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Revisiting Maisières-Canal (Hainaut, BE)
New results on tool use and hafting

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1. Introduction

Recent methodological advances have allowed the identification of hafted tools archaeologically by looking at lithic wear evidence alone. Subsequent applications on e.g. Middle Palaeolithic material have demonstrated that the hafting wear method is a powerful way to investigate tool design, development of technologies, and their links to the broader patterns of past human behaviour, also in the periods from which organic material has not generally preserved (see e.g. Rots, 2003, 2010a, 2013, 2015; Rots *et al.*, 2011). Despite the advantages of the approach, it has not been extensively applied to Upper Palaeolithic assemblages (see, however, Rots, 2002a, 2005; Tomasso *et al.*, 2018). We present here new results on the Gravettian collection from Maisières-Canal and discuss tool use, hafting, and their links to raw material exploitation as well as their effect on tool morphology and lithic assemblage characteristics.

Maisières-Canal is an open-air site located by the river Haine near the present-day town of Mons. Rescue excavated in the 1960s, it has yielded an Early Gravettian occupation layer preserved in a secure stratigraphic context. Its lithic industry is very particular and characterised by numerous burins and elaborately shaped tanged and non-tanged points made on large blades in exceptionally fine-grained and homogeneous flint (Haesaerts & de Heinzelin, 1979; Otte, 1979; Pesesse & Flas, 2012; Haesaerts *et al.*, 2016). The abundancy of burnt bone and the volume of the material deriving from the production of lithic and osseous artefacts on-site suggest that Maisières-Canal was not a short-term camp (Lacarrière *et al.*, in press) but rather a medium or long-term settlement (Touzé, 2019: 411). The subfossil state of the ivory worked at the site as well as the large-scale exploitation of the high-quality flint resources of the Mons Basin have recently led investigators to propose that the presence of mammoth remains (including at least one tusk) and the vicinity of the flint outcrops have been among the reasons why the occupants of the site chose this particular location (Lacarrière *et al.*, in press; Touzé, 2019). In addition, it has been argued that the site's proximity to a ford may have made it attractive also from a hunting strategic point of view (Haesaerts & de Heinzelin, 1979: 48; Lacarrière *et al.*, in press). The first evidence of seasonality indicates human presence at least in the late summer or autumn (Lacarrière *et al.*, in press).

Previous studies on the lithic assemblage have focused on technology (Otte, 1976, 1979; Pesesse & Flas, 2012; Touzé *et al.*, 2016; Touzé, 2018, 2019) and use and hafting wear analysis of tanged tools (Otte & Caspar, 1987; Rots, 2002a, 2002b). In the recent years, projectile armatures, particularly tanged points, have been the subject of a detailed functional and ballistic study. These works have established that the lithic collection includes hafted tanged and non-tanged projectile points (Rots, 2002b; Coppe, 2020; Taipale *et al.*, 2017; Taipale, 2020) and that also domestic tools (at least burins) were hafted at the site (Rots, 2002a). The site therefore holds high potential for understanding Upper Palaeolithic tool design and its links to raw material strategies. In addition, a recent re-examination of the faunal remains has shown that the site is equally relevant for inves-

tigations into Early Gravettian subsistence strategies and osseous industries (Goutas *et al.*, in prep.; Lacarrière *et al.*, in press).

The goal of the present study was to shed more light on the practices of stone tool hafting, its links to tool use, and its effects on lithic assemblage variability at the site of Maisières-Canal. The study was framed in the context of an inter-site comparison that focused on classic Upper Palaeolithic stone tool categories, particularly scrapers and burins, in an attempt to understand technological variability in the younger part of the Upper Palaeolithic and the general trends in technological change during this period with a focus on tool hafting (Taipale, 2020). The emphasis was particularly on domestic tool categories since for them, hafting is not an obligation like it is for projectile points (e.g. Rots, 2003). This means that domestic tools can better reflect variability in technological choices linked to hafting and inform us about factors affecting them.

The principal objective of our work was to expand on the previous studies and to investigate tool use and hafting from a broader perspective that incorporates different tool categories and, importantly, also non-tanged tool morphologies. In the first place, the aim was to find out whether evidence of hafting could be found among previously unexamined tool classes and how tool hafting, use, and maintenance (resharpening) reflect on lithic assemblage variability. While the focus was not on detailed understanding of site function, the data collected here allow certain perspectives to site use and occupation duration as well as to aspects of lithic raw material economy.

2. Analysed sample and method of analysis

The sampling focused on three main tool categories: burins, scrapers and points (tanged points and Maisières points). The retouched tool collection as a whole (n = 945) is rather heavily dominated by burins (n = 382) and points (n = 214) whereas scrapers are less numerous (n = 49) (Touzé, 2019: tab. 19). Tanged burins have been addressed in a previous study (Rots, 2002a, 2002b) and were examined here only for comparative purposes.

We first screened all the burins and scrapers stored at the Royal Belgian Institute of Natural Sciences macroscopically and under the stereomicroscope to obtain a preliminary view of wear patterns and surface preservation. We then sampled these sub-collections for more detailed analysis by attempting to include all the main tool morphologies and observed wear patterns in representative proportions as well as tools with evidence suggestive of hafting. The point collection was sampled differently because it includes a relatively large number of projectiles identified previously (Taipale *et al.*, 2017; Rots, 2002b; Coppe, 2020). In screening this material, the items with clearest evidence of impact (cf. Coppe, 2020; Taipale, 2020) were left aside and the preliminary examination and sample selection focused on those with subtler edge damage that could be the result of other (mainly knife) use (Tab. 1).

Our analytical approach combined observations made at different scales, i.e. macroscopically, with a stereomicroscope using oblique lighting at magnifications below 100× (see e.g. Tringham *et al.*, 1974; Lawrence, 1979; Odell & Odell-Vereecken, 1980; Odell, 1981), and with a metallurgical microscope using incident lighting at magnifications between 50× and 500× (Keeley, 1980; Vaughan, 1985; Juel Jensen, 1994). Hafting wear identifications likewise rely on a method that takes advantage of both low and high magnifications and has been developed through experimentation and blind testing (Rots, 2002b, 2003, 2005, 2010a; Rots *et al.*, 2006). The rare potentially functional residues encountered during the analysis were further analysed by D. Cnuts using optical microscopes and the SEM.

Tool category	*Low magnification*	*Low and high magnification*	*Complete assemblage*
Burins	72	37	382
Endscrapers	17	11	44
Sidescrapers	1	1	5
Scraper-burins	2	2	*NA*
Tanged points	21	7	56
Other tanged tools	2	2	83
Maisières points	12	6	121
Distal fragments of points	6	7	20
Total	*133*	*73*	*711*

Tab. 1 – Size of the samples selected for detailed analysis after the initial screening of the entire retouched tool assemblage (counts for the complete assemblage from Touzé, 2019: tab. 19). Projectile points are excluded from the counts. The low magnification burin sample included eight tanged burins that had not been analysed previously, and two of them were briefly examined also under high magnification. A recent count for scraper-burins was not available to us, but these tools are rare. Touzé reports 11 combination tools in total (Touzé, 2019: tab. 19).

The reference collection used in the study is hosted at TraceoLab, University of Liège, and includes more than 5000 experimental tools, most of which are flint. These replicas were used in a wide range of tasks (many of them relevant for Upper Palaeolithic contexts) and represent different hafting arrangements as well as hand-held use. In addition, particular sub-collections have been created that focus on e.g. production wear and taphonomic wear (e.g. Rots, 2010b; Michel *et al.*, 2019). The latter are particularly relevant for Maisières, where long and elaborate shaping sequences of some of the tools have resulted in the accrual of varied production wear, and where storage conditions have produced particular traces (see Taipale & Rots, submitted). A reference sample of tanged projectile points analysed prior to their hafting and use (Coppe, 2020) as well as material from previous experiments simulating storage and transport conditions were used in the present study to ensure that production and post-excavation wear were not confused with functional traces.

3. Results

The microscopic analysis allowed a detailed reconstruction of tool use patterns as well as the identification of a number of hafted tools in all the tool categories. The wear on the burins is rather varied as a consequence of recycling (cf. Schiffer, 1987) and flexible tool use. The scrapers, on the other hand, were consistently used in hide working even though some of them also show evidence of recycling. Significantly, we identified a considerable number of knives among the pointed tools (tanged points and Maisières points). Our use-wear data show that also the tools previously characterised as 'tanged scrapers' (Otte & Caspar, 1987; Pesesse & Flas, 2012; Touzé, 2019) are better understood as knives.

In the following, we present our observations focusing on tool use (3.1.), hafting (3.2.), resharpening and the length of tool use-lives (3.3.), and tool manufacture and design (3.4.). The artefacts are grouped primarily according to broad typological categories that guided the sampling (burins, scrapers, and scraper-burins). The knives form an exception as this category includes implements previously classified as 'points', 'scrapers', and 'tanged tools'. They are grouped here together for the sake of simplicity and described in further detail in an upcoming publication (Taipale & Rots, submitted). Use-wear patterns on tanged and non-tanged projectile points and their implications for understanding weapon design and propulsion modes are presented elsewhere (Taipale *et al.*, 2017; Coppe, 2020; Taipale, 2020), and the focus here is solely on tools with evidence of knife use. The discussion below largely builds on the high magnification samples as they offer the highest level of detail.

