Every hunter needs a knife: hafted butchering knives from Maisières-Canal and their effect on lithic assemblage characteristics

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Abstract

Despite the central role butchering tools have had in the origins and development of human technologies, they have been overlooked in technological and functional studies with few exceptions. We use new results on the Gravettian assemblage from Maisières-Canal (Belgium) to illustrate how butchering knives were integrated in lithic production sequences and how the hafting, use and maintenance of these tools have affected the characteristics of the resulting lithic assemblage. The detailed low and high magnification analysis of a sample of knives, previously characterised as "tanged points", "Maisières points", and "tanged scrapers", shows that these hunting knives were nearly always used hafted and had extensive use-lives. They were therefore an important component in the toolkits of the Gravettian hunter-gatherers occupying the site and are partly responsible for some of the most idiosyncratic traits of the lithic assemblage. These results underline the importance of maintaining a broad view of different tasks and needs to which toolkits responded, and encourage future studies to approach lithic assemblages from this perspective instead of prioritising projectile armatures.

Keywords

butchering tools; lithic use-wear; hafting; tool design; Gravettian

1 Introduction

Hunting weapons continue to fascinate prehistoric archaeologists above all other tool categories whereas butchering tools that can be considered equally relevant for human evolution have received much less attention in use-wear literature and elsewhere (see, however, e.g. Claud, 2008; Jacquier, 2015; Odell, 1980; Plisson and Beyries, 1998; Rots, 2015, 2013). This situation is peculiar given that butchering tools have belonged to lithic toolkits since the very dawn of human tool-making. The earliest unequivocal evidence of the use of stone tools in meat extraction currently dates back to more than 2.5 million years ago and consists of cutmarks on bones found in association with stone tools (see e.g. Barham and Mitchell, 2008, pp. 95–107; Bunn and Kroll, 1986; de Heinzelin et al., 1999; Domínguez-Rodrigo and Pickering, 2017). In contrast, the earliest solid evidence of lithic weapon armatures is about 250,000 years old (Rots, 2013; for a critical evaluation of recent claims made for older contexts, see Rots and Plisson, 2014) and the oldest preserved self-pointed wooden spears date to about 400,000–300,000 years ago (Allington-Jones, 2015; Oakley et al., 1977; Rots, 2015, p. 385; Thieme, 1997). While the considerable gap between the earliest dates for stone tool-assisted butchering and hunting may be partly explained by the rarity of direct evidence of the latter in faunal assemblages (cf. Boëda et al., 1999) and by the difficulties in reliably identifying lithic armatures at old sites based on use-wear evidence (for a discussion and recent developments, see Coppe, 2020; Coppe and Rots, 2017; Rots and Plisson, 2014), it is obvious that butchering knives are among the oldest human-made tools. We argue that they have therefore substantially affected the goals of lithic production sequences in contexts where hunting (or scavenging) contributed to the human diet and that they can provide a window into long-term technological change and/or continuity in such settings. Here, we discuss newly identified butchering knives from the Early Gravettian site of Maisières-Canal and the influence they have had on the lithic technology at the site. We show that in Upper Palaeolithic contexts, an overemphasis on projectile armatures at the expense of other tool categories prevents seeing technical solutions in their full versatility and adaptivity.

Maisières-Canal (c. 28,000 BP) is known for its distinct stone tool industry characterised by the production of skilfully shaped tanged and non-tanged pointed tools as well as numerous burins and other implements made on very large blades in high-quality flint. The collection has previously been subject to technological analyses (see e.g. Otte, 1979; Pesesse and Flas, 2012; Touzé, 2018) and both blank production and shaping sequences have been addressed recently in high level of detail (Touzé, 2019). Earlier functional studies have demonstrated the considerable potential of the assemblage for microwear analysis – and particularly for the study of Upper Palaeolithic hafting practices – by identifying hafted tanged burins in the collection (Rots, 2002a, 2002b). Nevertheless, the hallmarks of the industry, i.e. tanged points and Maisières points, have not been extensively examined from a functional perspective until now. The work done in the most recent years has focused exclusively on projectile identification and weapon reconstruction (Coppe, 2020; Taipale et al., 2017) while the potential non-projectile uses of the points have received little attention. Previously only three pointed tools have been found to show indications of use as butchering knives in contrast to seven points and nine tang fragments interpreted as remains of hunting weapon armatures (Rots, 2002a).

To correct this bias and to gain a broader view of the technological strategies at the site, we sampled the collection for detailed functional analysis with the specific goal of identifying possible non-projectile (particularly knife) use as well as traces of hafting. We show that besides the previously identified projectiles, the point collection includes a large number of hafted butchering knives that were an integral part of the toolkits used by the occupants of the site. We discuss the use-lives of the tools as well as the impact of knife use and hafting on assemblage characteristics, paying particular attention to clear technological markers such as invasive (flat) direct retouch, use of the tranchet blow, and the presence of a tang. We show that the need to shape, haft, and maintain prey processing tools has contributed significantly to the techno-typological idiosyncrasies of the assemblage, or, more broadly, the industry named after it (see e.g. Pesesse and Flas, 2012). These results highlight the importance of gaining a good understanding of the manufacture and use of not only weapon armatures but different parts of hunter-gatherer toolkits in attempts to understand long-term technological change and its links to human adaptive strategies (for a similar view of Middle Palaeolithic lithic assemblages, see Plisson and Beyries, 1998). Successful hunting requires not only effective weaponry but also the right tools for the subsequent processing of the prey, which means that different parts of hunting toolkits should be studied in parallel – and preferably in combination with so-called domestic tools – to arrive at a better understanding of overall technical systems and the place of chipped lithics within them.

2 Material

2.1 Gravettian occupation at Maisières-Canal

Maisières-Canal is an open-air site located on the northern edge of the alluvial plain of the Haine River near the town of Mons. Excavated mainly in the 1960s, it is one of the few Gravettian open-air sites known from the region (Haesaerts et al., 2016; Haesaerts and de Heinzelin, 1979; Miller, 2004). The archaeological remains were remarkably well preserved in situ within a loess sequence. Thirteen radiocarbon dates consistently place the human occupation to around 28,000 BP (de Heinzelin, 1973; Haesaerts and Damblon, 2004; Jacobi et al., 2010).

In prehistoric times the site was ideally located along animal migration routes in the proximity of a ford in the river Haine (Haesaerts and de Heinzelin, 1979, p. 48). Of large mammals, reindeer and horse are best represented in the faunal assemblage, followed by bear, bos/bison and cervids. Small fauna (hare, fox, birds) are abundant and may indicate varied hunting strategies, including trapping (Gautier, 1979, p. 68; Lacarrière et al., in press). Frequent cutmarks on the bones testify to butchering activities (Lacarrière et al., in press).

The abundancy of burnt bone and the volume of lithic and osseous manufacturing waste indicate that the site was occupied for a relatively long period of time, and the presence of mammoth remains (including at least one tusk) as well as the vicinity of the flint outcrops may have been among the reasons why the occupants chose this particular location (Lacarrière et al. in press; Touzé, 2019).

2.2 Lithic collection and pointed tools

The lithic collection from Maisières is extremely rich. The flint used at the site is black in colour and generally of extremely high quality. It was sourced locally, from within c. 10km radius. The lithic industry is characterised by large blades produced from bidirectional cores. These blanks were worked into various tools, including tanged points (n=56) and so-called Maisières points (n=121) shaped with invasive retouch. The assemblage also comprises a small number of other tanged tools such as burins and scraper-like implements (Fig. 1). Bladelet production is practically non-existent (Moreau et al., 2016, 2013; Otte, 1979; Pesesse and Flas, 2012; Touzé, 2019, 2018; Touzé et al., 2016; counts from Touzé, 2018, table 2).

Figure 1. Examples of flint tools from Maisières-Canal. Top row: Maisières points and point fragments (from left to right, MP14, MP15, MP16, MP17, P1, MP10, MP11); bottom row: tanged tools (from left to right, P2, P14, TP21, TP15, S9, S8, Burin B). The artefacts in the top row all show a tranchet blow.

It has been proposed that the making of the points was taken into account in core reduction by producing blanks with a predetermined shape (a thin and acute-angled distal tip) (Otte, 1979, p. 69; Pesesse and Flas, 2012, p. 97). The finished points vary greatly in the amount of retouch applied on the limb, and also in their dimensions (Touzé, 2018). They frequently show a so-called tranchet blow at their distal extremity, which gives the tip its final shape (see Fig. 1). This blow is struck longitudinally so that it removes a portion of the distal lateral edge initially shaped by transverse retouch (see Otte, 1979, p. 71; Pesesse and Flas, 2012; Touzé, 2019, 2018).

