## Chapter 10

# STONE TOOL FUNCTION AT STAROSELE: COMBINING RESIDUE AND USE-WEAR EVIDENCE

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## INTRODUCTION

The recent history of paleoanthropological research into the Middle Paleolithic has been shaped by the debate over the origins of modern humans and the place of Neanderthals in human phylogeny (e.g., Kuhn 1995; Lieberman and Shea 1994; Marean 1998; Mellars 1996; Shea 1998; Stiner 1994), and Neanderthal behavior (Binford 1981, 1984, 1985; Cachel 1997; Chase 1986, 1989; Grayson and Delpech 1994; Klein 1995; Marean 1998; Marean and Kim 1998; Mellars 1996). In the context of this debate, investigations into the behavior of Middle Paleolithic hominids have usually focused on identifying differences in their behavior in contrast to anatomically modern humans (Binford 1981, 1984, 1985; Cachel 1997; Chase 1986, 1989; Grayson and Delpech 1994; Klein 1995; Marean 1998; Marean and Kim 1998; Mellars 1996). A common theme of many avenues of research is to explain the transition to "modern human behavior" (Marean 1998). Underlying this approach is an assumption that Middle Paleolithic hominids had behaviors that were not modern (or less than modern).

Faunal analysis and zooarcheology have contributed the vast majority of information for the reconstruction of Neanderthal subsistence. Neanderthals have been variously portrayed as obligate scavengers (Binford 1981, 1984, 1985) or opportunistic scavengers (Stiner 1991, 1994; Stiner and Kuhn 1992). Others counter and infer Neanderthals were hunters (Chase 1989; Berger and Trinkaus 1995; Geist 1981; Lieberman and Shea 1994; Shea 1988, 1989, 1993, 1998) who engaged in either close-quarter battles (Berger and Trinkaus 1995; Geist 1981) or assisted hunting using stone-tipped spears (e.g., Lieberman and Shea 1994; Shea 1988, 1989, 1993, 1998). With a few notable exceptions (Beyries 1987b, 1988; Anderson 1980; Anderson-Gerfaud 1981, 1986, 1990; Hardy 1994; Shea 1988, 1989, 1993, 1998), these reconstructions are bereft of essential knowledge of how stone tools actually were used, gripped, or attached to a handle.

This chapter offers a methodology of microscopic residue and use-wear analysis for investigating the function of and materials exploited by stone tools. By combining techniques, we have developed a more detailed picture of stone tool function. Use-wear analysis can identify use-action, hafting traces, relative hardness of the contact material, and sometimes, broad categories of contact material. Residue analysis can provide insight into use-action by the patterning of residues on a tool, while also specifically identifying a used material such as plant versus animal, hair, or starch. Furthermore, the independent observations of the two techniques cross-check one another. When they agree, the argument about tool function is stronger, significantly more detailed, and affords a more accurate evaluation of tool use. Although specific to the Middle Paleolithic of Starosele, our research has broader implications for understanding subsistence pursuits and other behaviors of Neanderthals.

## SAMPLE

Thirty-one artifacts ranging in age from approximately 40,000-80,000 BP from the 1995 excavation of Starosele were independently assessed (Table 10-1). The majority (20 or 64.5%) are from Level 3. Two (6.45%) are from Level 1. Levels 2 and 4 account, respectively, for four (12.9%) and five (16.12%). Following Marks and Monigal's classification (Marks and Monigal 1998), there are 19 scrapers, five points (one from Level 2 is bifacial), one denticulate, and two each for retouched pieces, cores, and flakes; the breakdown by level is provided in Table 10-1.

TABLE 10-1
Starosele, Formal Tool Classes by Level for Residue and Use-Wear Sample

| | *Level 1* | *Level 2* | *Level 3* | *Level 4* | *Total* |
|---|---|---|---|---|---|
| Scrapers | 1 | 3 | 11 | 4 | 19 |
| Points | 1 | 1 | 2 | 1 | 5 |
| Denticulates | – | – | 1 | – | 1 |
| Retouched Pieces | – | – | 2 | – | 2 |
| Cores | – | – | 2 | – | 2 |
| Flakes | – | – | 2 | – | 2 |
| Total | 2 | 4 | 20 | 5 | 31 |

## METHODS

The use-wear and residue methods used by the authors are detailed in the preceding chapters, along with their independent results. At the time of excavation, the artifacts destined for specialized analyses were placed unwashed into individual plastic bags and were sent for residue analysis. Hardy performed light reflected microscopy at magnifications ranging from 100-500x to identify use-related residues and occasionally removed residues for further examination using scanning electron microscopy. Once the residue analysis was complete, the artifacts were forwarded to Kay, who cleaned then analyzed them using a differential-interference binocular microscope with polarized light Nomarski optics at magnification ranges of 100 to 400 diameters. Hardy and Kay were neither aware of the other's methodology, nor did they discuss any of the results until both sets of analyses were finished. Use-wear and residue observations were recorded on plan drawings (Hardy) or photographs (Kay) of the artifacts. This method of recording allowed direct comparisons of the relative positions of functional evidence (e.g., fig. 10-1) and was used to arrive at a final interpretation of tool function. For recognition of prehension or of hafting, the use-wear evidence took priority.