3.1. Tool use

3.1.1. Burins

No evidence of the use of burins as cores could be found either in the screening or the subsequent detailed functional analysis, which confirms the earlier view that bladelet production plays a marginal role in the lithic industry at the site (Touzé, 2019: 410). Instead, the burins from Maisières abundantly show use-related scarring in their active parts. The most frequent single function for the tools analysed in detail is grooving (n = 9, or 24.3 %, in the high magnification sample, and n = 34, or 47.2 %, in the low magnification sample). This contrasts with the abundant evidence of perforating found previously on tanged burins (Rots, 2002a). In the present samples, the relative frequency of use in a rotative motion can be estimated to vary between 5.4 % and 12.5 % when tools where the motion was interpreted as 'grooving or perforating' are included in the counts (Taipale, 2020: tab. 9.5).

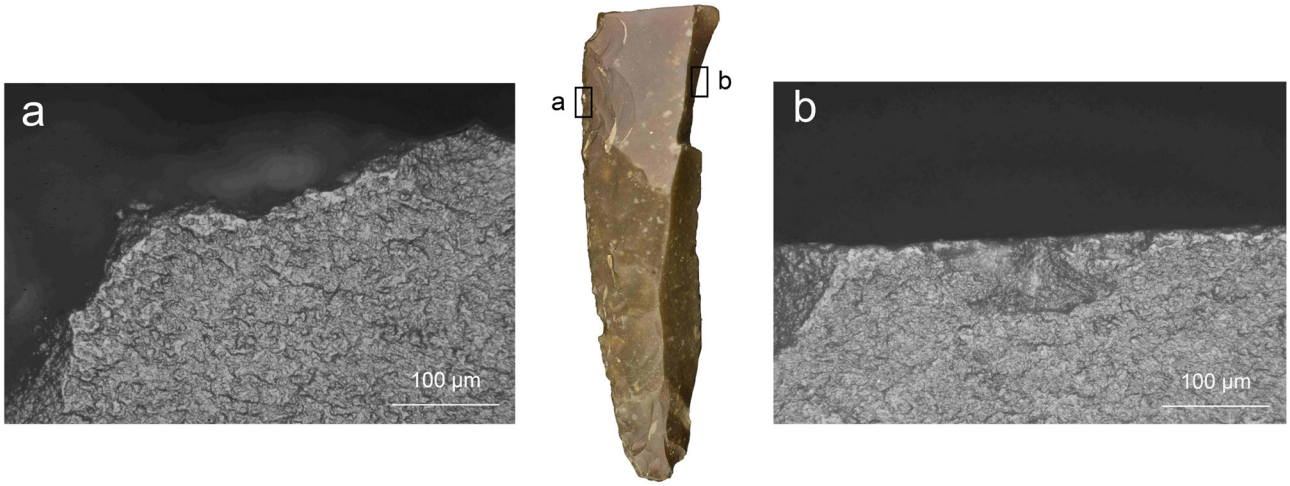
Notably, many of the tools in the present sample show evidence of several kinds of use. While the proportion of such tools is moderate in the low magnification sample (n = 13, or 18.1 %), it increases considerably in the high magnification sample (n = 19, or 51.4 %). This most probably results from both the higher level of detail gained by the combined use of low and high magnification and from sampling bias in favour of tools with abundant wear evidence. The high magnification sample can be divided into four main categories: burins used in a single action (n = 13), burins used in multiple actions (n = 11), burins with evidence of earlier use (i.e. recycled tools; n = 5), and burins with evidence of secondary use (n = 3) (cf. Schiffer, 1987; Tab. 2).

The majority of the artefacts analysed under high magnification showed moderately developed use polish at best. Because of this, detailed worked material identifications are infrequent. In some instances, the material could be identified more specifically as antler (n = 3) or bone (n = 2) but in all these cases, the interpretation remains somewhat tentative. A single tool has probable functional residue preserved on a burin facet. This deposit showed an elemental composition consistent with hard animal material (i.e. peaks of Ca and P; see Taipale, 2020) but could not be characterised in further detail. Because of the lack of morphologically diagnostic micro-residues and the rarity of well-developed polish, a large portion of the high magnification sample (n = 14) could only be assigned to the generic 'bone, antler or ivory' category. Significantly, no positive ivory identifications were made in the present study despite the growing body of evidence of on-site processing of mammoth tusks (Goutas *et al.*, in prep.; Lacarrière *et al.*, in press). This absence of evidence is probably at least partly due to the currently limited reference material available for ivory wear, and some of the tools with antler-like polish could be linked to the working of this material.

Tool use		*Worked material*	*n*
Burins used in a single action	Grooving	Hard animal material	9 (2)
	Perforating	Hard animal material	2 (0)
	Transverse	Hard animal material	2 (0)
Burins used in multiple actions	Grooving and transverse	Hard animal material	4 (1)
	Grooving and/or perforating	Hard animal material	4 (0)
	Grooving and longitudinal	Several?	2 (0)
	Perforating and transverse	Hard animal material	1 (1)
Other tools recycled into burins	Former knife	Several	4 (1)
	Former projectile point	Several	1 (0)
Burins with secondary use	Grooving and percussion	(At least) hard animal material	2 (0)
	Grooving and indet*	Several	1 (1)
Indet/no use-wear	NA	NA	5 (0)
Total			*37 (6)*

Tab. 2 – Tool use and worked material identifications in the high magnification burin sample. The number of tentative interpretations within each category is given in brackets. The case marked with an asterisk (*) is the tool with possible mineral wear (potential strike-a-light) mentioned in the text. Many of the worked material identifications are uncertain, and in six cases, the use polish is somewhat wood-like.

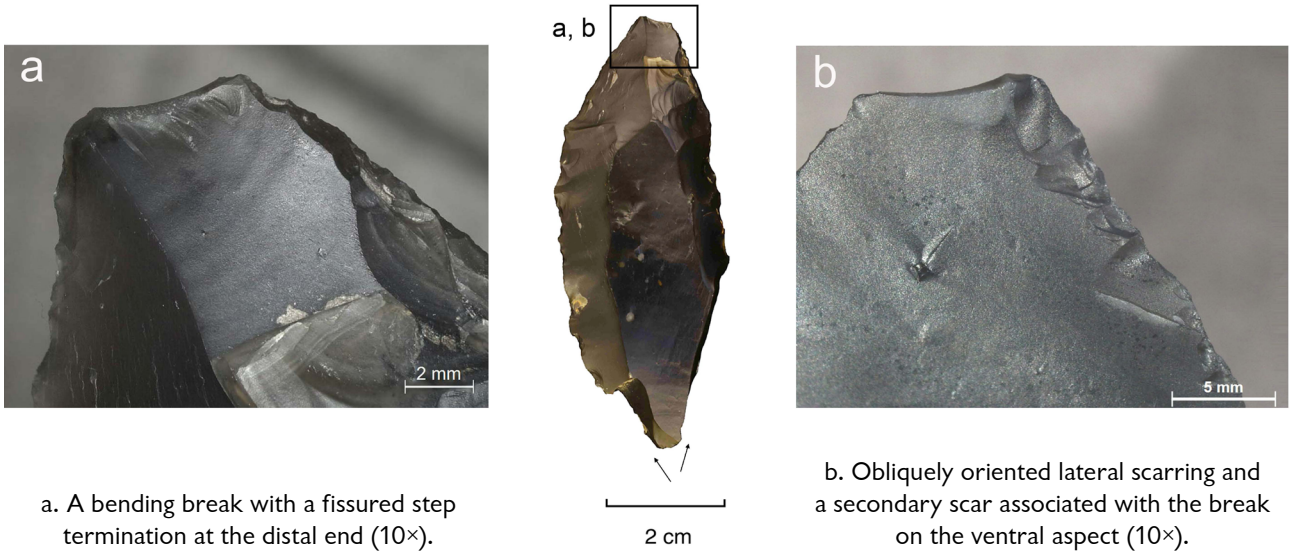
Flexible use of burins in a combination of motions is prevalent in the sample (Tab. 2). In addition, both evidence of use that predates burin use and postdates it are present. The most frequent example of the former is earlier knife use. Altogether four tools present evidence consistent with it, albeit to varying degrees of explicitness. Two of them (B70 and B76) can be said to fit with wear patterns observed on butchering knives (see below) even though the evidence is rather limited (Fig. 1). A distal fragment of a burin (B25) likewise showed evidence of use in repetitive cutting motion. The fourth piece (B14) is a fragmentary tanged burin that was not included in the initial study (Rots, 2002a, 2002b) and may be the first example of a tanged knife recycled into a burin (Taipale & Rots, work in progress). Among the seven tanged burins analysed previously, only a single tool has been found to show tentative evidence of initial use as a projectile (Rots, 2002b). In contrast, earlier projectile use is evident on one of the non-tanged burins in the present analytical sample (Fig. 2).



a. Polish from the ventral aspect of the left edge from previous knife use (400×).

b. Bone-like polish from transverse use on the ventral aspect of the burin facet edge (400×).

Fig. 1 – Use-wear on burin B76 from Maisières.
The tool also shows more tentative evidence of the use of the tip in grooving.



a. A bending break with a fissured step termination at the distal end (10×).

b. Obliquely oriented lateral scarring and a secondary scar associated with the break on the ventral aspect (10×).

Fig. 2 – Evidence of impact on burin B51 (reworked from a used projectile).
These features are associated with faint striations that cannot be attributed to impact with certainty.

Two burins were used secondarily as percussion tools. One of them was interpreted as a wedge and displays wear from earlier use probably in grooving motion (Fig. 3) whereas the tip of the other tool shows removals for which the closest experimental match are tools used as punches in making indentations in ivory (cf. Dutkiewicz, in press; Fig. 4). At present, however, other use in percussive motion should not be excluded for the Maisières tool.

