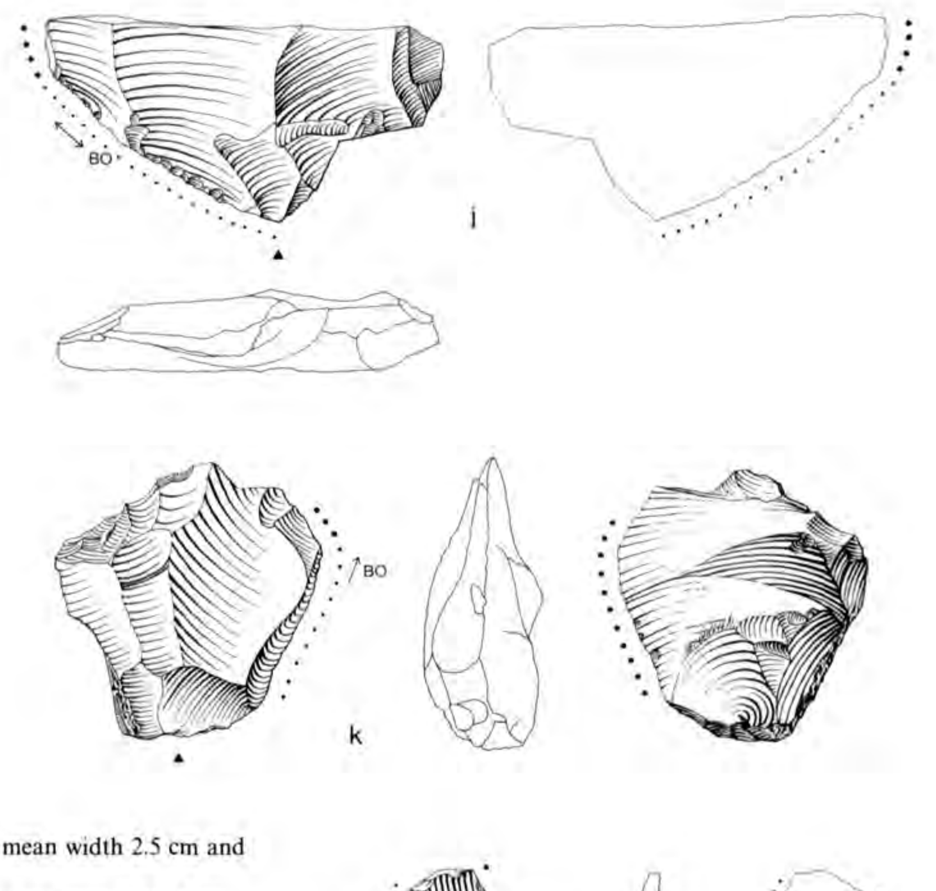


Fig. 56 cont. j) bone-sawing implement B1/29, k) carving tool A1/27, l) bone-sawing implement A1g/34 (1:1).

pieces (N = 337) comprised 3.0 cm, mean width 2.5 cm and mean thickness 0.7 cm.

The artefacts were not systematically cleaned with chemicals. Only in those cases where a film of unknown substance appeared to be overlying the surface, were the flint immersed in a 10% HCl solution and treated in an ultrasonic cleaning tank. To avoid a continuing reaction between stone and HCl (Van Gijn 1989) flints were only immersed for a short period of time and afterwards thoroughly rinsed in tap water and neutralized with KOH. Artefacts not exhibiting deposits were only soaked in luke-warm soapy water. During analysis tools were regularly wiped with alcohol to remove finger-grease.

The character of the post-depositional surface modifications is difficult to ascertain. Most likely it concerns mechanical abrasion. The matrix in which the artefacts were deposited varies from clayey fine sand to slightly sandy clay. Sand is known to be a highly effective abrasive, while experiments have shown that even clay quickly polishes a flint surface, especially if water is present (Van Gijn 1986a). Trampling on the levee surface by inhabitants of the site, and 'settling' of the sediments, might have been responsible for abrasion (cf. *4.2.3*).

It should also be noted that raw material type 3, displays post-depositional surface modifications (pdsm) more frequently than the other raw material types (see *table 30*). This observation corresponds with the fact that artefacts from archaeological units D3, E3 and F3 show a higher incidence of pdsm; raw material type 3 predominates in the units attributed to occupation phase 3. Whether type 3 raw material is more vulnerable to abrasion or whether more trampling took place during phase 3, is impossible to tell. Unit M1 also displays a high incidence of pdsm.

6.2.3.2 Activities inferred

In this paragraph the results of the use-wear analysis will be

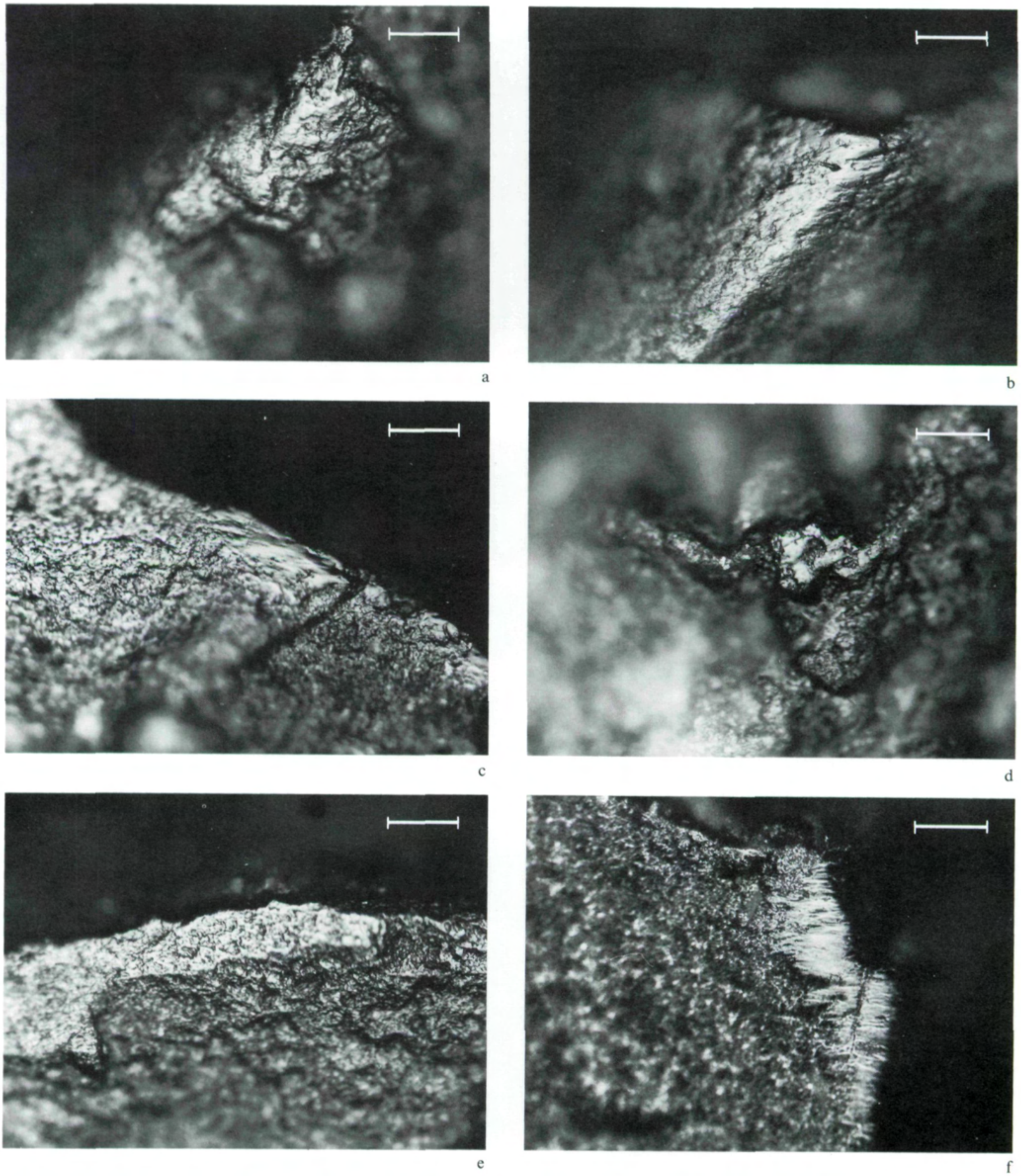


Fig. 57 Hekelingen III: micrographs of traces interpretable as being the result of contact with bone (see *fig. 56*). All scale bars equal 50 μ. a) D3/3 (200x), b) A1/23 (200x), c) B1/24 (200x), d) B3/18 (200x), e) M1/5 (200x), f) B3/15 (200x).

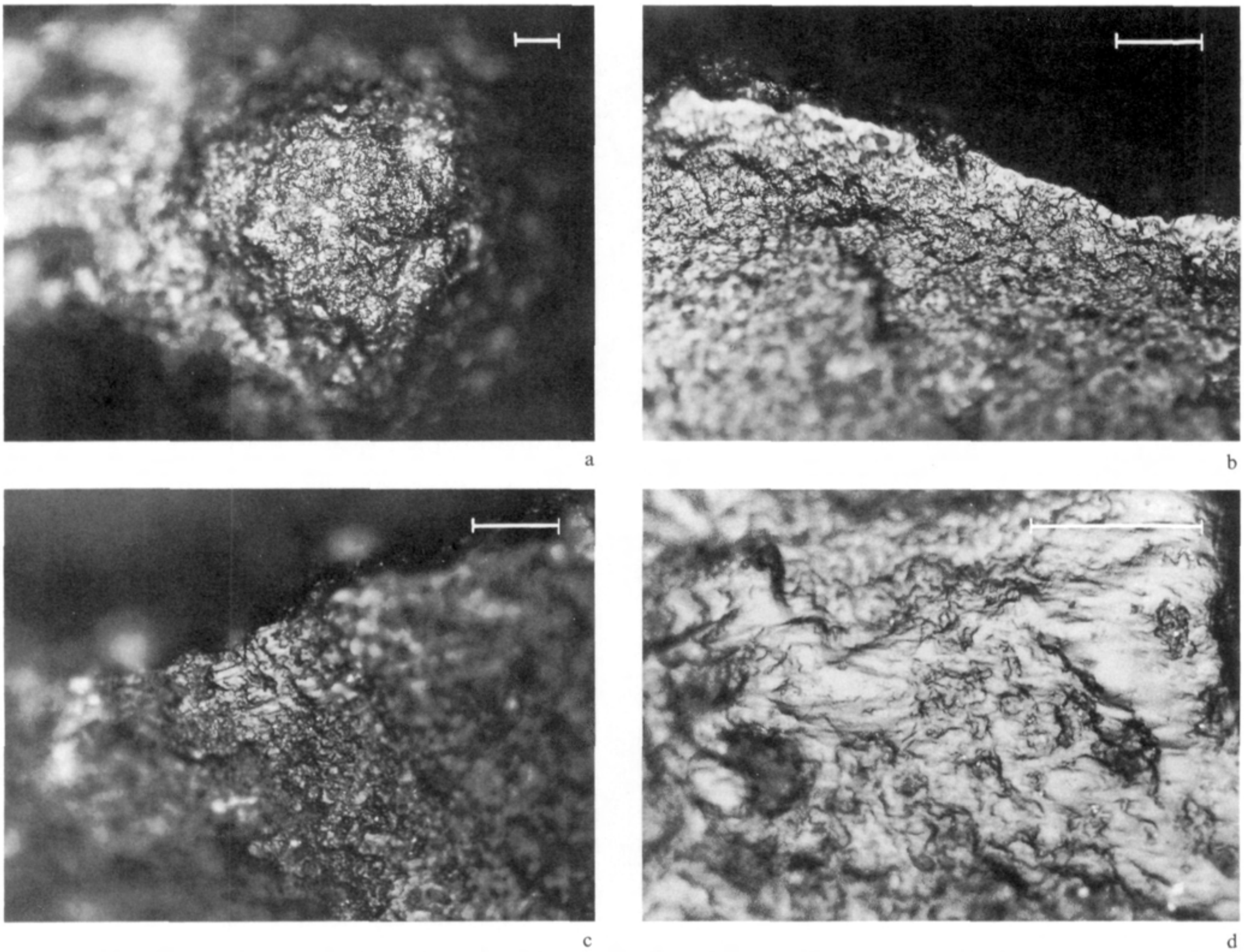


Fig. 58 Hekelingen III: micrographs of traces interpretable as being the result of contact with bone (see *fig. 56*). All scale bars equal 50 μ. a) A1g/10 (100x), b) B1/13 (200x), c) A1/27 (200x), d) A1g/34 (400x).

discussed for Hekelingen III as a whole (*table 31*). I will describe the various tasks inferred and attempt to relate them to other sources of information concerning the site.

BONE-WORKING

A major activity which was inferred is the working of bone (*fig. 56*). A total of 27 PUAs on 21 implements is interpreted as having been used on this material. On the basis of directionality within the polish two major motions could be distinguished: on 12 PUAs a parallel directionality indicates sawing or cutting, on nine PUAs a diagonal polish orientation suggests a carving motion. The carving tools exhibit a smooth, very bright polish with comet-shaped pits (*figs. 57b-f*). The distribution of the polish is limited to the very edge. Because of the remarkable similarity of the wear traces on experimental and archaeological bone-carving implements, these inferences have a very high probability. This is less so with the edges used in a longitudinal motion: the polish is somewhat rougher and is it not impossible that some antler-cutting tools were included here (see *3.4*). Edge-scarring on the latter pieces is quite extensive, involving step- and hinge fractures and trapezoidal-shaped scars. Striations are absent.

Interestingly enough, a large number of bone awls and chisels, as well as numerous waste pieces and rejects, have been encountered at Hekelingen III. Maarleveld (1985), who has studied the bone tools, reports that for the most part these tools have been produced on the metapodia of red deer and, to a lesser extent, on metapodia of roe deer. He suggests the following manufacturing sequence for the awls and chisels (*fig. 59*). The first step involved the deepening of the natural furrows present on the anterior and posterior aspects of a metapodium, with a pointed flint tool. The second step consisted of sawing a groove around the circumference of the bone, again with a flint tool, in order to

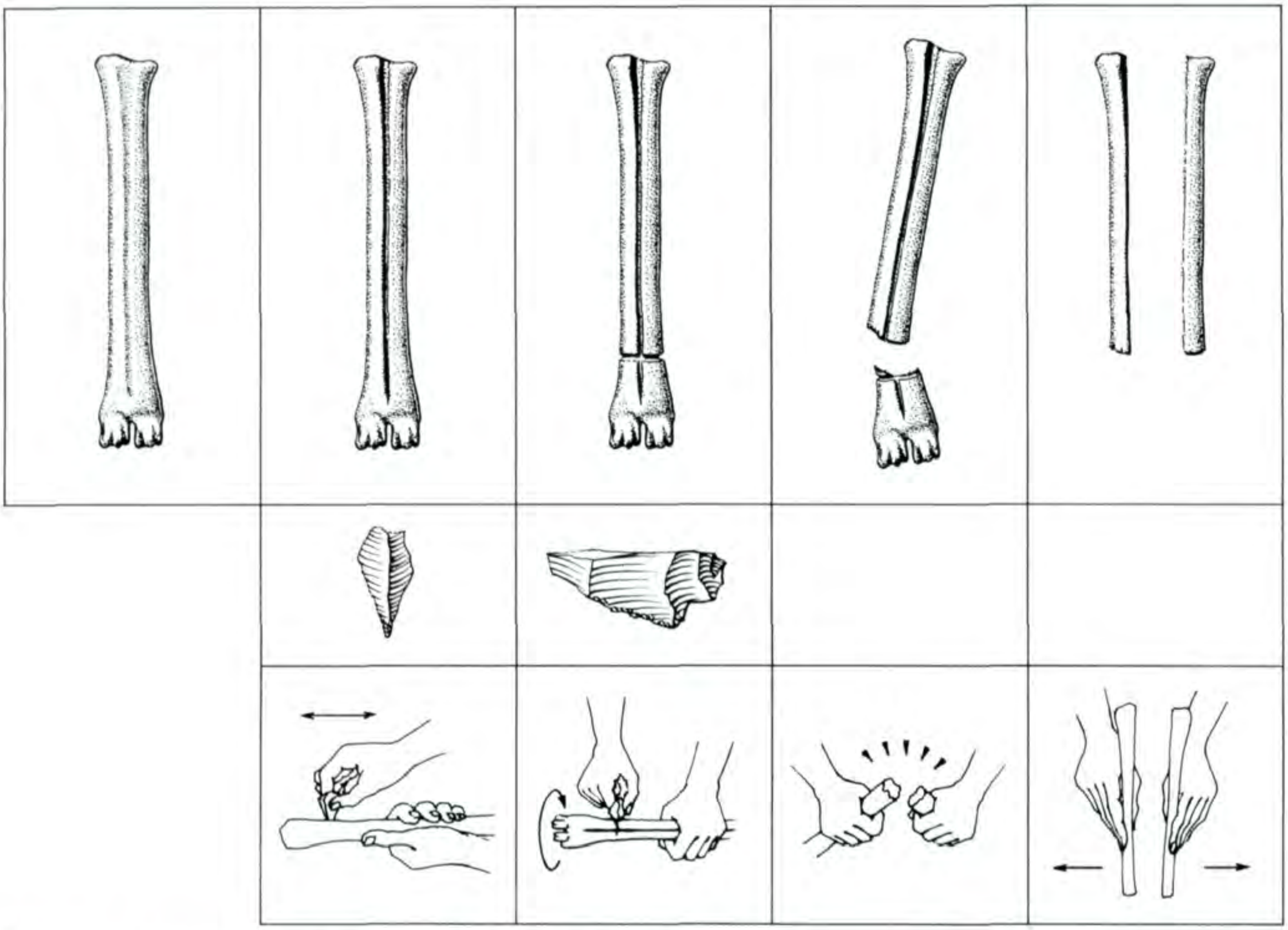


Fig. 59 Manufacturing sequence of bone awls and chisels (after Maarleveld 1985).

enable the removal of the knobby distal end by breaking it off. Lastly, the metapodium was split in half lengthwise, after which the two sections could be ground into their final shape. Van den Broeke (1983), who examined the bone points and awls from Hazendonk, arrived at the same production sequence.

Van den Broeke did some experiments with flint tools in order to test their suitability for carving and sawing bone. I examined the implements he used, all of them made of a rather fine-grained variety of Rijckholt flint (experiment nos. 63-72; see *appendix II table 3*). The wear traces observed on the experimental carving tools (*fig. 17c*) show a remarkable similarity to those on the archaeological pieces, interpreted as having been used for carving bone. One possible explanation is that the pointed flakes on which these traces were found (*figs. 56f-h*) had been employed for deepening the grooves on the metapodia. Some of the archaeological artefacts used in a sawing motion might have played a role during the second stage of awl and chisel manufacture, but the similarity in polish is not so striking as in the case of the carving-implements. All in all, it seems that here we have an example of a reconstruction of the exact task involved, because of the detailed archaeological context available. It is also interesting to note that 'simple', unretouched, flakes were involved in the task of bone awl and chisel manufacture.

In addition to the carving and sawing tools, four implements appear to have been used for scraping bone (*fig. 56b*). These scrapers had rather steep edge angles, while the polish exhibited the 'beveling' (see *3.4.2.1*) such as is reported by Plisson (1985a). Lastly, several borers with 'bone-polish' had been found (*figs. 56a, 56c, 56e, 56i*). Their tips were very heavily rounded, with a clear directionality visible in the polish (*fig. 58a*). One of these borers was probably hafted (B3/15, *fig. 56a*); this tool was also used for carving bone.

SOFT PLANT-WORKING

A total of 16 used zones on 14 tools display traces interpretable as being the result of contact with soft plants. The most interesting are six artefacts exhibiting a pointed end

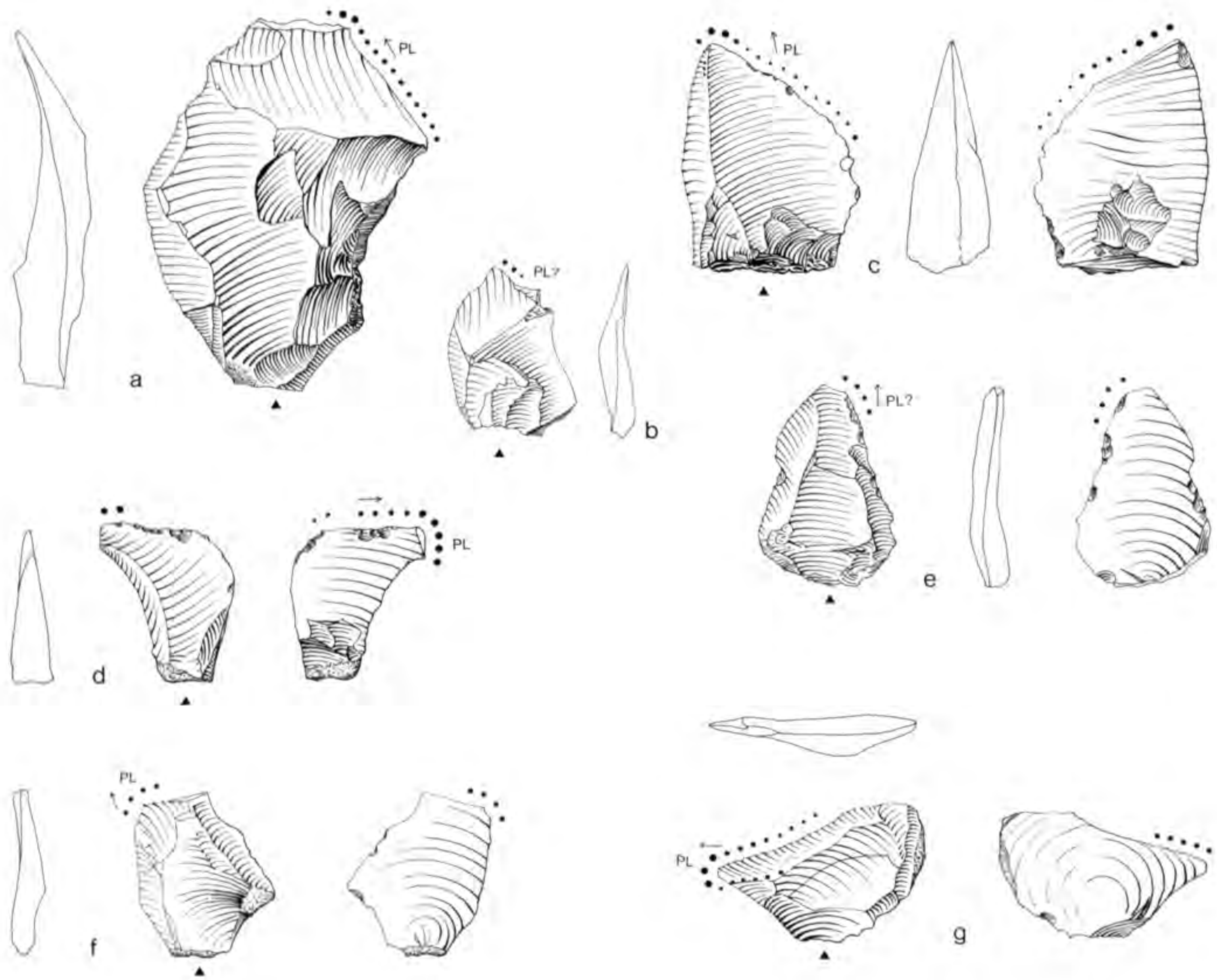


Fig. 60 Artefacts from Hekelingen III displaying wear traces interpretable as being the result of soft plant-processing. a) B3/31 used for cutting grasses, b-g) plant-splitting implements: b) B3/33, c) D3/20, d) D3/19, e) H2/31, f) H2/37, g) E3/14 (1:1).

(see *figs. 60b-g*). Little micro-scarring is present on these tips, but they are covered by a bright, smooth polish extending c. 3 mm from the edge of the tool (*fig. 61b-f*). It has not been possible to exactly reproduce this combination of wear-traces. Initially, it was assumed that the implements would have been used to split willow branches for basketry or matting (*fig. 62*). However, this kind of activity does not create the same polish as is visible on the archaeological tools. Experiments with splitting reeds did not produce a similar use-wear pattern either (*fig. 62*). Nevertheless, with particular reference to the distribution of the polish, I would argue that splitting non-silicious soft plants or twigs is the most likely explanation for the traces observed on these artefacts.

The other soft plant-working tools include three blades or elongated flakes such as B3/31 (*figs. 60a, 61a*), used in a cutting motion. The polish extends 0.5-1.0 mm into the piece, is very bright and smooth, and somewhat resembles 'sickle-gloss'. These tools display little or no edge-removals. It is the limited width of the polish band which gives rise to the interpretation that these artefacts have been used to cut wild grasses (possibly for basketry). As has been shown before (see *3.5*), there is a significant difference in distribution between gloss induced by grasses and by cereals or

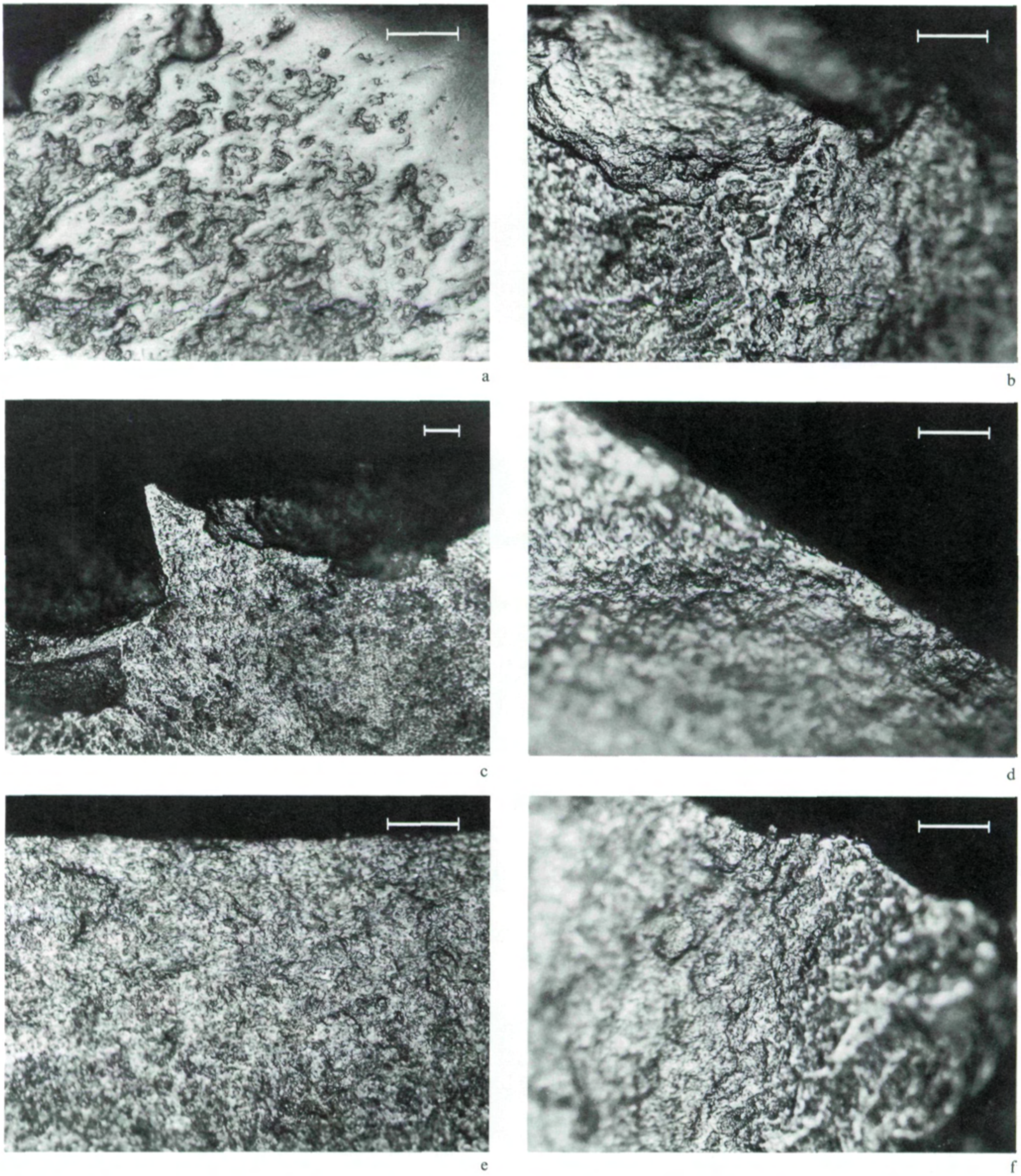


Fig. 61 Hekelingen III: micrographs of traces interpreted as being from soft plant-processing (see *fig. 60*). All scale bars equal 50 μ. a) B3/31 (200x), b) D3/19 (200x), c) D3/20 (100x), d) H2/37 (200x), e) B3/33 (200x), f) H2/31 (200x).

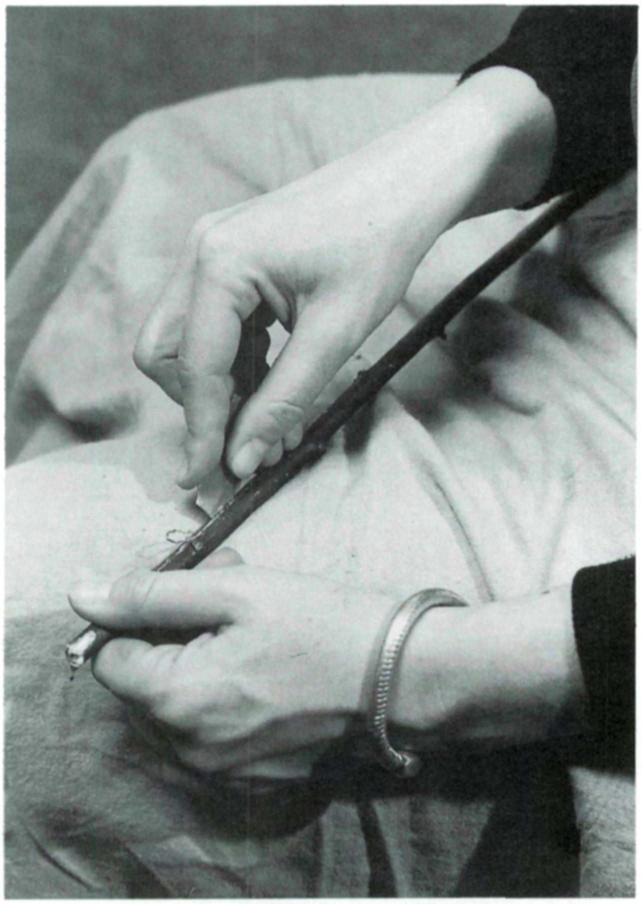


Fig. 62 Experiments with splitting willow (above) and reed (below) as an attempt to replicate the archaeological traces interpreted as being from splitting plants.

reeds. Polish caused by the latter two plant categories covers an area along the edge of the tool of c. 1 cm wide. In contrast, grasses inflict a polish band of maximally c. 2 mm.

No soft plant scrapers were found. Of one implement the motion in which the tool was involved could not be ascertained. Of the remaining six PUAs the 'soft plant'-polish is interpreted as being the result of a binding for hafting. These implements will be discussed in the paragraph on hafting (see below).

HIDE-WORKING

Hide-working was a very common activity: 41 PUAs on 38 tools were interpreted as having been in contact with hide (*fig. 63*). Characteristic wear attributes include a heavily rounded edge (*figs. 64a-d*), little or no edge-removals, and a band of rough polish, which extends into the retouched scars. The traditional distinction between gloss from dry and fresh hide is not very clear (cf. *3.2.2*); if a polish is 'matt' it is assumed to be the result of scraping a dry hide, whereas a polish with a greasy 'wet' appearance suggests contact with a fresh hide. In Hekelingen III, 26 of the hide-working tools display a 'matt' appearance and therefore they customarily would be interpreted as having been used on dry hide. However, in paragraph 6.2.6 I will argue that the 'matt' appearance of the polish and the edge-rounding on these tools could be due to the addition of abrasives while scraping very moist and greasy raw hides such as those of fox and bear.

Motions inferred, include scraping (22 PUAs), cutting (7 zones) (*fig. 63j*), and boring (N= 3) (*figs. 63c, 63k*). Lastly, four PUAs displayed 'hide-polish' in such a way that hafting was inferred; these will be discussed in a later paragraph.