Some of the pointed tools have been identified as projectiles in a preliminary functional study (Rots, 2002a) and also in a subsequent technological study that relied exclusively on so-called diagnostic impact fractures (DIFs) (Pesesse and Flas, 2012). Projectile use has later been confirmed through in-depth functional analyses (Coppe, 2020; Taipale, 2020; Taipale et al., 2017). In contrast, other possible functions have received less attention. The first microscopic study on the collection involved 20 tanged tools and mentions two of the artefacts as knives (Otte and Caspar, 1987, fig. 2) but provides no functional details for them. Three pointed tools with low magnification evidence indicative of use as butchering knives have subsequently been identified (Rots, 2002a), and technological attributes such as overall morphology and edge characteristics have been taken as signs of potential functional variability among the pointed tools (Otte and Caspar, 1987; Pesesse and

Flas, 2012). Yet, a comprehensive study aimed at identifying non-projectile use has not been undertaken prior to the present one.

3 Methods

3.1 Analysed sample and analytical procedure

To investigate possible non-projectile use of the pointed tools, we first screened the whole collection with low magnification. A sample of 41 potential knives was selected for more detailed low magnification analysis and 24 of these were also examined with high magnification. Besides pointed tools (tanged points, Maisieres points, and distal fragments), the sample included two tanged tools with scraper-like distal extremities as well as a single sidescraper. After the first confident identification of knife wear and the observation that resharpening has often made the use-wear difficult to interpret, altogether 15 tools of the sample of 24 were re-examined with both low and high magnification and the remaining nine with low magnification. The discussion of wear features here largely builds on this re-examination that offers the highest level of detail. In addition to the tools themselves, six tranchet flakes and one shaping flake identified among the waste material in a previous technological study (Pesesse and Flas, 2012) were analysed for use-wear. No systematic attempt has yet been made to refit these flakes with tools.

Wear can form in all the stages of the life cycle of a tool, including production, hafting, use, deposition and burial (see e.g. Hayden, 1979; Keeley, 1980; Levi Sala, 1986; Odell, 1981; Odell and Odell-Vereecken, 1980; Rots, 2012, 2010a, 2010b; Semenov, 1964; Tringham et al., 1974), and sometimes also excavation and/or post-excavation storage and handling. Among the most important sources of error in identifying use and hafting wear in the Maisières-Canal collection are production and storage wear. These aspects are therefore briefly discussed before presenting the results on functional wear.

The reference collection used in the study is hosted at TraceoLab, University of Liège, and comprises nearly 5000 experimental tools, which cover a wide range of tool use activities as well as different hafting arrangements. For the present purposes, two experiments are particularly important to highlight. The first, designed to investigate butchering wear in further detail, involved the processing of two fresh carcasses (*Equus ferus caballus*) outdoors by a professional butcher who used flint flake tools. In addition, a single replica of a tanged Maisières knife, used in butchery for 45 minutes, was added to the existing body of reference material as a first test to allow an initial comparison of use and hafting wear. The second experiment in turn addressed the question of hafting and propulsion mode (weapon system) of the tanged points from Maisières (Coppe, 2020; Taipale et al., 2017). For this work, careful replicas of the Maisières artefacts were made, hafted in different ways, and shot into a target using different propulsion modes (hand-cast and thrusting spears, spearthrower, bow). This reference material helped understand variability, including partial overlap, in edge damage and microwear from butchering and projectile use (cf. e.g. Rots and Plisson, 2014). The TraceoLab reference collection also contains artefacts subjected to simulated taphonomic processes (Michel et al., 2019) as well as subcollections representing different kinds of production wear (see Rots, 2010b), which help avoid confusing functional wear with these traces.

The wear interpretations rely here on a combination of observations made macroscopically, with a stereomicroscope using oblique lighting at magnifications below 100× (e.g. Lawrence, 1979; Odell, 1981; Odell and Odell-Vereecken, 1980; Tringham et al., 1974), and with a metallurgical microscope using incident lighting at magnifications between 50× and 500× (e.g. Juel Jensen, 1994; Keeley, 1980; Vaughan, 1985). Hafting wear was identified following principles outlined in previous publications (Rots, 2010a, 2005, 2003, 2002a; Rots et al., 2006). Given that the Maisières collection had been washed and handled previously, residues were not a focus here. The tools were nevertheless screened for potential functional residues prior to cleaning them for analysis with ethanol and/or acetone. The rare residues potentially linked to human activities encountered during the analysis (see Taipale, 2020) are not relevant for the questions at hand and are therefore not discussed here.

The material was analysed at the Royal Belgian Institute of Natural Sciences using two stereomicroscopes, a Leica S9i (magnifications 6.1–50×) and a Nikon 229030 (magnifications 8–40×) and an Olympus BH2-UMA metallurgical microscope (magnifications 50–500×). The photos were taken under low magnification using the integrated camera on the Leica S9i with the LAS software (version 4.12.0). The high magnification photos were taken with a Nikon digital camera D7200 mounted on the microscope with an adapter NDPL-1(2X). The software Nikon Camera Control Pro 2 was used for image capture and Helicon Focus Lite for z-stacking. A limited number of artefacts were further analysed and imaged at TraceoLab under low magnification using a Zeiss Macro-Zoom Macroscope V16 and Zeiss AxioVision software for image capture and Helicon Focus Pro for z-stacking. The high magnification photos for these tools were taken with a Zeiss reflected light microscope AxioImager (magnifications between 50× and 1000×) and the AxioVision software and stacked in the same software.

3.2 Production wear

The flint used at Maisières is very fine-grained and wear forms easily as a result of both anthropogenic and taphonomic processes. Production (knapping) wear is abundant in the collection, particularly on the tanged pieces due to the lengthy shaping process that involves several stages of careful preparation (Touzé, 2018). To gain a better understanding of the microwear formed during the shaping process, a number of experimental tanged points produced for projectile experiments (Coppe, 2020) were examined under both high and low magnification before hafting and use. These replicas had been shaped with sandstone and deer antler hammers using a wooden anvil to aid the final shaping of the tang. Examples of experimental and archaeological production wear are shown in Figures 2 and 3.