A single tool showed edge rounding that stands apart from that typically seen on tools used on hard animal material (Fig. 5). The rounding is partly associated with striations visible under high magnification but the traces are not very well developed. They were interpreted as potential mineral wear and could derive, for instance, from relatively brief strike-a-light use although intense scarring is lacking. Other use on mineral material should therefore be maintained as an option. Maisières-Canal has yielded evidence of

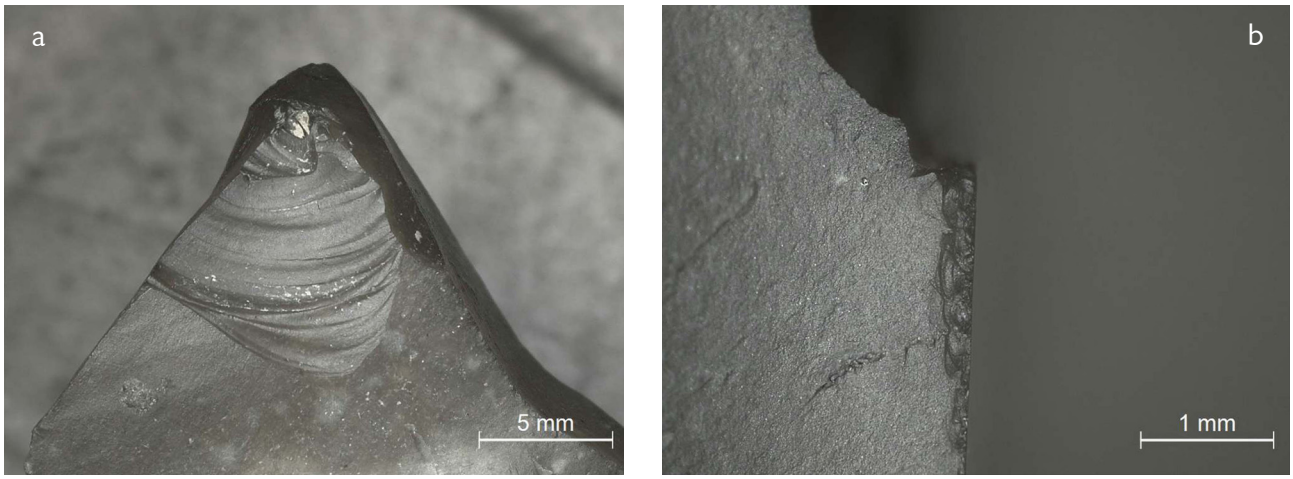


Fig. 3 – Use-wear on burin B3.
a. A large ventral removal and smaller crushing from use as a wedge (6.1×);
b. The ventral removal shown in a. cutting into edge damage from earlier use (probably grooving) on the right burin facet (30×).

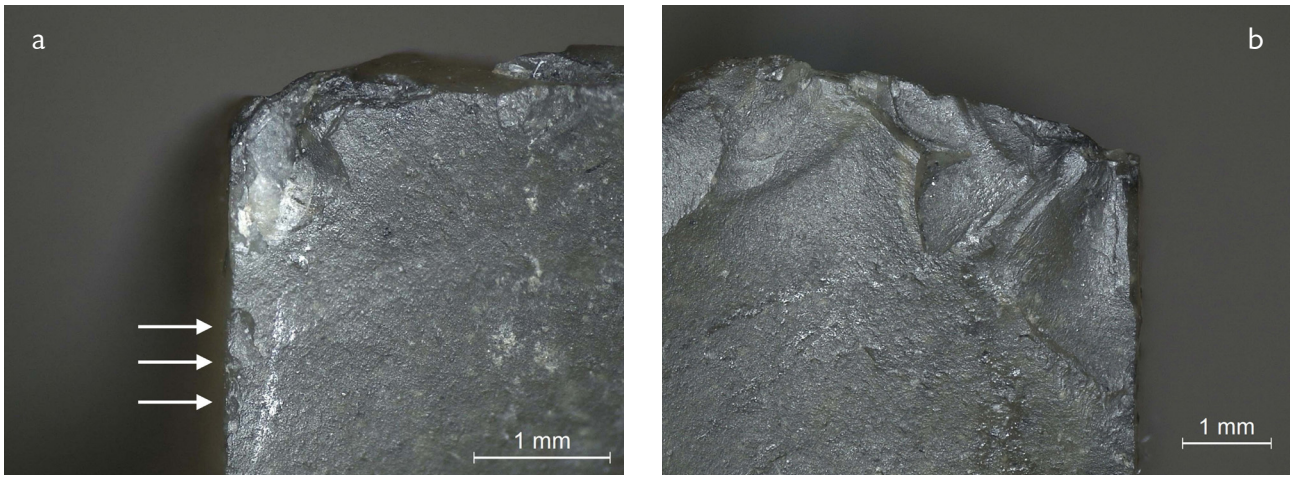


Fig. 4 – Use-wear on burin B18.
a. Heavy damage on the left aspect of the tip with smaller, differently oriented damage from grooving (arrows) (30×);
b. Invasive damage on the right aspect of the tip associated with the damage shown in a. and consistent with percussion motion (20×).

fire in the form of burnt bone and lithics (de Heinzelin, 1973; Gautier, 1973). A residual deposit on a tanged tool (S8) matches in elemental composition with pyrite/marcasite (peaks of S and Fe). Even though it appears to have formed through precipitation and is therefore probably postdepositional in origin (D. Cnuts, personal communication; see Taipale, 2020: appendix 3), it may indicate that sulphuric iron was deposited at the site as a result of human activities. Evidence of the working of soft stone by grooving is to our knowledge absent, but the tool may have been transported from elsewhere after its use. By far, the collection has not been systematically screened for mineral wear, and it is therefore difficult to evaluate whether the wear pattern is anomalous on the scale of the assemblage.

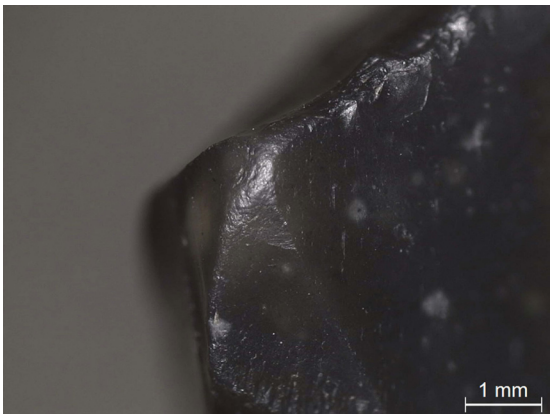


Fig. 5 – Edge rounding possibly from contact with mineral material on the tip of burin B18 from Maisières (20×).

3.1.2. Scrapers

Most of the scrapers in the analysed samples (seven out of 11 in the high magnification sample and 12 out of 15 in the low magnification sample) appear to have served in a single task, scraping hide. The wear varies in development but is sometimes readily visible already under low magnification or even with the naked eye (Fig. 6). While the state of the worked hide (fresh/dry) could not be determined for most of the scrapers, there are a number of occasions (four in the high magnification sample) where the degree of edge rounding and the presence of clear striations suggest that the tools were used on dry hide.

Two pieces showed convincing evidence of other types of use in addition to scraping, and two have evidence that is more tentative. Of the first-mentioned, S20 has traces along one lateral edge that are longitudinal, transverse and diagonal in orientation, and wear from longitudinal use on the other. The lateral edges of the second scraper (S10) were used longitudinally. It was initially thought that all the traces had formed within the same functional context (working of hides), but considering that the polish photographed on

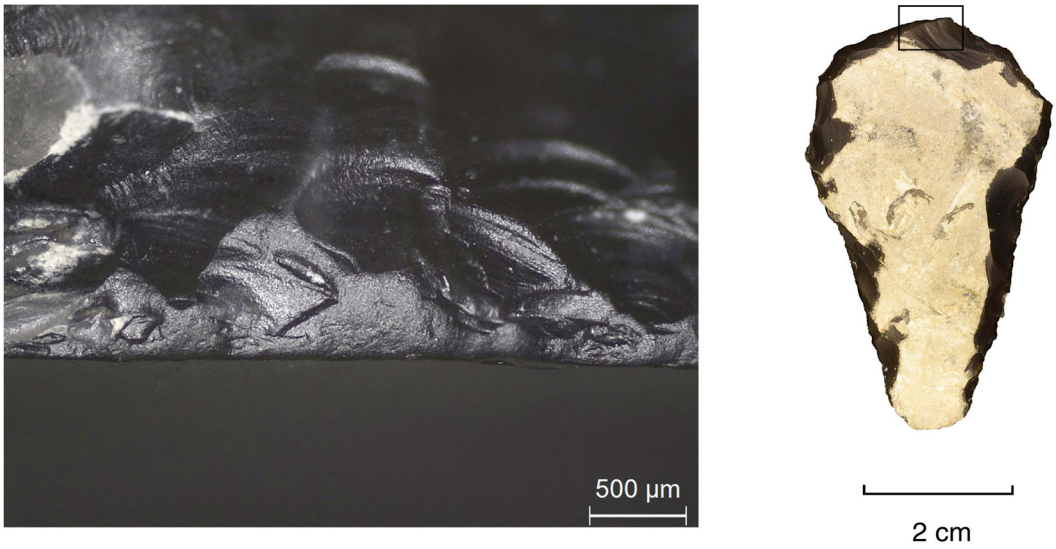


Fig. 6 – Extreme edge rounding from hide-working on the dorsal aspect of S13 (40×).