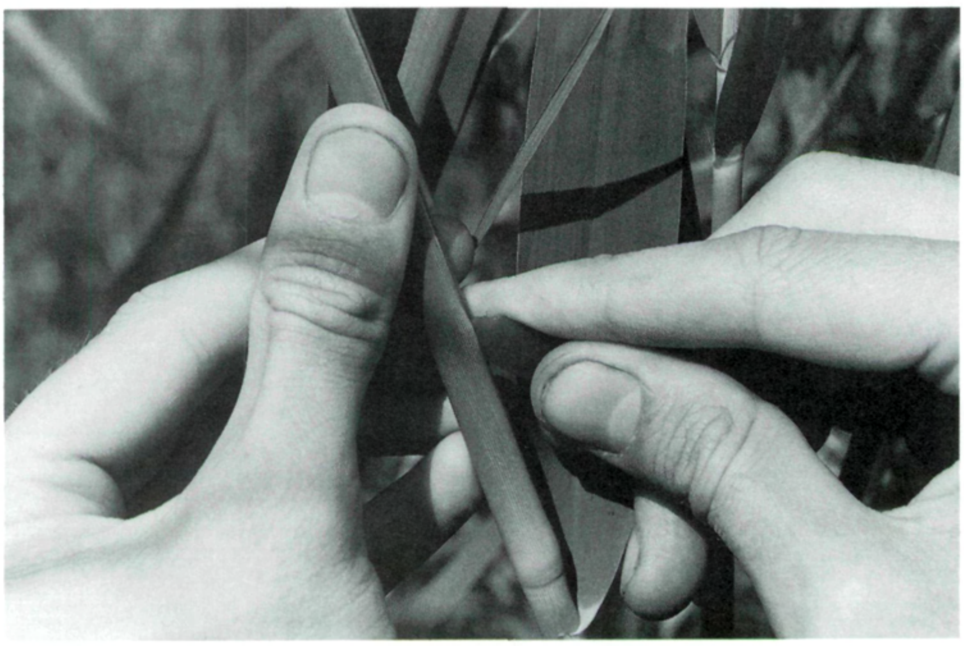
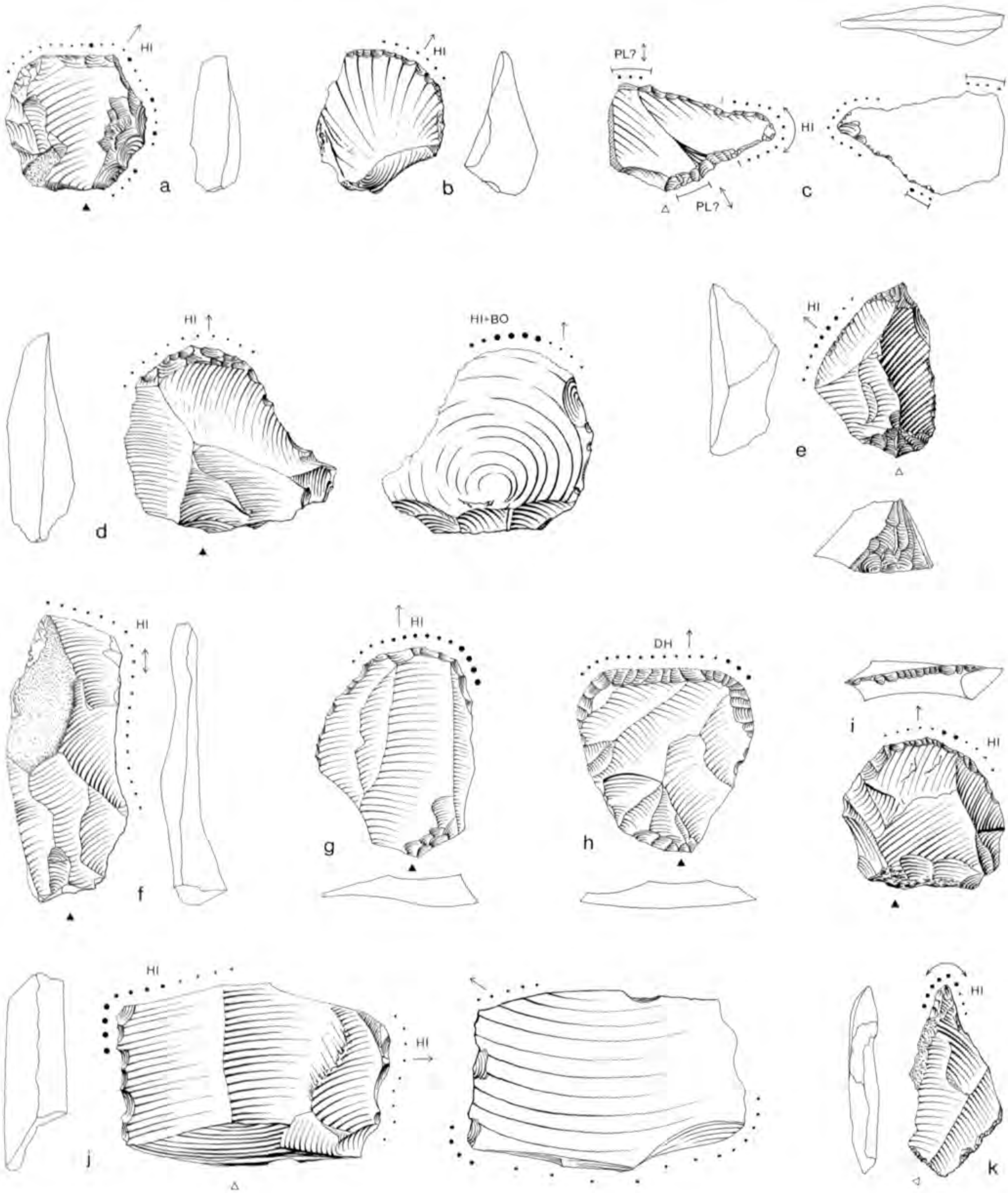


Fig. 63 (opposite) Hekelingen III: implements displaying wear-traces inferred as being from processing hides. a, b) scraping (B1/16, A1g/28), c) boring implement B1/9, also displaying traces of a possible haft with plant-fibre binding, d, e) scraping (H2/1, B1/4), f) cutting (A1g/44), g-i) scraping: g) B1/21, h) H2/2, i) A1/3, j) cutting (H2/39), k) boring (B1/5) (1:1).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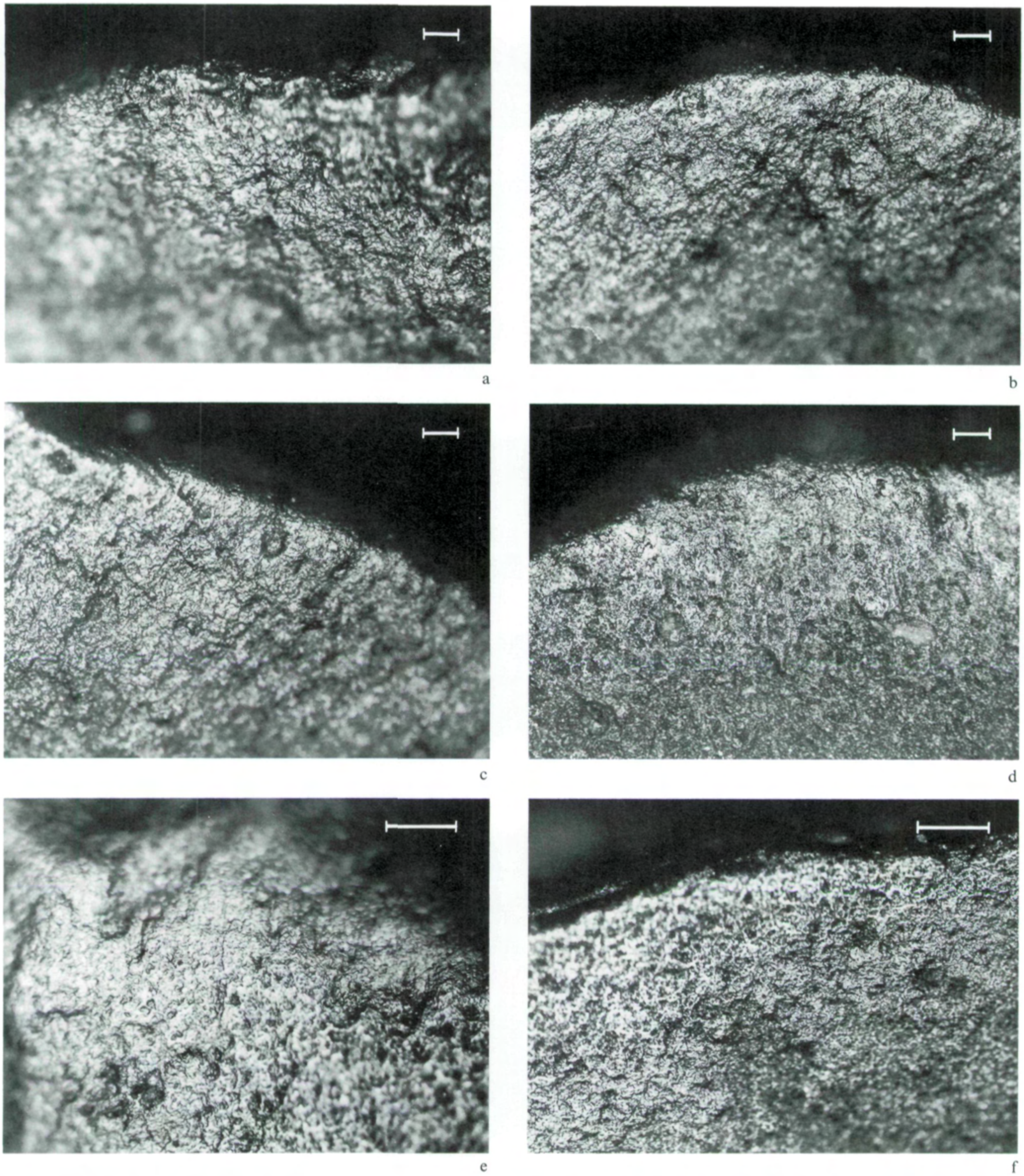


Fig. 64 Hekelingen III: micrographs of inferred hide-working traces on tools depicted in fig. 63. All scale bars equal 50 μ. a) B1/21 (100x), b) B1/16 (100x), c) B1/16 (100x), d) A1/3 (100x), e) H2/39 (200x), f) A1g/44 (200x).

WOOD-WORKING

Hekelingen III has yielded a number of wooden artefacts, notably a paddle, a bow of yew, and an axe shaft of maple. In addition, several hewn poles have been found, probably forming part of constructions. With such an assortment of wooden objects it is not very surprising to encounter a number of wood-working tools: 21 PUAs on 18 artefacts can be reported (*fig. 65*). The wear attributes include a rather smooth undulating or domed polish, which never extends very far across the tool, and moderate edge-scarring (*figs. 66a, 66b*). A number of activities are represented by these artefacts. Some of them (9 PUAs) such as E3/1 and D3/14 had been used for cutting (*figs. 65a, 65d*), others such as H2/10 for whittling activities such as, possibly, the straightening of arrow shafts (*fig. 65c*) (6 PUAs). One implement (F3/3) was employed both in a boring and scraping motion; one whittling tool was also used for scraping (H2/10) (*fig. 65c*), while one artefact was only employed for scraping. Lastly, on one wood-working implement, no evidence for motion was present.

WOOD-/BONE-/ANTLER-WORKING

On three PUAs (located on three implements) traces were found which could either be ascribed to contact with bone or antler. In two of these instances the motion in which the implements were used could not be inferred, in the third instance, it was probably used for cutting. All three tools derive from archaeological unit M1 from which a great many bone- and antler-working implements derive. From unit B1, a borer originates with a polish which, because of its domed appearance and presence of striations, could be interpreted as either have been used on wood or on bone/antler.

ANTLER-WORKING

Although it is often impossible to differentiate between the polish and edge-damage resulting from contact with antler and that from bone (see *3.4.2*), scraping antler usually produces a fluid, rather characteristic polish which I have never observed on bone-scraping implements. Eight PUAs (on seven tools) displayed this kind of bright, smooth almost 'wet' polish. The distribution of this polish was limited to the edge. These pieces were largely confined to archaeological unit M1, exceptional in many other respects (see below), where we find five of the eight PUAs with antler-working traces. From the directionality present in the polish a scraping (2 PUAs), a cutting (1 PUA), and a carving motion (1 PUA) could be deduced, as well as an unknown motion (4 PUAs). One tool (M1/32) bore traces of both scraping and grooving antler.

STONE- AND SHELL-WORKING

From archaeological unit M1 originate a few interesting miscellanea. One borer seems to have been used on soft stone (*figs. 66d, 67c*). It has an extremely rounded tip and exhibits virtually no polish. Stones with perforations are unknown from Hekelingen III or other VL sites, with the exception of some jet and amber beads from Voorschoten and Leidschendam. A possible alternative is that the tool was used on pyrite in order to start a fire. Another interesting implement was a borer interpreted as having been used on shell; the polish has the 'streaky' distribution characteristic for this contact-material (*figs. 66c, 67d*).

THE USE OF PROJECTILE-POINTS

Three PUAs on two projectile points displayed damage in the form of impact fractures at their tip. This feature seems to occur rather consistently on projectile points (Moss 1983a; Fisher et al. 1984; Odell/ Cowan 1986). One barbed point from unit B3 (B3/5, see *fig. 67a*) had an impact fracture on its tip. In addition, it also had extremely rounded edges at the barbs. No clear polish was visible on them but these traces are reminiscent of what Crabtree and Davis (1968) have already described. These authors suggest that projectile point edges were sometimes intentionally ground, not only to stabilize them, but also to protect the binding of hafts. Unit A1g produced a flake of a polished axe with a small amount of retouch along its edges (*fig. 67e*) which, at least typologically, we would hesitate to classify as a projectile point. Nevertheless this tool displayed an impact fracture at its tip and MLITS on another edge, as well as traces of hafting on its lateral sides. One barbed arrow head from H2 displays a possible impact fracture, while one transverse specimen from M1 was too abraded to allow an interpretation of its former use.

WORKING HARD AND SOFT MATERIAL

On some implements it was possible, on the basis of polish-distribution and the nature of the edge-removals, to differentiate between contact with soft material (on 14 PUAs) and hard material (10 PUAs). Inferred motions include cutting, scraping, boring and 'unknown'.

WORKING UNKNOWN MATERIAL

From a considerable number of used zones (22 AUAs or 13.3% of all AUAs) the substance which had been worked could not be specified. Motions inferred encompassed cutting (N = 1), scraping (N = 3), boring (N = 4), projectile (N = 3), hafting (N = 2) and unsure (N = 9) (*figs. 66f, 67b, 67f*).

HAFTING

Microscopic traces of hafting have been observed on 12 used zones representing seven tools; in five instances it concerned an 'uncertain' interpretation. On six zones a smooth 'plant-like' polish was visible, interpreted as being

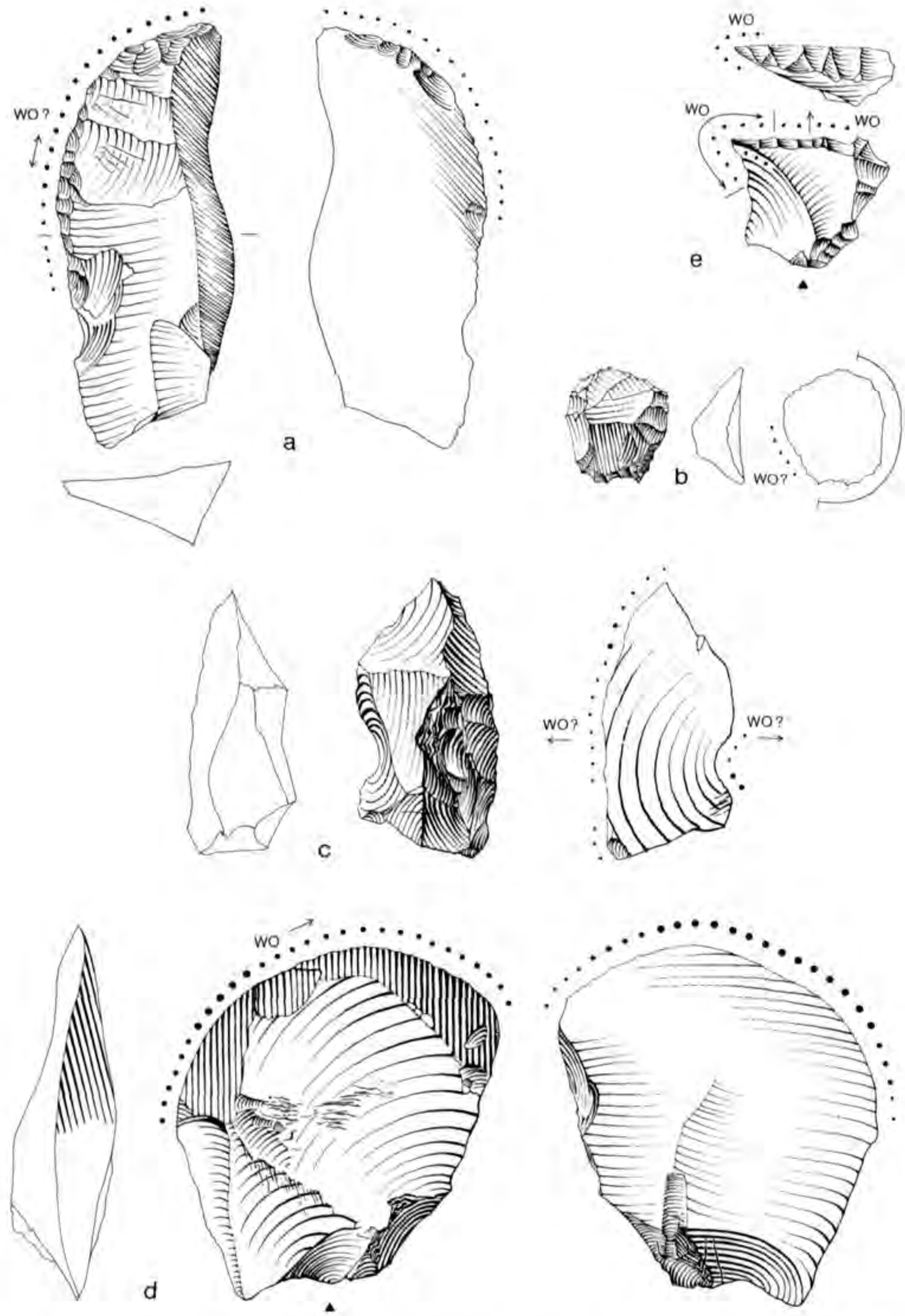
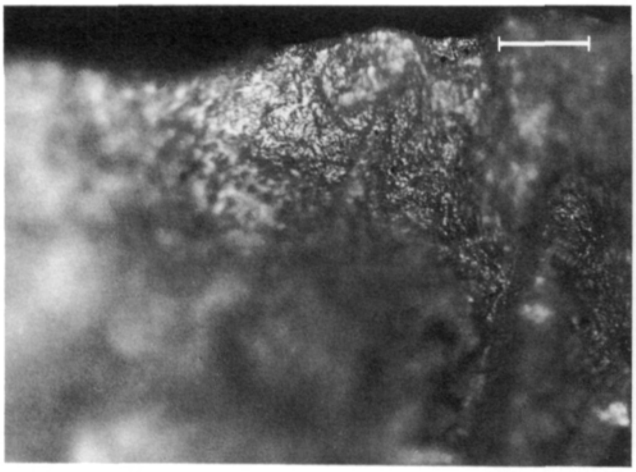


Fig. 65 Artefacts from Hekelingen III showing wear interpreted as being the result of working wood. a) cutting/ sawing (E3/1), b) scraping tool A1g/16, possibly showing traces of hafting, c) scraping (H2/10), d) cutting (D3/14), e) boring (F3/3). (1:1)



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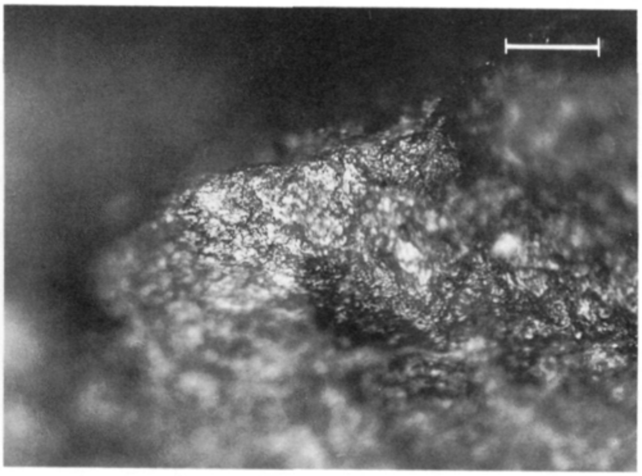

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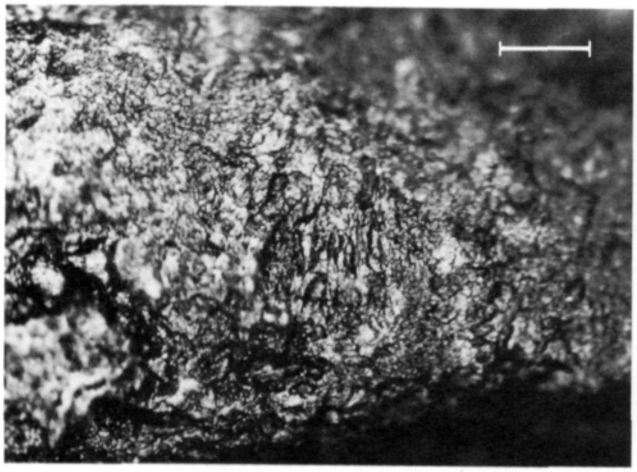

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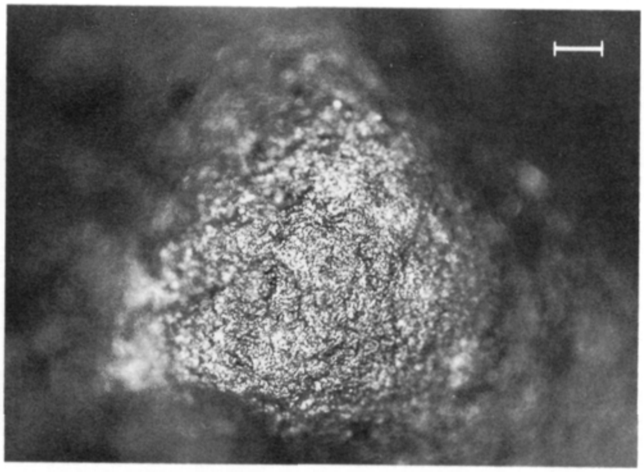

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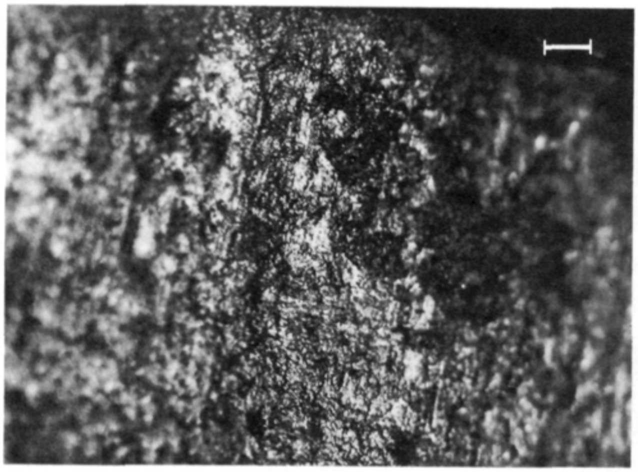

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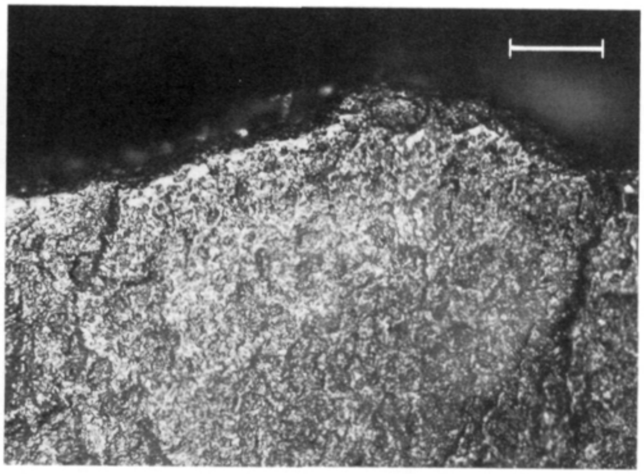


f

Fig. 66 Hekelingen III: micrographs of inferred tool uses (see *figs. 65, 67*). All scale bars equal 50 µ. a) E3/1; wood sawing (200x), b) H2/10; wood-whittling (200x), c) M1/22; shell-boring (200x), d) M1/3; soft stone-boring (100x), e) A1g/55; hafting traces (100x), f) B1/1: scraping unsure material (200x).

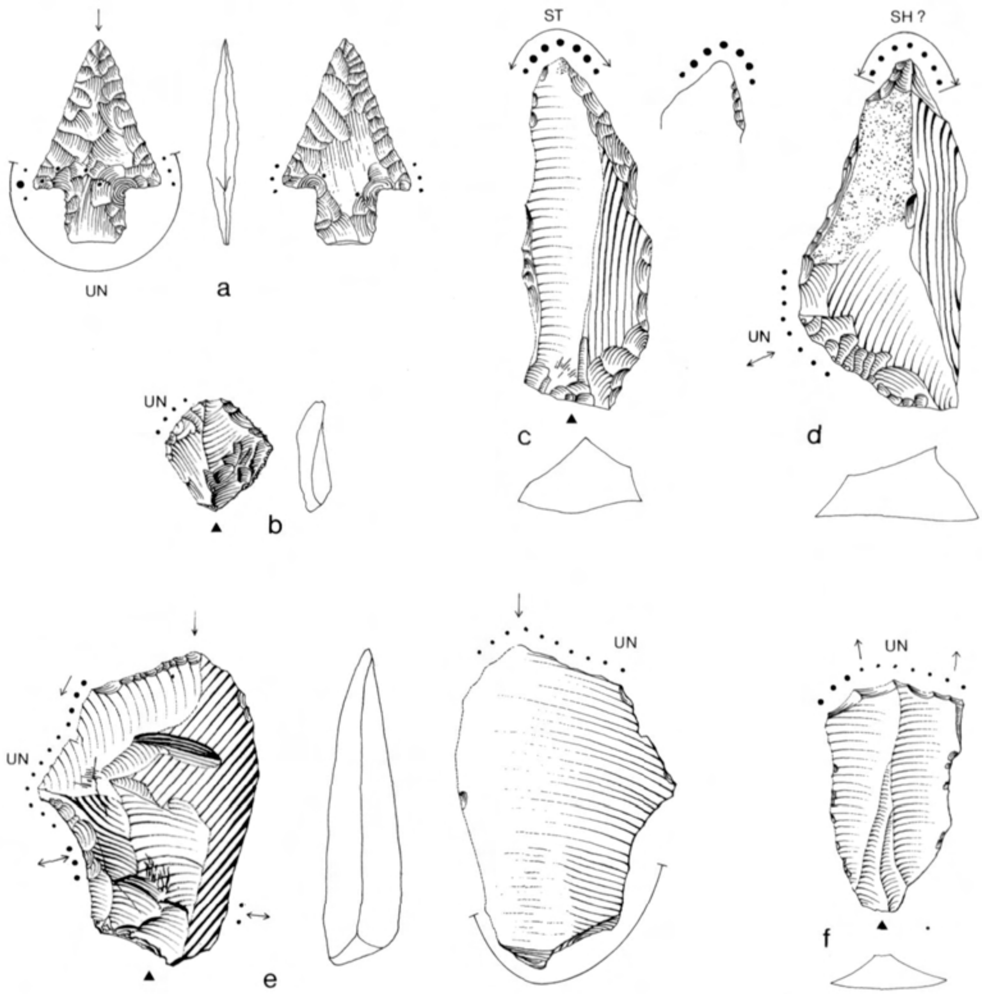


Fig. 67 Hekelingen III: artefacts displaying traces of use. a) projectile (B3/5), b) scraper (A1g/30) used on unknown material, c) borer (M1/3) used on soft stone, d) borer (M1/22) used on shell, e) flake used as projectile (A1g/55), f) steeply retouched flake used on unknown substance (B1/1). (1:1)

the result of binding with plant fibres. Four used zones displayed a 'hide-polish' distributed in such a fashion, i.e. perpendicularly oriented and located on the dorsal ridges and lateral edges alike, as to infer that the flint insert was bound with leather onto the haft. Lastly, two PUAs exhibit streaks of a bright matt polish, oriented perpendicular to the edge, caused by an unknown substance (see *fig. 66e*). Traces of, for example, bone-polish caused by a 'jam haft' (Keeley 1982) were not observed.

The relative scarceness of microscopic traces of hafting in the form of polish and striations is not surprising for a number of reasons. Firstly, experiments with hafting (Keeley 1982, 1987; Moss 1983a, 1987b) have indicated that the associated traces do not develop on a 100% basis. It depends to a large extent on the type of haft used and the relative 'fit' of the flint insert (and thus how much the tool can move within its haft) as to whether or not wear-traces result. If mastic, such as resin or tar, is used to fasten the flint, little damage is inflicted because the flint is immobilized and no friction occurs during work[2]. A 'jam haft', in contrast, can cause quite a bit of damage, due to the friction between haft and flint tool upon contact with a worked material. We do not know what sort of hafts, i.e. bone, antler or wood, were used at Hekelingen III because none was found.

The second reason why hafting traces are scarce in the assemblage, is the character of the raw material. Although some of the flint is relatively fine-grained, it is coarse in comparison to the North-European chalk flint. The latter type of flint exhibits traces of wear much more quickly than coarser grained varieties of flint (see *2.2.6*). As well as the slow formation rate of microscopic hafting traces and the relative invisibility of these traces on the types of flint predominating at Hekelingen III, the secondary modifications (see *chapter 4*) mask incipient wear-traces.

With so little positive evidence for hafting coming from the microscopic analysis, we can turn to morphological attributes of the tools for indications of hafting. These would include morphological facilities for hafting such as a notch, a retouched concave edge or the presence of bitumen (cf. *2.6.1*). However, it should be remembered that such morphological indications were considered 'hypotheses-to-be-tested' (see again *2.6.1*). Of the 337 artefacts examined, 21 were retouched in such a way that this might possibly be to facilitate hafting, while 13 had a notch, presumably for the same purpose. On three artefacts traces of bitumen were preserved. Of these 37 tools with macroscopic features possibly related to hafting, only five actually displayed microscopic traces (sometimes on two PUAs) attributable to the former presence of a haft. Therefore, in only these latter instances was the term 'possibly hafted' justified.

Another indication for hafting are traces of resharpening. Examining this feature seems to be, at least when discussing hafting, only relevant for the very small tools. The proposition is that one cannot resharpen a very small tool, such as a thumb-nail scraper, unless it is hafted. Resharpening can be inferred when the polish appears to be fragmented and removed by subsequent retouching. This was observed in six cases (four of which derived from unit A1 or A1 creek). Another indication for resharpening is formed by steep overhanging dorsal edges, i.e. with an excessively steep edge angle being larger than 90°; only five tools display such an edge.

It can be concluded, that traces of hafting, both microscopic and macroscopic, are rare. This might mean several things. Firstly, hafting traces were really absent because the hafts were fastened so tightly to the flint that the latter did not get damaged. Possible traces of hafting might also have been obscured by post-depositional surface modifications. Another possiblity is that most tools were used unhafted; this might very well be feasible for the larger implements. However, the tiny scrapers and some of the borers seem too small to be effectively used in such a way, while projectile points can only be used when hafted. Moreover, in those cases where traces of hafting were observed, it was always on such small tools. It is also possible that retooling did not take place at Hekelingen III on an extensive scale.

NOTEWORTHY 'ABSENTEES'

Two activities which might have been expected to be present are lacking: cereal-harvesting and fish-processing. It is obvious that one should never consider the absence of certain traces as proof that the associated task was not carried out. First of all, only a sample of the total assemblage has been studied and it can never be excluded that such traces are extant in the remaining of the excavated material. Secondly, during an excavation one already 'samples' the total variability present in the man-land relationship. Many activities will have taken place outside the excavated area, especially those related to the subsistence-quest, or 'dirty' and space-demanding work like the processing of hides. The absence of implements with sickle-gloss at Hekelingen III, i.e. evidence for cereal-harvesting, is therefore not significant in itself. Such tools could have been discarded near the agricultural fields upon completion of the harvesting task. However, other avenues of research, especially the palaeobotanical research, indicate that cereals were probably not cultivated locally (Bakels 1986, 1988). The absence of sickle blades provides support for the assumption, based on palaeobotanical results, that cereal cultivation was not practised in the area of Hekelingen III.

The absence of 'fish-polish' is much more surprising and clearly requires an explanation. Hekelingen III has yielded ample evidence for the exploitation of fish: obviously its location was ideal for this purpose. It has even been suggested that the site owed its very existence to the capture of sturgeon (Louwe Kooijmans 1983b). The sturgeon is an anadromous fish which, in early summer enters freshwater streams in order to spawn. The flooded backswamps behind the levees of the main creek provided excellent spawning-grounds and could be reached by way of the small tributaries such as the one beside archaeological unit F3. In this narrow side-creek a cluster of poles has been found, which, in analogy with the site of Vlaardingen was interpreted as a fish-trap, apparently intended for catching sturgeon (cf. Boddeke 1971).