## RESULTS

The separate results of use-wear and residue analyses for the 31 artifacts considered here are reported in Chapters 8 and 9. However, comparing the use-wear and residue evidence for each tool provides a more complete picture of tool use. A large percentage (80.6%) of the artifacts had both types of functional evidence and the distribution of this evidence was compared to ascertain how much the two studies agreed. Tools compared this way fell into one of four categories:

complete agreement—both types of traces had the same overall distribution (other than for hard contact materials) or no functional evidence was found at all (26);

consistent—predictably, only use-wear traces indicative of hard material contact were present along a tool edge (1);

new insight—both kinds of traces were present but their distributions only partly overlapped (2); and,

not applicable—only use-wear evidence was observed (2).

Twenty-six of the thirty-one artifacts (83.9%) were in complete agreement on the trace distribution data. Not all artifacts showed evidence of use. Three Level 3 artifacts (STR95-7, 9, 12; Table 10-2) had neither residues nor use-wear. The remainder had consistent residue and use-wear evidence and were either hand-held (8/31, or 25.8%) or hafted (15/31, or 43.4%). For these tools, the used edge(s) was clearly identified by both residues and use-wear.

Classed as consistent with predictions was a single hafted burin from Level 3 (STR95-22; Table 10-2) used on a medium hard contact material. The tool lacked residues for both the haft element and the tool edge.

Two other artifacts from Level 3 were classed as not applicable because they had no residues. Both were hand-held core tools according to the use-wear evidence. The unifacial discoidal core (STR95-4, Table 10-2) was used on medium hard materials as a scraper plane on its opposing ends; the other, an orthogonal core (STR95-8, Table 10-2), was a cut/scrape tool used on soft to medium hard materials.

The residue and use-wear evidence partly overlapped for the remaining two tools (STR95-3, 26; Table 10-2). For one (STR95-3) the use-wear was classed potentially as pseudo-wear, but it was in exactly the same location with raphides and plant tissue. On the surface opposite this portion of the tool, there were Falconiforme feather barbules, but no use-wear. We both regarded our independent results as inconclusive for this artifact. However, when its residues are compared to the use-wear evidence, a more plausible explanation is apparent. It appears likely this tool was hafted and was used to cut or scrape (i.e., to butcher or process) a raptor. For the other artifact (STR95-26, Chapter 9, fig. 9-5), a clear tool edge was identified by use-wear. At one end of the tool edge and continuing across the ventral surface was a black resin. It is possible, perhaps likely, the resin indicates a hafting mastic. Thus, for these two tools, the combined results afforded new insights that would not have been apparent were our results not compared.

In summary, the comparison of residues and use-wear produced completely comparable results in over 83% of the cases. This percentage is a conservative measure, as the results for two other tools (6.45%) provided complementary information and truly new insights, and a third tool (3.22%) had use-wear which predicted the actual lack of residues. The most conservative estimate of our comparative "success" rate is thus more than 83%; the most optimistic view would place our success rate at over 92% when considering the complementary information that results by combining both approaches.

It is also clear from this comparison that neither technique by itself is fully adequate to address functional information pertaining to all artifacts in the sample. The use-wear analysis fairs somewhat better than that for residues, as wear traces occur on three tools (STR95-4, 8, 22; Table 10-2) for which there are no corresponding residues. For two other specimens (STR95-3, 26; Table 10-2) the use-wear analysis by itself would have seriously overlooked functional evidence afforded only by residues. Given these results, the most satisfactory way to address stone tool function is, not surprisingly, to do both types of study and then compare the information.

TABLE 10-2

Starosele, Residue and Use-Wear Results for Individual Artifacts

| *Specimen* | *Level* | *Tool Class* | *Hafting Evidence (Use Wear and Residue* | *Other Residue* | *Other Use-Wear* | *Interpretation* |
|---|---|---|---|---|---|---|
| STR95-1 | 1 | scraper (point) | prox. ½-striae, starch grains, raphides | none | impact striae | hafted projectile pt., soft to med. hard |
| STR95-2 | 2 | scraper | prox. ½-striae, microplating | starch grains in lines moving back from edge | striae/microplating along edges | hafted scraper, soft to med. hard starchy plant |
| STR95-3 | 2 | scraper | none | plant tissue, raphides, feather barbules (Falconiforme) | none | inconclusive |
| STR95-4 | 3 | discoidal core | none | none | microplating | hand-held, cutting/scraping med. hard |
| STR95-5 | 3 | flake | none | plant tissue, starch grains | edge damage, microplating, striae | hand-held burin, gouging soft to med. hard plant, cutting on opposite edge |
| STR95-6 | 3 | semi-leaf point | prox. ⅓- striae, starch grains, plant tissue | feather barbules (Anseriformes, Falconiformes) | impact striae, striae parallel and oblique to edge | hafted multi-use projectile pt./butchery tool |
| STR95-7 | 3 | flake | none | none | none | unknown |
| STR95-8 | 3 | orthogonal core | none | none | striae parallel and oblique to edge, invasive cutting along opposite edge | unhafted cutting/scraping soft to med. hard |
| STR95-9 | 3 | scraper | none | none | none | unknown |
| STR95-10 | 4 | scraper | none | hair fragments | striae parallel to edge in same spot as hair | unhafted, light cutting/butchery |
| STR95-11 | 3 | scraper | striae, microplating, recrystallization, desiccation cracks | plant tissue | striae parallel to longitudinal axis, edge rounding | hafted scraper, med. hard plant |
| STR95-12 | 3 | scraper | none | none | none | unknown |
| STR95-13 | 3 | scraper | prox. ½- striae, microplating | hair fragment, insect exoskeleton fragment | impact striae, edge rounding along one side near tip | hafted projectile point/knife, soft to med. hard |
| STR95-14 | 3 | scraper/point | prox. ⅓- striae, microplating, starch grains, plant fibers | none | impact striae | hafted point, soft to med. hard |
| STR95-15 | 3 | scraper | prox. ¼- striae, microplating, starch grains, plant tissue | 2 types of plant tissue on opposite edges | striae parallel to one edge, striae perpendicular and oblique to opposite edge, striae parallel to distal edge with rounding | hafted knife/scraper, cutting/scraping plant, gouging hard material with distal end |