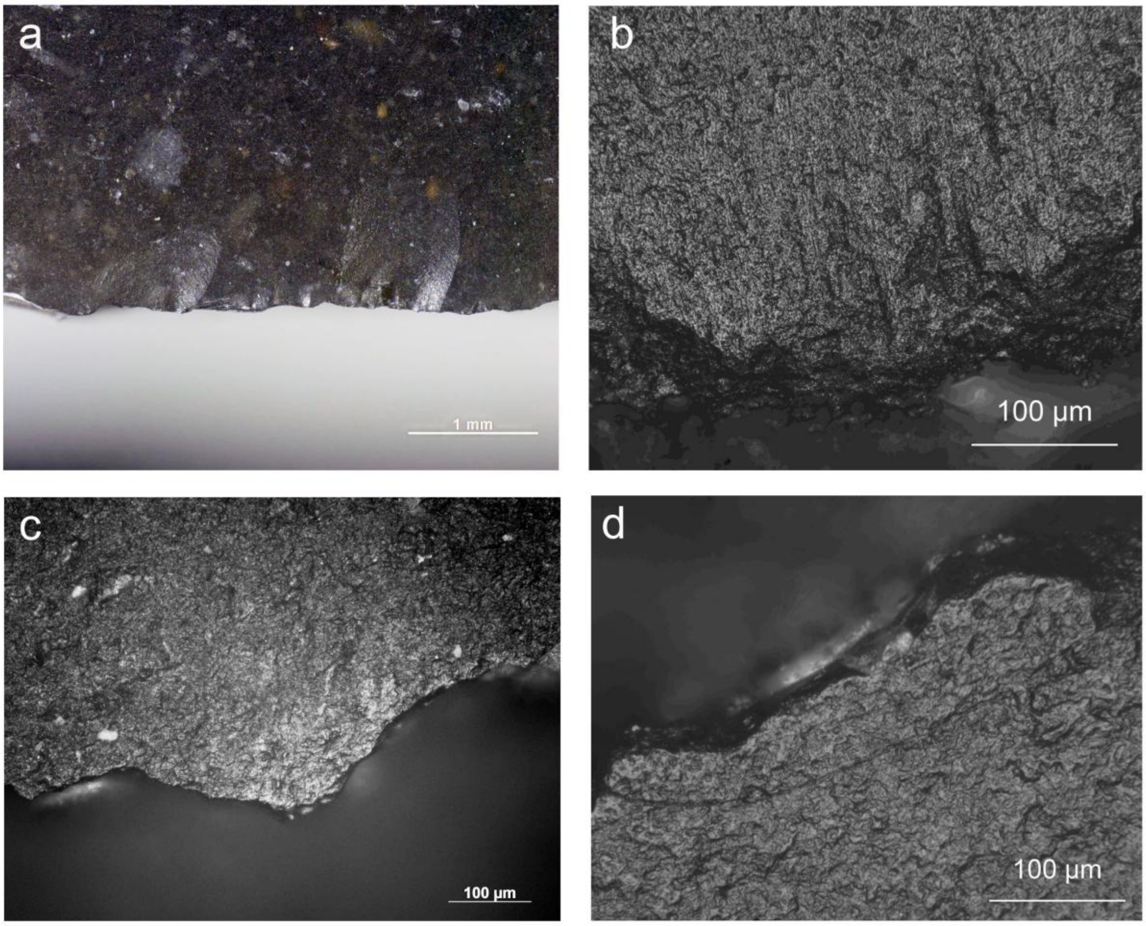

Figure 2. Production wear on experimental and archaeological tanged tools. a. Ventral scars from incidental hammer contact on the ventral medial tang edge of Exp. 78/04 (50×); b. Heavily striated edge on the ventral proximal right part of the tang on P356.B6.2 from Maisières-Canal (400×); c. Hammer polish and striations on the ventral medial left tang edge of Exp. 78/05 (200×); d. Edge rounding and polish from an organic hammer and an incipient crack witnessing an unsuccessful blow on the ventral distal right tang edge of TP15 from Maisières-Canal (400×).

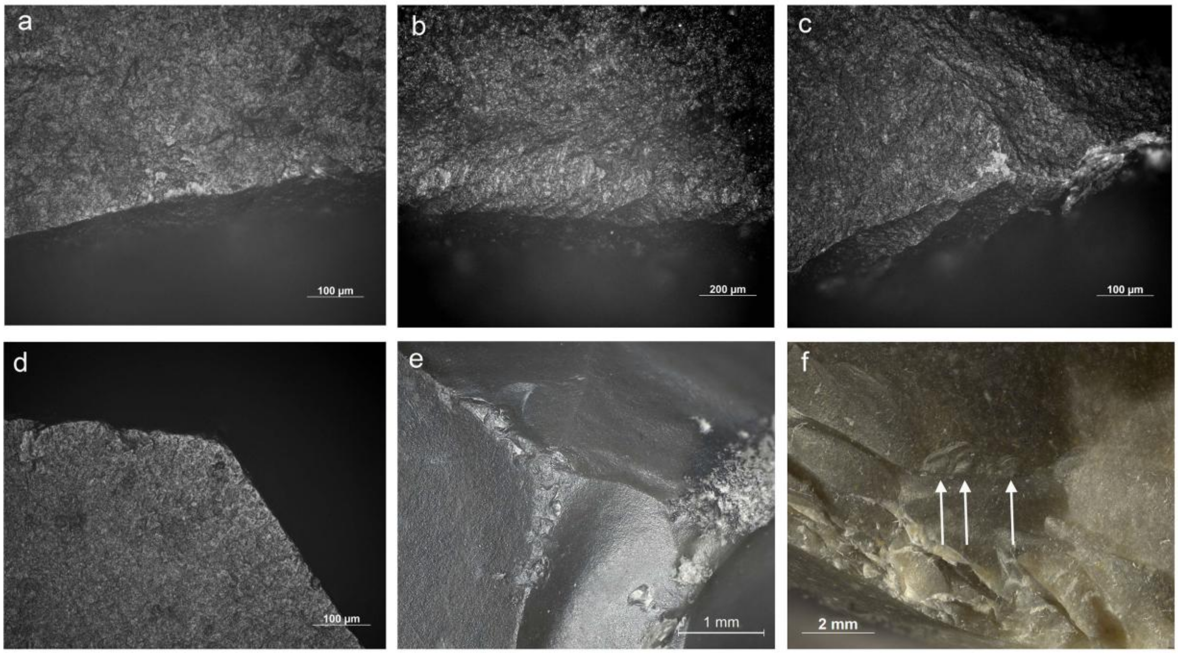

Figure 3. Production wear on experimental and archaeological tools. a. Transverse flint-on-flint polish on the dorsal ridge of the tang on Exp. 78/07 (200×); b. Transverse striations on the dorsal ridge of the tang on Exp. 78/01 (100×); c. Production-related bright spot on a tang ridge on Exp. 78/30 (200×); d. Wood anvil polish on the dorsal ridge of the tang on Exp. 78/53 (200×); e. Macroscopic anvil wear on the dorsal distal ridge of scraper S1 from Maisières-Canal (30×); f. Secondary scars (arrows) at the termination of a shaping scar on the medial left edge of the tang on Exp. 78/01 (20×).

3.3 Storage wear

In addition to the taphonomic wear attributed to soil processes, the assemblage shows numerous striations that probably derive from storage (see also Otte and Caspar, 1987). The material is stored on large wooden trays in cardboard boxes that contain several artefacts, and when the trays are moved, the artefacts move against each other, which leads into the formation of linear features. These striations are often long and can be broad but are usually superficial and are matched with traces on experimental flint flakes that were moved around in boxes. Also traces linked to more intense localised friction can occur (Fig. 4).

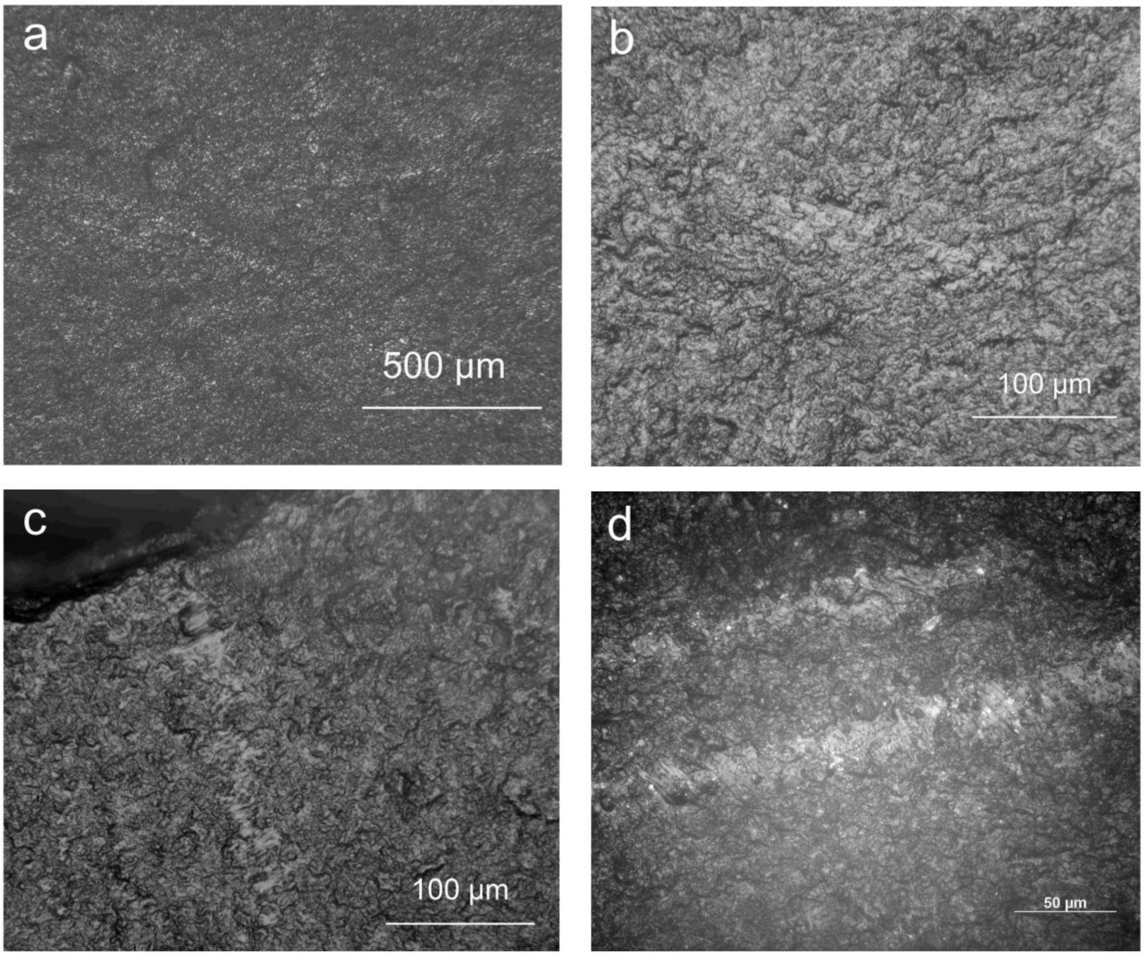

Figure 4. Storage wear on experimental and archaeological tools. a. Striations on burin B6 from Maisières-Canal (100×); b. Same striation at 400×; c. Flint-on-flint polish with internal linearity perpendicular to the orientation of the feature itself on the ventral medial right tang edge of TP15 from Maisières-Canal (400×); d. Similar features on Exp. 18/06 involved in a storage experiment (500×).