Characteristic for anadromous fishes such as sturgeon and salmon is their sudden arrival in great masses. Consequently, they can only be caught during a brief period, but then in large quantities. A fish-trap can be interpreted as a tended facility (*sensu* Oswalt 1976). The location of the trap at Hekelingen III, right within the settled area, enables the occupants to keep an eye on the imminent arrival of the sturgeon. We find a similar situation, for example, among the Netsilik Eskimo, who set up camp close to their weirs in order to spot the fish runs (Balicki 1970). Once the sturgeon had been caught the inhabitants are unlikely to have hauled the large (1.5 to 2.5 m long) fishes to a far-off location for cleaning. I assume they would process the catch right next to the trap, just as for instance the Kutchin set up their cutting tables and drying racks adjacent to their fish-traps (Nelson 1973). The rows of postholes adjacent to the main creek of Hekelingen III might be an indication for the presence of such racks.

All these considerations taken into account it seems strange that no flint tools interpretable as having been used on fish were encountered. Several authors have drawn attention to the fact that in very few archaeological cases traces of 'fish-polish' have been found, despite its distinctive character (Juel Jensen 1986: 25; Moss 1988). In a previous paper I have attributed this absence of evidence to the fact that the distinctive 'fish-polish' only occurs on tools used for scaling fish. As catching such fish usually concerns individual specimens, it is imaginable that either insufficient wear has developed for us to discern (especially recalling secondary use and/or abrasion), or that the scaling occurred outside the settled area at the catch-spot itself with tools being discarded there. As far as the processing of sturgeon is concerned, experiments have shown that, generally, regular 'bone-polish' developed; such tools might therefore be 'hidden' among the bone-sawing/ -cutting implements (Van Gijn 1986a).

6.2.4 Intra- and inter-unit variability

In this paragraph I will first examine whether activity areas can be differentiated within the occupation zone. Next, I will address possible variation in the range of demonstrated activities between the archaeological units analyzed. Lastly, possible changes through time (i.e. between the three VL occupation phases) will be discussed.

The possible existence of activity areas and the related topic of refuse-management (Hayden/ Cannon 1983) is a hotly debated issue. Primary refuse is scarce in activity areas of sedentary communities: because people have to use their house and the area immediately adjacent to it continuously, they regularly clean up and deposit the vestiges of their activities in dumps (hence secondary refuse) (Schiffer 1985). It is clear, however, that (semi-)permanent features, such as walls, benches or hearths, to a large extent structure the inhabitants behaviour, causing activities to regularly take place in designated spots (Cribb 1983). This would theoretically result in set activity areas, but how activity-specific such areas would be is another matter and depends on a great many variables. These include, among others, an anticipated future re-use of a spot (Siegel/ Roe 1986), the need to schedule certain activities concurrently because of 'time-stress' (Torrence 1983) and certain cultural preferences.

Whatever the outcome of such theoretical considerations, the fact remains that use-wear analysts have been able to demonstrate the existence of activity areas on the basis of the wear-traces present on the flint tools. In the Mesolithic site of Vaenget Nord, Denmark, Juel Jensen and Brinch Petersen (1985) have distinguished hide-working activites in the peripheral zone of the site, while minor crafts such as bone-working took place around the hearths. Keeley located a bone and antler workshop at the settlement of Meer, Belgium (Cahen et al. 1979).

When we examine the situation at Hekelingen III, the situation is less clear. Figures 68-73 depict the spatial distribution by 1 × 1 m squares of the inferred contact-materials for the various archaeological units. This distribution

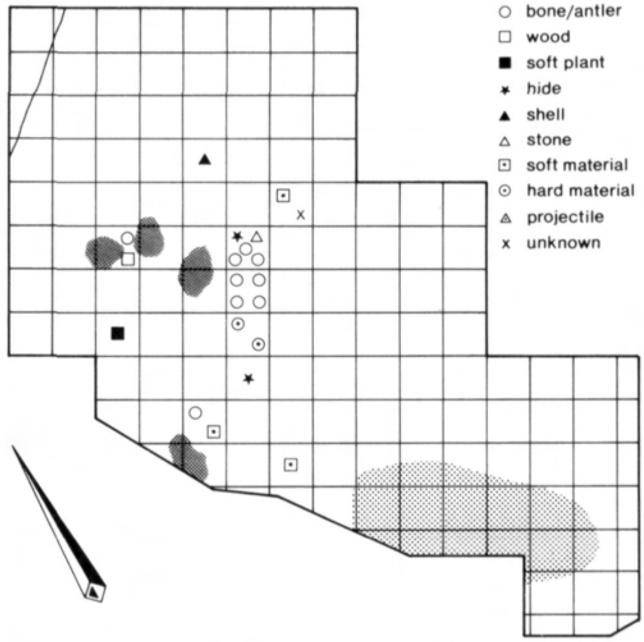


Fig. 68 Hekelingen III archaeological unit M1: spatial distribution of inferred contact materials. Note that on figs. 68-73 the dark-toned spots indicate hearth-areas, while the lighter-toned surfaces locate various disturbances. The wavy line (not present on all figures) gives the approximate edge of the main creek and/or its tributaries.

conforms roughly to the one derived from pottery densities (Van de Velde *in prep.*). The units have rather clearcut boundaries within which all settlement activities are confined, whether they be 'dirty' work like cleaning raw hides, or minor, 'clean' crafts such as bone-tool manufacturing. The location of the find clusters coincides with that of the posthole clusters, seen as evidence for the presence of round or oval huts (Louwe Kooijmans 1986: 18).

Unit M1 is a typical example of this confined distribution. When we look at figure 68 we observe that all bone-/antler- and wood-working tools are clustered around the hearth areas, but so are the few hide-working tools inferred. Obviously we can explain the presence of hide-scrapers close to a hearth by assuming that retooling took place here: exhausted scrapers were removed from their hafts and replaced by fresh specimens (Keeley 1982). Examination of the M1 hide-scrapers for traces of exhaustion such as overhanging dorsal edges, however, suggests that this cannot have been the case as the edges are still usable. A more likely explanation for the characteristic find-distribution of M1 can be found in the circumstance that it might concern a short-lived settlement, possibly revisited several times (see *6.2.6.2*). Unit A1 displays much the same structure as M1 with all used

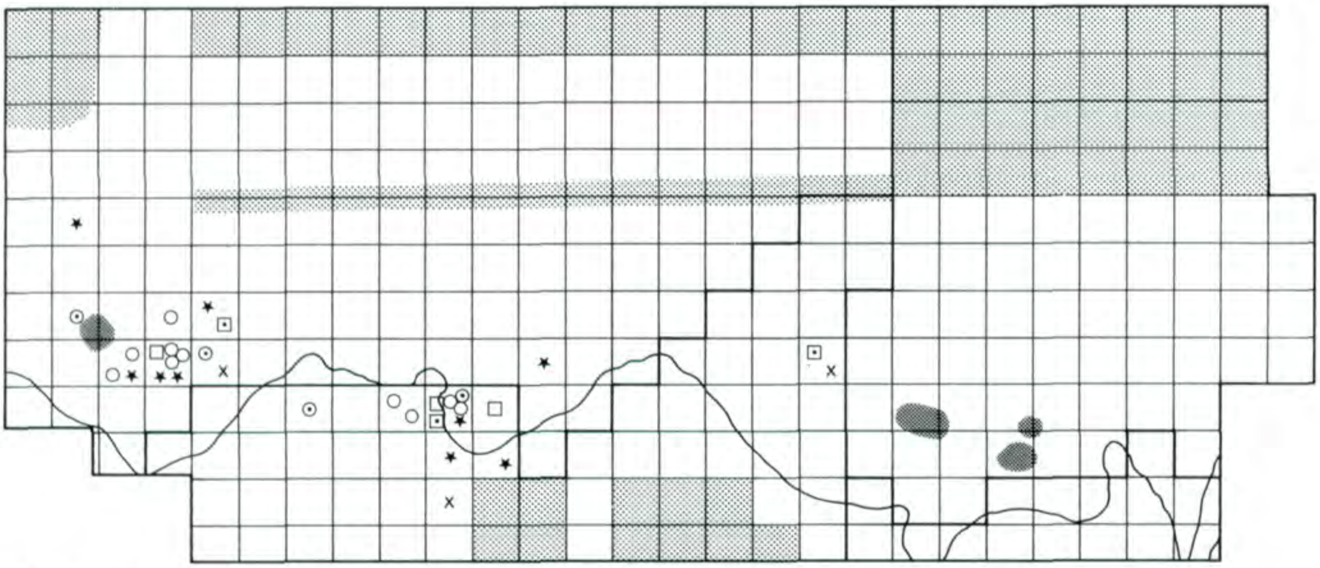


Fig. 69 Hekelingen III archaeological unit A1 and A1g: spatial distribution of inferred contact materials.

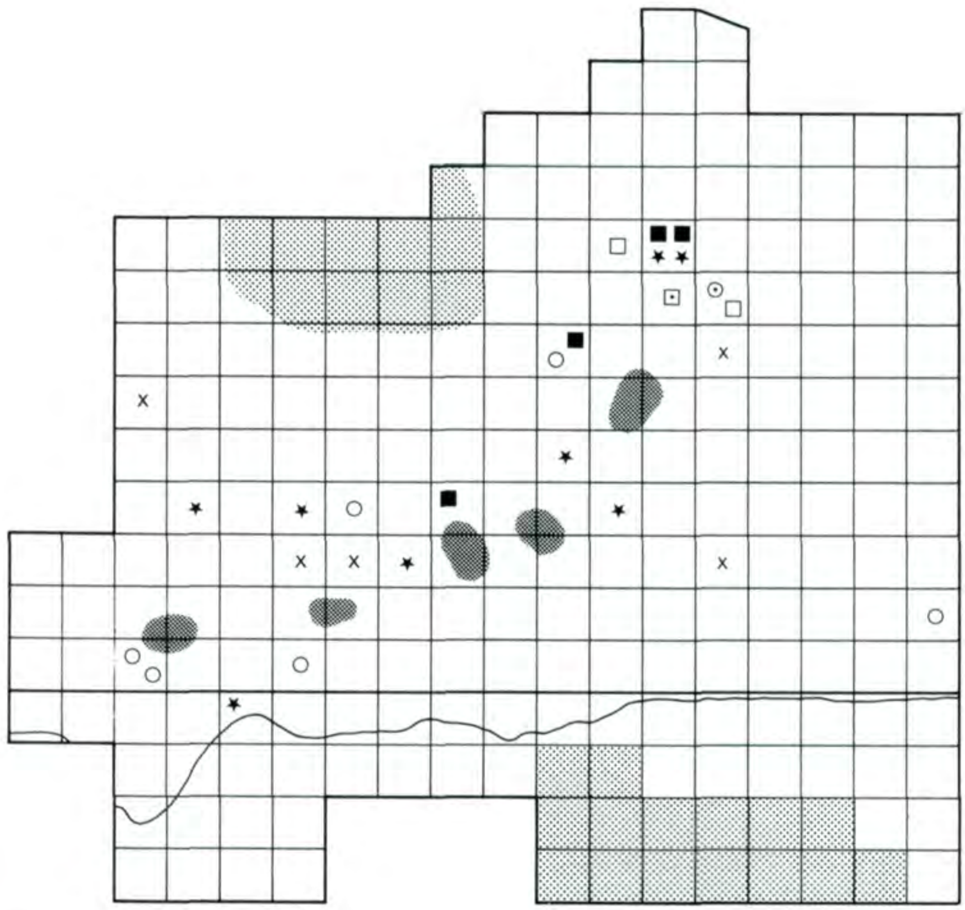


Fig. 70 Hekelingen III archaeological unit B1: spatial distribution of inferred contact materials.

Fig. 71 Hekelingen III archaeological unit H2: spatial distribution of inferred contact materials.

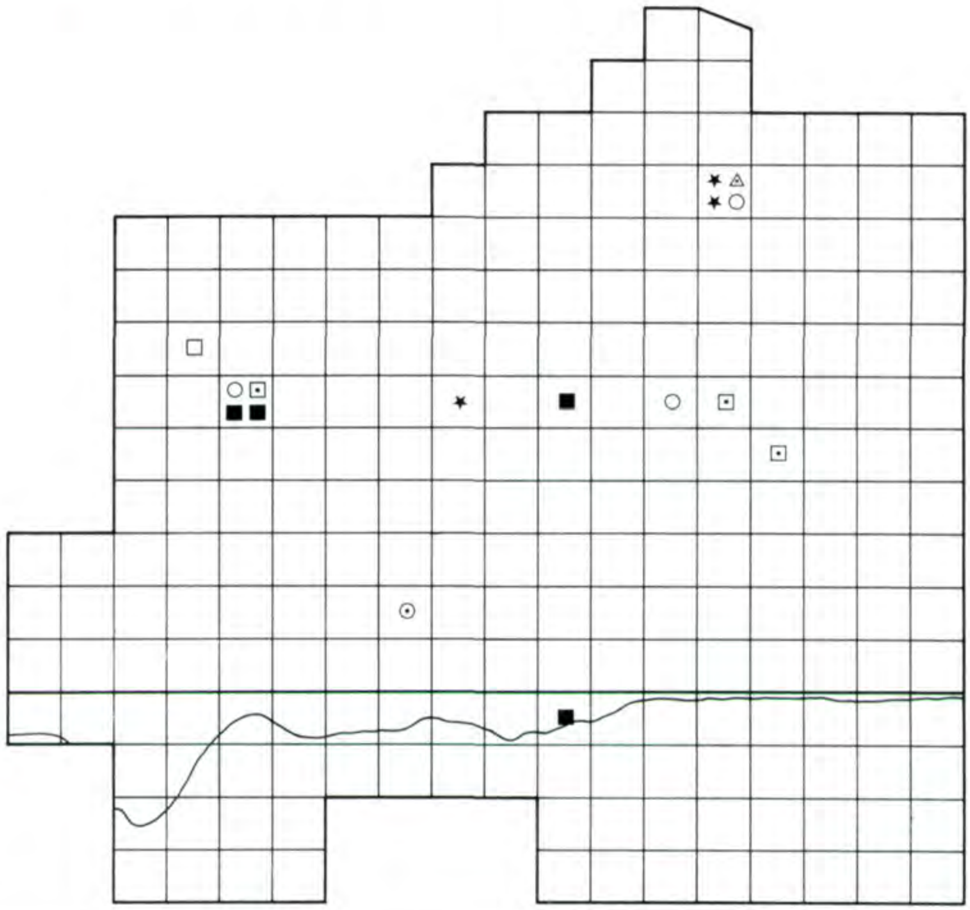


Fig. 72 Hekelingen III archaeological unit B3: spatial distribution of inferred contact materials.

tools clustered around the hearth (*fig. 69*). Unit B1 (*fig. 70*) demonstrates a more diffuse configuration; no concentrations are evident. At unit H2 bone- and wood-working tools are found near the hearths, with four of the six hide-working tools in the periphery. Although the number of tools is too small to carry out a significance test for this distribution, it might be suggested that in unit H2 we have a hint at spatially separate activities (*fig. 71*). Archaeological unit B3, like B1 also exhibits a random and rather wide distribution in which concentrations of tools for specific activities could not be distinguished (*fig. 72*). The same applies to units D, E and F, all attributed to phase 3, with the additional difficulty here that the number of PUAs which could be interpreted is so small that talking about

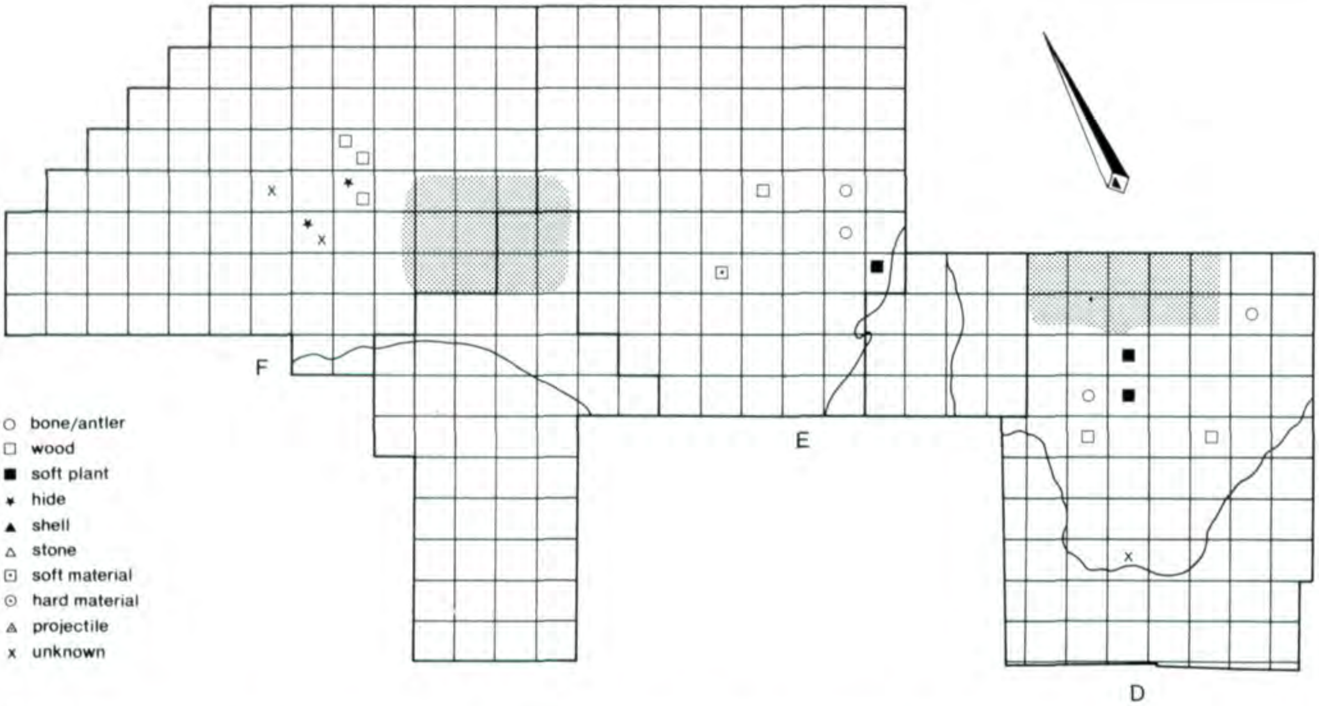


Fig. 73 Hekelingen III archaeological unit DEF/3: spatial distribution of inferred contact materials.

activity areas becomes rather pointless (*fig. 73*).

As far as the question about variability in activities between units is concerned, it should be clear that the numbers involved are really extremely small and, quantitatively, we cannot conclude too much (*table 32*). It is evident that a wide range of activities has been carried out at each unit. Some differences can be noted. Compared with units A1, A1g, B1 and H2, unit M1 has yielded remarkably little evidence for hide-working; instead a number of antler-working tools were encountered, absent, or rarely occurring at the other units. The significance of this last observation is doubtful as not only M1, but most other units as well, yielded small quantities of worked antler (Bodegraven 1986). Unit A1 and A1g display mainly hide- and bone-working tools, soft plant-working apparently being absent. H2 is remarkable because of a significantly higher number of wood-working zones. B3 displays evidence for a variety of performed activities, whilst the number of used zones at DEF/3 is too small to observe any trends.

If the units are grouped into the three habitation phases differentiated at Hekelingen III, the above-mentioned differences become slightly more pronounced, although the numbers are still too small for clear-cut statements (*table 33*). During phase 1 activities involving animal substances such as bone, antler and hide predominate. During phase 2, represented by unit H2 only, plant- en especially wood-working become more important, while during phase 3 tasks involving soft plants seem to become even more prominent, at the expense of hide-processing. I am hesitant, however, to attach behavioural implications to these observations as the numbers are so small. Such conclusions must await the results of other lines of research; a combination of all sources of information can test the above observations.

6.2.5 Aspects of form and function

In the following paragraphs various morphological characteristics of potentially used edges will be examined with respect to the motion in which they were used, the inferred contact-material, and the intensity of wear evident on them (see also *5.5*). It should be stressed that one morphological aspect, the form of the cross-section of the edge, constituted a sampling criterium (cf. *2.3.1*) and was therefore omitted from this analysis (388 of the 455 PUAs had such a straight cross-section). As the type of raw material used appeared to be related to habitation phases at Hekelingen III (cf. Verhart 1983), this was also omitted from further examination. It was considered to be more relevant to examine possible changes in use-patterns between the three phases than between raw materials (see previous paragraph).

Table 32 Hekelingen III: contact-material inferred per archaeological unit by actually used area (AUA).

	M1	A1	A1g	B1	H2	B3	D3	E3	F3	total
hide	2	7	11	9	7	3	–	–	2	41
soft plant	2	–	–	4	3	4	2	1	–	16
wood	1	1	3	2	7	1	2	1	3	21
wood/bone/antler	3	–	–	1	–	–	–	–	–	4
bone	1	5	5	5	5	2	2	2	–	27
antler	5	1	–	–	–	1	–	–	1	8
soft stone	1	–	–	–	–	–	–	–	–	1
shell	1	–	–	–	–	–	–	–	–	1
hard material	2	2	2	1	2	1	–	–	–	10
soft material	3	1	5	1	–	3	–	–	–	14
unknown	1	1	10	5	2	1	1	1	1	22
total	22	18	36	28	26	16	7	5	7	165

6.2.5.1 *Edge angle*

As has previously been observed in the case of Beek-Molensteeg, edge angle can be considered a determinate factor for the motion in which an implement is used (*table 34*). Edges with angles between 40-99°, with a peak in the 60-79° range, were mostly used for scraping. Cutting edges, on the other hand, have edges of 20-59° for the most part. Tools inferred as having been employed in a splitting motion display angles between 20-59°, while those apparently used for carving are more sturdy, having angles between 40-79°. It should be noted here that the three instances of carving, and the 17 cases of boring, in the edge angle range below 20°, concern points for which no edge angle measurements could be taken (cf. *2.6.2*).

When examining inferred contact-material in relation to the edge angle (*table 35*), there is very little relationship. Omitting angles of 20° and less, because of the inclusion of 17 boring implements in this category, it can be seen that edges with angles between 40-79° display wear-traces of a variety of contact-materials. Exceptions include instances of soft plant-cutting tools with angles mostly falling in the 20-39° range, and some hide-woking implements with an angle between 80 and 99°. It is clear that edge angle primarily defines the motion to which an implement is put, and only secondarily the contact-materials. A relationship between edge angle and contact substance is therefore only evident where a correlation exists between motion and contact-material such as for instance between soft plant and cutting (low edge angles). These results contradict to some extent suggestions made by Tainter (1979) and Wilmsen (1968).

With reference to the intensity of wear in relation to edge angle, again, few differences can be noted between the various edge angle classes (*table 36*). The relatively low percentage of lightly, medium and heavily worn edges in the 80-99° range, is compensated by a higher frequency of 'unsure' inferences. The high percentage of worn edges in general, and heavily worn ones in particular in the <20° class, can be attributed to the inclusion of boring tools. The percentage of PUAs without traces of wear is, however, about equal for all categories differentiated.

Table 33 Hekelingen III: contact-material inferred, per phase by actually used area (AUA).

	phase 1	phase 2	phase 3
hide	29 (27.9%)	7 (26.9%)	5 (14.3%)
soft plant	6 (5.8%)	3 (11.5%)	7 (20.0%)
wood	7 (6.7%)	7 (26.9%)	7 (20.0%)
wood/bone/antler	4 (3.8%)	–	–
bone	16 (15.4%)	5 (19.2%)	6 (17.1%)
antler	6 (5.8%)	–	2 (5.7%)
soft stone	1 (1.0%)	–	–
shell	1 (1.0%)	–	–
hard material	7 (6.7%)	2 (7.7%)	1 (2.9%)
soft material	10 (9.6%)	–	4 (11.4%)
unknown	17 (16.3%)	2 (7.7%)	3 (8.6%)
total	104	26	35

6.2.5.2 *Shape of the edge*

A second question to ask is whether a relationship can be demonstrated between the shape of the edge (see *2.6.2*) and the inferred motion to which the tool was put. Five edge-categories were differentiated: straight, slightly convex, slightly concave, pointed and irregular. It is clear that a relationship does indeed exist: convex edges are mostly used for scraping and only secondarily for cutting. Straight edges, for the greater part, serve cutting purposes, while whittling required a concave edge. Carving was performed with either straight or concave edges, splitting with a straight edge (*table 37*). The results confirm what we would intuitively expect. If we examine how the shape of the edge relates to worked material, the picture is less clear: straight, convex, pointed and, to a lesser extent, concave edges display evidence for virtually all contact-materials. There is only a relationship between hide and convex edges (*table 38*). Neither is there much correlation between shape of the edge and intensity of wear, with the exception of the category 'pointed'. This category includes the borers, many of which were intentionally modified for use as such (*table 39*).

Table 34 Hekelingen III: edge-angle, divided into classes, versus inferred motion by actually used area (AUA).

	< 20°	20-39°	40-59°	60-79°	80-99°	⩾ 100°	total
scraping	2	2	8	20	8	–	40
whittling	1	1	2	2	–	–	6
cutting	3	14	17	3	–	–	37
carving	3	–	6	2	–	–	11
splitting	–	4	2	–	–	–	6
boring	17	–	–	–	–	–	17
projectile	1	–	–	2	–	–	3
hafting	–	–	4	4	4	–	12
unknown	3	3	9	12	6	–	33
total	29	24	49	45	18	–	165

Table 35 Hekelingen III: edge-angle, divided into classes, versus inferred contact-material by actually used area (AUA).

	< 20°	20-39°	40-59°	60-79°	80-99°	⩾ 100°	total
hide	5	3	14	14	5	–	41
soft plant	1	7	4	2	2	–	16
wood	3	3	11	3	1	–	21
wood/bone/antler	1	–	1	2	–	–	4
bone	4	4	10	7	2	–	27
antler	1	–	3	2	2	–	8
soft stone	1	–	–	–	–	–	1
shell	1	–	–	–	–	–	1
hard material	3	5	1	–	1	–	10
soft material	4	1	3	4	2	–	14
unknown	1	–	–	2	–	–	22
total	29	24	49	45	18	–	165

Table 36 Hekelingen III: edge-angle, divided into classes, versus inferred intensity of wear by potentially used area (PUA).

	< 20°	20-39°	40-59°	60-79°	80-99°	⩾ 100°	total
no traces	9	19	29	19	8	1	85
lightly worn	2	1	4	6	1	–	14
medium worn	7	7	11	4	1	–	30
heavily worn	12	6	8	10	1	–	37
resharpened	–	–	–	6	–	–	6
probably used	7	13	17	12	5	–	54
not interpretable	10	31	44	49	17	1	152
unsure	8	10	25	19	15	–	77
total	55	87	138	125	48	2	455

Table 37 Hekelingen III: shape of the edge versus inferred motion by actually used area (AUA).

	straight	convex	concave	pointed	irregular	total
scraping	4	34	–	1	1	40
whittling	2	1	3	–	–	6
cutting	14	19	2	1	1	37
carving	6	1	3	1	–	11
splitting	5	1	–	–	–	6
boring	1	–	–	16	–	17
projectile	1	1	–	1	–	3
hafting	5	5	1	1	–	12
unknown	8	23	1	1	–	33
total	46	85	10	22	2	165

Table 38 Hekelingen III: shape of the edge versus inferred worked material by actually used area (AUA).

	straight	convex	concave	pointed	irregular	total
hide	7	27	1	5	1	41
soft plant	9	5	1	1	–	16
wood	6	7	6	2	–	21
wood/bone/antler	1	2	–	1	–	4
bone	9	13	2	3	–	27
antler	2	6	–	–	–	8
soft stone	–	–	–	1	–	1
shell	–	–	–	1	–	1
hard material	3	6	–	1	–	10
soft material	3	8	–	3	–	14
unknown	6	11	–	4	1	22
total	46	85	10	22	2	165

Table 39 Hekelingen III: shape of the edge versus inferred intensity of wear by potentially used area (PUA).

	straight	convex	concave	pointed	irregular	total
no traces	45	36	2	1	1	85
lightly worn	1	11	–	2	–	14
medium worn	11	12	2	5	–	30
heavily worn	10	12	5	9	1	37
resharpened	–	6	–	–	–	6
probably used	21	21	10	1	1	54
not intrepretable	64	74	9	2	3	152
unsure	23	44	4	5	1	77
total	175	216	31	26	7	455

6.2.5.3 Shape of the aspect surfaces

Another morphological attribute recorded was the shape of the surfaces constituting an edge (see *2.6.2*). It was assumed that an edge with one convex and one straight plane would be more suitable for scraping, while an edge straight on both aspects would possess good cutting properties. From table 40 we can see that the relationship is not so straightforward, although there appears to be a tendency for some of the edges with one convex aspect (categories 12, 21 and 32) to have been used more often for scraping purposes. When this morphological attribute is studied for inferred substance, an even greater variability is evident. On those combinations occurring most frequently, i.e. 11 and 12 (resp. N = 35 and N = 81), the entire range of contact-materials is represented. The same variability is present when comparing intensity of wear and shape of the aspect surfaces. Consequently, no tables were produced.

6.2.5.4 Tool type

In the previous paragraphs emphasis lay on morphological attributes of individual PUAs. In the following, the question will be asked whether tool types are homogeneous in terms of function.

Not less than 22 of the 37 AUAs on convex scrapers were indeed used in a scraping motion, while straight edges on retouched flakes were selected for cutting purposes (*table 41*). As might be expected, borers were employed in boring

Table 40 Hekelingen III: shape of the aspect surfaces versus inferred motion by actually used area (AUA).

	11	12	13	21	22	23	31	32	absent	total
scraping	3	20	1	4	1	–	–	11	–	40
whittling	2	1	1	1	–	–	–	1	–	6
cutting	8	23	–	2	2	–	–	1	1	37
carving	4	5	–	1	–	–	–	–	1	11
splitting	3	2	–	–	–	–	1	–	–	6
boring	4	3	–	–	7	–	1	–	2	17
projectile	–	2	–	–	1	–	–	–	–	3
hafting	3	7	–	–	2	–	–	–	–	12
unknown	8	18	1	1	–	2	1	2	–	33
total	35	81	3	9	12	2	3	15	4	165

or piercing. Otherwise, most tool types seem to have functioned in a number of motions. Especially retouched and unretouched flakes, multiple scrapers, and *encoches* were apparently quite versatile. It should be noted that the registration system used, with its emphasis on edges rather than entire tools, may result in some confusion. Obviously, an *encoche* cannot have been used for boring (see *table 41*). However, apart from a retouched concave edge (which led to the tool's typological classification as *encoche*), the tool possessed another edge which was unretouched, but suitable for boring. In a sense, tables 41-43 are therefore somewhat misleading, because not all the PUAs represented were responsible for the type into which they were classified. To be

Table 41 Hekelingen III: relationship between tool typology and inferred motion by actually used area (AUA).

	scraping	whittling	cutting	carving	splitting	boring	projectile	hafting	unknown	total
unretouched blades	–	–	1	–	–	–	–	–	1	2
unretouched flakes	3	1	4	–	1	–	–	–	4	13
unretouched waste	–	–	1	1	–	–	–	–	1	3
retouched blades	–	–	2	2	–	–	–	–	1	5
retouched flakes	6	1	22	1	5	–	–	–	7	42
retouched waste	3	–	–	–	–	–	–	–	–	3
cores	1	–	–	1	–	–	–	–	–	2
convex scrapers	22	1	3	–	–	–	–	–	11	37
thumbnail scrapers	1	·	–	–	–	—	–	2	2	5
multiple scapers	1	1	3	2	–	–	2	2	3	14
composite tools	1	–	–	–	–	2	–	–	–	3
encoches	–	1	1	2	–	1	–	2	–	7
borers	2	1	–	2	–	14	–	4	1	24
points	–	–	–	–	–	–	–	–	2	2
barbed arrow heads	–	–	–	–	–	–	1	2	–	3
total	40	6	37	11	6	17	3	12	33	165

Table 42 Hekelingen III: relationship between tool typology and inferred contact-material by actually used area (AUA).

	hide	soft plant	wood	wood/bone antler	bone	antler	soft stone	shell	hard material	soft material	unknown	total
unretouched blades	–	1	–	–	–	1	–	–	–	–	–	2
unretouched flakes	4	3	2	–	–	–	–	–	1	1	2	13
unretouched waste	–	–	–	–	2	–	–	–	–	1	–	3
retouched blades	2	–	–	1	2	–	–	–	–	–	–	5
retouched flakes	6	6	7	–	7	2	–	–	7	4	3	42
retouched waste	1	–	1	–	1	–	–	–	–	–	–	3
cores	–	–	–	–	–	2	–	–	–	–	–	2
convex scrapers	17	–	1	2	5	3	–	–	1	2	6	37
thumbnail scrapers	3	–	1	–	–	–	–	–	–	1	–	5
multiple scrapers	2	–	1	–	5	–	–	–	–	1	5	14
composite tools	1	–	–	–	1	–	–	1	–	–	–	3
encoches	–	2	3	–	1	–	–	–	–	1	–	7
borers	3	4	5	1	3	–	1	–	1	2	4	24
points	–	–	–	–	–	–	–	–	–	1	1	2
barbed arrow heads	2	–	–	–	–	–	–	–	–	–	1	3
total	41	16	21	4	27	8	1	1	10	14	22	165

more concrete, several unretouched edges which are present on convex scrapers in addition to the intentionally retouched convex, scraping edge are included among the 37 AUAs on convex scrapers. Despite of its slightly misleading character, table 41 illustrates that we should be prudent about the functional significance of the types differentiated: a convex scraper may have usable edges other than the edge which led to its typological classification.