S10 (Fig. 7) resembles that on a knife resharpening flake (see Taipale & Rots, submitted: fig. 9), it is possible these scrapers initially served as (butchering) knives.

The two tools with more ambiguous evidence of mixed use include a scraper (S17) with edge damage at the distal end that could be consistent with percussion. Unfortunately, the surface is quite badly preserved and microwear that would confirm this interpretation is absent. The second piece (S7) has ventral edge damage at the distal end and relatively bright polish limited to the outermost edge that could come from brief secondary transverse use on medium-hard material, but the traces are too limited to rule out the option that they are production-related.

The lateral edges of one tool (S3) showed well-developed hide wear similar to that observed on the main working edge. These edges may have been used after the breakage of the tool within the same functional context.

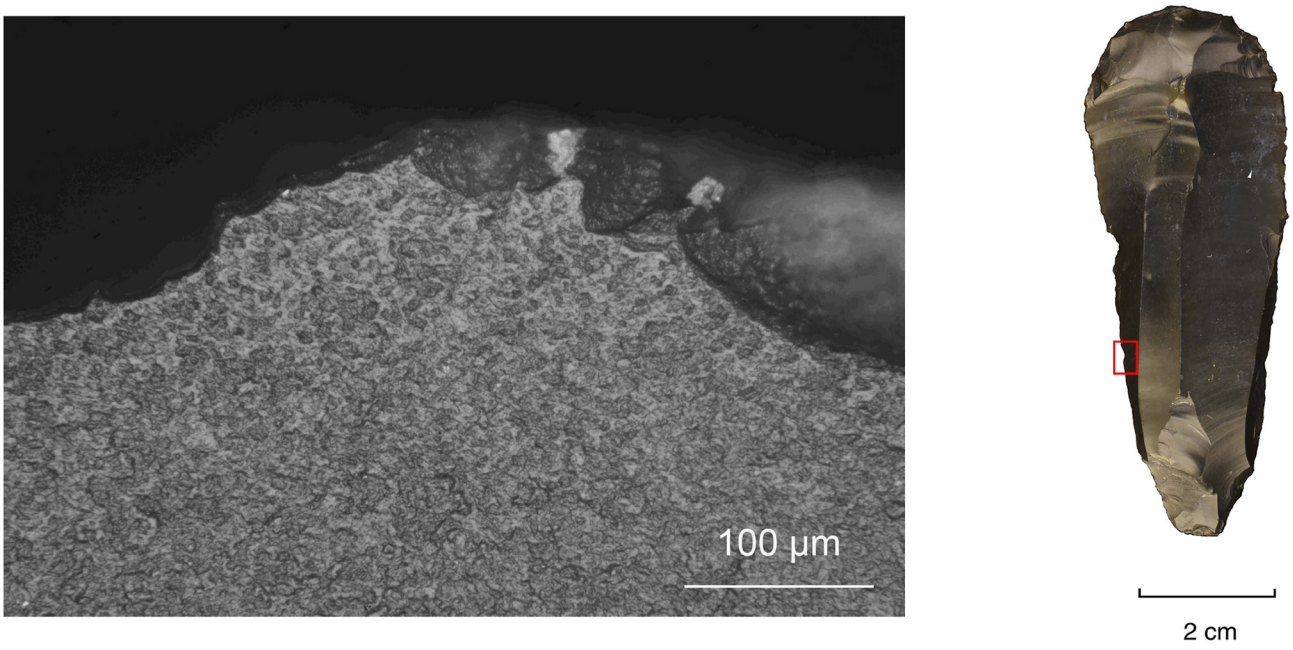


Fig. 7 – Longitudinal wear from knife use on the ventral aspect of the proximal left edge of S10 (400×).

3.1.3. Scraper-burins

The scraper edges on both analysed scraper-burins were used on hide. In the case of SB1, the edge rounding is heavy enough to suggest dry hide. The polish associated with it is somewhat particular and was initially interpreted as having been affected by taphonomic processes, but it also bears strong resemblance to the heaviest wear found on some of the butchering knives identified later. Prolonged contact with fresh hide should therefore be considered as an explanation. The polish on SB2 is quite similar but less extensively developed.

SB2 has traces from grooving and possible transverse use on hard animal material (maybe antler) at the burin end. The use-wear evidence available thus far therefore matches with that documented in the actual scraper and burin samples. The burin end of SB1 shows a failed burin blow and no evidence of use.

In addition to the wear at the scraper end, the lateral edges on SB1 show mixed, ambiguous edge damage and microscopic features. Part of the wear appears taphonomic. The rest can be hafting wear, wear from earlier (knife) use, or a mix of the two.

3.1.4. Knives

The knives we have identified among tanged points, Maisières points, and tanged tools with blunted distal extremities all show mixed wear consistent with butchering. It includes oriented, often invasive scarring on distal edges, striations, and edge rounding and polish in varying stages of development. The use-wear is often patchy and subtle due to the frequent resharpening of the working edges prior to the discard of the tools. The wear patterns on the knives are described in detail elsewhere (Taipale, 2020: appendix 4; Taipale & Rots, submitted). Four of the butchering knives show indications of previous use as projectiles (Taipale & Rots, submitted), and the evidence described in the sections above indicates that some knives were later recycled into other functions.

3.2. Hafting

3.2.1. Burins

Previous work has shown that tanged burins were hafted at Maisières (Rots, 2002a, 2002b). Our present analysis demonstrated that also tools without tangs were sometimes hafted for use. Even though they are not frequent in the sample, the evidence is solid on the best examples classified here as 'hafted' (Tab. 3). It consists of edge damage and microscopic features (bright spots and striations) that occur in diagnostic combinations (cf. Rots, 2010a). The tools labelled as 'possibly hafted' show traces indicative of hafting in their non-active parts, but even when both low magnification and high magnification features are present, truly diagnostic combinations are lacking. Well-developed prehension polish is absent in the present sample, which means that the category 'not hafted' consists of tools where evidence suggestive of hafting was not found and where the dimensions and/or morphology of the non-active part of the tool were considered unsuitable for hafting.

Interpretation	*Low magnification*	*Low and high magnification*
Hafted	0	2
Possibly hafted	13	5
No evidence	14	6
Not hafted	23	9
No interpretation	22	15
Total	*72*	*37*

Tab. 3 – Hafting wear interpretations for the burin samples.

Of the two examples with the most explicit hafting wear, the first tool (B27) is a dihedral burin on a crested, possibly overshot blade. The burin bit was made at the proximal end whereas the distal extremity is narrow and thin, triangular in cross-section, and shows a proximal dorsally initiated snap/feather-terminated break. This break can represent intentional snapping in anticipation of hafting, especially if the view that the blank originally had an overshot termination is correct. The tool was used for grooving and possibly perforating hard animal material judging from scarring, edge rounding and polish found in the active part. Some of the edge damage in the non-active part is associated with bright spots and striations, a typical combination of traces diagnostic of hafting (Fig. 8).

The use-wear on the second burin (B18) suggests a combination of grooving and perforating, and possible secondary use as a strike-a-light (see above). It is also made on a crested blade, and has direct invasive retouch on the steep-angled proximal right edge. Here, the burin bit is at the distal end. The proximal cross-section is trapezoidal. The tool has damage on the edges as well as on a dorsal ridge in the non-active part.