| | | | | | | |
|---|---|---|---|---|---|---|
| STR95-16 | 3 | scraper | none | plant tissue on opposite ends | one edge-complex invasive striae, microplating opposite edge-striae parallel to longitudinal axis crosscut by invasive transverse striae | hand-held invasive cutting tool, soft to med. hard plant |
| STR95-17 | 3 | scraper | none | plant tissue on one edge | microplating, striae parallel to one edge, edge rounding and striae on opposite edge | unhafted, cutting/scraping, soft to med. hard, plant on one edge |
| STR95-18 | 3 | scraper | prox. ¾- striae, microplating, plant tissue, starch grains | none | striae parallel to longitudinal axis on distal edge, narrow contact zone | hafted burin, gouging med. to hard |
| STR95-19 | 3 | scraper | none | plant tissue along edge with wear | striae, multiple orientations | unhafted, cutting/scraping med. hard plant |
| STR95-20 | 3 | denticulate | none | plant tissue with starch grains along edge with wear | microplating, edge damage, narrow contact zone | unhafted, cutting/scraping hard plant |
| STR95-21 | 4 | scraper | none | starch grains along one edge | striae parallel, transverse and oblique to edge, invasive | hand-held cutting/scraping soft to hard plant |
| STR95-22 | 3 | scraper | none | none | striae transverse and parallel to longitudinal axis, abrasives | hafted?, burin, med. hard |
| STR95-23 | 3 | denticulate | prox. ½- striae, microplating, starch grains | none | distal edge, microplating, striae parallel and perpendicular to longitudinal axis | hafted, gouging soft to med. soft |
| STR95-24 | 3 | point | prox. ⅓- striae, microplating, plant tissue | starch grains along one edge near tip | impact striae, microplating, edge faceting | hafted point, soft to med. hard, starch grains present on one edge |
| STR95-25 | 4 | scraper | prox. ⅓- striae, starch grains | none | microplating, sequenced striae perpendicular to edge | hafted burin, soft to hard |
| STR95-26 | 4 | point | prox. ½- black residue (mastic?) | none | striae oblique and transverse, microplating along one edge | hafted?, cutting/scraping med. hard |
| STR95-27 | 3 | retouched blade | prox. ½- plant tissue, black residue | none | impact striae, cutting striae, edge damage | hafted point, cutting/scraping soft to med. soft |
| STR95-28 | 2 | scraper | none | plant tissue along edge with wear | striae parallel and oblique to edge, microplating | hand-held, cutting/scraping med. hard plant |
| STR95-29 | 4 | scraper | prox. ⅓- striae transverse and parallel longitudinal axis | scattered plant tissue and raphides | striae parallel to distal edge | hafted burin, soft to med. hard |
| STR95-30 | 1 | scraper | prox. ½- striae, microplating, plant tissue and raphides | none | microplating, edge rounding | hafted scraper, soft |
| STR95-31 | 2 | bifacial point | prox. ½- striae parallel and transverse to longitudinal axis, raphides | none | distal 1/3- striae transverse to longitudinal axis, microplating | hafted point, soft to med. hard |

## RESULTS BY FORMAL CLASSIFICATION

There is a detailed formal typology for the Starosele assemblages (Marks and Monigal 1998), but because this study is concerned with tool function and because sample sizes are relatively small, artifacts were grouped into broad tool classes, including scrapers, points, denticulates, retouched blades, flakes and cores (Table 10-1). For the discussion of results by tool type, we have considered Levels 1-4 as a single sample. Differences based on stratigraphic level will be discussed below.

### Scrapers

The sample contained 19 scrapers which were used in a variety of ways ranging from hafted points, to processing plant and animal, to unknown use or were unused. Ten out of 19 (52.63%) have hafting evidence in the form of striae confined to one portion of the tool (Chapter 8). Six of the 10 (60%) have plant tissue, starch grains, or raphides confined to the same area as the use-wear striae suggesting the use of starchy plants as part of a binding or mastic. Two of the hafted pieces are typologically categorized as scrapers but have edges that converge to a point. Impact striae found close to the tips of these artifacts suggest that they were used as hafted points or projectiles. The remaining hafted scrapers were used on materials ranging from soft to hard. Residues suggest that the majority of these materials were plant, but animal residues are present as well (see Chapter 9 for discussion of possible under-representation of animal residues). Hand-held scrapers (9/19, 47.3%) show a similar pattern with materials ranging from soft to hard. Results were inconclusive on 3/19 (15.9%) scrapers. Two of these have no identifiable use-wear or residue traces. The third has both plant tissue and Falconiforme feather barbule fragments (Brom 1986; Chapter 9), but they are insufficiently patterned to suggest a specific use.