When examining the relationship between tool type and inferred contact-material, the variability is even more evident. Although a large number of PUAs on convex scrapers were employed on hide, more resistant materials such as bone and antler were worked as well. PUAs on other tool types, most notably multiple scrapers, retouched flakes and borers, display wear-traces from many different contact substances (*table 42*). With respect to degree of wear it can be observed that PUAs on borers are significantly more heavily worn than PUAs on other tool types (*table 43*).

6.2.5.5 Discussion

Finally, I would like to draw attention to the fact that a certain number of unretouched edges nevertheless exhibit traces of use (*table 44*). Although only 9% of the unmodified edges could be interpreted as having been used, this sample includes some crucial information. Sometimes the bone-carving-polish, presumably indicative of the manufacture of bone awls and chisels was observed on artefacts without any trace of modification (*fig. 56d*). Also, four of the six implements interpreted as having been employed in splitting plants appear to be flakes lacking either retouch or 'use-retouch' (*fig. 60c, 60e-g*). The evidence for both bone-tool production and plant-working adds considerably to our

Table 43 Hekelingen III: relationship between tool typology and inferred intensity of wear by potentially used area (PUA).

	no traces	lightly worn	medium worn	heavily worn	resharpened	probably used	not interpretable	unsure	total
unretouched blades	5	–	2	–	–	3	1	–	11
unretouched flakes	29	2	4	–	–	6	32	7	80
unretouched waste	2	–	–	–	–	1	1	3	7
retouched blades	–	–	1	2	–	2	8	1	14
retouched flakes	13	4	8	13	–	8	47	17	110
retouched waste	4	1	–	–	–	1	8	2	16
cores	2	–	2	–	–	1	–	–	5
convex scrapers	18	4	3	4	5	14	31	21	100
thumbnail scrapers	1	1	1	–	1	2	–	2	8
multiple scrapers	3	–	1	2	–	8	7	11	32
composite tools	2	1	1	1	–	1	1	–	7
encoches	–	1	2	4	–	2	4	–	13
borers	–	–	5	11	–	3	2	8	29
points	–	–	–	–	–	–	3	2	5
barbed arrow heads	3	–	–	–	–	–	1	3	7
transverse arrow heads	–	–	–	–	–	2	6	–	8
polished axes	3	–	–	–	–	–	–	–	3
total	85	14	30	37	6	54	152	77	455

Table 44 Hekelingen III: intensity of wear per observed phenomenon.

	retouch ⩾ 1mm	retouch < 1mm	unretouched straight	polished fragments	points	total
no traces	27 (14.1%)	17 (11.5%)	38 (34.2%)	3	–	85
used	38 (19.9%)	37 (25.0%)	10 (9.0%)	–	2	87
possibly used	21 (11.0%)	20 (13.5%)	13 (11.7%)	–	–	54
not interpretable	63 (33.0%)	53 (35.8%)	36 (32.4%)	–	–	152
unsure	42 (22.0%)	21 (14.2%)	14 (12.6%)	–	–	77
total	191 (100 %)	148 (100 %)	111 (100 %)	3	2	455

picture of the site Hekelingen III. As has already been outlined in chapter 3, many activities, if executed in a skilled way and if suitable edges are selected, induce very little, if any, use-retouch on the tools. Moreover, it has also been demonstrated that even long-term work does not necessarily produce polish on the tools. This implies that an even higher percentage of unretouched flakes than the 9% demonstrated for the Hekelingen III assemblage, might have been used but cannot be detected.

From the preceding paragraphs it can be concluded that shape, especially edge angle, was of importance to the kind of motion to which the artefacts were put. Even though the flint technology practised at Hekelingen III appeared to be haphazard and the tool types not clearly defined and standardized, edges were apparently carefully scrutinised for their possible suitability. The decisions the users made were consistent; however, is was the shape of any individual edge that prevailed above the appearance of the total artefact. Tool types were therefore extremely heterogeneous in terms of the use to which they were put (*6.2.5.4*).

6.2.6 Duration of occupancy at Hekelingen III

One of the questions raised by the examination of settlements such as Hekelingen III, is whether or not these sites in the Rhine/ Meuse delta were occupied yearround during the Late Neolithic and the extent to which they were dependent upon hunting and gathering. It appears that people occupied Hekelingen III during various seasons and it would therefore seem unlikely that we are dealing with a special purpose camp ('station'), only briefly visited to exploit one particular resource. Such camps are common in Palaeolithic times, but were also present in fully Neolithic societies and even during the Bronze Age (cf. Bergschenhoek and Oldeboorn). Hekelingen III was located in an area which was, at least from an economic point of view, attractive in different seasons and offered the opportunity of extracting a variety of resources. Were these exploited from a permanently inhabited settlement on the spot, or is the diversity in finds a reflection of recurrent shorter or longer visits?

6.2.6.1 Evidence from the use-wear analysis

There is a number of ways in which the use-wear analysis of the flint can contribute to the discussion about duration of occupancy. It has been postulated that labour-intensive activities, such as the processing of hides, wood- and bone-/antler-working, as well as retooling, would indicate long-term or even permanent occupation. It is only when people settle for an extended period, that they allocate time for executing such tasks. At 'stations', briefly visited to exploit a specific resource, all the available time must be devoted to subsistence tasks.

Hide-processing is often regarded as a task for which one has to be sedentary for quite some time. This is not an unreasonable assumption, as far as the tanning and softening stages of hide-working is concerned. Gallagher (1977), who has studied Ethiopian tanners, mentions that it takes six hours to scrape an entire cow hide, working without interruptions. However, cleaning and drying of fresh hides is often done on the kill site. Binford describes the butchering as being done on the raw hides; they are subsequently dried, held down to the grass by some stones (Binford 1983: fig. 71). These dried hides are very light and therefore easy to transport, even in great quantities. Wet hides on the contrary are quite unmanageable.

The analysis of the Hekelingen III assemblage has indicated the presence of scrapers with a matt polish and considerable edge-rounding, i.e. 'dry hide' working tools. It is often assumed that 'dry hide' scrapers have been used to soften tanned hides. The occurrence of such artefacts would, therefore, suggest that the site was inhabited for an extended period of time. Quite apart from the question as to how long such a stay would have to last before this task was accomplished (a month seems to be quite sufficient), there is yet another reason why we cannot draw this conclusion so easily: flint scrapers can display the same edge-rounding, perpendicular scratches and matt, rough polish as a result of working fresh hides if abrasives are added. Whether this is necessary depends on the presence of fat under the skin. Most fur-bearing animals such as bear, fox and badger have such a fatty layer, while deer, for example, do not. When skinning deer, the hide comes off cleanly (apart from some small scraps of meat adhering to it), and can be dried or processed immediately. However, a fresh fox hide is covered with a large quantity of grease. When attempting to scrape it off, I noticed that this was virtually impossible without adding flour or fine sand which could absorb the fatty moisture. Such a procedure would also prevent that fat accumulates on the scraping edge, hindring its effective use (cf. Brose 1975). Other researchers have also drawn attention to the problem of scraping fatty hides and have described the wear features resulting from the addition of what they call 'abrasives' (Brink 1978b; Mansur 1983). In chapter 3 I have already described the difficulties of differentiating the experimental wear-traces of the separate stages and variations in hide-processing. Here we have such a problem in an archaeological context: do we have to interpret the 'dry hide' scrapers of Hekelingen III as tools used for the labour-intensive softening activities or as implements for cleaning fresh hides with abrasives?

A large majority of the game animals identified at Hekelingen III consist of red deer; for the cleaning of their hides no abrasives were needed, so it would seem that the 'dry hide' scrapers were used in the softening process. However, the amount of scrapers is relatively small, whereas it is generally assumed that softening is very flint-consuming. Gallagher (1977) states that the Ethiopian tanners need four scrapers for softening one cow-hide (it must be noted that this concerns obsidian scrapers which might wear out at a different rate than flint scrapers). Furthermore, the use-wear analysis of the Beek-Molensteeg flint (cf. *chapter 5*) has revealed the presence of a large number of 'dry hide' scrapers, all of them much more rounded and exhibiting much more polish than those from Hekelingen III. The Beek-Molensteeg tools were interpreted as 'real' dry hide scrapers, i.e. used in the softening stage of hide-processing, while the lesser-worn scraping implements from Hekelingen III do not seem to have been employed that way.

The archaeozoological analysis has shown that small numbers of fur-bearing animals were also trapped or hunted. The 'dry hide' scrapers could thus possibly have been used to clean the fresh, fatty hides of bear and pine marten. The relative scarceness of 'dry hide' scrapers and the fact that they were not exhausted would support this hypothesis. One objection to this proposal could be that, in this case, one would expect to find the scrapers used and discarded at the kill sites (see above). However, this pertains mainly to a situation where large numbers of animals are killed simultaneously, such as is the case with reindeer (Binford 1983). The killing of fur-bearing animals, however, is an isolated occurrence probably taking place in the vicinity of the settlement. The cleaning of the fresh hides of fur-bearing animals is quite time-consuming and it seems likely that the animals were simply hauled back to the settlement before being butchered. Ethnographic accounts of Athabascan Indians, who still practise trapping in the forests of northern Canada, support this assumption (Brody 1981). To conclude, I suggest that the 'dry hide' scrapers of Hekelingen III were used in the fresh hide cleaning stage of fatty skins. If this is the case, then the presence of these tools cannot be considered as evidence of a long-term, let alone permanent, occupation of Hekelingen III.

The second activity which is often mentioned as being very time-consuming is bone-working. Ethnographic accounts of Eskimo communities describe how they fill the long and dark winter months with labour-intensive tasks such as the manufacturing of bone and antler objects. It is from such examples that the idea has sprang forth about, for instance, bone-working being associated with winter- or base-camps. Undoubtedly these kinds of activities do take place at sites only occupied during the winter. However, bone- and antler-working are not confined to such types of settlements. Torrence (1983) has rightly drawn attention to the fact that these tasks are eminently suitable to pass the time with, while, for example, waiting for game or for supper. The tools needed to produce bone and antler objects are few in number and small in size. As long as the projected bone or antler objects are relatively small (like the bone awls and chisels of Hekelingen III), it is easy to carry the entire toolkit and semi-manufactured products around for craft activities during short periods of leisure between other tasks, more directly related to the subsistence quest. To conclude, the presence of bone- and antler-working tools cannot be used to determine the type of settlement involved at Hekelingen III.

Recently, Juel Jensen has suggested that the relative frequency of wood-working tools may provide a clue for establishing the duration of occupancy of a site (Juel Jensen/ Brinch Petersen 1985). She states that wood-working is 'neutral' with respect to seasonality (in contrast to hide), and that wooden tools need repair throughout the year. She uses this argument for the interpretation of the Mesolithic settlement of Vaenget Nord (Denmark), where she was able to find only a small number of wood-working tools. Asserting that 'wood-polish is one of the clearer and more easily recognizable polishes' (Juel Jensen/ Brinch Petersen 1985: 52), she concludes that the relative scarcity of wood-working tools is 'real' and forms a reflection of the character of Vaenget Nord, i.e. a place which was visited briefly and for specialized purposes.

I would suggest that there is a stronger argument for wood-working as indicator of duration of occupancy, than its alleged neutrality in terms of seasonality. One would expect that the longer a site is occupied, the more elaborate the dwellings. In those areas where wood constitutes the main building material, one should find more wood-working implements on permanent settlements. The problem with all of the above arguments is, however, that it is not wood-working *per se* which suggests duration of stay, but its relative frequency; how are we to differentiate between wood-working implements produced by permanent inhabitants and those deposited by people who came to visit the site for a few weeks (hence, a shelter) year after year? Returning to Hekelingen III, it was seen that, especially during occupation phases 2 and 3, quite a number of wood-working implements were encountered. We can conclude that the site was therefore not visited briefly but that, instead, people stayed for some time. Whether this stay encompassed a few weeks during various seasons year after year (i.e. a palimpsest of occupations), or whether it concerned yearround settlement, is impossible to tell on the basis of relative frequencies.

Another criterium to determine the duration of habitation at Hekelingen III would be the relative frequency of hafting traces. Based on Yellen's (1977) observation that the longer a site is occupied, the more maintenance activities are carried out, Keeley (1982) has proposed that such settlements would yield a relatively high frequency of once-hafted tools. He argues that it is at those sites that people would repair their implements in preparation of special-purpose trips: when going out on a hunting expedition it is better to have one's toolkit ready in advance. At the base-camps or permanent settlements worn-out or broken tools would be removed from their hafts, while the latter are 'retooled'. The basic assumption is that the hafts require a lot of labour and are being re-used over and over again. Again, we have the problem that this criterium may enable us to differentiate a briefly occupied site from one inhabited for a longer period, but not between a so-called base-camp and a permanent settlement: retooling activities are likely to have taken place at both. There is an additional difficulty that hafting traces are not only frequently absent, but also notoriously difficult to interpret (cf. Stordeur 1987). With respect to Hekelingen III, hafting traces are relatively rare, but, due to the effect of pdsm, this should not be taken as reflecting the 'real' situation.

All in all, the spectrum of activities attested for at Hekelingen III on the basis of wear-traces present, confirms the suggestion that the site cannot have been a briefly-visited 'station'. Evidence for the performance of a variety of activities argues against such an interpretation. It seems quite beyond doubt that the site reflects a (series of) longer-term stay(s). Unfortunately, none of the demonstrated activities could be unequivocally attributed to either a permanent inhabitation or a 'long visit'. Alternative approaches towards solving the problem were therefore sought.

6.2.6.2 *Alternative evidence*

A different approach towards estimating the duration of occupancy at the site, not directly based on the spectrum of activities inferred from the use-wear analysis, is to determine to what extent evidence exists for economizing behaviour with regard to flint. When people inhabited a site such as Hekelingen III on a permanent basis, where plentiful supplies of raw materials are hard to come by in the immediate vicinity, we would expect them to be careful with discarding flint. There are several ways of resolving this question. Firstly, we could examine the degree of wear exhibited by the Hekelingen III tools: 85 (18.9%) of the 449 PUAs were interpreted as unused, while 159 (35.4%) were used to varying degrees. The evidence is not unequivocal: the flint seems neither to have been 'curated' nor wasted, but it should be mentioned that this result can have been distorted by the presence of pdsm.

Another avenue to approach the problem of economizing behaviour is the number of PUAs and AUAs per tool. When raw material is scarce it is assumed that more than one working edge per artefact would be created, i.e. the production of combination tools. At Hekelingen III generally only one PUA per tool was found (N = 242 or 72%) On 78 implements (23%) two PUAs were present, while three PUAs were observed in only 17 cases (5%). Of course these results could be a consequence of poor technology, or of faulty sampling on our own part, but still the number of PUAs per artefact is small and generally confined to one edge, most frequently one of the lateral edges (235 of the 449 PUAs). It would seem that the inhabitants of the site were not really concerned with the conservation of their flint. This would seem even more so when we examine the number of actually used areas (AUA) per PUA: evidence for multiple use-instances on the same edge was only present in six cases. I am sure this actually occurs more frequently but cannot be detected by the use-wear method, as traces for primary use on e.g. meat are masked by subsequent activities. The frequency of hafting traces is yet another indication of economizing behaviour (Keeley 1982), but will not been used here because of the under-representation of these traces in the case of Hekelingen III, due to the occurrence of pdsm (see *6.2.3.2*).

To conclude, we possess at Hekelingen III, evidence for a rather expedient way of dealing with the flint. It has definitely not been saved or used up, which is somewhat surprising when we recall that all material was imported. The pattern does conform, however, to what might be expected for a temporary habitation: a relatively small amount of flint, is taken along, enough to fulfill the necessary subsistence tasks and to practise some craft activities appropriate to the place (e.g. bone-working, basketry). When the objectives had been attained, the flint is left behind, even though most of it had not been exhausted. At Hekelingen III, probably all attention was focused on the catch of sturgeon or game and how this could be carried back to the main settlement; leaving usuable flint behind seems of no concern because of an anticipated future use of the site. As such, the place, or better the shelters present, form an 'artefact trap' where flint and other implements could accumulate over the years. Still usable objects were left behind because they were easy to replace back at the permanent settlement. I therefore tend to disagree with the idea that the evidence for a large number of vessels contradicts the interpretation of Hekelingen III as a seasonally occupied place (cf. Louwe Kooijmans 1986).

The interpretation of Hekelingen III as being the result of seasonal visits is corroborated by the character of the find-distributions. Ethnoarchaeological evidence suggests that in the case of permanent occupation find clusters will be less discrete, because the living areas are cleaned frequently. The more permanent the settlement, the more secondary refuse is present. Cleaning is less important if a 'task group' is inhabiting a place for just a limited amount of time (see also *6.2.4*). In Hekelingen III the find material is clustered around the hearths, gradually petering out further away from these central features, a distribution which is not so typical for houses occupied on a yearround basis: we would expect their central area to be more devoid of finds. If a clustered find-distribution is more characteristic of temporary encampments, it must be explained why activities took place at more or less the same spot, season after season. This is not impossible, as apparently shelters or houses were erected on the levee, as testified by the presence of postholes (Louwe Kooijmans 1986). Walls and hearths could structure the inhabitants' behaviour and discard patterns (Cribb 1983). Still usable objects are also likely to have been left behind within the structures. The presence of such dwellings is not surprising when it is recalled that one of the main reasons for coming to Hekelingen was the catch of sturgeon; this implies waiting at least some time for the fishes to arrive (see *6.2.3.2*). As the exploitation of this resource can be anticipated to occur every year, houses can be re-used. In ethnographic context, it is not uncommon to leave a temporarily occupied shelter more or less intact for some later re-use as evidenced by Northwest Coast Indian plank houses or the fishing cabins of the Huron Indians (Tooker 1964; Trigger 1967) (see also *3.7.1*).

6.2.7 CONCLUSION

The use-wear analysis of the Hekelingen III flint assemblage has provided additional insight into the activities of the site's former inhabitants. Crafts included basketry and matting, the making or repair of wooden objects, and the boring of shell, perhaps to make pendants. One borer used on stone might have been used for fire-making. It was already known that bone awls and chisels were produced locally; the use-wear analysis has shown which flint tools were employed in this task. There seemed to be no evidence for the rather time-consuming softening of dry or tanned hides. The hide-scraping tools present were interpreted as having been used for the removal of fat with abrasives from fur-bearing animals. The use-wear analysis has not provided much additional insight into the subsistence tasks: the hypothesis that cereals were not grown locally has not been falsified (i.e. no sickle-gloss has been observed). Fish-processing tools or butchering implements have not been encountered, probably due to various post-depositional processes.

At all archaeological units the used tools were situated around the hearths, irrespective of the kind of traces observed on them. The only exception is found in unit B1 where bone- and wood-working implements were found around the hearths, with hide-working tools located more at the periphery of the find concentration. When examining chronological trends in the wear-spectrum inferred, it can be noted that contact with bone, antler and hide is more frequent during phase 1, while during phase 3 plant-working seems to become more prominent, at the expense of hide-processing. Hekelingen phase 2, represented solely by unit H2, displays a high frequency of wood-working.

With respect to the relationship between form and function, the most noteworthy aspect is the rather high frequency of wear-traces on unmodified edges. Especially traces inferred as being the result of plant-splitting, and those of bone-carving, were often observed on unretouched artefacts. Another conclusion is that types are not functionally homogeneous: apparently the suitability of edges was of more concern than the total appearance of the implement. This seems to be common for Late Neolithic flint assemblages (see also Deckers 1985). The choice of implements was primarily dependant on edge angle and, to a lesser extent, on the shape of the edge when viewed from above.

The last question to be addressed was that of seasonality, or the duration of occupancy at Hekelingen III: does it concern a permanently occupied settlement or was the site merely visited during various seasons? Neither the evidence for bone-tool manufacturing, nor for wood-working or hafting, provided sufficient grounds for establishing the character of the site. Softening dry or tanned hides is also frequently associated with a base camp or permanently occupied settlement. Despite the fact that a demonstration of this activity still does not provide an answer to our question, it was argued that the 'dry hide' scrapers from Hekelingen III were used to remove the subcutaneous fat from the hide of fur-bearing animals. The only clue about the question of permanent versus seasonal habitation comes from the apparently rather careless way in which the flint was consumed, especially considering the fact that all flint was of non-local origin and had to be imported. Had the inhabitants been living in the area on a yearround basis, one would expect them to either use up the imported flint more than they seem to have, or to have relied more on nearby flint sources (i.e. rolled pebbles from the Meuse). Yet another corroborative argument, not derived from the wear-trace analysis, comes from the find-distribution apparent at the various archaeological units: it was argued that one is more likely to encounter such a concentration of finds around hearths in a temporary, rather than in a permanent, shelter. In the latter case it seems that debris would be cleaned out from the hearth area, supposedly the most frequented part of the house. On the other hand, the dwellings present on the levee at Hekelingen III might have constituted an artefact-trap: implements, left behind in anticipation of a future use of the site, could accumulate here over the years.

To conclude, it is argued that the case for recurrent seasonal visits is the stronger one. Hekelingen III is interpreted as being the result of a strategy of logistic mobility embedded in a system of permanent farming settlements. The introduction of agriculture and animal husbandry, whether by a process of colonisation or by acceptance of the local hunter-gatherer groups at the northwestern margin of the European plain (Dennell 1985), was still a relatively recent phenomenon. Consequently, we might consider the situation to be the one of a static frontier (Alexander 1978), with all the associated stress phenomena. The prime areas for farming had been fully occupied earlier and the sea inhibited further expansion. The seemingly endless possibilities for expansion of the preceeding period had come to an end, causing the pioneer-farmers to develop a perception of the diminished productivity of their surroundings. Alexander has outlined a number of ways of alleviating such stress conditions. One strategy could be warfare, but a milder form of territorial behaviour seems more likely in our case. Another option might be migrating to new regions or, alternatively, starting to utilize marginal areas for farming. A fourth choice, which is of concern here, implies exploiting certain wild resources. It should be stressed that the area around Hekelingen constitutes an ecotone yielding resources from different environmental zones. As such it is, from a perspective of hunting-gathering-fishing, all but a marginal area. It is suggested that Hekelingen III represents a site from where auxiliary wild resources were obtained by a farming community, presumably located to the south. Such a situation might be somewhat analogous to what has been demonstrated for, for instance, the Danish TRB site of Sølager, located at the coast while an agricultural settlement has been found 3 km inland[3] (Skaarup 1973).

I am aware that this hypothesis remains to some extent a very speculative one. Clearly, with new data from specialized studies becoming available, or with a different theoretical perspective, a convincing argument may also be presented for an interpretation of Hekelingen III as a permanent settlement. In this respect, it might be useful to briefly draw attention to the nearby presence of Hekelingen I, where a much thicker occupation level was found. It has been suggested that Hekelingen I was the permanent settlement from which activities 'spilled over' into Hekelingen III (L.P.Louwe Kooijmans *pers.comm.*). However, if such had been the case, I would expect Hekelingen III to have displayed evidence for fewer performed activities, as well as a more equally-spread, thinner find-distribution. Whatever the outcome of these debates, other sites have posed for their researchers similar interpretative problems as for instance Swifterbant (Deckers et al. 1980) and Bistoft (Johansson 1981). It would definitely be worthwhile to further explore the question as to what exactly would differentiate a permanently inhabited settlement from a site recurrently visited. Evidence for specialized subsistence is by itself not the answer!

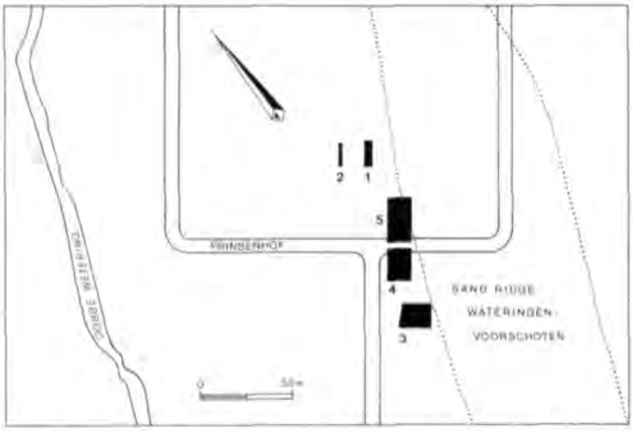


Fig. 74 Location of excavation trenches at Leidschendam (redrawn after Glasbergen et al. 1967: 98).

6.3 Leidschendam trench 4

6.3.1 Introduction

The site of Leidschendam is located northeast of The Hague on a former coastal dune ridge (*fig. 53*). Five trenches were excavated from September 1963 to March 1964 by Prof. Dr.W. Groenman-van Waateringe of the Institute for Prae- and Protohistory (IPP) in Amsterdam. The topsoil was removed with a backhoe and finds were collected in 1 x 1 m squares. This report will only deal with trench 4, totalling an area of c. 280 m² (*figs. 74, 75*). The use-wear analysis of the flint from Leidschendam was carried out in 1983 in the course of free-lance work for the research of drs. B.L. van Beek (Van Beek 1977, *in prep.*), who was to examine the habitation sequences of Leidschendam, Voorschoten and Vlaardingen, based on the pottery from certain trenches from each of the three sites. In the case of Leidschendam, trench 4 was selected. In what way, and to what extent, the concentration on one trench distorts our picture of the prehistoric activities is hard to tell, also because the site has not been entirely excavated (as is the case for all of the VL settlements). It would definitely be worthwhile to do an analysis of the entire assemblages from all three sites.

The landscape during the inhabitation of Leidschendam can be described as follows: underlying the Old Dune sand on which the occupation took place we find deposits of a coastal barrier. The barrier was blown over by sand, probably around 4800 BP, forming the 'Old Dune ridge'. This was a period of coastal aggradation, and the shoreline shifted 2-3 kms to the west. Here, the beach flats were protected from marine incursions by newly-formed coastal barriers. The flats, with occasional lakes and alder brushwood, formed a natural grazing area. The sandy dune soils, especially those along the dune edges, were relatively moist and easy to till, and as such constituted perfect arable land. The occupation remains are embedded in a c. 20 cm thick

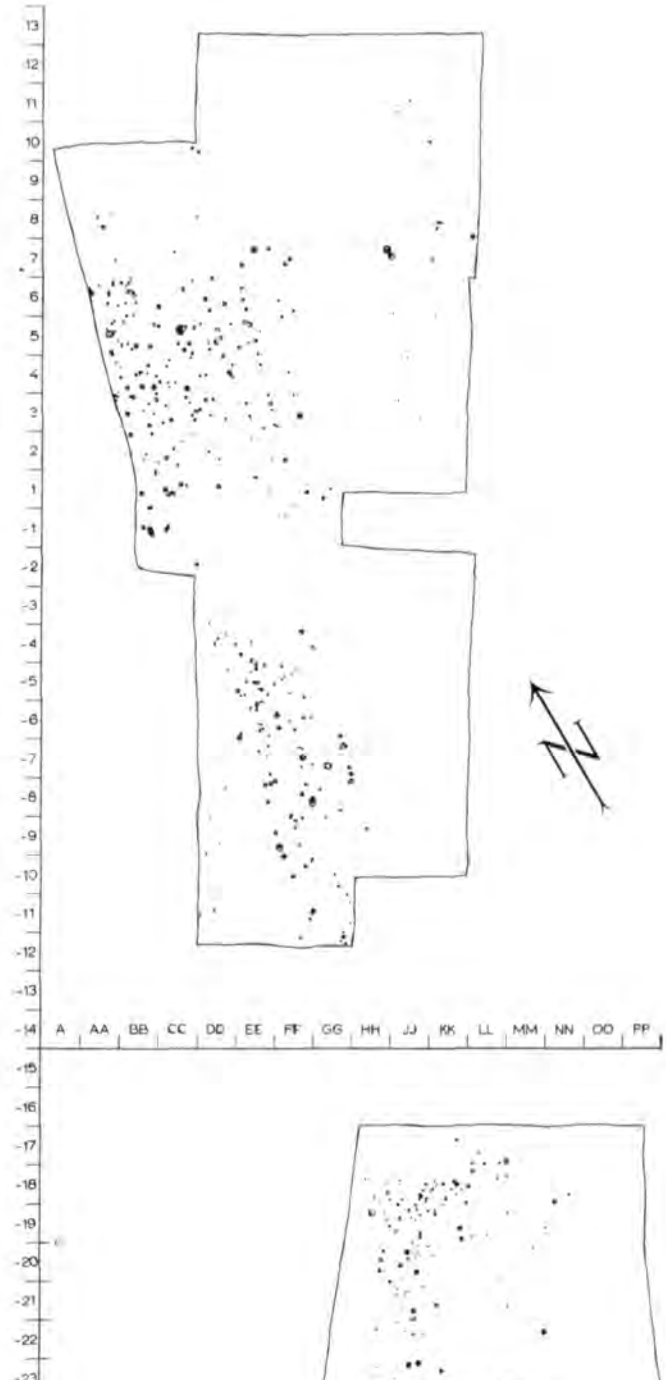


Fig. 75 Clusters of postholes observed in Leidschendam trenches 3,4 and 5 (after Glasbergen et al. 1967: 98).

ancient soil, formed on top of the dune ridge. Along the edges of the dunes, this layer was subsequently covered by peat which started to form on the beach flats as a result of a steady rise of the groundwater table.

Two ^{14}C dates are available for trench 4, both derived from charcoal: 3810 ± 60 BP (GrN-5828) and 3660 ± 80 BP (GrN-5029). These dates seem far too young. According to the pottery typology Leidschendam must be placed in VL phase Ib (Glasbergen et al. 1967: 115; Louwe Kooijmans 1974; Lanting/ Mook 1977).

During the occupation the dune ridge was covered with a deciduous forest consisting of oak (*Quercus*), lime (*Tilia*) and elm (*Corylus*). Hazel predominated at the periphery of the ridge, while on the edge of the adjacent beach flats an alder carr was present. There was no danger of flooding or getting wet feet: the top of the dune ridge lay up to c. 3 m above mean high water (Louwe Kooijmans 1974).

The analysis of the zoological material shows a reliance on animal husbandry rather than hunting (Groenman-van Waateringe et al. 1968), somewhat in contrast with the situation at Hekelingen III (Prummel 1987) and Vlaardingen (Glasbergen et al. 1961). Domestic animals included cattle, pigs and, to a lesser extent, sheep or goat. Red deer was the prevailing game-animal, followed by roedeer, grey seal and beaver. Very few sturgeon remains were encountered, perhaps because of the rather distant location of the site with respect to the Rhine and Meuse estuaries. Agriculture was practised on the dune ridge (Groenman-van Waateringe et al. 1968). Unlike at Zandwerven, ard marks have not been observed at Leidschendam, nor at any of the other VL sites within the environmental zone of the dune ridges.

Postholes were found in great abundance. The excavators report a rectangular concentration of postholes in trench 4, oriented SSW-NNE and measuring 16.75 x 4.75 m, which they interpret as a house plan (Glasbergen et al. 1967: 100) (*fig. 75*). However, even though the cluster of poles exhibits a definite directionality, the presence of a distinct house plan seems somewhat questionable. Hearths were absent and no other features such as an entrance-way were visible which could give an indication of its exact plan. Building wood must have been available in the vicinity, contrary to the situation at the levee sites.

The pottery, amongst which some clay disk fragments, was mostly quartz tempered. Both VL and PFB wares were represented, indicating that the occurrence of PFB sherds at the VL site of Zandwerven (Van Regteren Altena/ Bakker 1961) and Voorschoten (Glasbergen et al. 1967) is not an isolated occurrence. Other finds include jet beads and pieces of amber (Glasbergen et al. 1967). From trench 5, one bone awl and some perforated bone objects originate.

6.3.2 The flint assemblage

A total of 1773 flint artefacts, not counting splinters, was recovered from the five trenches, including 131 cores, 51 flakes with polished axe facets (11 of which were modified into convex scrapers), 116 scrapers, six borers, four blades and seven transverse arrow heads (Glasbergen et al. 1967: 110).

The total number of flint artefacts recovered from trench 4, amounts to 929, 215 (23.1%) of which had been burnt to varying degrees. The total weight comes to c. 2.5 kg, which results in a mean artefact weight of 2.7 g. The quantity of retouched tools is 57, including three retouched blades. In addition seven implements show 'dubious retouch'. This number disagrees with the original counts: on the distribution map published in the initial site report, 84 retouched/ 'used' tools are marked (Glasbergen et al. 1967: 104). This discrepancy can be partially attributed to a different perception as to what constitutes use-retouch, but also to the fact that in the past material has been removed for study or exposition. It is very unfortunate that a few prime pieces (Glasbergen et al. 1967: fig. 34) have disappeared, probably never to be traced again.