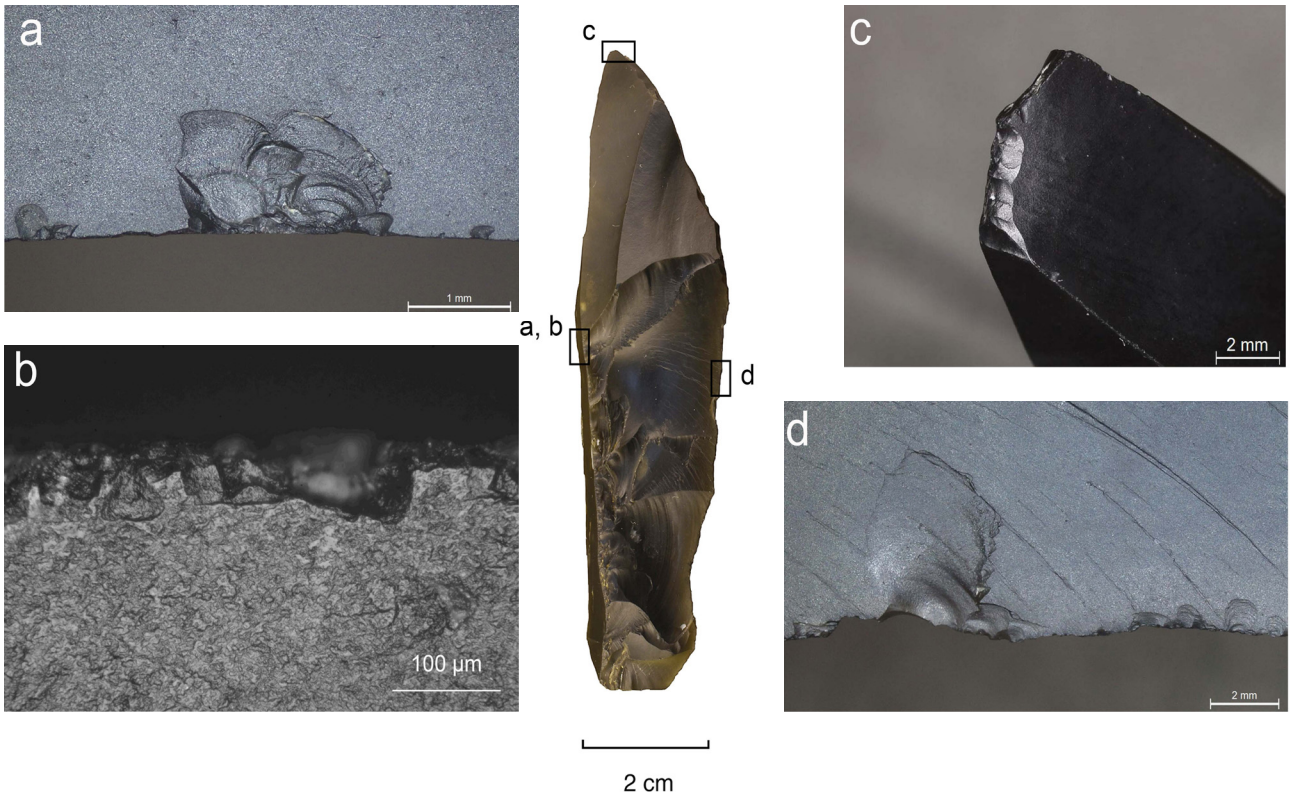


Fig. 8 – Example of a hafted burin (B27).
a. Ventral edge damage at haft limit on the left edge of the tool (30×);
b. Edge damage associated with bright spots and striations on the dorsal aspect in the same location (400×);
c. Edge damage from use on the burin tip (10×);
d. Hafting scarring on the ventral aspect of the acute-angled right edge of the tool (10×).

Even though the piece is rather sturdy, it narrows and thins down towards the proximal part, which makes it – similarly to burin B27 – suitable for hafting without the need for substantial secondary modifications.

Neither of the two newly identified hafted burins has haft polish that would be well developed enough to allow the identification of the raw material of the handle. The edge damage and ridge damage on the pieces suggest direct contact with relatively hard material at least at places, although it should be noted that considerable portions of the edges are too obtuse-angled to allow the formation of characteristic bending-initiated scars that would indicate contact with softer bindings. For these reasons, detailed reconstruction of the hafting arrangement is not attempted here.

3.2.2. *Scrapers*

The scrapers in the analysed samples proved to be dominantly hafted tools (Tab. 4). The difference between them and the burins in frequency of hafting is obvious. The abundant hafting wear in the scraper sample suggests that its near absence among the burins is unlikely to be due to difficulties in detecting it given that hafted tools should show increasingly explicit haft wear when the hardness of the

Interpretation	*Low magnification*	*Low and high magnification*
Hafted	4	5
Possibly hafted	10	4
Not hafted	0	1
No interpretation	3	1
Total	*17*	*11*

Tab. 4 – Hafting interpretations for the scraper samples.

worked material increases. The lever effect caused by the movement of the tool against its handle is more or less similar in the case of grooving and scraping motions, which can be expected to lead into the formation of heavier haft wear on burins used on hard material than on scrapers used on soft material (Rots, 2002b, 2010a).

The wear on the scrapers varies in intensity, but is in most cases distinct enough to stand out from postdepositional alterations. The five pieces with clearest evidence typically display a combination of edge damage and bright spots and/or striations that can be considered diagnostic of hafting (Rots, 2002b, 2010a). Examples of these traces are shown in Figure 9. Some of the pieces also show polish and edge rounding formed through contact with the haft. The polish is sometimes striated and longitudinal in orientation.

The only piece that could be interpreted as hand-held in the sample is S20. This piece shows no hafting wear, and its size and morphology are supportive arguments for hand-held use. It has been made on a sturdy, long, slightly curved, partly cortical blade, the proximal end of which forms a comfortable natural handle. This tool bears close resemblance to a hand-held scraper identified in the assemblage from the Magdalenian site Verberie (VBC 8; Rots, 2005: fig. 3).

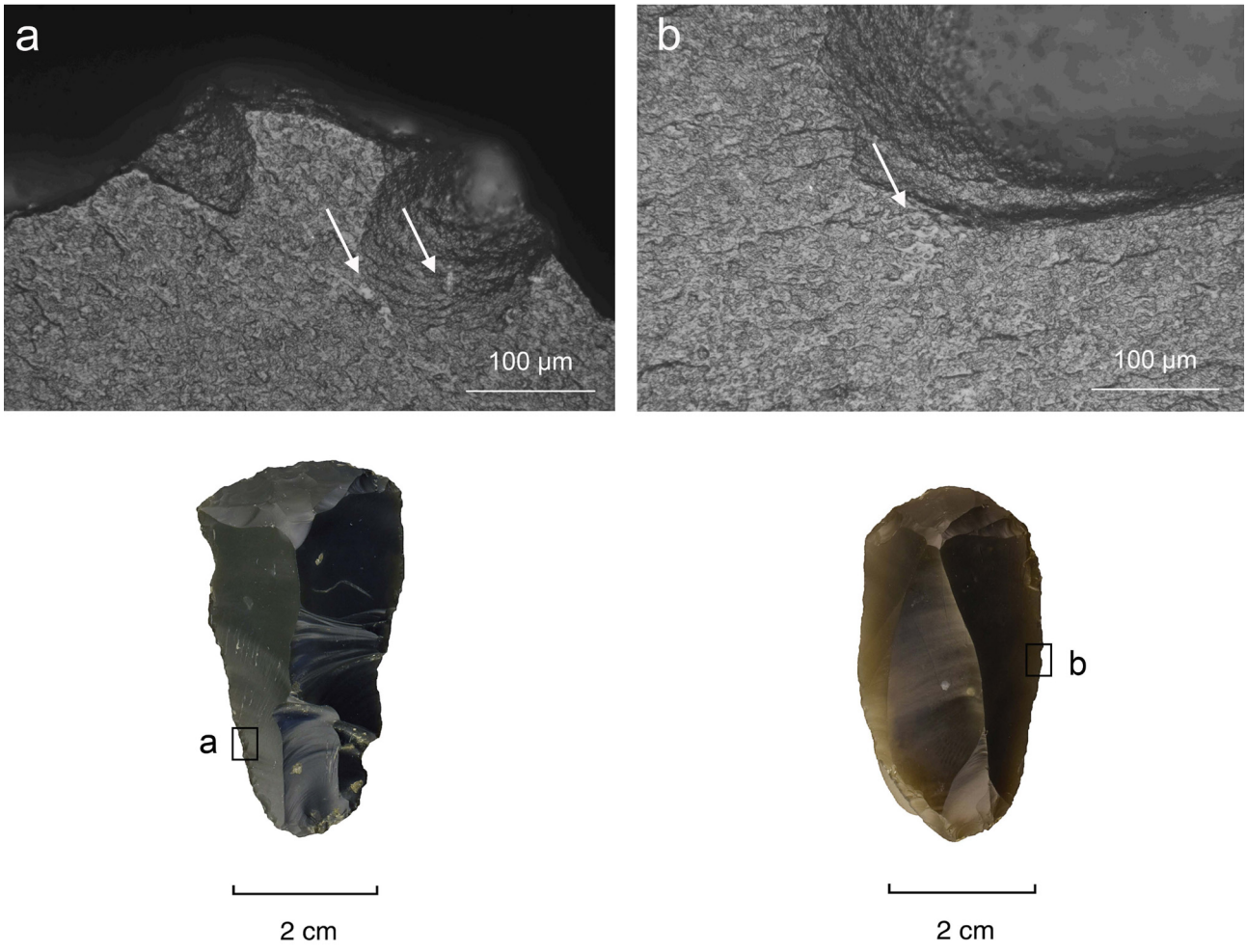


Fig. 9 – Hafting wear on two scrapers from Maisières.
a. Edge damage associated with a striation and bright spots (arrows) on the ventral proximal left edge of S15 (400×);
b. A scar associated with a bright spot on the dorsal medial right edge of S16 (400×).

Comparable to the burins, none of the scrapers show haft polish that would be well-developed enough to allow the identification of the haft raw material. Three of them (S7, S1 & S15) nevertheless show bending-initiated lateral scars indicative of the use of bindings and/or wrappings. This suggests that for the domestic tools, at least one hafting arrangement in addition to direct hafting in antler (Rots, 2002a) was in use at the site.

3.2.3. Scraper-burins

Both of the scraper-burins were interpreted as possibly hafted. The evidence on SB1 is more abundant, but not entirely conclusive (Fig. 10). Given that the burin blow failed, the only hafting wear found on this piece would be related to its use as a scraper. The most convincing combination of traces is that of edge damage and flint-on-flint friction features on the ventral distal left edge. The lateral edges in general show varied scarring that was under low magnification considered too ambiguous to distinguish between use and hafting with certainty. The hafting identification therefore remains cautious, and it is clear that the evidence is not as explicit as on some of the actual scrapers.