In several cases, scrapers appear to have served multiple functions. STR95-15, for example, appears to have been used differently on each of its edges (fig. 10-1). The proximal ¼ of the tool shows striae and microplating consistent with hafting wear (see Kay 1996, 1997, Chapter 8). Starch grains and plant tissue are distributed over approximately the same area and may have been part of a binding or mastic. This hafted tool has three potential working edges. Figure 10-1a-b shows striations oriented roughly perpendicular to one edge and plant tissue located in the same location on the dorsal surface. The wear patterning suggests the edge was used for scraping plant material (Chapter 8; Hardy and Garufi 1998). The opposite edge (fig. 10-1c-d) has striations running parallel to it and a different type of plant tissue in the same location on the dorsal surface. The plant tissue has long rectangular cells, which may come from woody plants, but diagnostic anatomy is lacking to confirm this identification. This edge is interpreted as having been used to slice or cut hard plant material. Finally, the transverse edge at the far end also has use-wear indicating that it was used to gouge a relatively hard material. No residues were found on this edge. Thus, residue and use-wear analyses both support evidence of hafting and use of two edges in different ways. In addition, use-wear also indicates that the distal edge was used.

Other scrapers show a similar convergence of evidence. Artifact STR95-10, for example, is a large double straight sidescraper approximately 10 cm in length. Despite its large size and extensive retouch, it shows little evidence of use. The only use-wear traces are an isolated patch of striations that run roughly parallel to the tool edge. The only residue evidence for function are several hair fragments trapped under the adhering matrix on both the dorsal and ventral surfaces in almost exactly the same location as the use-wear (see Chapter 9, fig. 9-2). The hair fragments alone, despite the fact that they occur on the tool edge, are insufficient evidence of tool function. However, the recognition of use-wear in the