4 Results

Knives proved to be frequent in the analytical sample but the use-wear is often discontinuous and untypical due to abundant resharpening. Many of the artefacts were securely identified as knives only after the re-evaluation that followed the first positive knife identification. Of the 15 tools that were re-evaluated both with low and high magnification, 11 showed wear consistent with use as butchering knives. A further seven pieces showed similar but not as conclusive evidence. The remaining artefacts (n=6) are either probable projectiles or the wear pattern on them does not allow distinguishing between projectile and knife use. Of the 11 artefacts with strongest evidence of knife use, nine have been shaped with characteristic invasive retouch, six show a tranchet blow, and a further three possible remains of a tranchet negative, cut by subsequent shaping (Table 1).

Tool ID	Functional interpretation	Tool class	Invasive retouch	Tranchet blow	Magnification
TP15	Butchering knife	Tanged point	Yes	Yes?	Combined
TP21	Butchering knife	Tanged point	Yes	No	Combined
P14	Butchering knife*	Tanged point	No	Yes?	Combined
TP12	Butchering knife	Tanged point	Yes	Yes	Low
S8	Butchering knife**	Tanged scraper	No	No	Combined
S9	Butchering knife	Tanged tool	Yes	Yes?	Combined
MP15	Butchering knife	Maisières point	Yes	Yes	Combined
MP16	Butchering knife	Maisières point	Yes	Yes	Combined
MP10	Butchering knife*	Distal fragment	Yes	Yes	Combined
MP11	Butchering knife*	Distal fragment	Yes	Yes	Combined
P1	Butchering knife*	Distal fragment	Yes	Yes	Combined
TP3	Probable butchering knife	Tanged point	No	No	Low
O3	Probable butchering knife	Maisières point	Yes	Yes?	Combined
MP5	Probable butchering knife	Maisières point	Yes	Yes?	Low
TP7	Possible butchering knife	Tanged point?	Yes	Yes	Low
MP14	Possible butchering knife	Maisières point	Yes	Yes	Low
MP13	Possible butchering knife	Distal fragment	Yes	Yes	Low
S14	Possible butchering knife	Sidescraper	No	No	Combined
TP9	Probable projectile	Tanged point	Yes	Yes	Low
MP17	Probable projectile	Maisières point	Yes	Yes	Combined
MP7	Probable projectile	Distal fragment	Yes	No	Combined
TP4	Projectile/butchering knife	Tanged point	Yes	Yes	Low
MP12	Projectile/butchering knife	Distal fragment	Yes	Yes	Low
MP1	Projectile/butchering knife	Distal fragment	Yes	No	Combined

Table 1. Functional interpretations for the sample of tools analysed in the highest detail (n=24). The tools marked with a single asterisk (*) have evidence indicative of previous use as projectiles. The tool marked with a double asterisk (**) was possibly used as a scraper in the final stage. The presence of characteristic shaping techniques, i.e. invasive retouch and tranchet blow, is indicated ("yes?" refers to cases where the supposed tranchet negative is only partially preserved). The last column shows the magnification used in the re-evaluation (low vs combined low and high). All tools were initially analysed with both low and high magnification.

If the three tools previously linked to butchering activities (Rots, 2002a) are included in the counts, the number of presently known certain and possible knives within the assemblage comes up to 21. This is a high count given that only a small sample was analysed in the highest detail. In comparison, the number of tanged points identified as projectiles with full certainty is currently 16 (J. Coppe, personal communication). While their actual number can be assumed to be somewhat higher because all projectiles do not present wear that would allow their identification using the strictest criteria (cf. Coppe, in press; Coppe and Rots, 2017; Rots and Plisson, 2014), the new data suggest that knife use was frequent among the lithic tools and should be considered when assessing the overall technological strategies. This view is further supported by the observation that a considerable portion of the knives identified with the highest degree of confidence have been shaped using invasive retouch and a tranchet blow, which are among the clearest technological markers in the assemblage.

4.1 Use-wear

The tools were identified as butchering knives on the basis of co-occurrence of relatively heavy (invasive) edge damage and microscopic features on the distal edges. The intensity of use-wear varies between the tools and frequent resharpening has often led to a discontinuous pattern. Trace combinations on individual tools are illustrated in the Supplementary material, focusing on the artefacts with the most explicit evidence.

All the tools show some form of scarring. At its most characteristic, it is found on the tip or in its immediate vicinity (Figs. 5a, S1a-b, S2a, S3b, S4c-d, S6a). The scars can vary in dimensions but are typically bending-initiated, rather invasive, and oriented longitudinally or obliquely to the main axis of the tool.