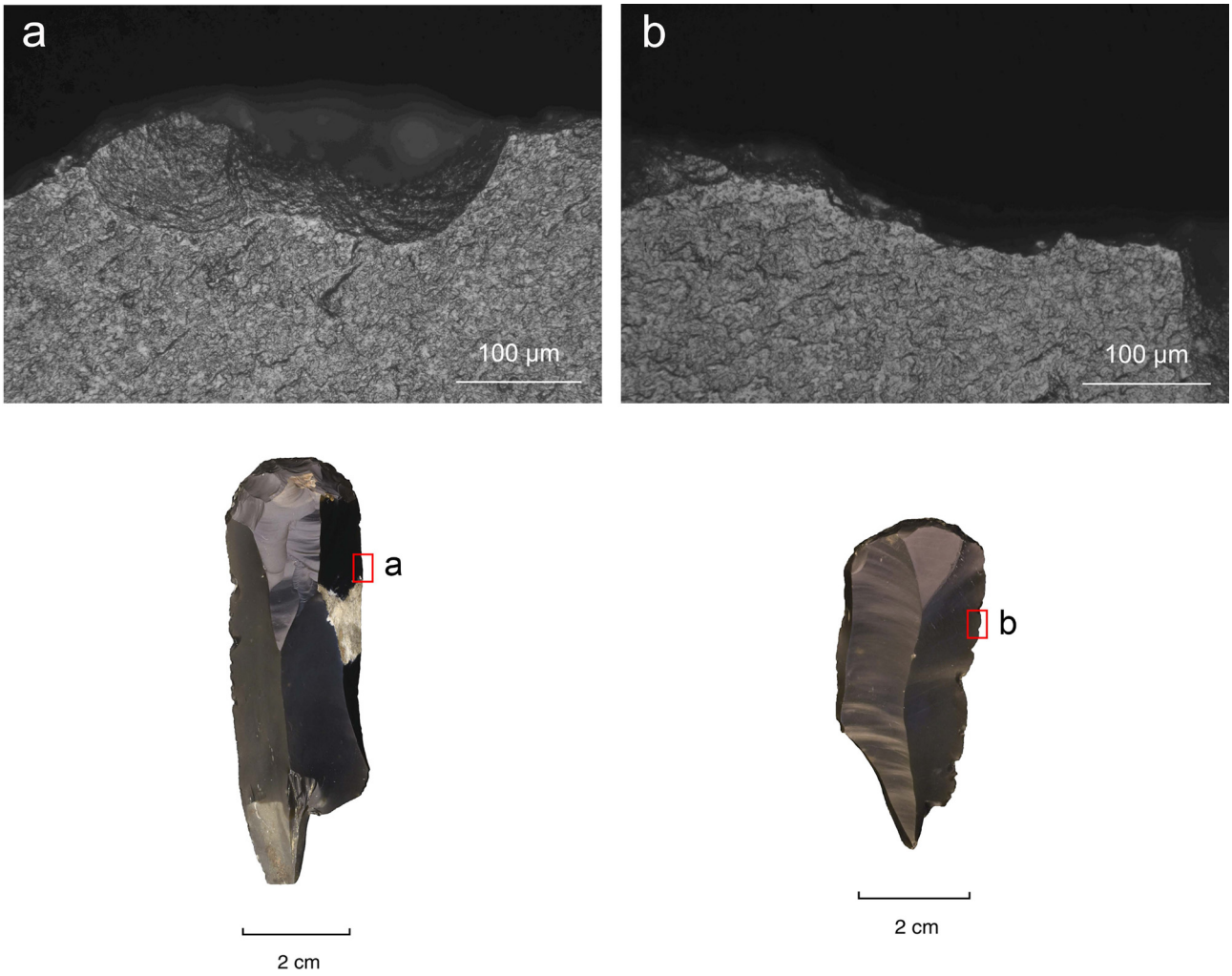


Fig. 10 – Possible hafting wear on the scraper-burins.
a. Bright spots associated with edge damage on the ventral distal right edge of SB1 (400×);
b. Possible haft polish on the dorsal distal right edge of SB2 (400×).

3.2.4. Knives

The butchering knives identified in the collection thus far show evidence of hafting with a single exception (sidescraper S14, interpreted as a butchering knife with a degree of hesitation). Haft wear is present on both tanged and non-tanged tools and is extreme in its development as the result of the prolonged use-lives of the tools. The wear is discussed in detail elsewhere (Taipale, 2020: appendix 4; Taipale & Rots, submitted). As was the case with the other tool categories, the polish from contact with the handle is not diagnostic of a particular raw material. On the knives, the most pronounced hafting wear features visible under high magnification are the result of flint-on-flint friction. Therefore, detailed reconstruction of tool design is currently not feasible, particularly because experimental reference material with matching use durations is not yet available for this category of tools. However, the current evidence allows establishing that both dorsal and ventral surfaces, and, in the case of tanged knives, also probably lateral sides of the tang, were in direct contact with hard material (i.e. the handle). In some cases, use of bindings as an extra measure could be tentatively proposed, but remains to be examined through experimental work (Taipale & Rots, submitted).

3.3. Resharpening and length of use

3.3.1. Burins

Due to the nature of burin resharpening (removal of large parts of previous use-wear evidence with a single spall), a considerable portion (n = 19) of the high magnification sample did not allow an interpretation at this level. Among the tools that were informative in this respect (n = 18), resharpening is very frequent (Tab. 5). It is present in the form of wear cut by a spall negative. Figure 11 shows a low magnification example.

Resharpened	*n*
Yes	14 (9)
No	4 (3)
No interpretation	15 (0)
NA	4 (0)
Total	*37 (12)*

Tab. 5 – Evidence of resharpening in the high magnification sample of burins that offers the highest level of detail. The number of tentative interpretations within each category is given in brackets.

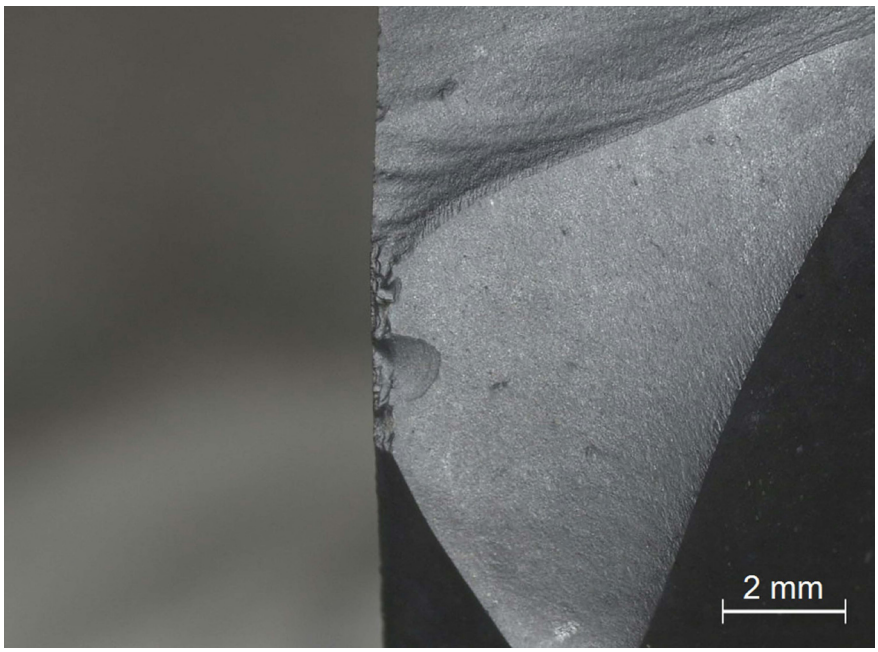


Fig. 11 – Evidence of resharpening on burin B49. A burin spall cuts into edge damage on the left facet (10×).

It is not easy to compare hand-held and hafted burins in terms of frequency of resharpening since the number of tools identified reliably as hafted is low. However, the proportionally high frequency of tools with evidence of resharpening (n = 8) as opposed to those without evidence (n = 2) among tools classified as 'not hafted' or having 'no evidence' of hafting (see Tab. 3 above) suggests that also (probable) hand-held tools were frequently maintained and did not necessarily have shorter use-lives than their hafted counterparts.

Resharpened	*Low magnification*	*Low and high magnification*
Yes	14 (2)	11 (0)
No	1 (1)	0 (0)
No interpretation	2 (0)	0 (0)
Total	*17 (3)*	*11 (0)*

Tab. 6 – Evidence of resharpening in the scraper samples. The number of tentative interpretations within each category is given in brackets.

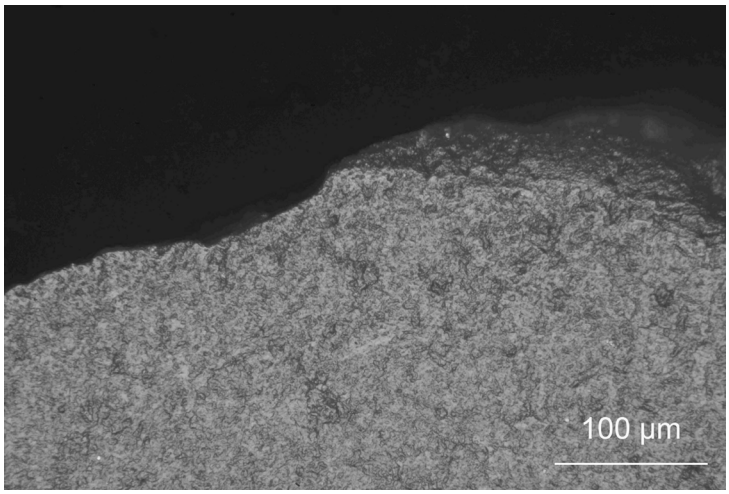


Fig. 12 – Use-wear cut by resharpening removals on S16 (400×).

3.3.2. Scrapers

Resharpening is extremely frequent on the scrapers, with all those analysed under high magnification showing evidence of it. In most cases, resharpening could be detected already under low magnification (Tab. 6) and is easily visible under high magnification as edge rounding cut by removals (Fig. 12). Of the scrapers on which several edges were used (n = 3), two have indications of resharpening on more than one edge and one only on the scraper edge.