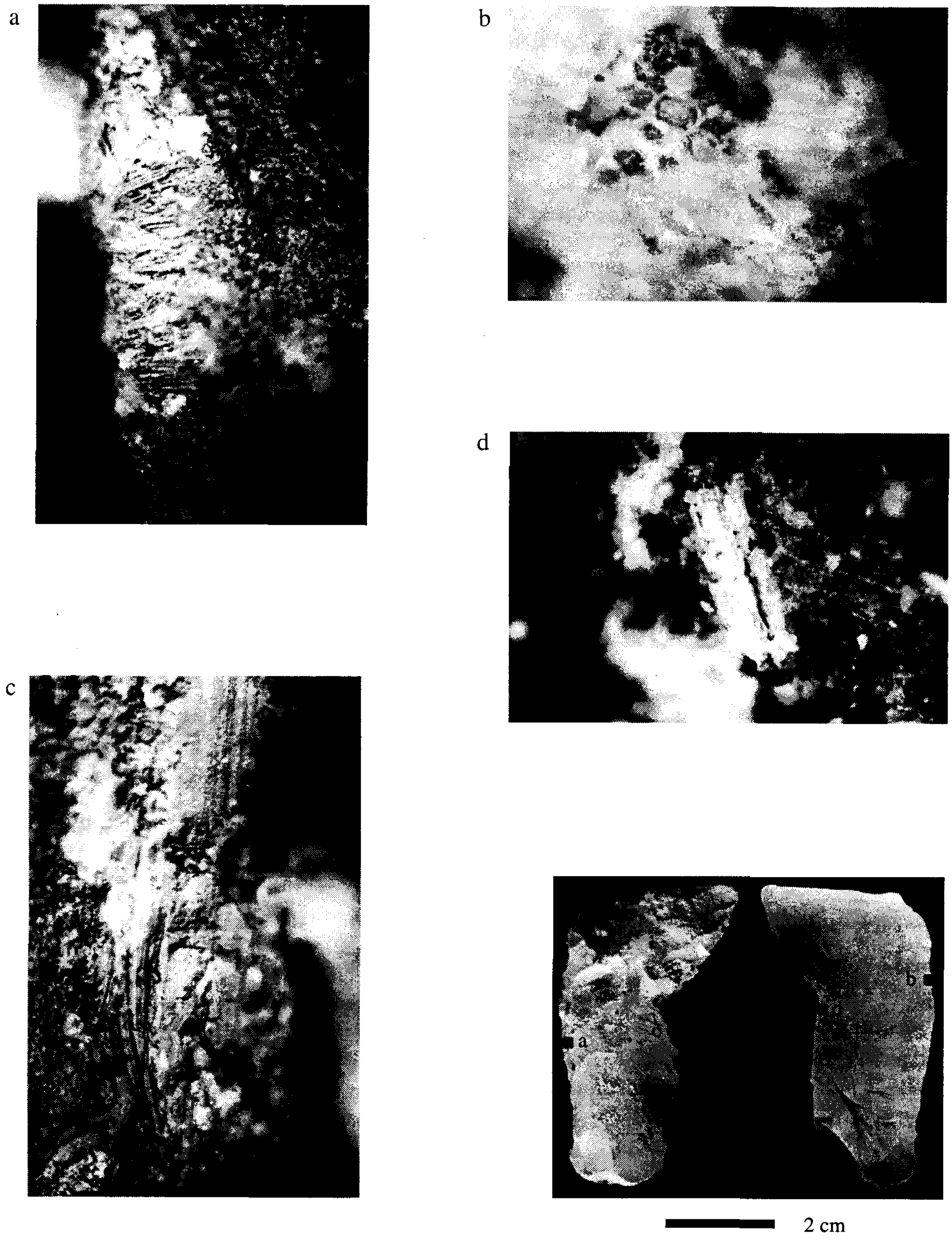


Fig. 10-1—Starosele Level 3 (STR95-15), *a*–striae perpendicular to tool edge (original magnification 400x); *b*–plant tissue in association with striae (original magnification 500x); *c*–striae parallel to tool edge (original magnification 400x); *d*–rectangular plant cells associated with striae (original magnification 100x).

same location suggests that both the hair fragments and the striae are use-related. The nature and orientation of the striae suggest that the tool was used for light cutting of a relatively soft material. The hair residues suggest that this soft material was animal hide or muscle tissue and that the tool was used for light-duty butchery. The hair fragments preserve scale patterns and are potentially identifiable to species (Brunner and Koman 1974). Work is under way to specifically identify the hair fragments (see Chapter 9 for a discussion of the problems involved with identifying isolated hair fragments).

Our results also indicate that typology and presumed working edges are not necessarily accurate predictors of function. STR95-18 is typologically classified was an atypical endscraper on a retouched blade. The retouched edges, almost denticulate in nature, converge at one end. The other end is a snap with subsequent light retouch. The retouched, denticulate-like edges appear to be the most likely working edges. However, approximately 3/4 of the tool surface, all except the snapped edge, exhibits hafting striae and plant tissue fragments with starch grains (fig. 10-2a, b, c). Thus, the most likely working edges appear to have been covered by a haft. The snapped edge, by contrast, shows use-wear consistent with working a relatively hard material (fig. 10-2d).

Thus, scrapers show a variety of different uses, and were both hafted and unhafted. They do not form a coherent functional category, but seem rather to reflect a variety of uses with ad hoc or multiple use of some artifacts. The resources exploited are diverse: ranging from soft to hard material, from starchy plant to hard plant (possibly wood), and including mammalian and avian tissues.

## Denticulates

One artifact is classified as a denticulate. This artifact has hafting striae on its proximal half and starch grains distributed across the same area. Use-wear indicates that the distal edge was used on a soft to medium soft material.

## Points

Five artifacts are typologically classified as points. All of these have evidence of hafting and may have been used as thrusting or projectile tips. STR95-6, however, served multiple purposes. The proximal third of the artifact has hafting striae and starch grains (fig. 10-3a). The tip has impact striae supporting the interpretation of the use of this tool as a projectile or thrusting point (fig. 10-3b). Furthermore, this artifact has striae running both parallel and oblique to the edge near the tip, suggesting a complex cutting motion on a soft to medium hard material (fig. 10-3c). The area with the cutting striations also has two types of feather barbules identified as coming from Order Anseriformes (geese, ducks, swans) and Falconiformes (raptors) (fig. 10-3d). This tool shows evidence of use as a hafted thrusting or projectile point followed by cutting of a soft to medium hard material, possibly avian feathers or muscle tissue. Once again, the use-wear and residue evidence are complementary and allow for a refinement of the functional interpretation.

## Cores

Two cores were analyzed, one discoidal and one orthogonal. Both have use-wear suggesting use on soft to medium hard material. There are no residues present and no evidence for hafting.