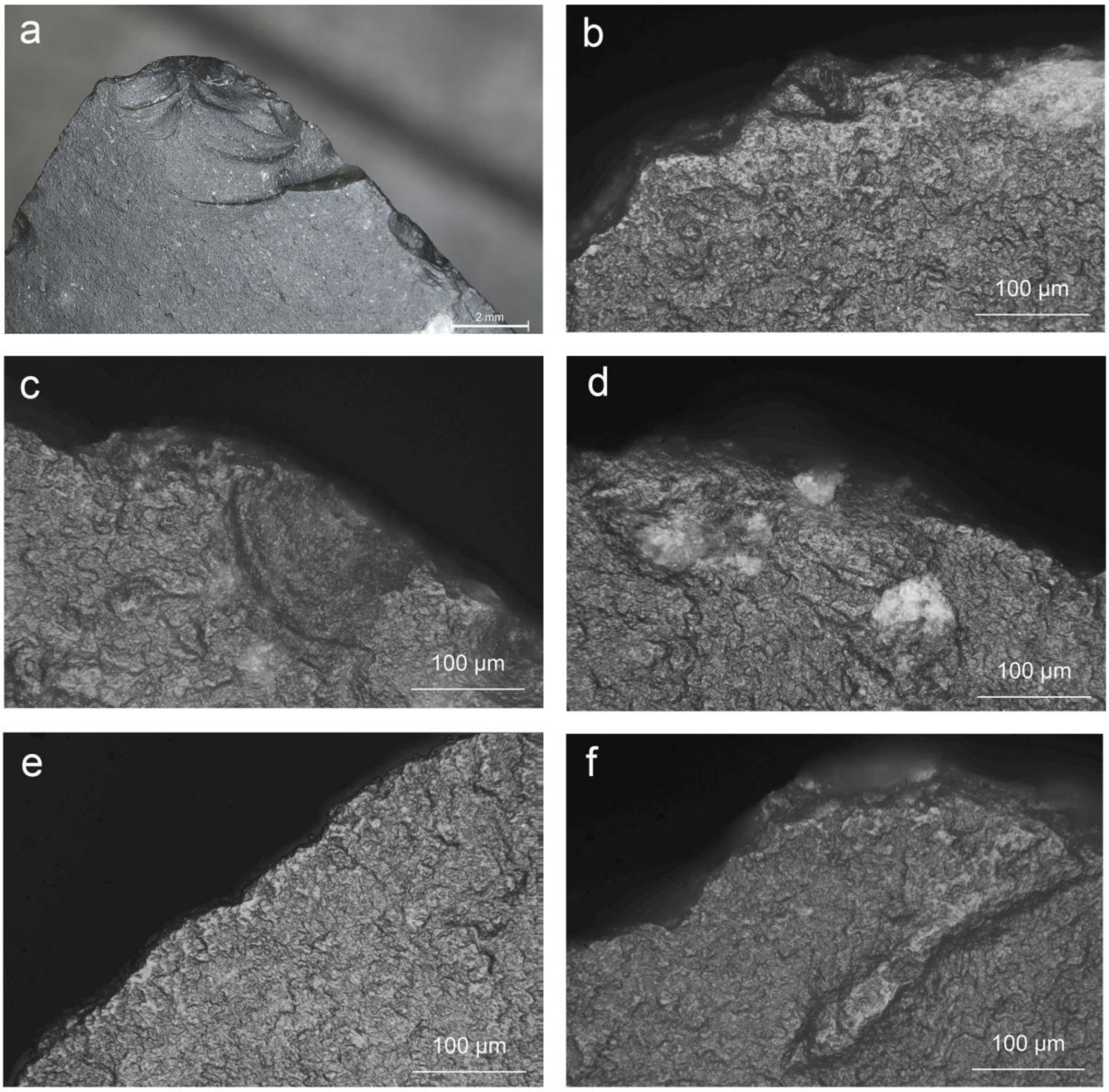

Figure 5. Examples of use-wear features on the knives from Maisières-Canal. a. Ventral edge damage on the tip of MP15 (10×); b. Rounding and bright polish on MP16 (400×); c. Edge damage, rounding and polish on MP16 (400×); d. Heavy edge rounding with clear longitudinal linearity on MP16 (400×); e. Narrow band of obliquely oriented flint-on-flint polish on MP14 (400×); f. Rounding and polish on the edge and high areas behind it on TP15, partly cut by resharpening removals (400×).

Well-developed edge rounding associated with polish is among the most distinct forms of wear encountered in this sample (Figs. 5b-d, S6b, S12a). In many cases, however, the microwear on the active edges is limited to a narrow band of polish (Figs. 5e and S3f) that is probably the result of friction between the edge of the tool and small chips detaching from it. Similar features have been previously documented on other archaeological butchering knives (e.g. Jacquier, 2015, fig. 37d).

Notably, bone polish is either lacking or not distinct enough to be identified with certainty. This is not necessarily in contradiction with the butchering knife interpretation considering that contact with bone is not desirable in most stages of the process (e.g. Frison, 1979) and that contact that is substantial enough to produce well-developed polish is likely to blunt the tool edge to a point where it needs resharpening.

Definite meat polish is rare in the present sample most probably because it is indistinguishable from the slightly altered surfaces (cf. e.g. Michel et al., 2019). The butchery interpretation is therefore based on edge damage indicative of contact with hard material and edge rounding and polish suggestive of contact with soft animal tissue. In rare cases, typical knife wear (invasive longitudinal polish) could be documented, but even then, it has been partly removed by resharpening (Fig. 5f).

Examples of the co-occurrence of different use-wear features on the knives are shown in Table 2. Four of the pieces with the strongest evidence of knife use (n=11) also show indications of previous use as projectiles (see Table 1 above; Figs. S8b, S9b-c, S10b-c). All the tools present evidence of resharpening, which affects the feature combinations.

Tool ID	Tip damage	Heavy edge rounding	Damage + flint-on-flint polish	Other polish	Striations	Bright spots
MP15	+	+	+	+	+	-
MP16	+	+	+	+	+	+
TP15	+	-	+	+	+	-
TP21	-	+	+	+	+	+
S9	+	+	+	+	+	+
S8	+	+	+	+	+	-
P14	-	+	-	+	+	-
P1	NA	-	+	+	+	-
MP11	+	+	-	+	+	-
MP10	+	+	-	+	-	-

Table 2. Combinations of use-wear features on the Maisières-Canal knives with the most abundant wear evidence. 'Tip damage' refers to invasive scarring on the tip or at the distal extremity. All tools also show other forms of edge damage. TP12, the last of the knives identified with a high degree of confidence, is not included here because it was only analysed with low magnification.

The overlap between edge scarring from butchering and (minor) damage from projectile use is evident from this sample, and hasty conclusions should clearly not be drawn to one direction or the other on the basis of low magnification evidence alone (cf. Claud, 2008; Plisson and Beyries, 1998; Rots and Plisson, 2014). In the case of Maisières, the patchiness and the occasional ambiguity of the microwear – the effect of the habitual resharpening of the knife edges – add to the potential confusion. Despite the long use-lives of the tools, they could be securely identified only by combining observations made with low and high magnification and by incorporating the hafting evidence (cf. Plisson and Beyries, 1998; Rots, 2010a; Rots et al., 2006).

4.2 Hafting wear

Hafting wear on the knives from Maisières is exceptional in its degree of development. Some of the features, such as bright spots, are so extensive that they were initially mistaken for taphonomic wear because the hafting wear identified in other tool categories is much subtler (cf. Taipale, 2020), but the clearly repetitive pattern of combinations of features between different tools finally allowed identifying them as extremely well-developed haft wear. The sidescraper S14 that has been identified as a possible butchering knife (Fig. S11) is the only hand-held tool in the sample.

The wear visible under low magnification consists of edge damage, edge rounding, and scarring and abrasion of ridges. Scarring can be pronounced on unretouched edges (i.e. on Maisières points). It occasionally resembles retouch, but the associated linear features are oriented longitudinally and demonstrate that it is incidental damage (Fig. 6a-c). On tangs, edge damage is usually either limited due to the steep angle of retouch and the flat ventral surface, or impossible to tell apart from production-related removals. Scars on tang edges were attributed to hafting only when they were found associated with diagnostic microscopic traces (Fig. 7a) or when their orientation clearly differs from what could be expected from production-related accidental removals (Figs. S5c, S7d and S13c; cf. Fig. 2a). The proximal parts of limb edges that are more acute-angled than the tang can show edge damage (Figs. S7c, S8c and S13b), sometimes associated with relatively heavy rounding. Also counter-pressure scars on the shoulders adjacent to the tang occur (Figs. S5c and S13c).