3.3.3. Scraper-burins

The scraper ends of both SB1 and SB2 display edge wear cut by retouch. This means that these working edges were maintained similarly to those of the actual scrapers. SB2, which is the only one of the two with burin wear, does not show direct evidence of resharpening at this end. The number of removals per facet has probably increased as a result of the failed spalls on the right side and is not necessarily reflective of the duration of use. The scraper edge of this tool therefore appears to be the more intensely used and maintained one.

3.3.4. Knives

Of the four tool categories included here, knives appear to have had the longest use-lives. Their frequent resharpening is witnessed by use-wear interrupted by both direct invasive lateral retouch and tranchet negatives on the tools themselves, by the well-developed use-wear recorded on a tranchet flake (Taipale & Rots, submitted: fig. 9), and by the heavy development of hafting wear even on tools where use-wear evidence is rather limited. While the absolute duration of use between resharpening episodes is currently difficult to estimate, a comparison with an experimental tool with a similar morphology, used for 45 minutes in butchery, suggests that the archaeological tools were used at least for several hours before rejuvenation. The detailed examination of the shaping sequence and wear distribution and development allowed proposing that some of the tools have been abandoned in the middle of resharpening (Taipale, 2020; Taipale & Rots, submitted).

3.4. Tool manufacture and design

3.4.1. Burins

Burins are the dominant tool category in the retouched tool assemblage from Maisières. Among the blanks on which they were made, blades from *plein débitage* are prominent (n = 123), but also blades from core preparation are relatively well represented (Touzé, 2019: 316). Recycling of previously used tools and preforms into burins has been proposed in the context of earlier technological studies (Pesesse & Flas, 2012;

Touzé, 2019) and is confirmed by the functional results presented here even though the status of tanged burins in this respect needs to be evaluated through further analysis (Taipale & Rots, work in progress).

In the class of burins, typological subtypes (dihedral burins, burins on break, etc.) do not straightforwardly reflect different kinds of tool use. The clearest link between burin typology/technology and function in the whole sample concerns those burins on truncation or break where there either is no proper bit or where the bit angle is less than suitable for activities like grooving (for tip angle tendencies, see Otte, 1976: 6). On these pieces, the facet edge was used in transverse motion. One tool shows that the burin spall was removed by a blow that made contact with the platform near a dorsal ridge instead of the edge, which resulted in a twisted spall that created an acute-angled facet edge. It is difficult to say whether this effect was intentional or accidental. While these observations may mean that some of the burins were specifically made for transverse use, their number is so low (n = 4) that it does not allow a meaningful comparison. Also other morphologies show evidence of transverse use, although most often mixed with other actions (see above).

The tanged and non-tanged hafted burins identified up to date illustrate that hafting modifications are variable in the assemblage. The non-tanged burins with the strongest hafting evidence show tentative signs of proximal shaping that may have aided hafting, but in both cases, blanks that were already relatively narrow and thin at their proximal extremity were selected instead of investing time and effort in extensively modifying them. This implies that varied strategies were in place to reach the same goal.

3.4.2. Scrapers

The tools identified here as hide scrapers are exclusively non-tanged endscrapers made on cortical or non-cortical blades. The other morphologies either previously described as scrapers or considered as such in the initial stages of the present study (tanged scrapers, a single sidescraper) turned out to be knives on a closer look although one of them (S8) may have served as a hide scraper in its final stages (see Taipale & Rots, submitted). Technologically speaking, the true scrapers form a relatively uniform category even if they vary in their dimensions to a certain extent.

The working edges of some of the pieces show retouch scars with pronounced bending initiations, suggesting the use of organic hammers in retouching. One piece (S13), on the other hand, has retouch striations in the form of clearly visible grooves, which points to a stone hammer and therefore suggests that different kinds of hammers were used in the making and/or maintenance of these tools. Use of a hard (most likely stone) anvil in retouching is visible on one of the scrapers (S1) as crushing and abrasion on the dorsal ridges in the distal and medial parts. It is particularly heavy in the distal extremity of the right main ridge (Taipale & Rots, submitted, fig. 3e). Under high magnification, this location shows grooves oriented transversally to the ridge and short flint-on-flint friction striations with slightly varying orientations.

Retouch in the non-active portions of the hafted endscrapers varies in quality and quantity. Some of the tools have unretouched proximal edges while certain scrapers present steep-angled bilateral retouch. This variability may partly have to do with the need to adjust proximal morphology to aid hafting. However, it is necessary to keep in mind that the sample may include examples of former knives recycled into scrapers. This means that the final shape of the lateral edges may be affected by hafting modifications as well as earlier stages in the use-lives of the tools.

3.4.3. Scraper-burins

The use-wear on one of the scraper-burins (SB2) corresponds well to that documented in the scraper and burin samples, which indicates that the tool functioned in two different functional contexts that were independent of each other. This would suggest that lithic recycling is responsible for the co-existence of two different working edges. Hafting wear on the piece is somewhat open to debate, but if the tool was hafted, this would be an additional argument against multifunctionality given that hafting one end would prevent its use unless the tool was constantly de- and re-hafted. SB1 likewise shows indications of hafting.

The sequence of burin and scraper use (or, in the case of SB1, scraper use and the failed attempt to turn the tool into a burin) could not be determined with certainty since the length of the tools is enough to prevent the burin spall negatives and scraper retouch (or the associated use-wear) from coming into contact with each other. Scraper-burins are not numerous in the collection and the interpretations here mostly rely on one tool, which limits the scope of conclusions. Nevertheless, it can be hypothesised that the artefacts analysed here represent the selection of previously used and discarded tools as blanks for new tools instead of the presence of truly multifunctional tools in the lithic toolkits (for similar observations on the Gravettian lithic assemblage from Hohle Fels, see Taipale *et al.*, 2020).

3.4.4. Knives

The functional knives identified thus far belong to a variety of typological categories. Leaving aside knives recycled into burins or scrapers (see above), these include tanged points, Maisières points, tanged scrapers, other tanged tools, and a single side scraper with low edge angles. This indicates considerable variability in terms of both distal and proximal morphologies. As discussed elsewhere (Taipale & Rots, submitted), two of the shaping techniques emblematic to the industry, namely direct invasive retouch and the tranchet blow (see Otte, 1976, 1979; Pesesse & Flas, 2012; Touzé, 2019), have frequently been involved in the shaping and maintenance of knives. Even though they were used also in the context of manufacture and repair of projectiles (Coppe, 2020; Taipale, 2020), the high number of knives identified so far, together with their extensive use-lives, give reason to argue that hunting/butchering knives are a tool category that has significantly affected the characteristics of the lithic assemblage and industry.

Hafting-related modifications on knives range from complete lack of retouch to the careful shaping of a tang. Both tanged and non-tanged knives have had extremely long use-lives, which means that the initial time investment in the knapping stage is not a good measure of the length of the use-life of the lithic tool.

4. Discussion

Despite the somewhat limited number of tool categories investigated here, the tools bear evidence of use in a relatively wide range of activities, and also reflect variability in hafting strategies. The results presented above will be discussed here from three points of view, namely links between lithic and osseous industries (5.1.), site function (5.2.), and hafting and tool design (5.3.). Butchering knives and their place in the lithic assemblage are discussed in a separate publication (Taipale & Rots, submitted), and the focus here is dominantly on scrapers and burins.

4.1. Lithic and osseous industry

The osseous industry from Maisières includes various objects made mostly of ivory and bone. The first group includes a piece that has been referred to as a pin (*épingle*), a thin, elongated object with a loop-like extremity (de Heinzelin, 1973: pl. XLII). Several pointed artefacts, some interpreted as possible projectile points, some as potential awls, and one tentatively as a fishing implement, have been also recovered (de Heinzelin, 1973; Otte, 1979). The assemblage in addition includes fragments interpreted as coming from ivory containers (de Heinzelin, 1973: pl. XLII; Otte, 1979: fig. 27:5, 7). Bone tools are represented by various implements fashioned particularly out of ribs of large mammals, but also out of shafts of long bones and other skeletal elements. Some of the tools have been further shaped by e.g. longitudinal scraping while others have been used unmodified. Also bird bones show evidence of having been worked (de Heinzelin, 1973; Lacarrière *et al.*, in press).

A recent in-depth technological analysis has identified hundreds of humanly modified ivory fragments, which had previously gone undetected in the assemblage, and thus established that ivory-working was one of the most prominent forms of the manufacture of osseous items at the site. Several technological markers indicate that the ivory was worked in a wet state (Goutas *et al.*, in prep.; Lacarrière *et al.*, in press), which has implications for use-wear patterns since the material becomes considerably more yielding.

Despite the abundant new data on organic production, the links between the osseous industry and the lithic tools examined in this study are not entirely straightforward to make. The straight, parallel scrape marks on ivory indicative of the use of strong, regular flint edges in transverse motion (Goutas *et al.*, in prep.; N. Goutas, personal communication) are a potential match for the transverse wear in the burin sample, but this kind of wear is relatively infrequent. Furthermore, we could not positively identify ivory wear in this study due to the limited experimental reference material available at the moment and the often weak development of use polish on the analysed tools. In addition to ivory, at least reindeer and bird bones show scrape marks (Lacarrière *et al.*, in press), which would support some of the tentative bone identifications in the burin sample. The traces on the faunal remains have not yet been compared to the lithic tool edges.