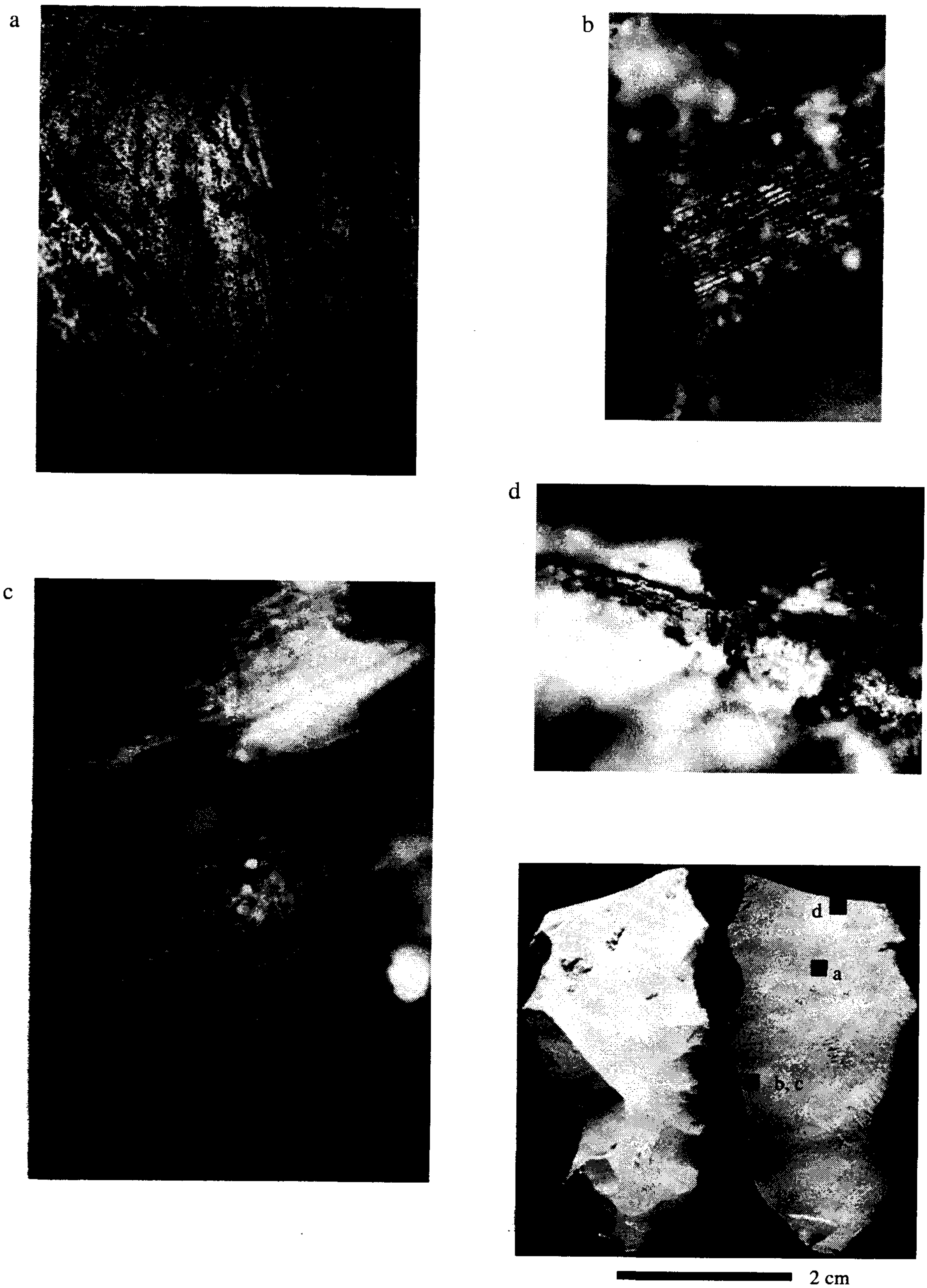


Fig. 10-2—Starosele Level 3 (STR95-18), *a*–hafting striae (original magnification 200x); *b*–plant tissue (original magnification 100x); *c*–higher magnification of (b) showing starch grain within plant tissue (original magnification 500x); *d*–wear along snapped edge (original magnification 400x).