The raw material available to the occupants of Leidschendam consisted of very small-sized rolled pebbles of fine grained flint. The pebbles and core-fragments from trench 4 (N = 54) possess a mean size of 3.5 x 2.5 x 1.6 cm. This raw material appears to be of local origin. In contrast to Hekelingen III and Vlaardingen, more than half of the retouched artefacts had cortex (56.2%), indicating that the inhabitants used primary and secondary decortication flakes for the manufacturing of their tools. Only 21 (2.3%) axe fragments were found, whereas at Hekelingen III they constituted 12% of the assemblage. A blade technology is virtually absent; one blade has almost certainly been imported, as it is made from northern erratic flint and exceeds the size-range of the other artefacts (6.5 x 3.1 cm).

As to the reduction sequence practised, a bipolar technique appears to have been used (see a.o. Hayden 1980 and Callahan 1987 for a discussion of this technique). The pebbles are very small and totally rounded, and provide no natural platform to start reduction. The only way to open such a pebble would be to hit it with a stone hammer while supporting it on an anvil. Such a practice would also explain the lack of bulbs of percussion, platforms and percussion rings. The shattered nature of the debitage also points to bipolar reduction. Moreover, on some flakes we can observe traces of shattering on two opposite sides of the tool.

The typological range exhibited by the Leidschendam trench 4 flint is limited. Convex scrapers (N = 21) represent the most frequently occurring tool type (*fig. 76c, 76e*); there are also 11 scrapers of more irregular shape (*fig. 76f*). In addition, six 'thumbnail' scrapers of about 1 cm in diameter were encountered (*fig. 76g*). Attention must be drawn to four scrapers which display retouch along their entire cir-

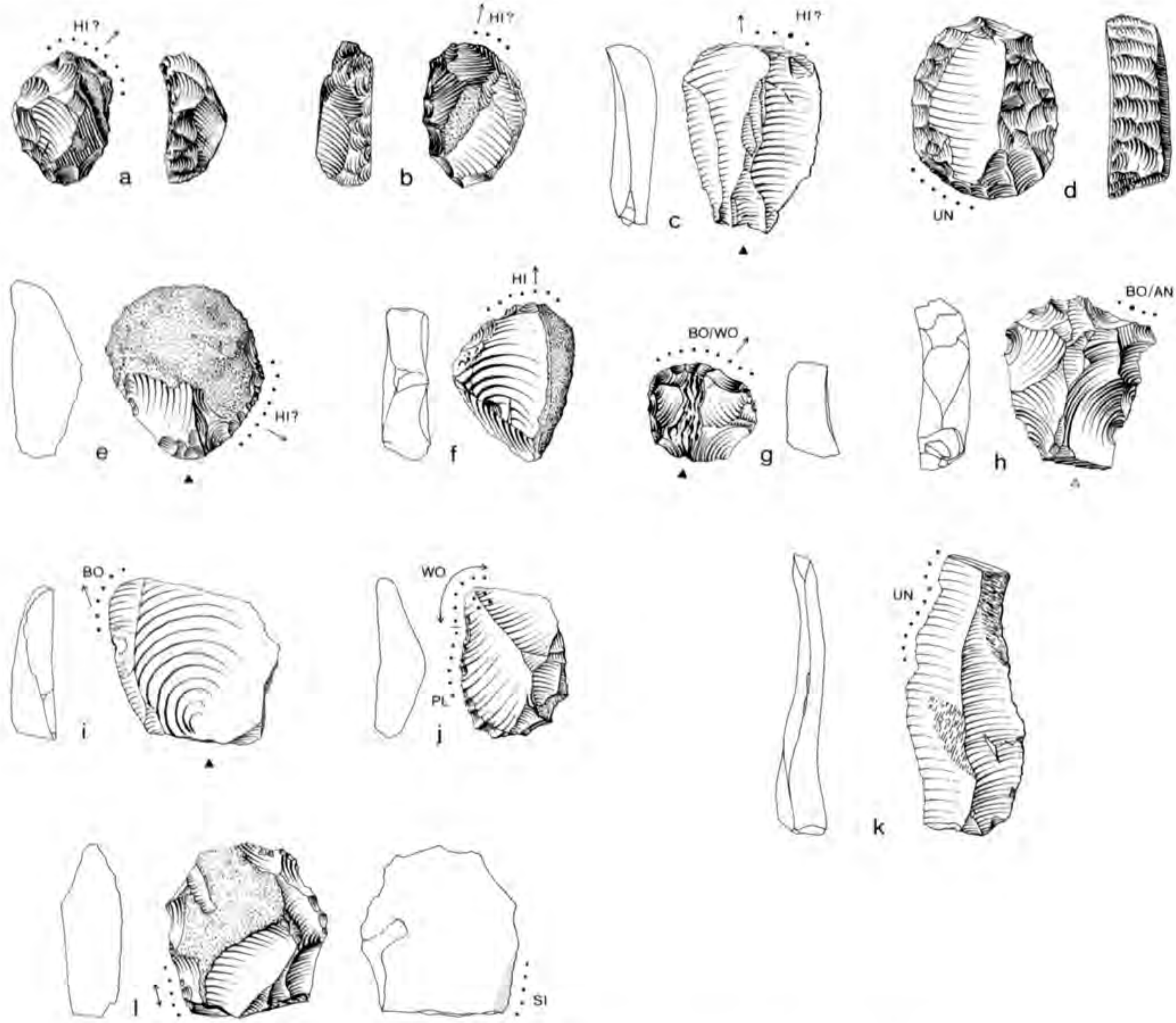


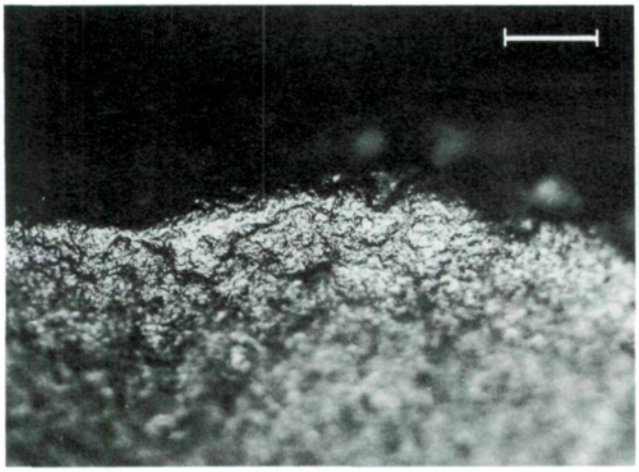
Fig. 76 Artefacts retrieved from Leidschendam trench 4. a-c) scrapers with traces inferred as being from hide: a) LSD27, b) LSD5, c) LSD17, d) scraper (LSD3) used on unknown material, e, f) tools LSD22 and LSD56 interpreted as having been employed to scrape hide, g) LSD49 with bone- or wood-working traces, h) LSD55 presumably used on bone or antler, i) LSD7 used for carving bone, j) LSD59 used for boring wood, k) blade LSD39 used on an unknown substance, l) LSD27 with sickle-gloss. (1:1)

cumference (*fig. 76a, 76b, 76d*). Their edge angle amounts to 84°, as compared with 70° for the remaining scrapers. Many of the scrapers have been resharpened as evidenced by the presence of overhanging dorsal edges. Two borers, two transverse arrow heads and one point were also retrieved from trench 4. The spatial distribution of the tools is depicted in *fig. 78* (cf. *6.3.3.2*).

6.3.3 THE FUNCTIONAL ANALYSIS

6.3.3.1 Sampling and methods

All intentionally retouched tools and the artefacts showing 'use-retouch', i.e. retouch < 1 mm, were studied for traces of wear. In many cases the 'use-retouch' actually consisted of damage inflicted on the edges by putting all the artefacts from each square meter into one paperbag. To make mat-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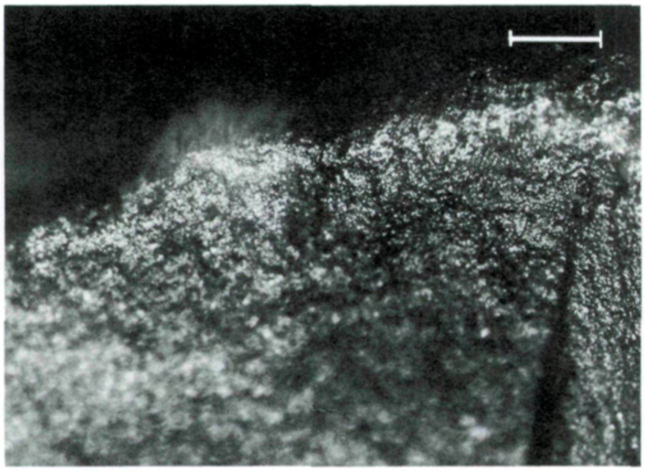
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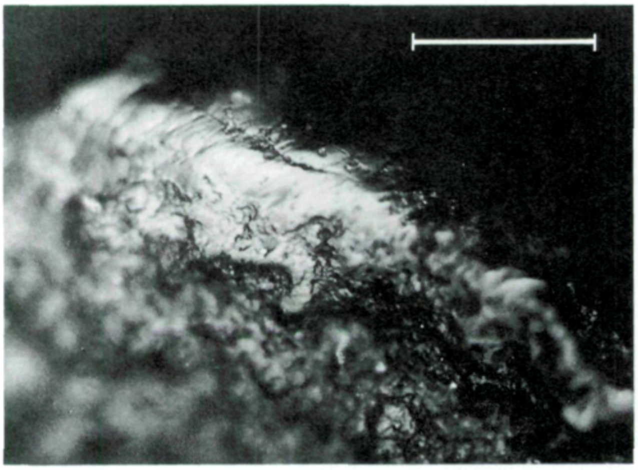
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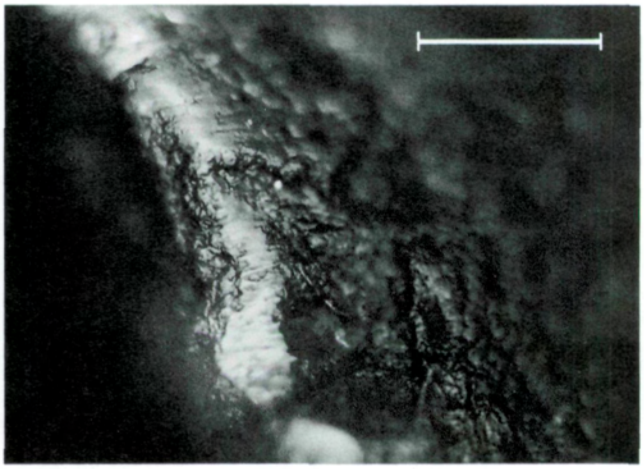
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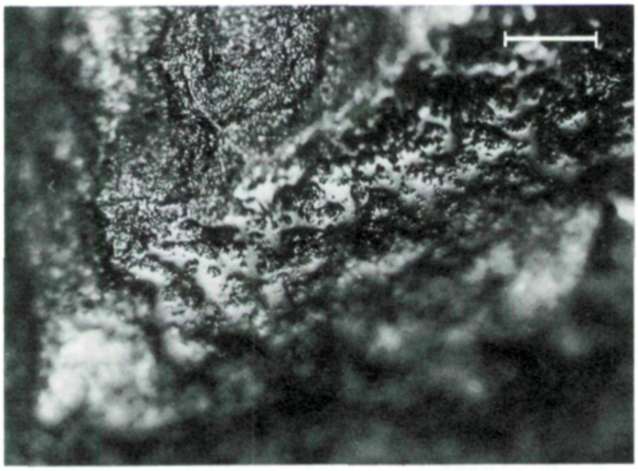
e

Fig. 77 Leidschendam trench 4: micrographs of observed wear-traces. All scale bars equal 50μ. a) LSD5 (200x), b) LSD56 (200x), c) LSD7 (400x), d) LSD59 (400x), e) LSD61 used on soft plant (200x).

ters worse, the material was used for educational purposes, and scattered onto tables and rebagged numerous times. When the assemblage was first examined in 1983, 64 artefacts were selected, all of them retouched ($\geqslant$ 1 mm and $<$ 1 mm). The interpretations were checked in 1985, and finally entered into the computer in 1987. During this last period the debitage was scrutinized for artefacts exhibiting a straight edge of $\geqslant$ 1.0 cm in cross-section: only two were found. They were added to the sample for use-wear analysis, plus seven pieces displaying dubious 'use-retouch', such as a core fragment with traces of battering on both ends. The mean length of the tools studied was 2.5 cm, mean width 2.1 cm and mean weight 4.6 g. A total of 73 implements was analyzed, resulting in 106 PUAs.

All tools were treated with HCl, rinsed in tap water but not neutralised with KOH. No use was made of an ultrasonic cleaning tank. The microscope available at the IPP in Amsterdam (where the initial analysis took place) was an Olympus BMH with magnifications ranging between 50-400x. The subsequent checking was done on Nikon-equipment (see *2.4*, *2.5*).

The examination of the wear-traces on the Leidschendam trench 4 implements was greatly hampered by the fact that a very high percentage of the tools was not analysable as a result of abrasion, probably due to trampling of the surface by the inhabitants. The matrix in which the tools were embedded, consisted of sand, which is a very effective abrasive agent: most 'sand-sites' have turned out not to be suitable for microwear analysis (cf. *chapter 4*). In addition, the rebagging during various stages of study has also affected the implements to some extent. At Leidschendam 59 of the 106 PUAs (55.7%) could not be analyzed. Apart from the problems with representativity raised by the examination of trench 4 only, the results presented here are severely biased by post-depositional surface modifications. Tools which were used for only a brief period of time will not be recognized as such because the wear-traces are not sufficiently developed to stand out from the general abrasion. Also, traces caused by, for instance, contact with meat, green plants and fresh hides, will be lacking altogether. The spectrum of activities presented in the following pages can not therefore be taken at face-value.

6.3.3.2 Activities inferred

Table 45 depicts the results of the wear analysis. A mere 30 PUAs displayed traces of wear, yielding 32 AUAs. The most common contact substance seems to have been hide (N = 10; 31.2% or 40.0% if we substract the category unknown). The very heavy edge-rounding and matt, rough polish (*figs. 77a, 77b*) suggests dry hide in eight cases. Two tools exhibit less edge-rounding and may have been used on either fresh or dry hide. Bone-working tools were also present (*figs. 76i, 77c*). It is assumed that the chance that bone-working tools are 'hidden' (*3.12*) is small; the four bone-working tools and three bone-/ antler-/ wood-working tools might thus approach the real number of such tools present in the sample. Two soft plant-working tools were attested and two artefacts displayed sickle-gloss (*fig. 76l*).

The range of activities performed seems therefore quite broad. Presence of 'sickle-gloss'[4] can be seen as a confirmation of the opinion that agriculture was practised locally. Maintenance tasks such as hide-processing were carried out; most probably it concerns softening activities of dried or processed hides. The manufacture of bone objects has been attested. The four bone-carving zones display a great similarity to those from Hekelingen III; perhaps they were employed for bone awl and chisel production (cf. Maarleveld 1985).

No clear-cut concentrations representing a distinct activity can be distinguished. The configuration of used tools conforms to the distribution of the flint artefacts in general, as evidenced by the plot of total weight per 1 x 1 m square (*fig. 79*). Tools with traces inferred as being the result of working hides are found across the entire trench. Bone-/ antler-working implements are mainly located in the northern part; however, the number dealt with here is obviously too small to attribute any behavioral significance to this observation.

6.3.4 Aspects of form and function

The number of PUAs for which an activity could be inferred is really too small to conclude much about the relationship between form and function. Of the 12 PUAs which were employed for scraping, 11 displayed a convex edge-shape. Straight edges had been used for a variety of activities and were not predominantly associated with cutting or sawing: of the four PUAs used for carving, three appeared to be straight. As to the shape of the aspect surfaces, the large majority of the scraping tools as well as the two cutting tools turned out to be plano-convex. Evidence of use for carving was found on tools varying in shape of the constituting aspects. A last morphological attribute of the PUAs is the form of the edge in cross-section. A variety of activities was performed with straight cross-sections. Convex cross-sections were limited to edges exhibiting traces of scraping or carving. The sample of unmodified flakes was small, because so few pieces exhibited a straight edge $\geqslant$ 1.0 cm. Nevertheless, of the five selected artefacts one was possibly used (*table 46*).

The Leidschendam trench 4 gives the impression that the correlation between the morphology of a tool and its working edges, and the motion to which it was put is not so clear-cut. Of course, maybe this has to be attributed to the fact that so few tools were interpretable (only 30 PUAs). On the other hand, the inferior quality of the raw material available to the inhabitants of Leidschendam might have led

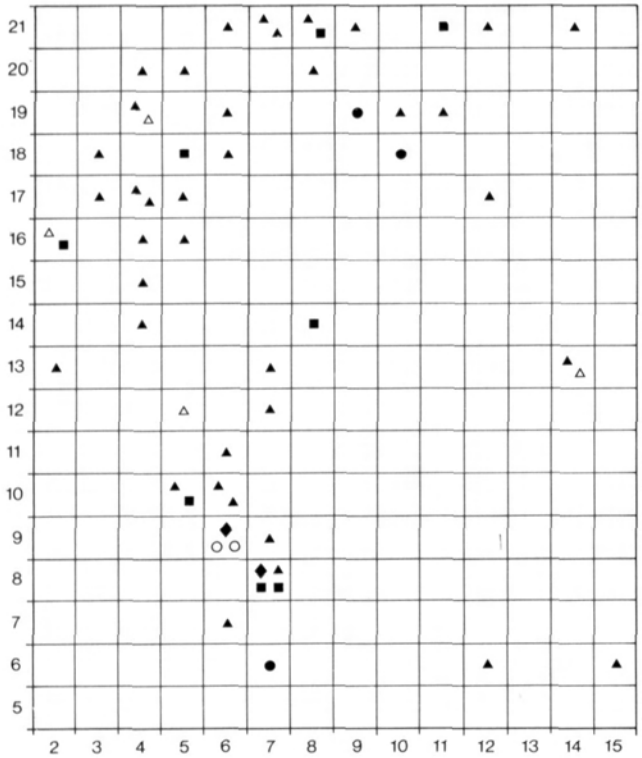

Fig. 78 Leidschendam trench 4: spatial configuration of the different tool types (point 2/5 corresponds with DD/10,50 of fig. 75).

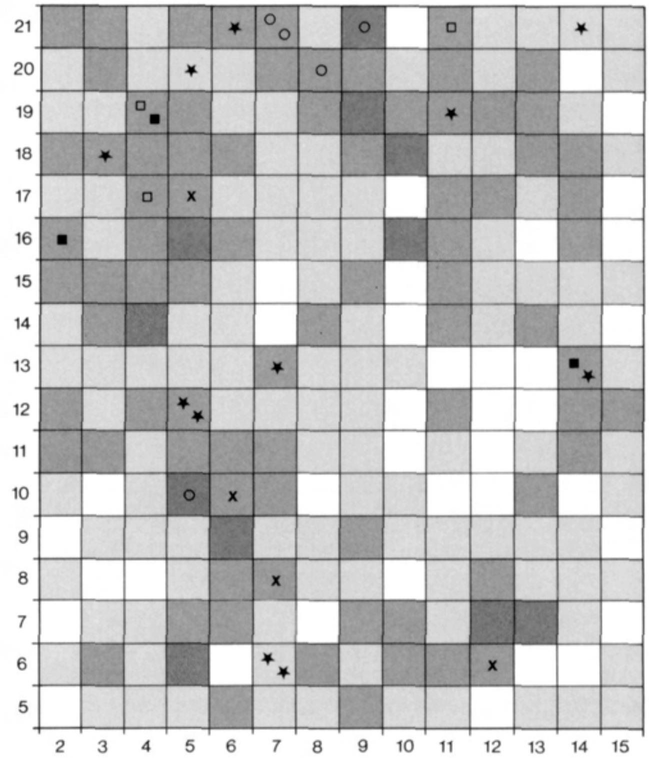

Fig. 79 Leidschendam trench 4: spatial distribution of implements with observable traces of wear. Weight-class distributions are indicated as well (per 1 x 1 m unit).

to a less critical examination of a tool and its edges, prior to use. The choices made are not so consistent.

6.3.5 Interpretation of the Leidschendam trench 4 assemblage

The Leidschendam trench 4 flint is not the most suitable material from which to derive conclusions, as the post-depositional surface modifications are extensive. Nevertheless we can catch a glimpse of daily life in the settlement, although the detail is less than at Hekelingen III. A diversity of activities was carried out at the site. Dry hide-working was one of the main tasks: the heavy edge-rounding on the scrapers suggests they were used intensively, possibly during the softening stage of hide-processing. This kind of work is generally assumed to have taken place at a base-camp or permanent settlement. Bone-working is not prominent but is nevertheless represented. Wood-working tools are very few in number. The two sickle blades provide additional support for the hypothesis that agriculture was practised locally.

Clear-cut activity areas were not evident, although bone/antler-working implements were confined to the northern part of the trench (*fig. 79*). Remarkable is that the middle section of the trench seems virtually devoid of finds. Such a configuration is suggestive of a central area within a relatively long-term or permanently inhabited dwelling, which was supposedly cleaned regularly (cf. *6.2.4*). However, assuming that the finds are indicating the approximate location of the walls, the inferred house would have a width of c. 10 m. Such a width is not only difficult to achieve technically, but also does not correspond with that of the only VL house plan known so far, of Haamstede (Louwe Kooijmans 1985: 50). An alternative explanation would be to postulate several overlapping building phases, with the house shifting in southwestern direction; in that case, however, there should have been more finds along the northeastern edge. All in all, the meaning of this empty section in trench 4 is not clear. It is hoped that the analysis of the other artefact categories will elucidate this (Van Beek *in prep.*).

The flint was used quite efficiently: 23 (31.5%) of the 73 tools examined possessed two PUAs. The scrapers which exhibited retouch around their entire circumference were counted as having one PUA, but obviously this represents

Table 45 Leidschendam trench 4: inferred motion and contact-material by actually used area (AUA).

	scraping	cutting	carving	boring	hafting	unknown	total
hide	10	–	–	–	–	1	11
soft plant	–	1	–	–	1	–	2
cereals	–	–	–	–	–	2	2
wood	1	–	–	1	–	1	3
bone/antler	1	–	4	–	–	2	7
unknown	–	1	–	–	–	6	7
total	12	2	4	1	1	12	32

Table 46 Leidschendam trench 4: degree of wear per observed phenomenon by potentially used area (PUA).

	retouch $\geqslant$ 1mm	retouch < 1mm	unretouched straight edge	protruding point	total
no traces	5	8	4	–	17
used	10	2	–	1	13
possibly used	10	3	1	–	14
not interpretable	30	9	5	1	45
unsure	7	10	–	–	17
total	62	32	10	2	106

substantial activity as the entire edge cannot have been used simultaneously. The number of AUAs is not great: 28 PUAs (26.4%) had one AUA, while two PUAs displayed two AUAs (1.9%). Clearly, the relatively small amount of AUAs is largely due to the fact that traces of wear have been obscured by abrasion. The degree of use was often not interpretable due to pdsm (N = 45); 17 displayed no traces, 13 PUAs exhibited various degrees of use, 14 PUAs were possibly employed and 17 PUAs were listed as unsure. The most convincing argument for a thrifty attitude towards the flint comes from the presence of overhanging dorsal edges, a phenomenon which can be ascribed to recurrent resharpening. This morphological feature cannot be obscured by secondary modifications. Resharpening was observed on 15 scrapers; this inference is supported by the fact that on 18 used PUAs the polish had clearly been present but was partially removed by resharpening flakes. I would therefore argue that the amount of raw material available to the inhabitants of Leidschendam was not abundant and that curative measures such as resharpening had to be taken. It seems that the problem of the shortage and the inferior quality of the locally available raw material could not be alleviated by an orientation towards imported flint. In this sense the people on the dune ridges appear to be more isolated than the ones living in or exploiting the freshwater tidal zone. A few blades and flakes are apparently imported and may be of northern origin which could suggest the direction in which the inhabitants of Leidschendam had contact with the 'outside world', i.e. possibly with the roughly contemporaneous PFB sites of Kolhorn, Aartswoud and the VL/PFB site of Zandwerven. This is supported by the presence of PFB-sherds at the sites located on the dune ridges.

6.4 Site differentiation within the Vlaardingen group

On the basis of similarities in, for instance, pottery assemblages, a number of sites are attributed to the VL group of which we already knew that they might differ in terms of their subsistence strategies. Sites belonging to this cultural group are situated in four different environmental zones. The sites on the dune-ridges such as Leidschendam and Voorschoten, have always been considered agricultural sites (Groenman-van Waateringe et al. 1968). On the other hand, Hekelingen III, located on the edge of the freshwater tidal area and the peat-zone, has, among other alternatives, been referred to as a semi-permanent camp for hunter-fishers-gatherers, who maintained contacts with agricultural settlements and exchanged products with them (Louwe Kooijmans 1985:103). The Hazendonk, the only site which has been investigated in the peat-area, could be a permanent settlement of fishers and hunters; in addition, the inhabitants apparently possessed livestock. It is unlikely that agriculture was practised here locally (Louwe Kooijmans 1985: 125-126). Lastly, sites in the river-clay zone, such as Ewijk, were, perhaps yearround, occupations of agricultural peoples (Asmussen/ Moree 1987). One of the objectives of the functional analysis of the flint was to address this diversity in subsistence strategies apparent among the VL sites.

The results of the present study demonstrate that Leidschendam indeed shows evidence, albeit not definitive, of having been a permanently settled agricultural community (see *6.3.5*). The inhabitants seem to have processed hides, manufactured bone or antler objects, and done some woodworking. Two tools displayed sickle-gloss, supporting the suggestion that cropping was done locally. Unfortunately, post-depositional surface modifications had affected a great many implements, so the results of the use-wear analysis cannot be considered representative. Additional evidence about the attitude of the inhabitants towards flint could be obtained from a study of certain morphological attributes of the implements. Use was made of locally available flint pebbles of very small size. A relatively high percentage of the tools turned out to be resharpened, whereas the number of PUAs per tool was high. These features are indicative of a relative scarcity of (suitable) raw material. There is virtually no evidence for import material to alleviate the shortage of good-quality flint. Leidschendam seems to have been quite isolated, at least from a 'lithic perspective'. What evidence exists for outside contacts points to the north: one blade strongly resembles northern moraine flint. Such flint is also present on the PFB sites of Kolhorn and Aartswoud (Van Iterson Scholten 1981). An orientation towards the PFB sites in the north by the Leidschendam occupants, is also supported by PFB cultural elements in the pottery assemblage (Glasbergen et al. 1967).

The functional analysis of the Hekelingen III flint assemblage resulted, at first glance, in a similar, albeit more detailed, spectrum of inferred activities as Leidschendam: evidence was present for the production of bone and antler objects, hide-processing, and wood-working. In addition, plants were splitted, probably for matting or basketry purposes. It was also shown which bone objects were manufactured with the flint tools displaying wear-traces indicative of bone. No sickle blades were found, supporting the assertion, based on palaeobotanical evidence (cf. Bakels 1988), that agriculture was not practised locally. Unlike the Leidschendam scrapers, the Hekelingen III hide-working implements were interpreted as having been involved in scraping the fresh hides of fur-bearing animals (cf. *6.2.6*). All flint was imported, most probably from the south (Verhart 1983). Nevertheless, the material was definitely not saved or intensively used up. The number of PUAs per tool is less than at Leidschendam, nor is there much evidence for the resharpening of implements. If Hekelingen III had been occupied on a permanent basis, one would expect the imported flint to have been used in a more thrifty manner, or else to have more evidence for the exploitation of more nearby sources of flint.

Although the interpretation of the function of Hekelingen III in a settlement system remains problematic, I favour the option that it concerned a recurrently visited place from where a variety of wild resources, such as sturgeon, birds, various game and plants, could be obtained. Remains the question whether the place was used by hunter-gatherers in their (yearly) seasonal round or by farmers for the acquisition of auxiliary resources. The fact that Hekelingen III also yielded remains of domestic animals, notably cattle, would argue for the latter possibility. Moreover, by the Late Neolithic all of the Netherlands shows evidence for farming, also the nearby VL sites of Leidschendam and Voorschoten, and the roughly contemporaneous PFB settlements of Kolhorn and Aartswoud to the north. This makes it unlikely that a group of hunter-gatherers could have maintained their traditional subsistence base, unaffected by the changes which had taken place all around them; the area in which they could maintain such a way of life became extremely limited. Hekelingen III can thus be interpreted as having been used by pastoralists/ agriculturalists who probably lived somewhere to the south: the type of flint used seems to point in that direction (Verhart 1983). From a lithic perspective there is no evidence that, for instance, the farmers of the coastal dune district were exploiting Hekelingen III, because the type of raw material is different for both sites.

Another site within the freshwater tidal zone concerns the type-site Vlaardingen. A preliminary use-wear analysis of the flint from trench 11 indicated a same range of performed activities as Hekelingen III and Leidschendam trench 4 (Van Gijn 1984). This study is currently being extended, and suggests a predominance of hide-working (31% of the implements were involved in this activity (R.Exaltus, *pers. comm.*). Two blade-like tools displayed a lustrous sheen, which could have been caused by cutting reeds. Evidence for the manufacture of bone and antler objects is present as well. The raw material used is of southern origin and closely resembles group 1 of Hekelingen III. The two flint assemblages also correspond in other respects: the size of the artefacts is similar, both display a high frequency of polished axe fragments, and the mean edge angle falls around 65°. It is, however, too early to tell whether the inhabitants of Vlaardingen exhibited a similar careless way of dealing with the imported flint as those of Hekelingen III; the Vlaardingen flint assemblage is only now being registered in terms of PUAs and AUAs. Despite the fact that the flint assemblages of Hekelingen III and Vlaardingen are similar, the sites are very different in other respects. At Vlaardingen much sturdier dwellings were erected than at Hekelingen III, requiring a considerable investment of time and materials. Also, evidence for PFB elements, such as a battle-axe, points to contacts with the north. As Vlaardingen is the topic of a dissertation in progress at present (van Beek *in prep.*), I will refrain from giving a 'functional' interpretation of the site.

Bienenfeld (1986) has studied a small sample of the VL assemblages from Hazendonk, the only site investigated in the peat-zone. From level VL-1a the number of pieces examined was too small to draw conclusions from. From VL-1b 41 of the 298 artefacts were studied, i.e. 13.8% of the collection; 16 of them showed no traces of use. A predominance of wood-working was attested, with some bone-/ antler-, soft plant- or hide-working having been practised as well. The absence of sickle blades supports the idea that no cropping took place on the dune.

From the fourth environmental zone, that of the river-clay deposits, no flint assemblages were examined for traces of wear. The material from Ewijk proved unsuitable for such an analysis. Other lines of evidence indicate that agriculture seemed to have been practised; whether the site was occupied on a yearround basis, is still open to question (Asmussen/ Moree 1987). The flint used includes some Valkenburg material, indicating contacts in southern direction, perhaps with the Stein-group.

What emerges is a picture of great variability between the various sites subsumed under the VL group. Leidschendam, and perhaps also Voorschoten, is interpreted as a permanently inhabited agricultural site with outside contacts towards the north (possibly the PFB sites of Aartswoud, Kolhorn and the VL/PFB site of Zandwerven). Hekelingen III, and perhaps also Vlaardingen and Hazendonk, can be seen as temporary settlements. As far as Hekelingen III is concerned, it is likely that the site was used by farmers living to the south, perhaps on the saltmarshes of Zeeland. Ewijk, located much further to the east is considered an agricultural settlement, probably occupied yearround and with an orientation towards Limburg (i.e. southeastern Netherlands). It can be suggested that, during the Late Neolithic, a mosaic of farming settlements was present in the Rhine/ Meuse delta. These were located on the dune-ridges, but perhaps also on the tidal flats. Further expansion had been arrested because all prime areas were occupied. To alleviate the perceived reduction of productivity[5], other avenues were sought: one option could have been the continued exploitation of the coastal areas for wild resources. Hekelingen III, and perhaps Hazendonk and Vlaardingen as well, might represent sites from where such activities were carried out.

notes

1 The fur of some animals, like caribou, is best during autumn instead of winter (Spiess 1979).

2 An exception form those cases of hafting in which use is made of a mixture of resin mixed with crushed stone particles. The latter is added to stabilize the resin and apparently cause some friction-gloss on the flint surface (H.Juel Jensen, *pers.comm.*).

3 Interestingly enough, local manufacture of bone implements has been demonstrated at Sølager (Skaarup 1973).

4 The term 'sickle-gloss' is generally used to refer to a polish clearly visible with the naked eye, with some width, and supposedly due to the reaping of cereals. It has been shown, however, that 'sickle-gloss' can also be caused by contact-materials other than silicious plants (a.o. Van Gijn 1988). At Leidschendam it concerns 'real' sickle-gloss.

5 The actual production, which can be approximated by us from an etic perspective, might have remained constant in the meantime.

7 The interpretative possibilities of microwear analysis [1]

7.1 Introduction

Methodological and technical issues have preoccupied the majority of microwear analysts nearly from the start. This is not surprising as the discipline is relatively new, while major problems (cf. *chapters 2 and 4*) became evident quite soon after its introduction. Most researchers were young and unexperienced, working in isolation, and generally with insufficient financial backing. In addition, almost everyone had to start out with the time-consuming task of creating a reference collection. Consequently, many analysts have done a lot of 'navel-staring'. This is, I believe, one of the main reasons why microwear analysis (but also use-wear analysis in general) has failed to become part of mainstream archaeology, despite the fact that, especially in the early phase of the discipline, very current or hotly-debated themes were addressed, such as the 'Mousterian problem' (Anderson-Gerfaud 1981; Beyries 1987), and the Upper Palaeolithic open-air sites of the Paris Basin (Moss 1983a; Plisson 1985a; Symens 1986; Keeley 1987).