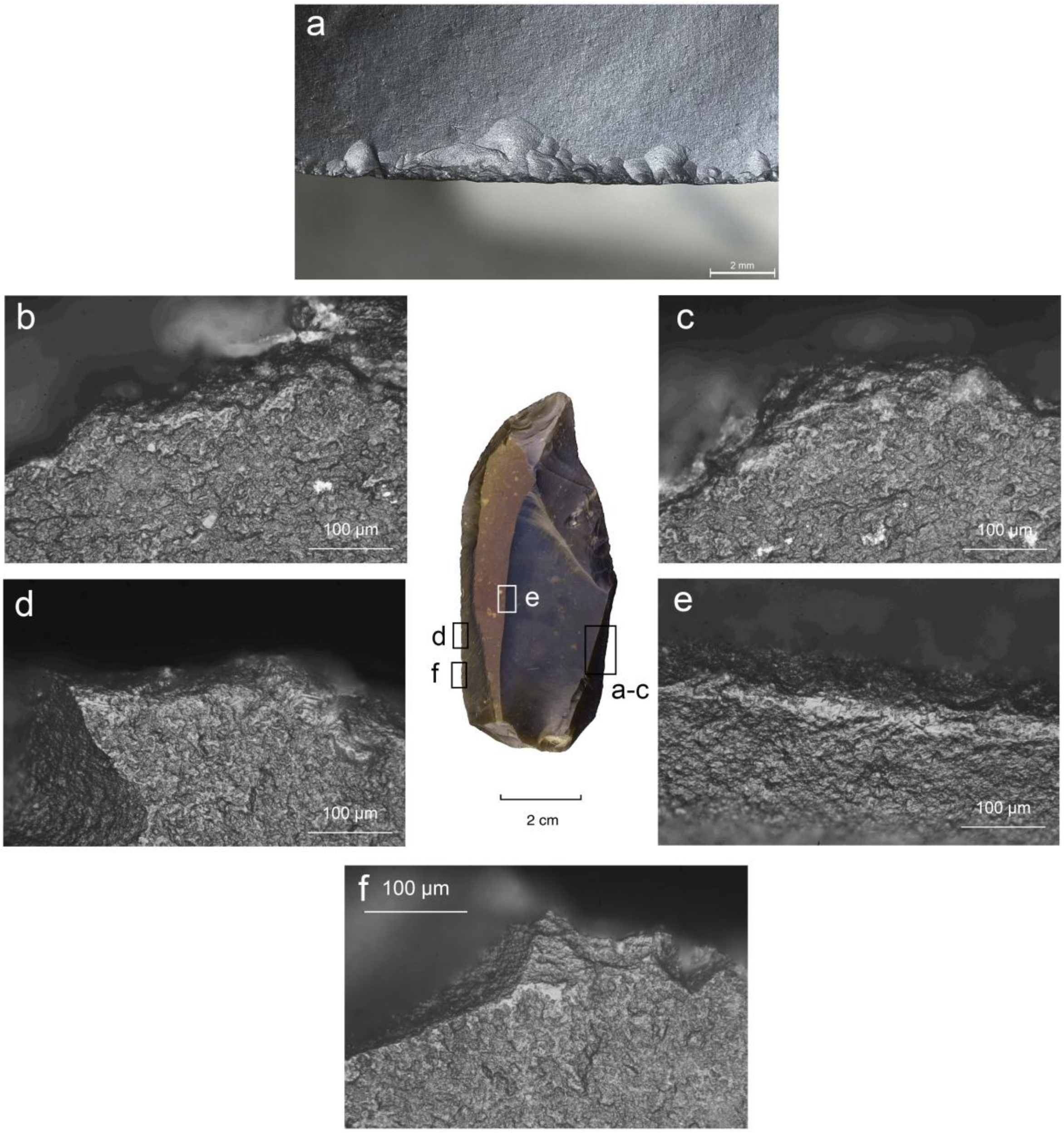

Figure 6. Hafting wear on butchering knife MP15. a. Retouch-like edge damage from contact with the handle on dorsal proximal right edge (10×); b. and c. Edge rounding and polish with longitudinal orientation on the ventral aspect of the area shown in a., demonstrating that the damage is due to movement in the handle (400×); d. Edge rounding and polish with embedded deep longitudinal striations on the ventral aspect of the opposite edge at the same height (400×); e. Strongly polished part of the ridge in the area where haft limit probably was (400×); f. Possibly hafting-related bright spots on the ventral proximal left edge (400×).

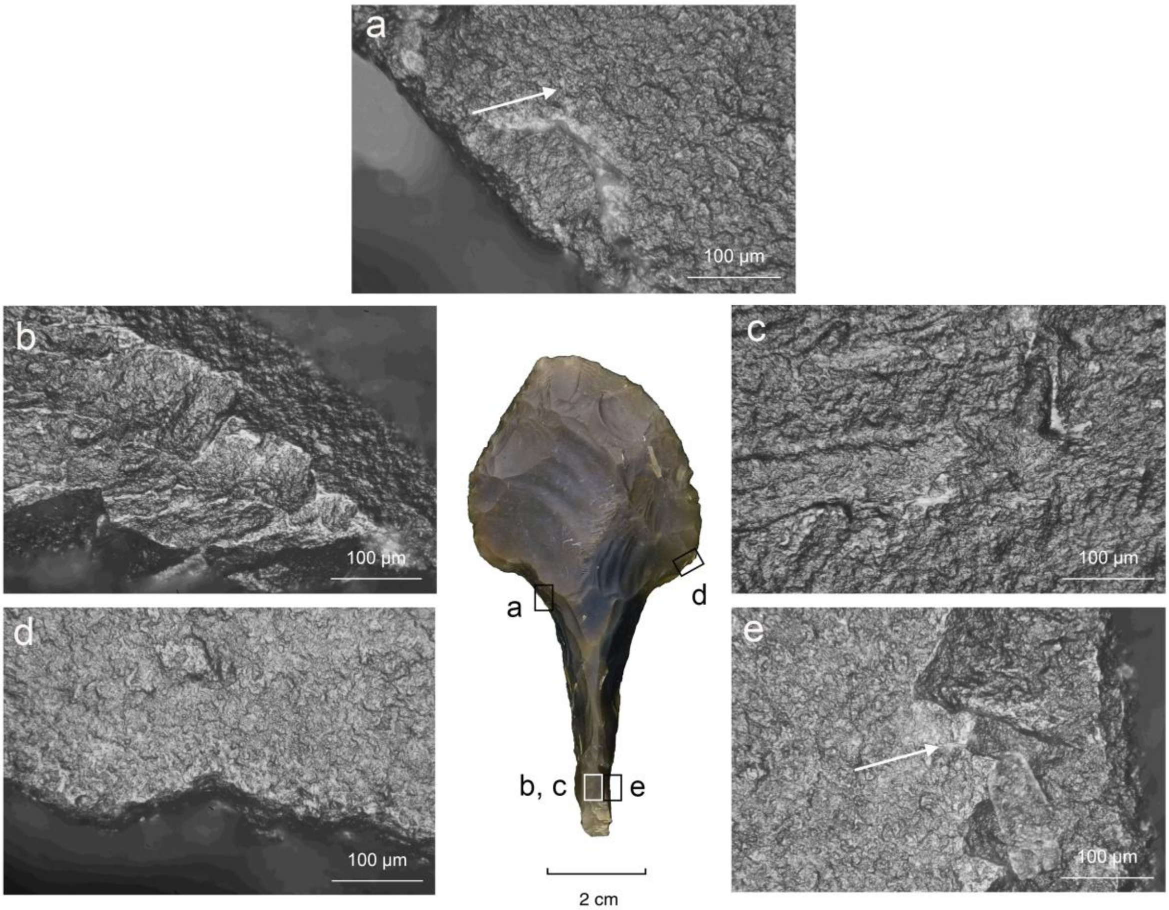

Figure 7. Hafting wear and possible production wear on butchering knife TP15. a. A striation (arrow) associated with a scar on the ventral side at the end of the tang (400×); b. Longitudinally oriented polish and bright spots on the dorsal ridges of the tang (400×); c. Longitudinally oriented bright spots on the dorsal surface of the tang immediately proximal of b. (400×); d. Edge rounding and polish on the ventral aspect of the shoulder, possibly from production (400×); e. A hafting striation (arrow) initiated on a ridge on the left lateral side of the tang (400×).

Well-developed ridge crushing and abrasion are likewise readily observable with the stereomicroscope (Fig. 8a), but care must be taken to not confuse them with anvil damage that can appear similar (Fig. 3e). The hafting-related macrowear can be associated with long, deep grooves and extensive bright spots or polished areas visible under magnification that can measure one or even two centimetres in length (Fig. 8). While tanged tools can show bright spots on dorsal ridges also as the result of the shaping process (Fig. 3c above), these are never as extensive as the friction areas identified here as hafting wear. The presence of these features on both tanged and non-tanged knives further proves that they are independent of the shaping process. Another useful criterion for distinguishing between production wear and haft wear is the orientation of linear features that in the case of the latter should be consistent with the direction of tool movement, i.e. longitudinal. This applies also to subtler forms of flint-on-flint polishing and striations (Figs. 6e-f, 7b-c and e, S2f). Notably, not all the tools here show (unambiguous) association of edge damage and striations or bright spots (cf. e.g. Rots, 2010a, pl. 41-43) that have allowed the identification of hafted tools in other studies (Table 3).