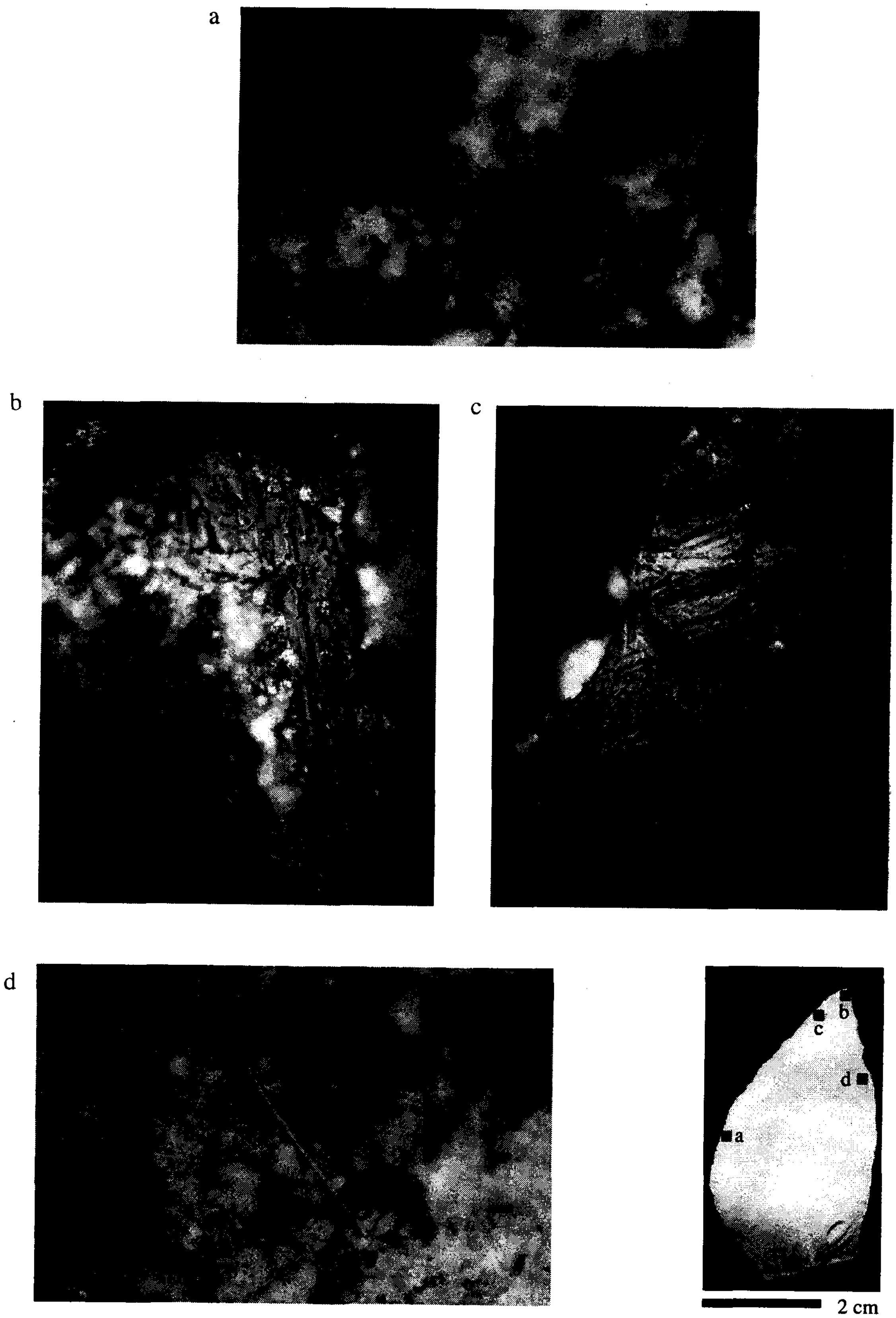


Fig. 10-3—Starosele Level 3 (STR95-6), *a*–starch grains associated with haft (original magnification 500x), *b*–impact striae (original magnification 400x), *c*–complex series of striae from cutting (original magnification 400x), *d*–feather barbule fragment (original magnification 100x).

### Flakes

Of the two unmodified flakes examined, one appears to be unused. The other has edge damage, microplating, and striae associated with plant tissue and starch grains. This edge may have been used as a burin to gouge soft to medium hard plant.

### Retouched pieces

Two artifacts are categorized as retouched pieces. The proximal half of one artifact has plant tissue and an amorphous black substance that may be a resin used in hafting. The opposite end has impact and cutting striae suggesting that it was used as both a projectile or thrusting point as well as a cutting tool (Chapter 9, fig. 9-6). The other retouched piece was unhafted and used to cut or scrape hard plant material, as evidenced by plant tissues and use-wear.

### Results by Level

The sample sizes for each level, with the exception of Level 3 (N=20), are very small (Level 1, N=2; Level 2, N=4; Level 4, N=5), making it difficult to examine tool use trends through time. Nevertheless, some observations are possible based on the presence of certain types of evidence. Hafting, for example, is found in all four levels. All four levels also have evidence for plant exploitation, either for use in hafting or being processed by the working edge of the tool. Levels 2 and 3 have feather barbule fragments suggesting use of avian resources. Hair fragments indicative of mammal exploitation are only found in Level 4, but this is possibly due to differential preservation or recognition (Chapter 9). Projectile or thrusting points are present in all but Level 4 in this sample and Level 4 has evidence for projectile or thrusting points from Kay's use-wear only sample (Chapter 8). More detailed observations of changing tool use through time are described in Kay's use-wear chapter.

## DISCUSSION

Contrary to the perception that Middle Paleolithic people focused mainly on meat exploitation, plant residues are common on the tools from Starosele. Carnivory in the Middle Paleolithic is emphasized in the literature for several reasons. First, modern high-latitude foragers are most often used as an ethnographic model for Neanderthal behavior (Cachel 1997). High-latitude foragers are generally heavily reliant on meat because they are inhabit extreme cold climates where plant productivity is limited. Neanderthals would presumably have also been limited in their access to plant resources because they were living in glacial conditions (Cachel 1997). However, plant foods can be found in extreme cold environments on a seasonal or periodic basis (Roebroeks et al. 1992; Cachel 1997). Furthermore, the climates of the late Pleistocene varied extensively and would have witnessed a variety of habitats (Roebroeks et al. 1992). The Neanderthals themselves occupied a range of latitudes from northern Europe to modern-day Israel (Mellars 1996).

The assumption that plant resources were unavailable stems partially from differential preservation of macroscopic plant remains and animal bones. Particularly for early time periods, the accepted wisdom is that plant remains do not survive except under unusual conditions of preservation (Mason et al. 1994). Because of this general belief, plant remains may not be targeted for fine-scale recovery techniques. However, as more researchers look for plant remains, more are being discovered (Mason et al. 1994; Hardy 1994; Hardy and Garufi 1998). The application of microscopic residue analysis of stone tools to Middle

Paleolithic contexts has potential for increasing recovery rates of plant remains and providing another line of evidence for Neanderthal subsistence reconstruction.