Recently, microwear analysts have become aware of their relatively isolated position in the archaeological world at large. In response, a conference was organized at the University of Uppsala, Sweden. The atmosphere was quite optimistic, with everyone confident of a future for microwear analysis, but much of the discussion still centred on methodological and technical issues. It is believed that, even though reflection and work on these matters is essential for the progress of the discipline, it is equally important to seriously start integrating the approach into general archaeological research.

Microwear analysis can be a tool for solving questions regarding the form and function of implements, and the activities and tasks carried out by the inhabitants of a settlement. At an intra-site level, functional data can assist in the search for activity areas, whereas in the case of inter-site studies, functional differentiation between settlements may be elucidated. All of these themes have already been addressed in chapters 5 and 6, and I shall not repeat in extenso the conclusions drawn. In this chapter, I would only like to highlight the potentials of microwear analysis, and illustrate this with some examples drawn from the case-studies.

7.2 Form versus function

Form-function problems were addressed almost immediately after the introduction of use-wear analysis, both from a 'macro'-perspective (a.o. Odell 1981) and from a 'micro' point of view (a.o. Moss 1983c). This is not so astonishing as each one of the approaches seemed to offer an objective method for assessing the validity of (functional) typologies. The latter had usually been arrived at in a rather subjective manner.

Juel Jensen, in her review of West-European research in microwear analysis, has examined the functional homogeneity of two tool types commonly encountered in archaeological assemblages, i.e. the scraper and the burin (Juel Jensen 1988a). With respect to the scrapers, Juel Jensen concludes that in the Upper and Final Palaeolithic end-scrapers are almost solely used on hide. From the Early Mesolithic onwards, inferred contact-materials additionally include wood and, to a lesser extent, bone/ antler. Working edges usually bear evidence of a scraping motion. The results obtained for the Neolithic assemblages of Beek-Molensteeg, Hekelingen III and Leidschendam also show scrapers to be almost exclusively used in a transverse motion. At the Early Neolithic site of Beek-Molensteeg the association between endscraper and hide-polish is very strong, while at the other two, Late Neolithic, sites more variability is displayed in terms of the material worked, with wood and bone/ antler also being present. Borers are virtually absent at Beek-Molensteeg, whereas no 'substitute' flint tool was attested. On the other hand, at Hekelingen III borers appear to be a common occurrence. They turn out to be almost invariably used for boring, although other motions are performed with them as well; the contact-material, however, is extremely variable.

Yet another tool type showed a very significant correlation between its form and function: the *quartiers d'orange* from Beek-Molensteeg. Without exception they exhibited the mysterious polish '23' (see *5.4.2.7*). Nevertheless, no exclusive correlation existed between the *quartiers* as a tool type and this unknown polish: two artefacts with a functional edge essentially identical to the ones of the *quartiers* displayed the same traces. It should be noted that but for microwear analysis the significance of these artefacts would not have been recognized. *Quartiers d'orange* were thought to be absent in Dutch LBK assemblages, and the slightly 'a-typical' specimens found at Beek-Molensteeg would probably have been classified as 'blocks', never to be looked at again. The same applies to the two unretouched blades displaying an identical pattern of wear-traces. Now that it is clear which morphological characteristics are important, (i.e. an unretouched, regular, straight or slightly concave edge, with a length of 6-9 cm, and an edge-angle of 70-90°), it has become possible to almost predict the presence of polish '23'. As the polish is also visible with the naked eye, this saves a lot of hours behind the microscope. Although it is, unfortunately, not yet known which contact-material caused these traces (the motion is undoubtedly transverse), the activity responsible for them constitutes an integral part of the LBK cultural complex. The traces were identified in almost every LBK assemblage so far studied for the presence of wear, from Hienheim in Bavaria, West-Germany, to Darion in Belgium, whereas they have, to my knowledge, never been reported for other periods. Hopefully, the functional riddle posed by polish '23' will be solved in the near future.

All other tool types of the assemblages studied displayed great variability with respect to inferred use, although there does seem to be some consistency in the kind of morphological attributes chosen for specific motions (see *5.5.*, *6.2.5* and *6.3.4*). Especially edge-angle and, to a lesser extent, shape of the edge, seem to be important in this regard. This would suggest that, if one is interested in function, it is generally more appropriate to look at the characteristics of the individual edges, than the overall shape of a tool, something which has also been stressed in ethno-archaeological studies (Gould et al. 1971; White et al. 1977; Hayden 1979). This does not imply that our typological notions have become worthless; they remain a very valuable means of classifying otherwise unwieldy assemblages and can also have great use as temporal or spatial markers. However, it would be fallacious to automatically associate a certain tool type with a specific use.

The functional analysis has not only questioned the functional homogeneity of several tool types. It has also demonstrated that many unretouched edges were employed for various purposes. This applies both to the blades from Beek-Molensteeg and to the more irregular flakes from Hekelingen III. In the case of Beek-Molensteeg, activities include the cutting of hide and soft plant, and the scraping of the contact-material being responsible for polish '23'. At Hekelingen III, unretouched flakes were used for splitting plants for matting or basketry. It was also shown that such flakes were considered appropriate for deepening the natural groove of the metapodia of deer; this procedure formed part of the task of bone awl and chisel manufacture (see *6.2.3.2*). The information obtained by also examining unretouched flakes and blades has therefore contributed considerably to a better understanding of the daily activities carried out at the various sites.

Since this study was directed at function, the question of style needs to be addressed, but will only be touched upon. Close (1978) considers style to be independent of function and argues that style can only be inferred by a process of elimination, of all the aspects that do not have a functional reason; Deckers (1985) takes a similar position. Other researchers have proposed procedures to separate style from function (e.g. Meltzer 1981). If we follow them, use-wear analysis would be an indispensable method to distinguish functional from stylistic traits. The underlying assumption is that style is added to the tool, having no other objective than to signal ethnicity or group affiliation. An alternative approach, that appears more credible at least for lithic studies, has been suggested by Sackett in a series of articles (a.o. 1982, 1986). Sackett views style

> 'not as a distinct realm of form but instead as a latent quality that at least potentially resides in all formal variation that has in one way or another passed through a culture's matrix' (Sackett 1986: 268).

This would mean that use-wear analysis provides no help in separating style from function. However, because there are usually several alternatives to solve a specific (functional) problem, choices must be made, which are, to some extent, bound by tradition. It might be possible for use-wear analysts to track these consistent choices. An example, presented in this study, are the steep-angled *quartiers d'orange*, which consistently display the same use, and almost seem to 'hallmark' the LBK lithic assemblages; however, it is almost impossible to determine which aspects of these tools can be considered functional and which ones stylistic.

7.3 Reconstruction of activities and tasks

In chapters 2 and 3 the way of arriving at a functional interpretation of individual working edges and entire tools was discussed (cf. *2.7.2*). In addition, it was outlined how it was sometimes possible to infer, not only the activity (i.e. the motion and contact-material), but also the task in which an implement was involved (see *3.1.2*). Remains the question which meaning we can attribute to these results. In the preceding pages it has frequently been stressed that the outcome of a microwear analysis can be biased by the presence of post-depositional surface modifications on the surfaces of the tools. These traces may have obliterated the less well-developed polishes, such as those from contact with meat, fresh green plants or fresh hides, as well as the evidence for short-term uses on other contact-materials. Such might also be the case when the flint the artefacts are produced of, is coarse-grained. Even if all conditions seem favourable, with no pdsm present, while the implements are made of fine-grained flint, there will still be an under-estimation of the activities involving the above-mentioned contact-materials (cf. *3.12*). All these factors have to be taken into account when attributing behavioural significance to the results of the analysis.

In addition, there are several taphonomic processes that must be considered when trying to reconstruct the activities important at the site being studied. First of all, tools are being carried around. At certain locations (presumably in the case of longer-term occupations), toolkits are prepared in anticipation of tasks to be performed at other sites, or maintenance and repair activities take place. This results in the deposition of artefacts which were actually used elsewhere. Obviously, it is very difficult to draw a line as to which off-site activities still belong to the activity pattern of a site; hide-scraping being done just outside a settlement clearly is part of this, so would be harvesting in the nearby fields. But what about fishing-gear used a kilometre away from the site and brought home? It is evident that such questions need to be born in mind, especially when there is evidence for curation (Binford 1979), or for hafting and retooling activities (Keeley 1982) (see also below).

Apart from the possibility that tools used off-site are deposited at the site, it can also occur that tools, employed in subsistence tasks forming part of the activity pattern of the inhabitants, but carried out some distance from the settlement, were lost or discarded during use, resulting in those low-density sites which are so rarely addressed in archaeological investigations (Roebroeks 1989). Absence of certain wear-traces can therefore not be taken at face-value. Obviously, negative evidence cannot constitute proof; at most it can be considered 'circumstantial evidence'. Nevertheless, when it concerns traces which are not easily obliterated, I would suggest that the absence of wear-traces indicative of a certain activity may lead to the conclusion that the activity in question was not part of the pattern of tasks of the settlement. Such traces would include those from working bone and from cereal-reaping. At Beek-Molensteeg the absence of bone-working traces was taken as reflecting the 'real' situation; secondary modifications were minimal and bone-working is an on-site activity, with deposition of the used artefacts likely to have taken place within the settled area. At Hekelingen III the absence of cereal-harvesting implements was taken for 'real' as well, and as a confirmation of the palaeobotanical interpretation (Bakels 1986, 1988), although it was realized that this absence might also be explained by loss of sickle blade-fragments in the fields. On the other hand, the absence of wear-traces attributable to fish-processing is probably not reflective of the 'real' situation (cf. *6.2.3.2*).

Yet another problem is the fact that we can be dealing with a palimpsest of occupations. Binford (1982) has demonstrated that the function of specific sites may vary from one year to the next, with sites 'changing positions' so to speak. This posits immense problems when trying to reconstruct the tasks carried out; separating these various use-instances of a site is almost impossible. Only when contextual evidence is present, in the form of other artefact categories, is this feasible, but the relationship between the artefact categories needs first to be demonstrated. When artefact categories are found at the same spot or adjacent to each other, and in the same vertical position (i.e. in 'archaeological association'), it is usually taken for granted that they represent one activity. Obviously, this does not necessarily have to be the case, as such a configuration could also be the result of a palimpsest of several use-instances of a particular location. Use-wear analysis offers a rather direct possibility to examine whether a 'real' association exists. An example comes from the Middle Palaeolithic Belvédère site G (the Netherlands), where a large backed-blade was found amidst a concentration of bones of young rhinoceros. The backed-blade displayed wear strongly resembling experimental traces from butchering elephant, i.e. a pachydermatous animal, making it very likely that this tool was used for the butchering of the young rhinos (Roebroeks et al. 1986; Van Gijn 1989).

With respect to the studies presented in this volume, it can be argued that the microwear analysis has added more detail to our picture of daily life at the sites, part of which could not have been attained any other way. Examples include the plant-splitting, hide-working, and stone-boring activities at Hekelingen III, and the hide-processing, fine wood-working, and the task behind polish '23' at Beek-Molensteeg. Regarding this last site, the absence of bone-working tools from flint may also be significant.

7.4 The search for activity loci

When introduced as a new method, microwear analysis held great promises for those interested in reconstructing past behaviour. It potentially offered the possibility of inferring activity areas within sites, not on the basis of hypothetical functions of specific tool types (for example burin = bone-/antler-working), but based on objective data. In some instances, such as at Verberie (Symens 1986: 220-221) and at Meer (Cahen et al. 1979), these expectations have come true, in that bone-/ antler-working areas could be identified around hearth areas. At Hekelingen III we catch a glimpse of them in archaeological units A1, M1 and H2 (see *6.2.4*), while at Vaenget Nord hide-working seems to have occurred away from the central area of the site (Juel Jensen/ Brinch Petersen 1985: 49). The configuration of bones of young rhinoceros and a backed-blade with butchering traces at Belvédère site G (described above), forms a good example of an activity locus as well.

Unfortunately, it is not always clear which meaning we should attribute to such spatial configurations. Keeley, in what was actually the first theoretical article to appear within the subject of microwear analysis, draws attention to the effect of 'retooling' activities (Keeley 1982). He asserts that hafted tools are brought 'home', where new flint implements are inserted into the hafts. The manufacture of hafts is a time-consuming task, so they are re-utilized, while the worn-out flint tools are discarded, far away from the location of their actual use, in the hearth areas of the settlement (whether it be a permanent or temporary one). This would imply that the interpretation of activity loci becomes a very tricky business for those assemblages with evidence of hafting. Dislocation of artefacts not only occurs from retooling; actually it takes place whenever tools are transported from the settlement to their location of actual use and back, i.e. in the case of all the implements used outside the settlement area. We therefore must first take the mobility of tools into account, prior to making any statements about configurations being activity areas.

A second situation in which activity areas are difficult to interpret, is exemplified by the Linearbandkeramik sites. It concerns permanent settlements where apparently a large part of the rubbish produced by the inhabitants was collected to be dumped in pits adjacent to the houses. The samples studied so far include Darion (Caspar 1988), Elsloo (Schreurs 1989) and Beek-Molensteeg (this volume). Despite the fact that most of the assemblage of the nearly completely excavated settlement of Darion was studied, no dissimilarities in the content of these pits which may indicate economic/ task differentiation between households were observed. In Elsloo, the sample was devised to include the pits of houses which showed variations in certain (perhaps socially defined) respects, but also in this case functional distinctions were not evident (Schreurs 1989). Whether these observations are 'real', i.e. have social implications, is difficult to tell. It is equally possible that the pits lay open for anyone to dump garbage into, and that their contents do not necessarily solely reflect the activities carried out in the houses situated adjacent to them.

Yet another situation in which taphonomic processes have to be taken into account when inclined to interpret an artefact concentration as an activity area, is the possibility that in permanently (or long-term) inhabited houses the more frequented areas of the dwelling are cleaned on a regular basis. In ethnographic context it has been observed that the areas which are most intensively used are virtually devoid of garbage or unused tools, while spaces which are seldom frequented abound with junk; when the people move out, the latter material is often not removed, becoming part of the archaeological record in due time (Van Gijn 1986b).

It will be clear that the interpretation of a given spatial distribution, such as an activity area, should be approached with considerable caution. Certainly, use-wear analysis adds an extra dimension to the reconstruction of past behaviour at a site, but the same reasoning about cultural and natural depositional factors now becoming so common in general archaeological practice needs to be applied to microwear analysis. The data cannot automatically be taken at face-value.

7.5 Tracing functional differentiation between sites

Following Binford's interpretation of Mousterian variability being related to different 'structural poses' of the same group of people, the potential of use-wear analysis to contribute to the question of 'site-typology' was recognized. In fact, in the early days of microwear analysis two theses have been addressed to this very problem (Anderson-Gerfaud 1981; Beyries 1987). The greater part of the more recent studies, however, has been rather site-oriented, although the theme, assessing the character or function of the settlement in question, has continued to be important (cf. Juel Jensen/ Brinch Petersen 1985; Dumont 1988). This emphasis on single sites is not so surprising considering the time involved in the analysis of an assemblage. An additional problem is that smaller (i.e. more manageable) collections have generally been selected for study (see also Juel Jensen 1988: 64-65), presently resulting in a severe under-representation of the larger sites. It is only when we will have data from the total continuum of settlement sizes within a given (micro-)region, that we might be able to conclude something about the 'movement of people through time' (Carlstein 1982). However, before such broad-scale studies are possible, more effective sampling procedures must be devised, involving for instance the use of stereomicroscopes (see next paragraph). The study of the Vlaardingen sites, presented in chapter 6, forms an attempt at establishing such a corpus for the Dutch coastal areas.

In paragraph 7.3 it has been demonstrated that many different factors must be taken into account before we can attribute a meaning to the inferred motions and contact-materials. The next step is to assign a specific *function* to the site: does it concern a permanently occupied settlement, a winter base-camp, a hunting station or a game-watching stand? Binford (1978a; 1978b; 1982) has been instrumental in outlining the great variety possible in types of sites. As has been argued before, we unfortunately have very little grip on the question which activities or tools are 'typical' for which type of settlement (Van Gijn *in press a*). Juel Jensen (1986: 31) has suggested that unretouched used blades should be employed as indicators for functional differences between sites, rather than intentionally retouched tools, as the latter are more likely to have been repaired or resharpened. Ethnographic information is seldom of much help (see *chapter 3*).

Obviously, there are some instances which are self-evident, such as the butchering area of Belvédère site G (Roebroeks et al. 1986), or, at the other extreme, the large, permanently inhabited, agricultural LBK settlements. However, in general we are dealing with minor variations along this continuum, which nonetheless have significance with respect to past human behaviour. It is very likely that certain settlements, actually different in terms of site typology, will display virtually the same spectrum of inferred tool uses. This was, for instance, the case at Hekelingen III and Leidschendam trench 4 (*chapter 6*). In those instances I would suggest we should actively search for possible variation and its meaning (Van Gijn *in press a*), incorporating as much evidence into our arguments as possible. Even if we have only the lithic component available, no other remains being preserved, I would maintain that use-wear data should be combined with information pertaining to the typological range of tools, technological features, availability and character of the raw material and so forth. With respect to Hekelingen III and Leidschendam, evidence for a different behaviour towards the flint provided an important clue for the inference that the sites had a different function. The people at Hekelingen III had sufficient amounts of exotic raw material at their disposal, which was treated in a rather careless fashion (see *6.2.6.2*). At the other hand, at Leidschendam only local flint of small size was available, which was used in a more thrifty manner (see *6.3.5*). These observations, among others, led to the conclusion that Leidschendam was occupied on a year-round basis, whereas the site of Hekelingen III was interpreted to reflect multiple visits of perhaps different duration, aimed at the exploitation of wild resources such as sturgeon and game (cf. *6.2.6*). Hence, by *actively* combining and confronting such a large variety of *lithic* data we will come a long way towards understanding site function, especially when more settlements are compared.

We now arrive at the final problem pertaining to the subject of site typology, the question of ethnic/ social group homogeneity. Even if it is demonstrated that one settlement was occupied during summer, and another during winter, how certain can we be that both were used by the same group of people? Once more we seem to arrive at the 'Mousterian problem'. Close has argued that only by examining stylistic variables is it possible to determine whether sites with a demonstrably different function were occupied by the same group of people (Close 1978: 234). One drawback to this approach is that, especially in lithics, stylistic and functional variables are almost impossible to separate (Sackett 1982, 1986). Other find categories, especially ceramics, might be of help, but some caution is warranted. For example, Hekelingen III and Leidschendam trench 4 have similar pottery, but seem isolated from each other from the point of view of lithics; does it concern the same group of people or not? Clearly, the line of reasoning will be different for every situation and will greatly depend on the archaeological material at hand.

7.6 The future of microwear analysis

Microwear analysis has gone through a historical development essentially similar to other relatively new disciplines, such as pollen analysis and ^{14}C-dating. When introduced by Keeley in the mid-seventies (Keeley 1974), expectations were very high. The method satisfied the current need for scientific approaches and seemed to offer a very direct clue to several aspects of prehistoric behaviour. After the initial elation came a phase during which many researchers were confronted with a variety of problems: polishes were not always diagnostic, post-depositional surface modifications occurred frequently, and the inferential leap from wear-traces to statements about prehistoric behaviour turned out to be tremendous. During this period of 'depression' several highly self-critical articles appeared and the world of microwear analysts was rather self-centred. Recently, it seems that the discipline is gradually moving into a third phase, characterized by a more mature, aware attitude.

Uneasiness with the method and its potentials nevertheless still remains. Microwear analysis was thought to hold great promises to become a scientific (read: infallible) approach. In compliance with this idea various 'high-tech' procedures were developed, mostly directed at quantifying polishes (a.o. Grace et al. 1986). As Juel Jensen has stressed, however, such attempts are bound to fail as long as the basic issue, the origin of polish formation, has not yet been clarified (Juel Jensen 1988a: 81). Solving this latter issue requires knowledge most archaeologists do not possess, and it is unlikely that a surface-chemist, specialized in silica, will be willing to solve the problem for us. It is thus to be expected that it will be some time before such results will appear. In the meantime, a formalization of the way interpretations are obtained remains a highly recommendable endeavour (Grace et al. 1988).

Another drawback of microwear analysis is the fact that so many assemblages are being rejected because they are deemed unsuitable. It has been suggested in chapter 4 that we should abandon the distinction between microwear (high-power) analysis on the one hand, and macrowear (low-power) analysis on the other, and, instead, apply a combination of both approaches, called use-wear analysis. The discipline of use-wear analysis would encompass a wide range of techniques, suitable for a variety of approaches, the specific use of which depending on the size and degree of conservation of the assemblage, the questions asked, and the time available. For instance, a stereomicroscope could be employed for the examination of complete assemblages; the results obtained could form a basis for taking samples with respect to a more detailed analysis with an incident light microscope. Although the degree of resolution obtained with low magnifications is not very high, such analyses have the advantage of being able to cope with large quantities of implements, which, in addition, do not necessarily have to be in mint condition. Despite lower-level inferences (restricted to statements about 'used' versus 'unused', rather than about the specific nature of the contact-material), this approach would lessen the bias that exists in regional site function studies.

When first introduced, microwear analysis was considered to be a viable alternative for palaeobotanical or archaeozoological studies at sites with poor organic preservation. It was thought that at settlements with only flint left, it would still be possible to obtain information about the role of plants and animals. However, it has been shown that use-wear analysis is also able to produce unique information for sites with abundant organic remains (cf. *chapters 5 and 6*). Lemonnier (1986: 154) has recently put forward the suggestion that we should study the interrelationships and interdependencies of the various techniques of a cultural system. In this manner it should be possible to determine regularities in the sort of choices made, which in turn would reflect social representations. Use-wear analysis of flint tools is potentially a very good method for the investigation of such interdependencies between techniques, as it links two (or more) 'artefact' categories and offers us glimpses of various '*chaines d'opératoire*'. This is indeed a very exciting prospect, and a challenge that needs to be confronted, to be able to contribute to the subject of 'the anthropology of techniques'. In such a way it might eventually be possible to move beyond a purely functional approach of the functional analysis of flint.

note

1 A conference under the same title was recently held in Uppsala, Sweden, organized by Kjel Knutsson and Jackie Taffinder (February 15-18, 1989).

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appendix I

NO VARIABLE	CATEGORY	SCORE
SITE FILE		
1 Site	Hekelingen III	1
	Leidschendam	2
	Beek-Molensteeg	3
	Leilan	4
	Belvédère	5
2 Individual	0-9999	
3 NS coordinates/house	0-99	
4 EW coordinates/pit	0-999	
5 Layer/height	0-9	
6 Length	0-999.9 mm	
7 Width	0-999.9 mm	
8 Thickness	0-999.9 mm	
9 Weight	0-999.9 gram	
10 Primary classification	flake	1
	blade	2
	core	3
	waste	4
	splinter	5
	core fragment	6
	other	8
	unsure	9
	rejuvenation platform:	
	tabular, facetted	10
	tabular, not facetted	11
	rejuvenation coreface:	
	parallel	12
	perpendicular	13
	crested blade	14
	decortication flake	15
11 Typology	blade (1..)	
	unretouched (1.0)	
	straight	110
	convex	120
	concave	130
	retouch ⩾ 1 mm (1.1)	
	straight	111
	convex	121
	concave	131
	retouch < 1 mm (1.2)	
	straight	112
	convex	122
	concave	132
	multiple scraper on blade	160
	composite tool on blade	170
	endscraper on blade	171
	flake (2..)	
	unretouched (2.0)	
	straight	210
	convex	220
	concave	230
	retouch ⩾ 1 mm (2.1)	
	straight	211
	convex	221
	concave	231
	retouch < 1 mm (2.2)	
	straight	212
	convex	222
	concave	232
	thumbnail scraper	224
	multiple scraper on flake	260
	composite tool on flake	270
	endscraper on flake	271
	core (3..)	
	unretouched (3.0)	
	straight	310
	convex	320
	concave	330
	retouch ⩾ 1 mm (3.1)	
	straight	311
	convex	321
	concave	331
	retouch < 1 mm (3.2)	
	straight	312
	convex	322
	concave	332
	polyhedral blade core	351
	blade core with two platforms	352
	discoidal	353
	flake core	354
	exhausted flake core	355
	unsure	359
	waste (4..)	
	unretouched (4.0)	
	straight	410
	convex	420
	concave	430
	retouch ⩾ 1 mm (4.1)	
	straight	411
	convex	421
	concave	431
	retouch < 1 mm (4.2)	
	straight	412

NO VARIABLE	CATEGORY	SCORE
	convex	422
	concave	432
	multiple scraper on waste	460
	transverse arrowhead	510
	truncated blade	520
	backed blade	530
	lanceolate point	550
	A-point	610
	B-point	620
	axe	710
	tranchet axe	711
	barbed arrow head	720
	leafshaped arrow head	730
	dagger	740
	borer	750
	point	760
	LBK-point	770
	not applicable	800
	quartier d'orange	850
	crescent-shaped sickle	890
	unsure	900
12 Cortex	none	1
	entire	2
	dorsal ⩾ 50%	3
	dorsal < 50%	4
	on platform	5
	ventral	6
	ventral + dorsal ⩾ 50%	7
	ventral + dorsal < 50%	8
	dorsal ⩾ 50% + on platform	10
	dorsal < 50% + on platform	9
	ventral + dorsal < 50% + on platform	11
13 'Patina'	not patinated	1
	lightly patinated	2
	heavy gloss patina	3
	unsure	9
14 Polished fragment	not	1
	dorsal ⩾ 50%	2
	dorsal < 50%	3
15 Burned	not burned	1
	glossy	2
	red spots	3
	craquele	4
	unsure	9
16 Raw material	Hekelingen group 1	1
	group 2	2
	group 3	3
	Rijckholt	4
	rolled material	5
	northern, moraine flint	6
	Hekelingen group 4	7
	other	8
	unsure	9
	light-grey Belgian	10
	Valkenburg	11
	Cap Blanc Nez	12
	North Sea flint	13
	Kristiansstad	14

NO VARIABLE	CATEGORY	SCORE
17 Grain-size	coarse	1
	medium	2
	fine	3
	glass-like	4
	unsure	9
18 Fragment	complete	1
	distal	2
	medial	3
	proximal	4
	along length	5
	potlitted	6
	not applicable	8
	unsure	9
19 Hafting	absent	1
	retouch	2
	notch	3
	bitumen	4
	with leather (experiments only)	5
	with bone/wood (experiments only)	6
	not examined	7
	not interpretable	8
	unsure	9
20 Percussion	hard hammer	1
	soft hammer	2
	not applicable	8
	unsure	9
21 State distal end	feather	1
	hinge	2
	reverse hinge	3
	with distal end core	4
	with cortex on distal end	5
	step	6
	not applicable (broken)	8
	unsure	9
22 Surface platform	smooth	1
	facetted	2
	cortex	3
	battered	4
	not applicable	8
	unsure	9
23 Dorsal face preparation	abraded	1
	microretouched	2
	not applicable	8
	unsure	9
24 Number of negatives	1-99	
25 Number of PUAs	0-10	

MACRO-FILE

26 PUA no.	0-10	
27 Location PUA	polar coördinates 1-17	
28 Observed phenomenon	retouch ⩾ 1 mm	1
	retouch < 1 mm	2

NO	VARIABLE	CATEGORY	SCORE
29	Edge angle	0-360	
30	Shape surfaces	straight	11
		convex	22
		concave	33
		(first central than dorsal)	
31	Shape edge	straight	1
		convex	2
		concave	3
		irregular	4
		broken	5
		slightly convex	6
		slightly concave	7
		pointed	8
32	Outline edge	not applicable	0
		serrated	1
		denticulated	2
		encoche	3
		cran	4
		epaulement	5
		museau	6
		languette	7
		pedoncule	8
		soie	9
33	Form cross-section	straight	1
		convex	2
		concave	3
		wavy	4
		irregular	5
		slightly concave	6
		unsure	9
34	Location retouch	ventral only	1
		dorsal only	2
		dorsal + ventral alternating	3
		dorsal + ventral bifacial	4
35	Distribution retouch	overlapping	1
		close/regular	2
		close/irregular	3
		wide/regular	4
		wide/irregular	5
		not applicable	8
36	Width retouch	0-99.9 mm	
37	Form retouch 1	scalar well-defined	1
		scalar vague	2
		lamellar	3
		half moon	4
		trapezoidal/square	5
		other	8
		unsure	9
		polish	3
		straight cross-section	4
		ground-axe fragment	5
		protruding point	6

NO	VARIABLE	CATEGORY	SCORE
38	Form retouch 2	scalar well-defined	1
		scalar vague	2
		lamellar	3
		half moon	4
		trapezoidal/square	5
		other	8
		unsure	9
39	Termination retouch 1	step	1
		hinge	2
		feather	3
		snap	4
		other	8
		unsure	9
40	Termination retouch 2	step	1
		hinge	2
		feather	3
		snap	4
		other	8
		unsure	9
41	Secondary modifications	no	1
		light	2
		medium	3
		heavy	4
		burned	5
		interpretable = 0	
		not interprable = 9	
42	Degree of wear	no traces	1
		lightly worn	2
		medium worn	3
		heavily worn	4
		lightly + possibly resharpened	5
		probably used	6
		perhaps hafting	7
		not interpretable	8
		unsure	9
43	Number of AUAs	0-9	

MICRO-FILE

NO	VARIABLE	CATEGORY	SCORE
44	PUA no.	0-99	
45	AUA no.	0-9	
46	Location AUA	polar coördinates 0-17	
47	'Use-retouch' location	ventral	1
		dorsal	2
		dorsal + ventral alternating	3
		dorsal + ventral bifacial	4
48	'Use-retouch' distribution	overlapping	1
		close/regular	2
		close/irregular	3
		wide/regular	4
		wide/irregular	5
		one impact scar	6

NO	VARIABLE	CATEGORY	SCORE
49	'Use-retouch' width	0-999 mm	
50	'Use-retouch' form	scalar well-defined	1
		scalar vague	2
		lamellar	3
		half moon	4
		trapezoidal/square	5
		other	8
		unsure	9
51	'Use-retouch' termination	step	1
		hinge	2
		feather	3
		snap	4
		other	8
		unsure	9
52	Edge-rounding	sharp	11
		slightly rounded	22
		very rounded	33
		nibbled	44
		(first ventral than dorsal)	
53	Polish location	dorsal + ventral, but dorsal more	1
		dorsal + ventral, but ventral more	2
		dorsal + ventral equal	3
		only dorsal	4
		only ventral	5
54	Polish distribution	scintillation	1
		on protruding points	2
		reticulated	3
		snowlandscape	4
		isolated spots	5
		thin line along edge	6
		band along edge	7
		band away from edge	8
		other	9
		spread	10
		greasy lustre	11
		streaks of polish	12
		isolated spots + streaks	13
55	Polish contrast	great	1
		medium	2
		little	3
56	Polish texture	smooth	1
		smooth and greasy	2
		smooth and matt	3
		rough	4
		rough and greasy	5
		rough and matt	6
		not applicable	8
57	Polish brightness	very bright	1
		bright	2
		dull	3
		not applicable	8

NO	VARIABLE	CATEGORY	SCORE
58	Polish topography	domed	1
		flat	2
		corrugated	3
		cratered	4
		pitted	5
		bubbly	6
		comet tails	7
		not applicable	8
		pitted and comet tails	9
		beveled	10
59	Polish width	0-9999 μ	
60	Polish directionality	absent	1
		linear perpendicular	2
		linear parallel	3
		linear diagonal	4
		random	5
61	Contact-material inferred	bone	1
		soft plant	2
		wood	3
		sickle-gloss	4
		'sickle-gloss'-like	5
		dry hide	6
		fresh hide	7
		hide unspecified	8
		antler	9
		bone/antler	10
		meat	11
		shell	12
		fish	13
		fired pottery	14
		clay/pottery	15
		soft stone	16
		hard material	17
		soft material	18
		soft animal material	19
		hard animal material	20
		tooth	21
		bone/wood	22
		polish '23'	23
		unknown	99
62	Degree of certainty	'certain' inference	1
		'uncertain' inference	2
		not applicable	8
63	Striations location	dorsal + vertral, but dorsal more	1
		dorsal + ventral, but ventral more	2
		dorsal + ventral equal	3
		only dorsal	4
		only ventral	5
64	Striations definition	deep/short/narrow	1
		deep/short/wide	2
		deep/long/narrow	3
		deep/long/wide	4
		shallow/short/narrow	5

NO VARIABLE	CATEGORY	SCORE
	shallow/short/wide	6
	shallow/long/narrow	7
	shallow/long/wide	8
	filled in	9
65 Striations direction	parallel	1
	perpendicular	2
	diagonal	3
	random	4
	unsure	9
66 Motion inferred	scraping	1
	cutting/sawing	2
	boring	3
	carving/engraving	4
	projectile	5
	hafting	6
	shaving	7
	planing	8
	unsure	9
	whittling	10
	adzing	11
	longitudinal	12
	transverse	13
	splitting	14
	piercing	15
	wedging	16
67 Degree of certainty	'certain' inference	1
	'uncertain' inference	2
	not applicable	8