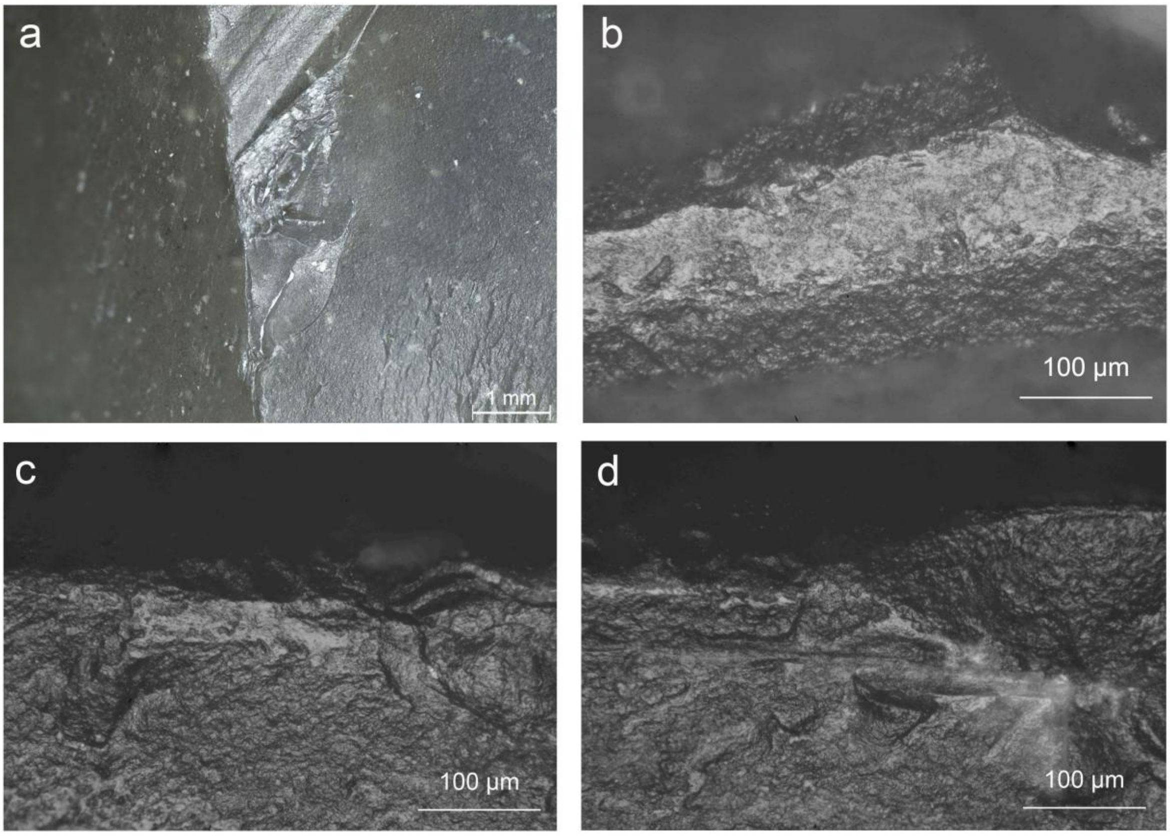

Figure 8. Examples of the most explicit hafting wear features on the knives from Maisières. a. Crushed ridge on the tang of S8 (20×); b. An extensive hafting bright spot on the tang ridge of TP21 (400×); c. A bright spot with longitudinal linearity on the dorsal ridge of a non-tanged knife MP16 (400×); d. Grooves in a broken down part of the same ridge (400×). The high magnification features are interpreted as flint-on-flint wear (caused by chips and smaller particles detaching from the tool itself).

	Edge damage + BS/S	**Bright spots**	**Edge or ridge rounding**	**Longitu-dinal BS/P**	**Ridge crushing/ grooves**	**Extensive polish/BS**	**ER possibly from bindings**
MP15	+	+	+	+	-	-	-
MP16	+	-	+	+	+	+	-
TP15	+	+	+	+	-	-	+
TP21	-	-	+	+	+	+	+
S9	-	+	+	+	-	+	+
S8	+	-	+	+	+	+	+
P14	-	+	+	+	-	-	+
P1	+	-	+	-	-	-	+
MP11	+	-	-	+	-	-	-

Table 3. Occurrence of selected hafting wear features on the knives with the most abundant wear evidence in the sample. All tools show edge damage and polish, which are therefore not included here as separate categories. MP10 is a distal fragment and therefore excluded here (cf. Tables 1–2 above). Abbreviations: BS=bright spots, S=striations, P=polish, ER=edge rounding. 'ER possibly from bindings' refers to traces observed on the proximal limb edges of tanged points and in the proximal extremity of P1.

Hafting wear on the butchering knives is much more extensively developed than that seen on experimental projectiles (see Taipale, 2020), which means that haft wear can help to distinguish between projectiles and butchering knives in cases where use-wear is largely removed by resharpening or the distal extremity of the tool is missing.

4.3 Hafting arrangement

Both tanged and non-tanged tools bear evidence of hafting, meaning that either several handle designs were available for butchering knives or one was used that was flexible enough to accommodate tools with varied proximal dimensions. Currently, hafted experimental butchering knives that would match with the Maisières tools in the degree of wear development are not available to us. The single tanged experimental knife that was hafted in a dry piece of rib and used for 45 minutes only shows very limited wear. The detailed reconstruction of the hafting arrangement is therefore left for future studies, particularly since well-developed haft polish indicative of handle raw material is lacking on the archaeological tools where the wear largely consists of flint-on-flint friction traces. Initial observations on the location of the haft wear and its implications are nevertheless offered here.

The amount of dorsal damage and flint-on-flint wear on prominent dorsal areas on both tanged and non-tanged knives indicates direct contact with resistant material, i.e. the handle (Figs. 6e-f, 7b-c, 8, S2d-f, S5e and S13a and e-f). Haft contact on ventral side is indicated by bright spots (Fig. S5d) as well as ventrally initiated scarring and associated microwear (Fig. 6a-d and f). On tanged tools, features on the lateral sides of the tangs (Fig. 7e) are not very frequent but can mean that also the sides made contact with the handle. The heaviest abrasive wear that probably marks the haft limit is usually located in the most distal part of the tang (Figs. S7a and S13a and e), which means that the morphological attributes and wear characteristics are in good agreement concerning the location of the haft limit. Yet, wear identified as hafting-related was sometimes found also distal of the tang. This pattern could reflect the use of bindings but experiments would be needed to investigate the matter further.

4.4 Resharpening and length of use

The use-wear on the knives can be discontinuous and only the patches where heavy wear has survived from resharpening allow estimating the original degree of wear development. These locations already suggest a long use-life for most of the tools. Hafting wear that is generally not affected by resharpening is a more robust indicator of the duration of tool use (cf. Rots, 2010a, 2002a) and is unmatched with that seen in the other tool categories (scrapers, burins) analysed from the same site (Rots, 2002a, 2002b; Taipale, 2020). This confirms that the tools had extended use-lives. Supporting evidence comes from the tranchet flakes analysed for use-wear (see Text S15). Particularly one knife resharpening flake is informative of the duration of tool use. The wear on it is much better developed than that seen on the knives themselves (Fig. 9).

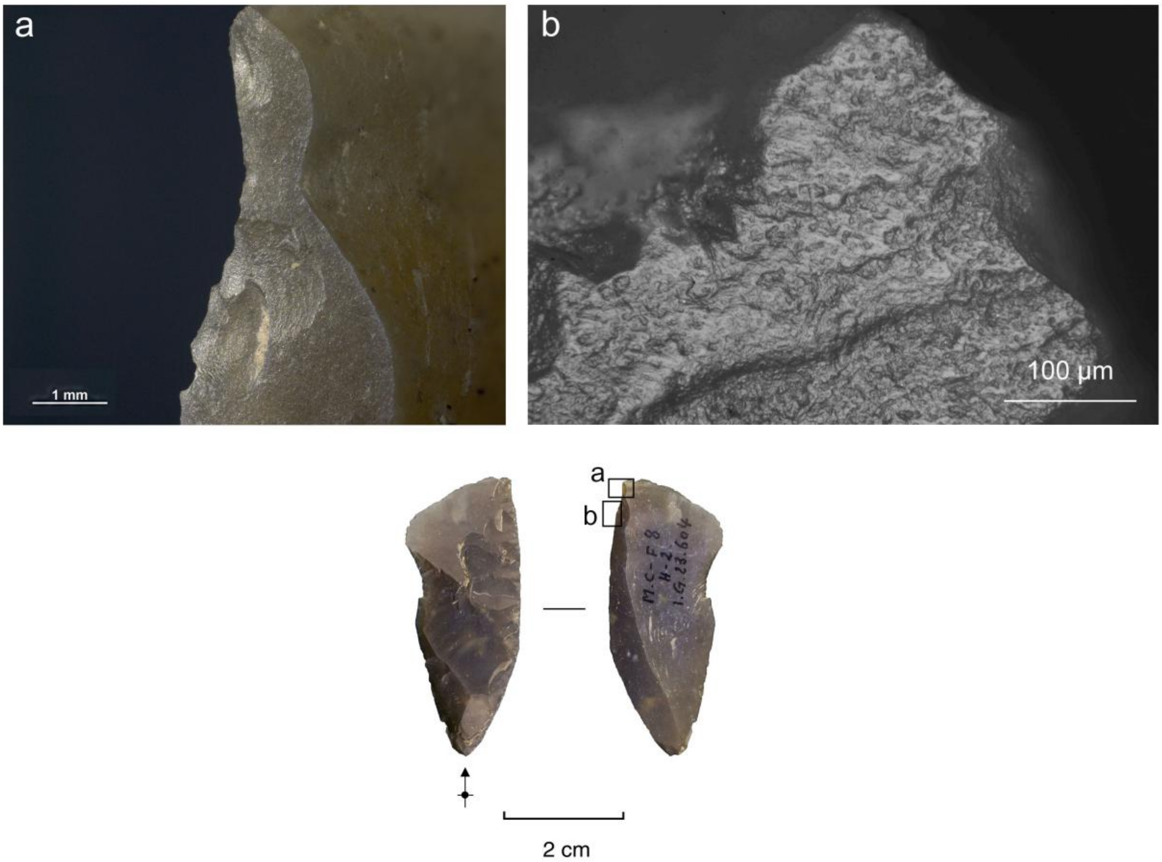

Figure 9. Use-wear on tranchet flake TF1 (a knife resharpening flake). a. Ventral edge damage on the former tool edge (32×); b. Extremely well-developed longitudinal polish indicative of contact with soft animal tissue on the former tool edge (400×).