At least some of the plant remains on Starosele tools are related to binding or mastic for hafting. Evidence for hafting of tools in the Middle Paleolithic has been found at a number of sites. Shea (1988, 1989, 1993, 1998) has found evidence of hafting in the form of impact fractures on the tips of tools at Kebara, Tabun, Qafzeh, Hayonim, and Tor Faraj. Anderson-Gerfaud (1981, 1986, 1990) and Beyries (1987b, 1988) have reported use-wear evidence of hafting at numerous Mousterian sites in France. Boëda et al. (1996) have recently identified traces of bitumen used as a mastic at Umm el Tlel, Syria. The hafted tools at Starosele include scrapers, denticulates, and points. Scrapers and denticulates have been reported as hafted by both Anderson-Gerfaud (1981, 1986, 1990) and Beyries (1987b, 1988) in the Middle Paleolithic of Europe, while Shea reports hafting of pointed pieces (Levallois flakes and Mousterian points) in the Levantine Mousterian (1988, 1989, 1993, 1998). At Starosele, both of these types of hafting are seen. Scrapers and denticulates are hafted and used for a variety of purposes with the haft presumably providing increased leverage during use (Brace 1995). Pointed pieces appear to have been hafted at Starosele as well. Shea interprets hafted points from the Levant as spear points, either thrusting or projectile. Pointed pieces from Starosele appear to have been used as projectile or thrusting points as well. The presence of thrusting or projectile technology provides several advantages in acquisition of meat. The hominid is removed from some of the danger associated with the capture of large or dangerous prey because of the increased range of the weapon (Shea 1998; Brace 1995). The wounds caused by hafted stone points may also be more severe and thus increase hunting success (Shea 1998). The presence of this type of technology argues against the close-quarters battle technique of hunting suggested by some (Geist 1981; Berger and Trinkaus 1995). In addition to being used as projectile or thrusting armatures, the points from Starosele also have evidence for use as cutting tools.

Boëda et al.'s (1996) report of bitumen on Middle Paleolithic tools suggests that hafting was at least sometimes accomplished with the aid of a mastic. Hafting evidence at Starosele provides further support of the use of mastics or bindings as part of a haft. The starch grains and plant material located in areas of use-wear on the proximal portions of a number of tools are most likely explained as traces of binding or mastic. These two findings suggest that hafting may have involved not only preparation of a handle for the haft, but the collections and preparation of binding and mastic as well. These factors may be important in the reconstruction of subsistence related activities.

Functional analyses of stone tools from Starosele also indicate that a wide range of resources was being exploited, including mammals, birds, and plants (wood, starchy storage organs). Faunal remains at Middle Paleolithic sites are typically dominated by species of large mammals. Small mammals and birds are usually less well-represented, either because they were not as heavily exploited or because their remains do not preserve as well. The recognition of feather fragments on stone tool surfaces provides another method of recovery of avian remains. While it is not possible to say whether the Starosele hominids were capturing birds for food or for some other reason, the recovery of feather fragments from stone tools may serve to encourage researchers to consider the possible significance of avian resources in future reconstructions of subsistence, as some have done in the past (e.g., Eastham 1989).

## CONCLUSIONS

While certain finds, such as wooden spears at Lehringen (Movius 1950) and Schöningen (Thieme 1997), clearly indicate that plants were at least occasionally utilized in the Middle

Paleolithic or earlier, plants as an exploitable resource are generally ignored. Authors will often make little more than a passing remark that plants may have been important in Middle Paleolithic subsistence (e.g., Shea 1998; Cachel 1997). This is partially due to the fact that little evidence for plant exploitation exists. The current study provides both a method for recognition of plant exploitation and evidence that plants were being use as Starosele. While much work remains to be done on specific identification of these plant residues (Chapter 9), the evidence thus far suggests the exploitation of both woody plants and starchy storage organs. Although the starchy storage organs appear to have provided material for hafting, they were probably also utilized for food (Mason et al. 1994).

Functional analyses at Starosele, therefore, have provided evidence for behavior and resource exploitation not usually associated with the Middle Paleolithic. Furthermore, the study has implications for interpreting stone tool typologies as they relate to function. Traditional typological categories often have names that imply function (e.g., hand-axe, scraper). Artifact categories are usually divided into a large number of sub-categories (e.g., convex sidescraper, concave sidescraper, double convergent convex sidescraper) resulting in as many as 63 different tool types for the Mousterian, at least in Western Europe (Bordes 1961). It is unlikely, however, that each of these tool types had a discrete function. Functional analysis of stone tools at Starosele suggests multiple use of tools and no clear correlation between typological category and tool function. While we do not wish to suggest that typological categories serve no purpose, the current evidence suggests that they should not be equated with particular functions, at least at Starosele.

Finally, the results obtained from this study would not have been possible without performing both microscopic use-wear and residue analysis. Each of the techniques alone, as presented in the preceding chapters, provides valuable information about stone tool function. However, by combining the two techniques, the results can be cross-checked and greater confidence can be placed on the functional interpretations. Furthermore, the two lines of evidence both augment and complement each other, allowing for more accurate and detailed functional reconstruction. This combination of functional analyses can provide a valuable new line of evidence for reconstruction of Neanderthal subsistence and behavior.

The analysis of stone tools at Starosele allowed the testing of a new combination of techniques. The results exceeded all expectations. A combination of use-wear and residue analysis allowed detailed functional interpretations. The behaviors reflected in these results included hafting of a variety of tool types as well as the exploitation of a wide range of resources, both plant and animal. Our results suggest that the debate over Neanderthal behavior and its difference or similarity with that of anatomically modern humans can greatly benefit from the functional analysis of stone tools.