FOR EXPERIMENTS ONLY

NO VARIABLE	CATEGORY	SCORE
68 Contact of surface	ventral + dorsal	1
	ventral	2
	dorsal	3
69 Effectiveness	very	1
	mediocre	2
	inappropriate	3
70 Exhaustion	still effective	1
	exhausted	2
	not applicable	8

appendix II

table 1 Hide-working experiments (N=49)

indiv	type	contact mat.	motion	durat.	csu	haf	rm	gs	ea	cs	ss	se	eff	exh	edr	rdi	rwi	rfo	rte	plo	pdi	pbr	pte	pwi	pdr	pto	sde	sdr	slo
104.0	750	fresh foxhide	boring	3	1	1	12	2		1	12	8	1	1	11														
94.0	750	dry leather	boring	10	1	1	12	3		1	12	8	1	1	11														
20.1	750	dry leather	boring	10	1	1	6	3		1	11	8	1	1	11														
228.0	110	dry leather	boring	29	1	1	6	3		1	11	8	1	1	22	5	200	1	3	3	2	3	5		1	8			
46.0	750	dry leather	boring	45	1	1	6	3		1	11	8	1	1	11														
250.0	750	humid deerhide	boring 100x	15	1	1	6	3		1	11	8	1	1	11														
229.0	110	fresh deerhide	cutting	6	1	1	6	3	39	1	11	6	1	1	22					3	1	3	5	50	1	8			
172.0	210	dry leather	cutting	8	1	1	6	3	44	1	11	6	1	1	11					3	1	3	6	100	1	8			
264.2	110	fresh elephant	cutting	10	1	1	6	3	52	1	11	1	1	1	22														
105.2	210	fresh harehide	cutting	10	1	1	12	3	15	1	11	4	1	1	11														
20.2	750	dry leather	cutting	10	1	1	6	3	55	1	11	6	1	1	11														
153.0	110	fresh foxhide	cutting	14	1	1	4	3	48	4	11	6	1	1	11														
163.0	210	dry leather	cutting	15	1	1	4	2	33	1	11	1	1	1	11					3	1	3	5	100	1	8			
320.0	110	dry deerhide	cutting	18	1	1	6	3	29	1	11	6	1	1	11	1	200	1	2	3	12	2	6	450	3	5	2	1	3
264.1	110	fresh elephant	cutting	20	1	1	6	3	28	1	11	6	1	1	22	3	50	1	3	3	7	2	5	500	3	4			
243.0	110	dry deerhide	cutting	30	1	1	6	1	27	1	11	1	1	1	22	3	200	5	2	3	12	1	6	2000	3	8			
225.0	210	dry leather	cutting	39	1	1	6	3	35	1	11	1	1	1	22					4	7	3	5	50	1	8			
290.0	110	fresh deerhide	cutting	40	1	1	6	3	37	1	11	1	1	1	22					3	7	2	5	70	1	8			
263.0	110	fresh elephant	cutting	45	1	1	6	3	25	1	11	4	1	1	22	3	150	1	3	1	7	2	5	1500	3	4			
262.0	221	wet harehide	depilating	8	2	1	6	3	73	1	12	2	1	1	11														
249.0	221	humid deerhide	ochre + liver	30	3	1	6	3	75	1	11	2	1	1	33					1	7	3	6	175	2	5			
98.0	221	fresh foxhide	scraping	10	2	1	12	2	78	1	12	2	2	1	11														
226.0	221	fresh deerhide	scraping	10	2	1	6	3	80	1	12	2	1	1	31					5	7	3	5	100	2	4			
93.0	221	wet leather	scraping	12	2	1	12	3	70	2	12	2	1	1	12														
227.0	221	fresh harehide	scraping	15	2	6	4	2	65	1	12	2	1	1	33					1	7	2	6	450	2	4			
100.0	221	fresh harehide	scraping	18	2	1	12	2	69	1	12	2	1	1	22					2	7	2	5	125	2	4			
85.0	221	fresh deerhide	scraping	20	1	1	4	2	77	1	12	2	1	1	22					2	7	1	6	120	2	4			
97.0	221	fresh deerhide	scraping	20	2	1	12	2	85	1	11	2	1	1	32					3	7	1	6	200	2	4			
92.0	221	fresh harehide	scraping	29	2	1	12	3	66	1	12	2	1	1	22					3	7	2	6	150	2	4			
31.0	221	dry leather	scraping	30	2	1	6	3	60	2	32	2	2	1	12					4	11	3	5	200	1	8			
272.0	221	fresh deerhide	scraping	30	3	1	6	3	75	2	11	2	1	1	23					1	7	2	5	1550	2	4			
230.0	221	fresh deerhide	scraping	30	1	1	6	3	63	2	31	2	1	1	33					1	7	3	5	450	2	5			
105.1	210	fresh harehide	scraping	30	2	1	12	3	43	1	11	1	1	1	12					4	6	3	5	75	1	4			
233.0	221	fresh deerhide	scraping	30	1	1	6	3	70	1	11	2	1	1	33					1	7	3	5	700	2	4			
14.0	221	dry leather	scraping	48	1	1	6	3	68	2	12	2	1	1	22														
101.0	221	fresh foxhide	scraping	50	1	1	12	2	76	1	12	2	1	1	22														
197.0	221	fresh harehide	scraping	60	2	1	6	3	66	1	12	2	1	1	22					3	7	2	5	75	1	4			
293.0	171	dry deerhide	scraping	60	2	1	13	3	65	1	12	2	1	1	21					2	2	2	5	100	1	8			
265.0	221	fresh elkhide	scraping	60	2	1	6	3	40	2	11	2	1	1	22					2	7	2	5	400	2	5			
266.0	221	fresh elkhide	scraping	60	2	1	6	3	70	1	11	2	1	1	11					3	6	3	5	100	1	8			
29.0	221	fresh cowhide	scraping	75	2	1	6	3	60	1	12	2	2	1	11														
289.0	221	fresh deerhide	scraping	150	2	1	13	2	60	1	12	2	1	1	22					3	7	2	5	50	2	8			
253.0	221	humid deerhide	scr.w. brain	30	3	1	6	3	86	1	12	6	1	1	11														
270.0	221	dry elkhide	scr.w.fat	20	3	1	13	3	72	1	12	2	1	1	13					4	2	2	5	1000	5	4			
271.0	221	dry elkhide	scr.w.fat	20	3	1	6	3	72	1	12	2	1	1	13					4	2	2	5	2000	5	4			
269.0	221	dry elkhide	scr.w.fat	20	3	1	6	3	74	1	12	2	1	1	12					4	2	2	5	200	5	8			
242.0	221	dry deerhide	scr.w.fat	60	1	1	4	2	69	1	12	2	1	1	23					1	2	2	5	2000	2	4	2	2	4
248.0	221	humid deerhide	scr.w. liver	30	3	1	6	3	70	1	11	2	1	1	11					4	2	3	6	400	2	8			
51.0	210	fresh deerhide	skinning	25	1	1	12	3	33	1	11	6	1	1	11														

table 2 Wood-working experiments (N = 62)

indiv	type	contact mat.	motion	durat.	csu	haf	rm	gs	ea	cs	ss	se	eff	exh	edr	rdi	rwi	rfo	rte	plo	pdi	pbr	pte	pwi	pdr	pto	sde	sdr	slo
84.0	750	soaked willow	boring	7	1	1	12	2		1	11		2	1	22					3	5	2	3		1	1			
88.0	750	soaked hazel	boring	7	1	1	12	2		1	11		1	1	11					5	5	2	3		2	1			
13.1	750	dry deal	boring	30	1	1	6	3		1	11	8	2	2	11					3	5	2	3		1	1			
244.0	711	soft fresh wood	chopping		1	6	6	3	55	4	11	1	1	1	22					3	10	1	3	5000	2	1	2	2	3
52.2	221	soaked hazel	debark.	7	2	1	12	3	75	2	32	2	2	1	11					5	11	3	8	100	8				
33.0	221	fresh cherry	debark.	10	2	1	4	2	16	4	11	6	3	8	11														
52.1	221	soaked hazel	debark.	12	2	1	12	3	50	3	13	1	1	1	11					3	11	3	8	200	8				
156.0	231	fresh willow	debark.	13	2	1	6	3	80	1	13	3	1	1	22					3	3	1	3	100	2	1			
295.0	221	fresh pine	debark.	15	2	1	13	2	67	1	12	2	1	1	11														
217.0	110	fresh oak	debark.	20	2	5	6	3	15	1	11	2	1	1	21	1	350	4	4	2	10	1	3	6000	2	1	2	2	5
61.0	221	fresh maple	debark.	22	2	1	4	2	40	2	32	2	1	1	22					1	3	1	3	600	2	1			
286.0	221	soft fresh wood	debark.	30	2	1	13	2	62	1	12	2	1	1	22					2	3	2	3	700	3	8			
284.0	131	fresh willow	debark.	30	2	1	6	3	70	1	12	3	1	1	22					3	7	2	3	30	1	1			
44.0	221	dry prune	debark.	35	2	1	4	2	71	1	12	2	1	1	21					5	3	2	3	100	1	1			
278.2	110	fresh willow	debark.	37	2	1	6	3	45	1	11	1	1	1	11					5	7	2	3	1200	2	8			
203.0	230	fresh willow	debark.	45	2	1	6	3	40	1	11	3	1	1	11	5	200	1	2	4	5	2	2	100	2	8			
60.0	221	fresh willow	debark.	52	2	1	12	3	75	1	12	2	1	1	12					2	6	1	3	75	1	1			
208.0	110	fresh birch	debark.	55	2	1	6	3	37	1	11	1	1	1	21	5	500	1	3	2	3	1	3	1200	2	1			
306.0	131	fresh willow	debark.	60	2	1	6	3	53	1	12	3	1	1	22	2	70	1	2	2	6	1	3	50	2	1	2	2	2
296.0	110	fresh pine	longit.	4	1	1	6	3	42	1	11	7	1	1	22	3	500	1	2	3	7	1	3	1000	3	1	5	2	3
161.2	230	dry deal	longit.	5	1	1	4	2	30	1	11	1	1	1	11	3	200	1	2	2	7	1	3	650	3	1	2	1	3
30.1	221	fresh prune	longit.	6	1	1	4	2	40	1	11	1	2	1	11														
74.0	220	soaked poplar	longit.	7	1	1	4	2	45	3	11	6	1	1	44	4	500	1	3	5	11	2	2	50	1	8			
5.0	220	dry deal	longit.	8	1	1	4	2	15	1	11	6	2	1	11	3	200	5	2	3	5	1	3	150	3	1	2	1	3
59.0	110	dry willow	longit.	17	1	1	12	3	25	1	11	1	1	1	21	5	100	1	3	2	5	2	3	100	3	1			
13.2	750	dry deal	longit.	17	1	1	6	3	42	1	11	1	1	1	22	5	150	1	2	1	1	2	3	500	3	1	2	1	1
81.0	210	soaked maple	longit.	18	1	1	12	3	36	1	11	6	1	1	11					2	1	3	6	400	3	8			
75.0	210	fresh willow	longit.	20	1	1	4	2	35	1	11	1	1	1	22	2	500	1	3	1	5	2	3	350	1	8			
45.0	110	fresh cherry	longit.	20	1	1	6	3	30	1	11	4	1	1	22	5	500	1	2	3	7	1	3	500	3	1	2	1	3
27.0	110	dry willow	longit.	22	1	5	6	3	32	1	11	1	1	1	11	5	50	1	3	5	2	2	3	50	1	1			
55.0	210	dry oak	longit.	25	1	1	4	2	40	1	11	1	1	2	11	3	700	1	2	3	5	1	3	700	3	1	2	1	3
260.0	210	soaked maple	longit.	30	1	5	6	3	35	1	11	1	1	1	22	3	500	1	2	3	10	1	3	2000	3	1	2	2	3
47.0	110	dry prune	longit.	30	1	1	4	2	40	1	11	1	1	1	21	3	200	1	2	3	7	1	3	200	3	1	2	1	3
280.2	110	fresh willow	longit.	30	1	1	6	3	15	1	11	6	1	1	11	1	200	1	2	2	7	1	3	1000	3	1			
294.2	110	soft fresh wood	longit.	45	1	1	13	3	35	1	11	1	1	1	22	3	500	1	2	2	7	1	3	200	3	1			
204.0	210	fresh maple	longit.	75	1	1	6	2	40	1	11	1	2	1	22	3	500	1	3	1	3	1	3	2000	3	1			
35.0	221	fresh prune	scraping	8	2	1	6	3	70	2	32	2	1	1	21					2	3	1	3	200	2	1			
38.0	221	dry deal	scraping	11	2	4	6	3	52	1	12	2	1	1	11														
30.2	221	fresh prune	scraping	14	2	1	4	2	65	2	31	2	2	1	11														
325.0	221	fresh oak	scraping	20	1	1	4	2	77	4	32	2	1	1	22					2	7	2	3	200	1	8			
209.0	211	fresh oak	scraping	30	2	1	6	3	55	1	12	1	1	1	21					2	3	1	3	200	2	1			
161.1	230	dry deal	shaving	15	2	1	4	2	45	3	11	3	1	1	22	5	100	4	2	2	3	1	3	350	2	1	2	2	3
294.1	110	soft fresh wood	shaving	45	2	1	13	3	35	1	11	1	1	1	22	2	100	1	3	2	7	1	3	1000	2	1			
324.0	110	fresh willow	splitting	5	1	1	6	2	32	1	11	1	2	1	11														
173.0	110	soak.cedar bark	splitting	10	1	1	6	3	52	1	11	8	1	1	11					1	6	2	3	20	1	1			
211.0	110	fresh willow	splitting	10	1	5	6	1	31	1	11	1	1	1	11														
292.0	110	soft wood	splitting	30	1	1	6	3	20	1	11	1	1	1	11					2	12	1	3	500	3	7			
212.0	110	fresh willow	splitting	41	1	1	6	3	32	1	11	8	1	1	11					1	3	1	3	2000	4	1			
198.0	110	fresh willow	splitting	55	1	1	6	3	55	1	11	8	1	1	11					4	5	1	3	400	4	1			
317.0	850	fresh brambles	transv.	45	2	1	13	3	78	1	11	1	1	1	22					2	7	2	3	50	1	1			
77.0	210	dry poplar	whittling	5	2	1	4	2	41	1	11	6	1	1	11														
221.0	230	soaked birch	whittling	6	3	1	6	1	32	1	11	1	1	1	11	2	100	1	1	5	7	1	6	200	2	3			
214.0	110	fresh willow	whittling	7	2	1	6	3	12	1	11	4	1	1	11					3	1	3	8	100	1	8			
79.0	210	fresh maple	whittling	10	1	1	4	2	20	1	13	1	1	1	11					5	1	3	8	500	1	8			
168.0	210	dry maple	whittling	10	1	1	6	3	50	1	11	7	1	1	12					4	5	2	3	20	1	8			
257.0	210	soaked maple	whittling	15	3	5	4	2	32	1	11	6	1	1	11	2	300	4	4	1	5	1	3	1200	2	1			
76.0	210	fresh elm	whittling	29	3	1	4	2	35	1	11	1	1	1	11														
50.0	110	soaked oak	whittling	30	3	1	4	1	30	1	11	1	1	1	22	2	250	2	3	1	5	1	3	900	4	1	2	3	1
321.0	110	fresh maple	whittling	37	3	6	14	2	37	1	11	1	1	1	22					3	6	1	3	50	2	7			
285.0	210	fresh willow	whittling	45	2	1	6	3	40	3	11	1	1	1	11	4	400	1	2	3	5	3	8	25	1	8			
202.0	130	fresh maple	whittling	50	2	1	6	3	35	1	11	7	1	2	11	5	300	4	2	2	3	1	2	1000	2	8			

table 3 Bone-working experiments (N = 53)

indiv	type	contact mat.	motion	durat.	csu	haf	rm	gs	ea	cs	ss	se	eff	exh	edr	rdi	rwi	rfo	rte	plo	pdi	pbr	pte	pwi	pdr	pto	sde	sdr	slo
16.0	750	fresh bone	boring	10	1	1	6	3		1	12	8	1	1	11					4	5	3	6	10	1	8			
215.0	750	fresh bone	boring	12	1	1	6	3		1	12	8	1	2	12					1	5	2	3		2	8			
205.0	750	fresh bone	boring	15	1	1	6	3		1	11	8	2	2	11														
49.0	750	fresh bone	boring	30	1	1	4	2		1	12	8	2	1	11					3	5	1	3		2	9			
72.0	210	fresh bone	carving	3	1	1	4	2	32	1	12	1	1	1	11	1	300	1	2	2	5	2	6	100	4	9			
71.0	750	fresh bone	carving	3	1	1	4	2	75	1	12	1	1	2	11	1	500	1	1	3	5	2	6	200	4	9			
213.1	210	soaked bone	carving	5	1	1	6	3	40	1	11	8	1	1	11					3	1	2	6	100	4	8			
69.0	212	fresh bone	carving	9	1	1	4	2	35	1	11	1	1	2	11	1	800	1	2	3	5	1	6	120	4	9			
66.0	111	fresh bone	carving	9	1	1	4	2	40	1	22	1	1	2	11	1	500	1	1	3	5	2	6	200	4	9			
82.1	750	fresh bone	carving	10	1	1	12	3	47	1	12	1	1	1	11	1	300	1	2	1	5	1	3	150	4	9			
70.0	111	fresh bone	carving	10	1	1	4	2	42	1	12	1	1	2	11	1	1200	1	2	1	5	2	6	50	4	9			
67.0	212	fresh bone	carving	10	1	1	4	3	50	1	12	1	1	2	11	1	500	1	1	1	5	1	6	300	4	9			
63.0	221	fresh bone	carving	10	1	1	4	2	32	1	22	1	1	2	11	1	1000	1	2	2	5	2	6	200	4	9			
64.0	112	fresh bone	carving	10	1	1	4	2	50	1	22	1	1	2	11	1	800	1	2	3	5	2	6	200	4	9			
259.0	210	fresh bone	carving	10	1	1	6	3	27	1	11	1	1	1	11	5	300	1	2	1	5	2	6	300	4	8			
65.0	110	fresh bone	carving	11	1	1	4	2	40	1	22	1	1	2	21	1	300	1	2	3	5	2	6	200	4	9			
68.0	750	fresh bone	carving	16	1	1	4	2	50	1	12	8	1	2	11	1	300	1	1	3	5	1	6	75	4	9			
110.0	110	soaked bone	carving	26	1	1	4	3	35	1	11	1	1	1	22	3	800	1	2	3	7	1	3	1000	3	9			
258.0	210	fresh bone	carving	30	1	1	4	3	32	1	11	1	1	1	11	5	300	1	2	3	5	2	6	200	4	8			
56.0	750	fresh bone	carving	35	1	1	4	2	50	1	11	1	1	1	11	3	800	1	2	3	10	1	6	500	4	9			
111.0	110	soaked bone	carving	35	1	1	4	2	40	1	11	2	1	1	12	5	300	1	2	2	2	1	3	600	3	9			
279.0	110	fresh bone	carving	45	1	1	6	3	45	1	11	8	1	2	11					3	7	1	3	100	2	9			
206.1	210	fresh bone	carving	45	1	1	6	3	35	1	11	6	1	1	11	3	700	1	2	1	5	1	3	1000	4	9			
19.0	221	fr.bone w.meat	de-meating	20	2	1	6	3	77	1	12	2	1	1	21					2	5	1	3	10	1	10			
32.0	110	fr.bone w.meat	de-meating	40	1	1	4	3	42	4	11	2	3	1	11														
278.1	110	fresh bone	longit.	4	1	1	6	3	32	3	11	1	1	2	11	3	500	5	1	1	2	2	6	80	3	8			
82.2	750	fresh bone	longit.	5	1	1	12	3	33	1	11	1	1	1	11	3	700	1	2	1	27	1	3	100	3	9			
322.0	110	fresh bone	longit.	8	1	1	6	3	40	3	11	1	1	1	11	3	1300	1	2	2	2	1	3	800	3	9			
213.2	210	soaked bone	longit.	9	1	1	6	3	15	1	11	2	1	1	11	5	1000	1	2	3	5	2	3	1000	3	8			
36.0	110	fresh bone	longit.	10	1	1	6	3	39	1	11	1	1	1	11	2	700	1	2	3	5	1	3	100	3	7			
299.0	110	fresh bone	longit.	10	3	1	6	2	25	1	11	6	2	2	11					1	1	3	6	50	1	8			
302.0	110	fresh bone	longit.	12	1	1	6	3	35	1	11	1	1	1	11	3	500	1	3	1	2	2	3	300	3	8			
281.1	210	fresh bone	longit.	12	1	1	6	3	32	1	11	1	1	2	11	3	500	5	1	1	2	3	6	50	3	8			
112.0	110	soaked bone	longit.	13	1	1	4	2	40	1	11	1	1	1	11	5	600	5	2	1	5	2	3	1000	3	8			
15.0	110	fresh bone	longit.	15	1	1	4	2	40	4	11	6	3	2	11	3	700	1	1	3	5	1	3	200	3	9	4	1	3
207.1	221	fresh bone	longit.	15	1	1	6	3	50	1	11	1	1	1	11	1	1200	1	1	3	10	1	3	1000	3	8	7	1	3
218.0	110	fresh bone	longit.	15	1	1	6	3	32	1	11	1	1	1	11	3	600	1	2	1	5	2	6	200	3	8			
109.0	110	soaked bone	longit.	20	1	1	4	3	35	1	11	1	1	1	22	1	800	1	2	3	7	1	6	1000	3	5	8	1	3
219.0	110	fresh bone	longit.	30	1	1	6	2	42	1	11	1	2	1	11	3	1000	1	2	1	5	1	6	50	3	9			
48.0	230	fresh bone	longit.	30	1	1	4	2	55	1	13	3	2	1	11	3	200	1	2	1	5	1	3	75	3	9			
303.2	110	fresh bone	polishing	10	2	1	13	3	105	1	11	1	1	1	21					2	7	1	3	50	2	10			
308.0	221	fresh bone	scraping	10	2	1	4	2	55	1	12	2	1	1	21					2	5	1	3	50	2	10			
207.2	221	fresh bone	scraping	12	2	1	6	3	73	1	12	2	1	1	22					3	2	1	3	100	2	8			
57.0	211	fresh bone	scraping	18	3	1	4	2	55	3	23	1	1	1	12	1	1200	1	1	4	5	2	6	100	2	2	8	2	4
220.0	210	cooked bone	scraping	20	2	1	6	3	22	1	11	2	1	1	21	5	300	1	3	5	7	1	3	200	2	10			
298.0	221	fresh bone	scraping	20	2	1	4	2	64	1	12	2	1	1	22					3	2	3	6	50	1	8			
21.0	221	dry bone	scraping	25	2	4	6	3	63	1	12	2	1	1	11														
255.0	271	fresh bone	scraping	45	2	1	4	2	86	1	12	2	1	1	22					2	5	1	3	200	2	5			
303.1	110	fresh bone	scraping	60	2	1	13	3	110	1	11	1	1	1	22					2	7	1	3	50	2	10			
276.0	221	fresh bone	scraping	60	2	1	6	3	67	1	12	2	1	1	21					2	7	1	3	100	2	10			
43.0	221	cooked bone	scraping	75	2	1	12	3	78	1	12	2	1	1	21					2	7	1	3	100	2	10			
281.2	210	fresh bone	shaving	35	3	1	6	3	45	1	11	6	1	2	12	3	800	1	3	1	2	2	6	100	2	2			
206.2	210	fresh bone	whittling	45	1	1	6	1	32	4	11	1	1	2	11	3	800	5	2	1	5	1	3	1000	4	8			

table 4 Antler-working experiments (N = 18)

indiv	type	contact mat.	motion	durat.	csu	haf	rm	gs	ea	cs	ss	se	eff	exh	edr	rdi	rwi	rfo	rte	plo	pdi	pbr	pte	pwi	pdr	pto	sde	sdr	slo
103.0	750	soaked reindeer	boring	7	1	1	12	2		1	12	8	1	1	11														
106.0	750	soaked reindeer	boring	15	1	1	12	3		1	11	8	1	1	11					3	5	1	3		2	1			
216.0	750	soaked roedeer	boring	25	1	1	6	3		1	11	8	1	1	22					3	10	2	3		2	8			
200.1	750	soaked roedeer	boring	30	1	1	6	3		1	11	8	3	2	11														
309.0	750	soaked roedeer	boring	66	1	1	6	3		1	11	8	1	1	11					3	5	1	3		3	1			
200.2	750	soaked roedeer	engraving	3	1	1	6	3	42	1	11	1	1	1	11														
222.0	210	soaked roedeer	longit.	10	1	1	4	1	37	1	11	6	1	1	11	5	400	2	3	1	5	2	5	100	1	8			
223.0	110	soaked roedeer	longit.	16	1	1	6	3	52	1	11	1	1	1	11	3	500	1	2	2	5	1	3	300	3	8			
170.0	210	soaked reindeer	longit.	18	1	1	6	3	60	1	11	1	1	1	22	5	200	1	3	1	7	1	3	200	3	2			
277.0	110	soaked roedeer	longit.	20	1	1	6	3	32	1	11	1	1	1	23	3	200	1	3	1	7	1	6	1400	3	2			
24.0	100	dry reindeer	longit.	30	1	1	6	3	40	1	11	1	2	1	11	3	400	1	2	3	5	2	3	120	1	1			
91.0	221	soaked reindeer	scraping	10	2	1	4	2	72	1	12	2	1	1	11					5	5	1	3	100	1	5			
96.0	221	soaked reindeer	scraping	15	2	1	12	2	78	1	12	2	1	1	22					2	5	1	3	150	2	8			
25.0	221	dry reindeer	scraping	20	2	1	6	3	65	1	12	2	2	1	11					5	6	2	3	20	1	1			
28.0	221	soaked reindeer	scraping	25	2	1	6	3	74	1	12	2	1	1	12					3	1	2	3	100	1	8			
201.0	221	soaked roedeer	scraping	35	2	1	6	3	75	1	12	2	1	1	21					5	7	1	3	100	2	5			
254.0	221	soaked roedeer	scraping	45	1	1	4	2	95	1	12	2	1	1	11					5	7	1	3	50	2	5			
200.3	750	soaked roedeer	whittling	10	2	1	6	3	32	1	11	7	2	1	11	2	700	1	2										

table 5 Soft plant experiments (N = 35)

indiv	type	contact mat.	motion	durat.	csu	haf	rm	gs	ea	cs	ss	se	eff	exh	edr	rdi	rwi	rfo	rte	plo	pdi	pbr	pte	pwi	pdr	pto	sde	sdr	slo
314.0	110	cat's-tail	cutting	27	1	1	4	1	17	1	11	1	2	1	11	3	2000	4	4	1	5	1	3	1000	3	7			
315.0	110	cat's-tail	cutting	32	1	1	6	3	20	1	11	1	2	1	11	3	800	4	4	1	12	1	3	800	4	7			
4.0	110	celery	cutting	25	1	1	4	3	64	3	11	4	2	1	22					3	10	2	6	7000	3	2			
150.0	210	celery stalks	cutting	15	1	1	12	4	12	1	11	1	1	1	11														
18.0	110	chinese cabbage	cutting	25	1	1	6	3	31	1	11	1	1	1	11														
186.0	210	dry grass	cutting	30	1	1	6	3	47	1	12	6	1	1	22	5	50	1	3	3	7	1	3	500	3	1			
185.0	210	dry grass	cutting	30	1	1	6	3	42	1	12	6	1	1	22					3	7	1	3	300	3	1			
190.0	221	dry grass	cutting	60	1	1	6	3	42	1	11	1	1	1	22					2	7	1	3	1000	3	2			
42.0	110	dry past.grass	cutting	10	1	1	6	3	27	1	11	1	1	1	11						2	2	3	50	3	8			
102.0	110	dry reed	cutting	7	1	1	12	2	31	1	11	1	1	1	11					1	7	2	3	100	3	1			
41.0	110	dry reed	cutting	10	1	1	6	3	32	1	11	1	1	1	22	5	150	1	3	1	10	1	3	2000	1	1			
26.0	110	dry reed	cutting	22	1	1	4	2	50	1	11	6	1	1	22					1	7	1	3	4000	1	3			
288.0	110	dry reed	cutting	30	1	1	6	3	43	1	11	1	1	1	22	3	500	1	3	2	7	1	3	3000	3	1			
287.0	110	dry reed	cutting	30	1	1	6	3	45	1	11	1	1	1	22					1	7	1	3	5000	3	1			
280.0	110	dry reed	cutting	40	1	1	6	3	35	1	11	1	1	1	22	3	200	1	3	3	7	1	3	400	3	1			
326.0	850	flax	transv.	65	2	1	13	2	75	1	11	1	1	1	22	2	200	1	2	2	12	1	3	800	2	1			
192.0	110	fresh reed	cutting	10	1	1	6	3	32	1	11	1	1	1	11					1	10	2	3	5000	3	8			
7.0	110	fresh reed	cutting	22	1	1	6	3	37	1	11	1	1	1	22	5	200	1	3	1	10	1	3	1500	3	1			
189.0	110	fresh reed	splitting	30	1	1	6	3	40	1	11	8	1	1	22					2	10	1	3	5000	4	2			
183.0	110	fresh reed	cutting	60	1	1	6	3	38	1	12	1	1	1	22					1	10	1	3	7000	3	1			
95.0	110	green past.grass	cutting	6	1	1	12	3	30	1	11	1	1	1	11														
261.0	110	green plants	cutting	15	1	1	6	3	22	1	11	1	1	1	11														
180.0	210	green plants	cutting	30	1	1	6	3	38	1	12	1	1	1	11														
311.0	110	horse-tail	cutting	30	1	1	4	2	30	1	11	7	1	1	22					1	7	1	3	6000	3	1			
312.0	110	horse-tail	cutting	30	1	1	6	3	32	1	11	1	1	1	22					1	7	1	3	2000	3	1			
313.0	110	horse-tail	cutting	43	1	1	14	3	36	1	11	1	1	1	22					1	7	1	3	2000	3	1			
282.0	110	moor grass	cutting	25	1	5	6	3	40	1	11	6	1	1	11					1	6	1	3	30	1	1			
283.0	110	moor grass	cutting	30	1	1	12	3	37	1	11	4	1	1	11					1	6	1	3	30	1	1			
188.0	210	stinging nettle	cutting	10	1	1	6	3	36	1	11	1	1	1	11					1	6	3	6	100	1	8			
178.0	110	stinging nettle	cutting	35	1	1	6	3	41	1	11	1	1	1	12					1	10	1	3	4000	3	1			
2.0	110	turnip	cutting	20	1	1	4	3	40	1	11	6	1	1	22	3	300	1	2	3	10	1	3	6000	3	2			
275.0	110	turnip	cutting	25	2	1	6	3	30	1	11	4	1	1	22					2	10	1	3	5000	1	2			
1.0	210	turnip	cutting	40	1	1	4	3	32	1	11	1	1	1	11	3	300	1	3	3	10	2	3	5000	1	1			
3.0	210	turnip	cutting	80	1	1	4	2	41	1	11	1	1	1	22					3	10	1	3	5000	3	2			
310.0	110	water hemlock	cutting	18	1	1	6	3	37	1	11	6	1	1	11	1	50	1	3	5	7	3	4	50	1	8			

table 6 Cereal-reaping experiments (N = 21)