While reindeer remains, including antler fragments, have been recovered at the site (Gautier, 1973, 1979; Lacarrière *et al.*, in press), evidence of worked antler is limited (Lacarrière *et al.*, in press; N. Goutas, personal communication). The hesitant antler identifications in the burin sample are therefore worth a note. Particularly soaked antler and soaked ivory can produce overlapping traces, and the antler identifications should be considered preliminary and checked against ivory wear in future. The latest findings indicate that blanks for ivory objects were obtained mainly by other means than grooving (Goutas *et al.*, in prep.; Lacarrière *et al.*, in press) but some of the finished artefacts bear marks from such working. The perforation on the ivory pin was made with a burin (de Heinzelin, 1973: 32, pl. XLII), and an ivory fragment shows incisions consistent with the use of a similar tool (de Heinzelin, 1973: pl. XLIII, fig. 4). This means that it is reasonable to assume that some of the burins with evidence of use on hard animal material were used on ivory. Yet, further work is needed to estimate whether the burins with wear from grooving were limited to this worked material, or whether they could offer insights into production sequences that are less well visible in the osseous material recovered at the site.

4.2. Perspectives to site function and occupation duration

The functional screening of the burin assemblage and the detailed analysis of a sample of tools confirm that these artefacts were used for working hard animal-derived materials at Maisières. This supports the recent view that organic production was one of the central activities at the site (Lacarrière *et al.*, in press). The recovery of a considerable number of damaged projectile points (Coppe, 2020) and the identification of butchering marks on the faunal remains (Lacarrière *et al.*, in press) attest to hunting and prey processing activities. The cutmarks on animal bones are now matched with a significant number of lithic butchering knives, which stand as proof of obtaining hides and meat from hunted animals at the site and/or in its vicinity. The hafted hide scrapers can be viewed as components of toolkits involved in the further processing of the prey.

Even though the butchering tools identified here are in most cases still quite large in size, a portion of them shows clear evidence of having been abandoned in the middle of resharpening due to one or several failed blows. Even the ones on which the working edges remain seemingly functional have evidently been used for extended periods before they were finally discarded at Maisières. This points to retooling activities (see Keeley, 1982), the presence of which is further demonstrated by the existence of shaping flakes (tranchet flakes) with use-wear (Taipale, 2020; Taipale & Rots, submitted). These flakes are direct proof of retooling at the site. Impact-damaged points, some of which had already been reworked prior to their discard (Coppe, 2020; Taipale, 2020; Taipale & Rots, submitted: fig. S14), add to the body of evidence. Longer-term settlement sites have been said to accumulate evidence of retooling in the form of once-hafted tools (Keeley, 1982: 804). This means that the retooling component noticed at Maisières can be indicative of the duration of occupation. The lithic data presented here would thus lend support to the recent interpretations that Maisières-Canal was an at least medium-term camp site (Touzé, 2019; Lacarrière *et al.*, in press). It needs to be noted, however, that the sampling strategy employed in the present study focused exclusively on formal tools and, among them, favoured artefacts with (potentially) lengthy use-lives and well-developed use and hafting wear. This means that there is a bias towards objects that had reached the end of their functional lives, and that the current view of the collection may overemphasise the retooling component in assemblage formation. Attempts to interpret site function should preferably rely on more balanced samples.

4.3. Hafting and tool design

The present study has demonstrated that in addition to projectiles and tanged burins, also non-tanged domestic tools as well as butchering knives were hafted at Maisières. Burin hafting does not appear to be the norm at Upper Palaeolithic sites (Taipale, 2020), and Maisières-Canal is distinct in that it shows definite evidence of hafting of both tanged and non-tanged burins. Yet, this practice is still relatively anomalous, particularly when compared to scraper hafting (for differences in rates of hafting between tool categories and for possible explanations, see Taipale, 2020). There appear to have been incentives that encouraged burin hafting, but only in particular cases. Details of tool use may offer at least a partial explanation.

A majority of the tanged burins analysed previously were used for perforating (Rots, 2002a), and the two tools with the most solid evidence of hafting in the present sample also show a damage pattern that is partly consistent with this kind of use. Using a hafted tool in perforating as opposed to grooving could imply lower risk of breakage since the

pressure would be applied axially rather than obliquely or perpendicularly to the length of the tool, which reduces the risk of bending breaks. This could make hafting a perforating tool a more attractive option. This hypothesis remains to be tested experimentally, and the matter could also be further investigated by analysing formal perforators recovered at the site (on the condition that worked materials would be similar in terms of relative hardness). What is more, the proposed mechanical explanation does not mean that other factors should be overlooked. These include, for instance, task specialisation and a possible higher investment in tool manufacture (including hafting) for motives that might not have been purely technical.

Despite the absence of polish that would be characteristic enough to determine what the hafts were made of exactly, the tools analysed here offer some clues to the variability in raw materials and hafting strategies used at the site. The scarring on some of the scrapers suggests that they were attached to their handles with the help of bindings (or wrappings). The two hafted non-tanged burins in turn have fairly steep-angled edges, so characteristic binding scarring would have been less likely to form, and the evidence available does not suggest much more than that parts of the edges were in direct contact with relatively hard material. Even so, considering the previous interpretation that the tanged burins were hafted directly into antler handles (Rots, 2002a), the current evidence suggests that a minimum of two separate haft designs were used for domestic tools at the site (one with bindings and one without). Analogously, the use-wear patterns and proximal dimensions of the tanged and non-tanged butchering knives indicate that either there were at least two parallel handle designs available for butchering tools, or that one was applied for both that was flexible enough to allow considerable differences in proximal dimensions and morphology (Taipale & Rots, submitted).

From the present data, it is evident that varied know-how and raw material strategies were associated with stone tool hafting at Maisières. Simultaneously, lithic production systems dealt with hafting in a versatile and flexible manner. Scraper hafting is very common at this site, but these tools are dominantly endscrapers made on simple blades, and proximal modifications are mostly minimal or absent. Equally, the burin collection, while containing a number of tanged tools, also documents the (infrequent) hafting of artefacts without a tang. These data indicate that hafting did not require a high level of standardisation in terms of proximal morphologies but could be applied on tools with various dimensions by adjusting the haft design.

5. Conclusions

Our functional study demonstrated that a variety of tools outside the category of projectiles, namely hide scrapers, burins, and knives, were hafted for use at the site of Maisières-Canal. The data imply that more than one handle design was available for domestic tools, which points to diversity in raw material use and technical know-how. The detailed examination of use-wear patterns and the reconstruction of tool use-lives further showed that different forms of lithic recycling can be detected in the assemblage. Burins in particular show evidence of both flexible use and of extended, multi-stage use-lives. Scrapers and butchering knives, in contrast, can be viewed as relatively specialised tool categories, but both of these groups nevertheless also bear some evidence of recycling behaviours. The present results establish the high potential of the lithic collection for understanding technical decision-making and raw material strategies. In doing so, they encourage further investigations into these aspects, preferably with a view on social organisation, mobility patterns, and the environmental setting of the site.

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Abstract

The Early Gravettian open-air site of Maisières-Canal (Belgium) is known for its rich lithic industry that involves unique tool designs such as large, elaborately manufactured tanged points. The flint exploited at the site is particularly fine-grained and exceptionally well preserved, and therefore an ideal subject for detailed technological and functional analyses. The site has also yielded a rich and diverse collection of osseous artefacts and their manufacturing waste as well as faunal remains informative of the Pleistocene environment and human subsistence strategies. Despite its consequently high potential for studies interested in Upper Palaeolithic technologies in their ecological and social context, the lithic assemblage has until recent years been studied from a functional point of view only to a limited extent. We present the results of the first use-wear study that included several tool categories as well as sizeable samples outside the collection of tanged tools. We analysed these artefacts with a combination of microscopic methods and could show that all the tool categories (burins, scrapers, scraper-burins, and pointed tools) bear evidence of hafting and allow a detailed reconstruction of tool use-lives. These results are informative of the technical choices made by tool users at the site. We discuss the data with an eye on the recent results on osseous industry, and offer points of view to the nature and duration of site occupation.

Keywords: Maisières-Canal, Prov. of Hainaut (BE), lithic use-wear, hafting, domestic tools, Upper Palaeolithic, Gravettian.

Résumé

Le site en plein air du Gravettien ancien de Maisières-Canal (Belgique) est connu pour sa riche industrie lithique avec des concepts d'outils uniques tels que de grandes pointes pédonculées taillées de manière élaborée. Le silex exploité sur le site est particulièrement fin et exceptionnellement bien conservé, et donc un sujet idéal pour les analyses technologiques et fonctionnelles poussées. Le site a également livré une collection riche et diverse d'artefacts osseux et leurs déchets de fabrication, de même que des restes fauniques reflétant l'environnement pléistocène et les stratégies de subsistance humaines. Malgré son fort potentiel pour les études portant sur les technologies du Paléolithique supérieur dans leur contexte écologique et social, l'assemblage lithique n'avait été étudié, jusqu'à ces dernières années, d'un point de vue fonctionnel que dans une mesure limitée. Nous présentons les résultats de la première étude tracéologique comprenant plusieurs catégories d'outils y compris des échantillons considérables d'outils non pédonculés. Nous avons analysé ces artefacts avec une combinaison de méthodes microscopiques et avons pu montrer que toutes les catégories d'outils (burins, grattoirs, grattoirs-burins et outils pointus) portent des traces d'emmanchement. Nos analyses ont également permis une reconstruction détaillée de la vie fonctionnelle des outils. Ces résultats traduisent les choix techniques effectués pour l'outillage sur ce site. Nous discutons aussi nos données lithiques en parallèle avec les résultats récents sur l'industrie osseuse, et proposons des points de vue sur la nature et la durée d'occupation du site.

Mots-clés : Maisières-Canal, Prov. de Hainaut (BE), tracéologie, emmanchement, outils domestiques, Paléolithique supérieur, Gravettien.

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