indiv	type	contact mat.	motion	durat.	csu	haf	rm	gs	ea	cs	ss	se	eff	exh	edr	rdi	rwi	rfo	rte	plo	pdi	pbr	pte	pwi	pdr	pto	sde	sdr	slo
116.0	110	barley	reaping	30	1	1	4	2	48	4	11	1	1	1	33	5	200	1	3	1	10	1	3	7000	3	2			
117.0	210	barley	reaping	30	1	1	4	2	37	1	11	1	1	1	12					1	10	2	3	1000	3	8			
119.0	110	barley	reaping	35	1	1	6	3	31	1	11	1	1	1	12					1	10	2	5	2000	3	8			
118.0	110	barley	reaping	60	1	1	6	4	45	1	11	1	1	1	22					1	10	1	3	5000	3	2			
121.0	220	barley	reaping	75	1	1	6	3	41	3	11	6	1	1	12					1	7	2	5	3000	3	8			
114.0	210	barley	reaping	90	1	1	4	3	35	1	11	6	1	1	22	3	300	1	3	1	10	1	3	8000	3	2			
122.0	110	barley	reaping	98	1	1	6	3	33	3	11	4	1	1	22					1	7	1	3	1000	3	2			
237.0	110	barley	reaping	140	1	6	6	3	33	1	11	1	1	1	33	5	150	1	3	2	10	1	3	9000	3	2			
238.0	110	barley	reaping	265	1	6	6	3	35	1	11	1	1	1	33	5	200	1	3	1	10	1	3	7000	3	2	5	1	3
234.0	890	barley	reaping	300	1	6	6	3	52	1	22	3	1	1	33					3	10	1	3	1000	3	2	7	1	3
239.0	890	barley	reaping	300	1	5	6	3	48	1	22	1	1	1	33					3	10	1	3	10000	3	2	7	1	3
316.0	110	barley-ears	picking	200	1	1	14	2	34	1	11	1	1	1	11					3	5	1	3	20	1	8			
318.1	110	barley/weeds	reaping	135	1	6	14	3	26	1	11	1	1	1	33					1	7	1	3	100	3	1			
318.2	110	barley/weeds	reaping	135	1	6	4	2	15	1	11	1	1	1	23					1	7	1	3	120	3	1			
318.4	110	barley/weeds	reaping	135	1	6	14	2	38	1	11	1	1	1	22					1	7	1	3	400	3	1			
318.3	110	barley/weeds	reaping	135	1	6	4	2	40	1	11	1	1	1	22					1	7	1	3	200	3	1			
319.0	110	barley/weeds	reaping	155	1	6	14	2	30	1	11	1	1	1	22	5	200	1	3	2	10	1	3	3000	3	1			
235.0	890	bread wheat	reaping	300	1	6	6	3	53	1	22	3	1	1	33					1	10	1	3	4000	3	2	7	1	3
120.0	110	emmer	reaping	30	1	1	6	3	40	1	11	1	1	1	22					3	10	1	3	3000	3	2	2	1	3
115.0	110	emmer	reaping	30	1	1	4	2	33	3	11	1	1	1	22					1	10	1	3	5000	3	2			
273.0	110	oats	reaping	60	1	6	14	2	41	1	11	1	1	1	22	5	100	1	3	1	7	1	3	2000	4	1			

table 7 Meat-cutting and butchering experiments (N = 12)

indiv	type	contact mat.	motion	durat.	csu	haf	rm	gs	ea	cs	ss	se	eff	exh	edr	rdi	rwi	rfo	rte	plo	pdi	pbr	pte	pwi	pdr	pto	sde	sdr	slo
158.0	110	fresh badger	butcher.	14	1	1	6	3	37	1	11	1	1	1	11					5	11	3	8	300	1	8			
54.0	210	fresh roedeer	butcher.	15	1	1	4	2	30	1	11	1	2	2	12														
53.0	210	fresh roedeer	butcher.	15	1	1	4	2	42	1	11	6	1	2	12	3	400	3	1	3	1	3	5	350	3	8			
151.0	110	fresh fox	butcher.	17	1	1	6	3	35	1	11	1	1	1	11														
157.0	110	fresh roedeer	butcher.	30	1	1	6	3	41	1	11	1	1	1	11	5	200	1	3	3	11	3	8	300	1	8			
152.0	210	fresh fox	butcher.	40	1	1	4	2	35	1	11	6	1	1	11	3	300	1	3	2	11	3	5	250	1	8			
224.0	110	fresh roedeer	butcher.	45	1	4	6	3	37	1	11	1	1	1	11	5	200	1	2	3	11	3	5	100	1	8			
58.0	221	fresh roedeer	butcher.	60	1	1	12	3	12	1	11	1	2	2	21					5	6	2	5	80	1	8			
162.0	210	fresh pork fat	cutting	8	1	1	4	2	31	1	11	6	1	1	11														
164.0	210	pork meat w.bone	cutting	10	1	1	4	2	32	1	11	6	1	1	11	3	500	1	2	4	5	1	3	75	3	8			
90.0	210	fresh lamb meat	cutting	14	1	1	4	2	35	1	11	6	1	1	11														
171.0	110	pork meat w.fat	cutting	45	1	1	6	3	35	1	11	6	1	1	22	5	100	1	3	1	7	2	5	150	3	8			

table 8 Fish-processing experiments (N = 27)

indiv	type	contact mat.	motion	durat.	csu	haf	rm	gs	ea	cs	ss	se	eff	exh	edr	rdi	rwi	rfo	rte	plo	pdi	pbr	pte	pwi	pdr	pto	sde	sdr	slo
179.0	110	sturgeon	cut. meat	10	1	1	6	3	35	1	11	1	1	1	11	2	25	2	3										
184.0	110	sturgeon	cut. skin	15	1	1	6	3	34	1	11	1	1	1	22	3	150	1	3	3	13	2	6	100	3	7	5	1	3
187.0	210	sturgeon	cut. meat	10	1	1	6	3	35	1	11	1	1	1	11	5	150	2	3	1	11	3	5	300	1	8			
191.0	210	sturgeon	cut. meat	20	1	1	6	3	30	1	11	1	1	1	11	5	850	1	3	1	13	2	6	900	3	8	1	1	1
176.0	210	whiting	decapit.	10	1	1	6	3	60	1	11	1	1	1	11	5	25	1	3	3	2	3	6	200	3	8			
195.0	210	rudd	decapit.	15	1	1	6	3	37	1	11	6	1	1	11	5	500	1	3	1	13	1	3	700	3	7			
8.0	110	whiting	filleting	35	1	1	4	2	35	1	13	1	1	1	22	3	100	4	2										
108.1	110	grey mullet	filleting	8	1	1	6	3	42	1	11	1	1	1	21	2	100	1	3										
155.0	110	rudd	filleting	13	1	1	6	3	52	1	11	6	1	1	21					2	5	1	6	170	1	7	5	1	2
23.0	110	bream	gutting	15	1	1	4	3	30	1	11	1	1	1	21	5	200	5	2	3	2	2	3	100	1	7	1	1	3
83.0	210	whiting	gutting	20	1	1	4	3	50	1	11	6	1	1	22	3	300	1	3	3	6	2	3	150	3	7			
108.2	110	grey mullet	gutting	6	1	1	6	3	38	1	11	1	1	1	21	2	120	1	2										

indiv	type	contact mat.	motion	durat.	csu	haf	rm	gs	ea	cs	ss	se	eff	exh	edr	rdi	rwi	rfo	rte	plo	pdi	pbr	pte	pwi	pdr	pto	sde	sdr	slo
196.0	210	rudd	gutting	35	1	1	6	3	36	1	11	1	1	1	11	3	400	1	2	2	13	2	3	200	3	7	5	1	2
297.0	110	rudd	gutting	35	1	1	6	3	30	1	11	1	1	1	12	5	400	1	2	1	2	2	6	150	1	7			
177.0	210	whiting	cut. tails	4	1	1	6	3	27	1	11	1	1	1	11	2	250	1	3	3	2	1	6	50	3	7	5	1	3
194.0	210	rudd	cut. tails	15	1	1	6	3	41	1	11	1	1	1	22	3	300	1	2	1	2	1	3	300	3	7			
6.0	110	roach	scaling	145	2	1	4	2	38	1	11	1	1	1	21					5	7	2	5	500	1	8			
22.0	110	bream	scaling	45	2	1	6	3	39	1	13	1	1	1	21	5	100	2	3	2	7	2	5	450	1	8			
80.0	221	grey mullet	scaling	8	2	1	6	3	78	1	12	2	1	1	11														
154.0	110	rudd	scaling	22	3	1	6	3	50	1	11	1	1	1	11	2	100	1	3	3	12	3	6	100	5	3			
193.0	210	rudd	scaling	40	3	1	6	3	32	1	11	1	1	1	12	3	300	1	2	4	12	3	6	1000	25	8	1	2	4
10.0	110	defrosted pike	scal + gut	10	1	1	6	3	32	1	11	1	1	1	11														
11.0	110	pike	scal + gut	7	1	1	4	2	48	1	11	1	1	1	11														
12.0	110	bream	scal + gut	15	1	1	4	2	28	1	11	1	1	1	21	3	150	5	2	3	12	3	6	450	5	8	1	1	4
86.0	210	grey mullet	scal + gut	15	1	1	4	3	50	1	21	1	1	1	21	2	100	4	4	1	2	2	3	150	3	7	1	1	4
107.0	110	pike	scal + gut	5	1	1	12	2	48	1	11	1	1	1	11														
175.0	210	whiting	scal + gut	15	1	1	6	3	37	1	11	4	1	1	11														

table 9 Projectile experiments (N = 9)

indiv	type	contact mat.	motion	durat.	csu	haf	rm	gs	ea	cs	ss	se	eff	exh	edr	rdi	rwi	rfo	rte	plo	pdi	pbr	pte	pwi	pdr	pto	sde	sdr	slo
135.0	510	roedeer	shooting	1	1	4	6	3	38	1	11	2	1	1	11	5	80	1	3	1	12	2	6		2	8			
144.0	510	roedeer	shooting	1	1	4	6	3	29	1	11	2	1	1	11	5	400	1	3	4	12	2	6		2	8			
142.0	510	roedeer	shooting	1	1	4	6	3	32	3	11	2	1	1	11	5	80	1	3	1	12	2	6		2	8			
149.0	510	roedeer	shooting	1	1	4	4	2	40	1	11	1	1	1	11														
127.0	510	roedeer	shooting	1	1	4	6	3	31	3	11	1	1	1	11	5	300	1	3	3	12	1	6		2	8			
130.0	510	roedeer	shooting	1	1	4	6	3	42	3	11	1	1	1	11	5	300	1	3										
147.0	510	roedeer	shooting	1	1	4	4	2	30	1	11	1	1	1	11														
128.0	510	roedeer/sand	shooting	1	1	4	6	3	29	1	11	1	1	1	11	3	200	5	2	3	12	1	6		2	8			
129.0	510	roedeer/sand	shooting	1	1	4	6	3	31	1	11	1	1	1	11	3	700	5	2	3	12	1	6		2	8			

table 10 Experiments with pottery (N = 8)

indiv	type	contact mat.	motion	durat.	csu	haf	rm	gs	ea	cs	ss	se	eff	exh	edr	rdi	rwi	rfo	rte	plo	pdi	pbr	pte	pwi	pdr	pto	sde	sdr	slo
167.0	750	cham.temp/baked	boring	7	1	1	6	3		1	12	8	2	1	11	3	400	1	2	2	5	2	6		2	3			
99.0	221	cham.temp/dry	scraping	18	2	1	12	3	85	1	12	2	1	1	33					1	7	1	6	2000	2	3			
210.0	221	cham.temp/dry	scraping	40	3	1	6	3	80	2	12	2	1	1	33					1	7	1	6	5000	2	3	4	2	4
34.0	110	quartz temp/dry	scraping	25	3	1	6	3	60	1	11	1	1	1	33					3	7	1	6	1000	2	3			
62.0	221	quartz temp/dry	scraping	40	3	1	12	3	96	1	12	2	1	1	33					1	10	1	6	10000	2	3	4	2	4
199.0	110	quartz temp/dry	scraping	30	3	1	6	3	40	1	11	1	1	1	33	5	300	1	3	1	7	1	6	3000	2	3	4	2	4
166.0	750	untemp/baked	boring	10	1	1	6	3		1	12	8	1	1	12					2	5	2	6		2	3			
37.0	110	untemp/dry	scraping	15	3	1	6	3	40	1	11	7	1	1	33					1	7	1	6	2000	2	3			

table 11 Experiments with shell, stone and tooth (N = 11)

indiv	type	contact mat.	motion	durat.	csu	haf	rm	gs	ea	cs	ss	se	eff	exh	edr	rdi	rwi	rfo	rte	plo	pdi	pbr	pte	pwi	pdr	pto	sde	sdr	slo
169.0	750	deer canine	boring	60	1	1	6	3		1	11	8	1	1	11	1	200	5	1	5	2	2	6	200	2	8			
78.0	110	limestone	longit.	2	1	1	4	2	32	1	11	1	1	1	11	3	500	1	3	1	2	2	3	400	3	1	1	1	1
113.0	110	ostrich shell	longit.	7	1	1	4	1	45	1	11	1	1	1	11	3	500	1	2										
291.0	750	shell	boring	60	1	1	6	3		1	11	8	1	1	11	1	500	5	2	5	5	2	6		2	8			
256.0	750	shell	boring	39	1	1	6	3		1	11	8	1	2	11	1	250	5	1										
307.0	750	shell	boring	5	1	1	6	3		1	11	8	1	2	22					3	5	3	8		2	8			
39.0	750	shell	boring	5	1	1	4	2		1	12	8	1	1	22					2	12	2	6	100	2	8			
174.0	750	shell	boring	3	1	1	6	3		1	11	8	1	2	11	1	300	5	1										

indiv	type	contact mat.	motion	durat.	csu	haf	rm	gs	ea	cs	ss	se	eff	exh	edr	rdi	rwi	rfo	rte	plo	pdi	pbr	pte	pwi	pdr	pto	sde	sdr	slo
40.1	110	shell	boring	6	1	1	4	2		1	11	8	3	2	11														
40.2	110	shell	longit.	2	1	1	4	2	40	1	11	1	1	1	11	3	400	1	3										
323.0	750	shell	boring	25	1	1	6	3		1	11	8	1	2	33					3	5	2	6		2	8			

table 12 Experiments with soil (N = 5)

indiv	type	contact mat.	motion	durat.	csu	haf	rm	gs	ea	cs	ss	se	eff	exh	edr	rdi	rwi	rfo	rte	plo	pdi	pbr	pte	pwi	pdr	pto	sde	sdr	slo
181.0	110	sods	cutting	30	1	1	6	3	42	1	11	6	2	1	33					1	10	1	6	12000	3	2	7	1	3
182.0	110	sods	cutting	35	1	5	6	3	55	1	11	6	2	1	33					2	10	1	6	20000	3	2	3	1	3
236.0	890	sods	cutting	60	1	1	6	3	50	1	22	3	1	1	33					3	10	1	6	24000	5	2	3	4	3
246.0	110	sods	cutting	60	1	1	6	3	60	1	11	6	2	1	33					2	10	1	6	30000	3	2	7	1	3
274.0	890	soil	hoeing	35	1	6	6	3	50	1	22	3	1	1	33					3	10	1	6	18000	5	2	3	4	3

Abbreviations used in appendix II

indiv	individual number
contact mat	contact-material
durat	duration of the experiment in minutes
csu	contact-surface(s)
haf	hafting (way of prehension)
rm	raw material
gs	grain-size of the flint
ea	edge angle
cs	form cross-section
ss	shape of the aspect surfaces
se	shape of the edge
eff	effectiveness
exh	degree of exhaustion after completion of the experiment
edr	edge-rounding
rdi	distribution 'use-retouch'
rwi	width 'use-retouch'
rfo	form 'use-retouch'
rte	termination 'use-retouch'
plo	polish location
pdi	polish distribution
pbr	polish brightness
pte	polish texture
pwi	polish width
pdr	polish directionality
pto	polish topography
sde	definition of striations
sdr	directionality of striations
slo	location of striations

For further information on these variables the reader is referred to 2.6.

Samenvatting

The wear and tear of flint: principles of functional analysis applied to Dutch Neolithic assemblages

De slijtage-slag van vuursteen: principes van gebruikssporen- analyse en de toepassing op Nederlandse neolithische vondstcomplexen

Gebruikssporen-analyse van vuursteen is een vrij jonge tak van wetenschap, welke in Nederland tot voor kort niet werd beoefend. Het hier gepresenteerde onderzoek kan beschouwd worden als een aanzet ten einde in deze leemte te voorzien. Aangezien het tot op heden gepubliceerde gebruikssporen-onderzoek een weinig systematisch beeld vertoont met betrekking tot gevolgde procedures en interpretaties van de resultaten, bevat de onderhavige studie een uitgebreide verhandeling aangaande methoden en technieken (hoofdstuk 2). Kort samengevat houdt gebruikssporen-analyse het volgende in. Ten gevolge van gebruik ontstaat slijtage op vuurstenen werktuigen. Deze slijtage kan vier vormen aannemen: gebruiksretouche, afronding van de werkrand, glans en krasjes. Binnen de gebruikssporen-analyse zijn twee onderzoeksrichtingen te onderscheiden: de macro-analyse die zich voornamelijk bezig houdt met gebruiksretouche, en de micro-analyse die zich concentreert op het bestuderen van glans en krasjes. Bij deze laatste onderzoeksrichting spelen de factoren gebruiksretouche en afronding evenzeer een rol, zij het van ondergeschikte betekenis. Een macro-analyse levert een indicatie van de relatieve hardheid van het bewerkte materiaal, terwijl met de micro-analyse een nadere precisering van de aard daarvan mogelijk is. De huidige studie is gebaseerd op de micro-analytische benaderingswijze; de analyses werden verricht met behulp van een opvallend-licht microscoop (vergrotingen: 50-560x).

Aanvankelijk heerste ten aanzien van gebruikssporen-onderzoek een groot optimisme: men dacht een objectieve manier te hebben gevonden om de funktie van werktuigen te kunnen identificeren. Helaas werden na korte tijd een groot aantal problemen duidelijk, die dit optimisme hebben doen temperen. Bij experimenteel onderzoek levert niet elk contact-materiaal een karakteristieke glans op: in veel gevallen is sprake van een aanzienlijke mate van overlap. Daarnaast resulteren bepaalde aktiviteiten, zoals het snijden van vlees, in niet- of nauwelijks waarneembare slijtage, zodat zij op grond van de gebruikssporen-analyse gewoonlijk niet te traceren zijn. Tenslotte werken secundaire oppervlakteveranderingen, zoals patinering of schuren, veel vaker versluierend dan aanvankelijk werd aangenomen. Het verdient dan ook aanbeveling niet langer te spreken van een identificatie, maar van een interpretatie van gebruikssporen.

Bij de analyse van de in deze studie besproken vindplaatsen worden drie niveau's van interpretatie onderscheiden: 1) de individuele werkrand ('potentially used area' ofwel PUA), 2) het werktuig als geheel, 3) het spectrum van aangetoonde aktiviteiten en taken. Indien gebruikssporen worden waargenomen op de werkrand (de 'potentially used area' wordt een 'actually used area' ofwel AUA), omvat de interpretatie daarvan drie stadia. Allereerst wordt op basis van de beschrijving van glans en krasjes een hypothese geformuleerd over de werkrichting en het gebruikte contact-materiaal. Deze hypothese wordt getoetst aan de aard van de gebruiksretouche. Tenslotte wordt nagegaan in hoeverre de veronderstelde funktie strookt met de morfologische kenmerken van de werkrand.

Op het tweede niveau van interpretatie, ten aanzien van het werktuig als geheel, wordt getracht de verschillende gebruikssporen met elkaar in verband te brengen. Bij eenmalig gebruik van een artefact komt de functie van werkrand en werktuig overeen. Bij meerdere soorten slijtage is niet altijd duidelijk welke betekenis moet worden toegekend aan de diverse combinaties van contactmateriaal versus richting van gebruik; deze kunnen het gevolg zijn van schachting, meermalig gebruik, of zelfs van één en dezelfde taak. In een enkel geval beschikken we over contextuele archaeologische informatie, waardoor het mogelijk is niet alleen de uitgevoerde aktiviteit te bepalen (bijv. 'het kerven van bot'), maar tevens, met een zekere mate van waarschijnlijkheid, de specifieke taak (bijv. 'het kerven van bot om de natuurlijke groeve van een metapodium te verdiepen ten behoeve van de fabricage van benen priemen' (zie hoofdstuk 6).

Het derde en laatste niveau van interpretatie betreft de waarde die kan worden toegekend aan het aangetoonde spectrum van aktiviteiten of taken dat in een nederzetting werd verricht. Een sterke vertegenwoordiging van bepaalde slijtagesporen hoeft niet per se te betekenen dat de betreffende aktiviteit van groot belang was voor de prehistorische gemeenschap. Het kan ook zijn dat secundaire oppervlakteveranderingen of bepaalde taphonomische processen de sporen van andere aktiviteiten onzichtbaar hebben gemaakt.

Gebruikssporen-analyse van vuurstenen werktuigen is niet mogelijk zonder een experimentele vergelijkings-collectie. In hoofdstuk 3 wordt dit aspect van het onderzoek behandeld. Onderscheid wordt gemaakt tussen algemene en probleemgerichte experimenten. Algemene experimenten omvatten aktiviteiten, waarbij een zo breed mogelijk scala van variabelen (ten aanzien van contact-materiaal, werkrichting, duur van het experiment en aard van het ruw materiaal) wordt betrokken. Probleemgerichte experimenten worden verricht wanneer informatie nodig is omtrent bepaalde archeologische slijtagesporen waarvoor geen equivalent aanwezig is in de bestaande vergelijkings-collectie. De archeologische context vermag in een dergelijk geval suggereren welke aktiviteiten mogelijkerwijs in aanmerking komen, terwijl ethnografische en ethnohistorische bronnen ideeën kunnen aandragen over de wijze van uitvoeren van dergelijke aktiviteiten.

In hetzelfde hoofdstuk komt de representativiteit van de resultaten van gebruikssporen-analyse aan de orde. Het is al geruime tijd bekend dat met name het bewerken van vlees, verse huid en bepaalde planten weinig slijtage veroorzaakt en derhalve in archeologisch verband moeilijk valt aan te tonen. Teneinde dit fenomeen quantitatief te onderbouwen, werden slijtage-attributen geteld.

Het volgende deel van de studie is gewijd aan secundaire oppervlakteveranderingen (hoofdstuk 4). Dit verschijnsel vormt een veel groter probleem dan aanvankelijk werd aangenomen, voor zowel de micro- als de macro-analyse. Er bestaat nog steeds weinig duidelijkheid over de vraag onder welke omstandigheden een assemblage goede perspectieven biedt voor gebruikssporen-onderzoek. Hoewel al veel experimenten ten aanzien van het effect van diverse chemische en mechanische factoren zijn uitgevoerd, is het nog steeds niet mogelijk om te voorspellen of een assemblage al dan niet 'vers' zal blijken te zijn. Besloten werd om reeds verricht micro-analytisch onderzoek (in West-Europa de meest gebruikte methode) te inventariseren en vervolgens na te gaan of bepaalde trends zichtbaar waren. Vroeg- en middenpaleolithische vondstcomplexen vertonen altijd secundaire oppervlakteveranderingen. Vanaf het laat-paleoliticum is dit niet langer systematisch het geval, hetgeen aangeeft dat de ouderdom van een vondstcomplex slechts tot op zekere hoogte een rol speelt. Opvallend is dat de laat-paleolithische vindplaatsen van het Parijse Bekken en de bandkeramische nederzettingen over het algemeen goed geconserveerd materiaal hebben opgeleverd. Het betreft in beide gevallen 'depositional contexts', waarbij het vuursteen al vrij snel buiten de invloedssfeer van externe factoren (menselijk of natuurlijk) geraakte, daar het respectievelijk door sedimenten werd afgedekt of in afvalkuilen was gedeponeerd.

In hoofdstukken 5 en 6 wordt de toepassing van de micro-analytische methode op Nederlandse vuursteen-assemblages uit het neolithicum beschreven. Hoofdstuk 5 behandelt de lineairbandkeramische vindplaats Beek-Molensteeg. In het opgegraven areaal, behorend tot een waarschijnlijk tamelijk grote nederzetting, werden een fragment van een huis en een afvalkuil ontdekt. Het vuursteen-onderzoek laat zien dat, wat betreft de gebruikte technologie en het vormenspectrum, Beek-Molensteeg overeenkomt met de andere LBK-vindplaatsen in Zuid-Limburg en omringende gebieden. Tot op heden werd aangenomen dat een bepaald werktuigtype, de zg. *quartier d'orange*, karakteristiek was voor de Belgische variant van de LBK, het Omalien. Nu echter is aangetoond dat dit type eveneens in Beek-Molensteeg en Elsloo voorkomt, zij het, typologisch gezien, in een iets minder uitgesproken vorm (figuur 48). Deze werktuigen vertonen onveranderlijk dezelfde sporen van een momenteel nog onbekende aktiviteit. Dit suggereert dat de betreffende aktiviteit een integraal onderdeel van het LBK complex vormde. De gebruikssporen-analyse maakt voorts duidelijk dat huidbewerking een veelvoorkomende bezigheid was. De glans die werd aangetroffen op de sikkelmesjes doet vermoeden dat met deze werktuigen graan werd geoogst in velden waarin tevens nogal wat onkruid voorkwam. Een aantal wat grotere werktuigen was gebruikt voor het vervaardigen en repareren van houten voorwerpen. Opvallend is de afwezigheid van beenbewerkingssporen. In het Beek-Molensteeg assemblage zijn de onderscheiden werktuigtypen vrij homogeen wat betreft hun functie: het overgrote deel van de eindschrabbers, bijvoorbeeld, diende voor huidbewerking. Opmerkelijk was dat slechts een gering aantal van de opgegraven artefacten sporen van gebruik vertoont; dit geldt in het bijzonder voor werktuigen vervaardigt uit Valkenburgvuursteen. Daarentegen is het exotische 'light grey Belgian' vuursteen herhaaldelijk en voor verschillende doeleinden aangewend.

In hoofdstuk 6 wordt de analyse van de nederzettingen Hekelingen III en Leidschendam (put 4) behandeld, beide toe te schrijven aan de Vlaardingen-groep. De voornaamste vraagstelling aangaande het materiaal van Hekelingen III betrof de aard van de bewoning, speciaal met betrekking tot het onderscheid tussen permanente en seizoensbewoning. Het Leidschendam onderzoek diende hoofdzakelijk een vergelijkend doel, omdat van deze vindplaats reeds min of meer vaststond dat het ging om een permanent bewoonde, agrarische nederzetting. De gebruikssporen-analyse leverde voor deze twee vindplaatsen een overeenkomstig spectrum van aktiviteiten op. In beide nederzettingen zijn benen voorwerpen vervaardigd, huiden geschraapt en heeft houtbewerking plaatsgevonden. Daarnaast werd in Hekelingen III plantaardig materiaal gespleten (waarschijnlijk voor vlechtwerk) en bestaan er aanwijzingen voor het bewerken van gewei, schelp en steen. Een van de weinige in het oog springende verschillen wordt gevormd door de aanwezigheid in Leidschendam van artefakten met sikkelglans, terwijl dit type werktuig in Hekelingen III niet voorkwam. Deze observatie lijkt een bevestiging te vormen voor de veronderstelling dat geen landbouw werd bedreven op de oeverwal waarop de laatste nederzetting gelegen was. Dit gegeven levert echter nog geen uitsluitsel omtrent de duur van de bewoning te Hekelingen III. Meer houvast in dit opzicht biedt de manier waarop in beide nederzettingen met het vuursteen werd omgegaan. In Leidschendam beschikte men slechts over plaatselijk voorkomend gerold vuursteen van geringe afmetingen. Dit vuursteen werd intensief en voor verschillende doeleinden gebruikt. Het materiaal van Hekelingen III daarentegen vertoonde een geheel ander beeld. Het hier aangetroffen vuursteen kende een zuidelijke herkomst, die mogelijk gezocht moet worden in zuid-west België. Desondanks werd het veel extensiever gebruikt dan het locale materiaal te Leidschendam. Geconcludeerd wordt dat Hekelingen III geen permanent bewoonde nederzetting vertegenwoordigt, doch veeleer een plaats die men in bepaalde seizoenen bezocht voor het exploiteren van specifieke voedselbronnen, met name steur en pelsdieren. Omdat men verwachtte telkens weer terug te keren, vormde het geen bezwaar niet opgebruikt vuursteen achter te laten. Deze interpretatie verklaart ook het relatief grote aantal vondsten, op zich ongewoon voor een tijdelijk bewoonde nederzetting. De onderkomens die men, getuige de aanwezigheid van paalgaten en haarden, op de oeverwal had opgetrokken, zouden als een 'artefact trap' hebben gefungeerd.

Opvallend is dat tot één culturele eenheid, de Vlaardingen-groep, twee in archeologisch opzicht zo verschillende vindplaatsen behoren. Niet alleen het karakter van Leidschendam en Hekelingen III is afwijkend, een permanent bewoonde agrarische nederzetting versus een louter in bepaalde seizoenen bewoonde locatie, maar ook hun externe contacten komen niet overeen. Leidschendam is, gezien vanuit een lithisch perspectief, nogal autarkisch; de aanwezigheid van kleine hoeveelheden morene-vuursteen wijst op (summiere) contacten in noordelijke richting, mogelijk met nederzettingen van Standvoetbeker-signatuur. Daarentegen is Hekelingen III duidelijk georiënteerd op meer zuidelijke streken.

In het laatste hoofdstuk tenslotte wordt ingegaan op de bijdragen die het gebruikssporen-onderzoek kan leveren ten aanzien van bepaalde archeologische vraagstellingen, zoals de relatie tussen morfologie en typologie enerzijds en functie anderzijds. Voorts kan de methode op intra-site niveau uitsluitsel geven omtrent het aktiviteiten-patroon van de bewoners van een nederzetting, benevens de aanwezigheid van aktiviteits-plaatsen. Op inter-site niveau biedt de discipline de mogelijkheid een eventuele functionele differentiatie van de vindplaatsen binnen een regio te onderzoeken. Hoewel de methode niet de panacee is waarvoor deze oorspronkelijk doorging, zou zij, speciaal door haar 'kruispunt'-functie, toch een integraal onderdeel moeten vormen van archeologisch onderzoek.

list of abbreviations

AUA	actually used area
BAI	Biologisch-Archaeologisch Instituut (Groningen)
BB	Bell Beaker culture
BP	before present
EDAX	energy dispersion analysis
IPL	Instituut voor Prehistorie Leiden
IPP	Instituut voor Prae- en Protohistorie (Amsterdam)
LBK	Linearbandkeramik
MLITS	microscopic linear impact traces
NWO	Netherlands Organization for Scientific Research
pdsm	post-depositional surface modifications
PFB	Protruding Foot Beaker culture
PUA	potentially used area
RMO	Rijksmuseum van Oudheden (Leiden)
SEM	scanning electron microscope
SOM	Seine-Oise-Marne culture
TRB	Funnel Beaker culture
VL	Vlaardingen-group

list of symbols

DH	= dry hide
HI	= hide
WO	= wood
PL	= soft plant
SI	= cereals
ME	= meat
BO	= bone
AN	= antler
ST	= soft stone
SH	= shell
'23'	= polish '23'
UN	= unknown
↑	= direction of motion
↕	= cutting/sawing
↷	= boring
↶	= hafting
·	= lightly worn
•	= medium worn
●	= heavily worn
?	= uncertain inference

acknowledgements

Many people, archaeologists and 'others', have been of help to me over the past years. Foremost I want to thank Leendert Louwe Kooijmans for his encouragement and his critical reading of the text. Discussions with Helle Juel Jensen (Aarhus) have been instrumental to me as well.

I owe much to other 'stone-minded' people in the Netherlands. I thank Peter Deckers (Nijkerk), Hennie Groenendijk (Groningen), Marjorie de Grooth (Maastricht), Wil Roebroeks (Leiden) and Leo Verhart (Leiden) for sharing their knowledge and data with me.

Meetings with my dispersed colleagues in the field of use-wear analysis have greatly contributed to my understanding. In particular, I would like to mention Patricia Anderson (Lyon), Paula Bienenfeld (Washington), Jean-Paul Caspar (Louvain-la-Neuve), Helle Juel Jensen (Aarhus), Lawrence Keeley (Chicago), Cristina Lemorini (Rome), Emily Moss (Boston), George Odell (Tulsa) and Hugues Plisson (Bordeaux). Closer to home I thank Take Albers, Richard Exaltus, Jeroen Flamman, Jos de Graaff and José Schreurs for their interest in this rather remote branch of archaeology. As research-assistent José Schreurs coded some of the material from Beek-Molensteeg.

Use-wear analysis of flint tools requires a wide range of skills and knowledge, much of which is beyond my field of competence. Many outside experts have therefore contributed in various ways. Foremost, I thank Jaap Beuker (Assen) for making most of the experimental tools; Bo Madsen (Lejre) and Harm Paulsen (Schleswig) also produced several implements. Henk Nijland (Arnhem) did many of the butchering experiments and provided an ample supply of dead animals. Jan Vlogtman (Rijswijk) was of great help during the SEM and EDAX analyses, Jet van Gijn (Leiden) did several pH determinations, while Sjoerd van der Zee (Wageningen) investigated adsorption-processes of residues in soils. A.C. Zeven, H. van Waningen (both Wageningen), W. Kunstman (Orvelte) and Bo Madsen (Lejre) were so kind to allow me to harvest crops on their experimental fields. Dick Brinkhuizen (Groningen) processed sturgeon with flint tools. Lastly, Hans van Eeuwen and his team (Leiden) were always willing to provide large quantities of wood for experimentation. I thank them all. I thank Josephine Say (Leiden) for correcting my (American-) English.

At the Institute of Prehistory in Leiden, Milco Wansleeben, Hans Kamermans and Harry Fokkens have been of great help in my efforts to deal with computers. The last-mentioned also took care of the computerization of the bibliography, for which I am most grateful. Corrie Bakels and Wim Kuijper coached me in matters concerning 'plants'. Jan Pauptit printed the photographs, while Henk de Lorm not only made all of the drawings (unless otherwise stated), but also took care of the lay-out. Marja Hospers and Marianne Wanders typed various versions of the text and kept my spirits up. The latter also did much of the editing.

Outside of archaeology, I want to thank my family and friends for regularly distracting me.

colofon

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photography: J. Pauptit and A.L. van Gijn
design, lay-out, cover and drawings: H.A. de Lorm
typesetting and printing: Orientaliste, Leuven