Currently, there are no experimental butchering tools available to us that would match the Maisières knives in their degree of wear development. The wear on the single tanged experimental knife, which replicates the morphology of the archaeological tools and was used for butchering for 45 minutes (see above), is so limited that it is safe to say that an individual use episode of an archaeological knife between the acts of resharpening must have been at least several hours long if the prehistoric and experimental butchering processes can be considered comparable. Odell (1980) has noted that a large mammal can be butchered using only one to three flake tools, and since this count refers to tools that are not resharpened during work, it is obvious that the repeatedly rejuvenated Maisières knives were used for considerable periods of time. We have planned further experiments to better estimate the duration of use of the tools recovered at Maisières and replicate the use and hafting wear patterns described above. Until this additional reference material becomes available, the absolute duration of use of the archaeological tools remains difficult to determine.

In their discussion of the extensively used Kostienki knives, Klaric et al. were able to provide a partial estimate of the duration of use by drawing a parallel to experimental woodworking tools used for 10–12 hours (Klaric et al., 2015, pp. 439–441) but mentioned that no experimental reference exists for the extremely well-developed meat and/or hide polish encountered on the knives that Semenov had previously described as having been used “for years” (Klaric et al., 2015, p. 436). Interestingly, the Kostienki and Maisières knives were both resharpened by combining lateral retouch and a longitudinally struck removal that took off a sliver of the distal edge (cf. Klaric et al., 2015, fig. 26; Touzé, 2018, fig. 17).

4.5 Effect of knife use and hafting on tool morphology

The knife sample is relatively varied in terms of distal morphologies. While many of the tools have retained a pointed distal shape, on some the extremity is blunted (see Fig. 1). This is a clear clue to their non-projectile function. Two tools (S8 and S9; Figs. 1 and S4–S7) were initially examined as potential tanged scrapers (cf. Otte and Caspar, 1987) but comprehensive high magnification analysis demonstrated that they are better understood as knives even though for one (S8), last use as a scraper should be maintained as a possibility. The distal lateral edges on some tools (e.g. MP16; Figs. 1 and S2) have become very steep-angled as the result of repeated resharpening, which helps distinguishing these tools from projectile points. Nevertheless, there are also implements on which edges remain very acute-angled thanks to the application of invasive (flat) retouch and/or a tranchet blow. Consequently, the variability in edge angles and distal shapes of these discarded implements is such that there is an overlap between them and scrapers on the one hand and projectile points on the other.

A frequent trait in the group of tools with the most explicit use-wear evidence is the presence of one convex distal lateral edge, usually in combination with another, straighter edge. The degree to which resharpening has affected the final morphology obviously varies from tool to tool, but it appears that this kind of configuration at least was not considered disadvantageous and could have been preferred by the tool users at Maisières. Whether the variation in the asymmetry of the knives with such a morphology is linked to handedness could be investigated in future by recording the use-wear distribution with respect to resharpening intensity in further detail.

Six of the tools with best evidence of knife use identified so far have a tang, which can be considered an obvious morphological adjustment related to hafting. Nevertheless, two of the knives with the most explicit haft wear (MP15 and MP16; Figs. 1, 6, S1–S2) have unretouched proximal extremities. This means that hafting did not always require extensive secondary modifications but could be dealt with by producing or selecting blanks with already suitable morphologies and/or by designing the handles so that they fitted non-tanged lithic tools. While the tang is the most readily visible indication of tool hafting in the Maisières collection (see also Rots, 2002b), it is now clear that hafting was not limited to this morphology but incorporated a wider range of tools.

5 Discussion

A functional perspective on the emblematic pointed tools from Maisières-Canal has helped explain some of the particularities of the lithic industry. The present study has also shed light on the practices of Upper Palaeolithic tool hafting and allows discussing the Maisières knives in the context of general trends in tool design over long periods of time.

Previous experimental work and archaeological analysis (Coppe, 2020; Touzé, 2019) have demonstrated that the invasive retouch and the tranchet blow characteristic of many of the points recovered at Maisières can produce acute-angled edges suitable for projectile use. The present results verify that the same techniques were valued at the site for the purposes of shaping and extensively maintaining knife edges. This means that the manufacturing and resharpening of knives has had a profound effect on the typo-technological characteristics of the assemblage. The extended use-lives of the butchering knives, witnessed by the extremely well-developed hafting wear as well as explicit evidence of resharpening, give reason to argue that these tools represent a premeditated, specialised tool design, and their high number in the analysed sample implies that their role in the technical system was not trivial. Therefore, certain preferences noted in the blank production strategy, such as the appreciation of large, naturally pointed blades (Otte, 1979, p. 69; Pesesse and Flas, 2012, p. 97), served not only the production of projectile points but of hunting equipment in general.

The present results also offer a new viewpoint to the role of tanged morphologies in the lithic technical system. The high frequency of knife wear in the present sample indicates that knife use was among the functions for which this proximal morphology was intended. This means that despite their uniformity in terms of shaping strategy (cf. Touzé, 2019), the tangs served several different functions. They have facilitated the hafting of large projectile points by compensating for blank curvature and by preventing the hilt effect (Coppe, 2020) and enabled the hafted use of some burins (Rots, 2002b). The tanged butchering knives add to the evidence of the versatility of this tool design. Hafting knives with the aid of a tang is a strategy that persists into our times (cf. Rots, 2002a, p. 36) and now demonstrably has precursors at least in the Upper Palaeolithic. Yet, the fact that also non-tanged knives (e.g. Maisières points) were hafted at the site indicates that hafting did not require a high level of standardisation in terms of proximal morphology, but could be flexibly applied to tools with various dimensions by adjusting the handle design.

Butchering knives are clearly one of the tool categories for which hafting was the norm at Maisières. Hafted butchering knives have been identified from sites that are considerably older than Maisières-Canal, such as the Middle Palaeolithic site of Biache-St-Vaast in France (Rots, 2013). This is not surprising given that these tools have been integrated into lithic toolkits ever since humans learned to flake stone (see above). Even though a sizable prey animal can be butchered with simple hand-held flake tools (cf. Odell, 1980), it is obvious that a long-lived tool that presents a comfortable handle and allows a sufficient reach as well as the exertion of enough force (cf. Rots, 2013, p. 499) and that can be kept sharp with relative ease can provide an advantage to the human hunter. It is probable that the design of butchering knives has been modified over time through trial and error in tandem with an increasing understanding of the working properties and availability of lithic and organic raw materials.

In this respect, it is interesting to note that the Maisières knives share a design trait with their Middle Palaeolithic counterparts. The Gravettian tools frequently show a distal morphology that combines a convex edge and a straight one into a convergent tip (see Fig. 1 above). The same general morphology has been documented for Middle Palaeolithic butchering tools from several different sites and is also preserved in the shape of present-day hunting knives (Plisson and Beyries, 1998; Rots, 2015, 2013). This resemblance points to basic tool designs that persist over long periods of time simply because of the functional advantages they provide. The particular tip morphology has been linked to the need to use the same tool for relatively varied actions, including skinning and cutting (Plisson and Beyries, 1998, p. 14). The traces on the Maisières knives are consistent with such mixed use. These implements can therefore be considered a variation of a somewhat universal design in a setting where the proximity to high-quality flint outcrops enabled the production of large blanks for tanged and non-tanged tools and the social organisation within the human groups had given rise to strategies that promoted high artisanship.

Our results encourage future studies to incorporate all parts of the hunting toolkit, i.e. both weapons and knives, in their research design to arrive at a better understanding of lithic assemblage variability and its significance for the overall development of human technologies. Instead of assuming beforehand that lithic production sequences were primarily structured around the manufacture of projectile points, Upper Palaeolithic assemblage variability should be approached with a view that acknowledges the varied needs to which hunter-gatherer toolkits can respond. The example of butchering knives shows that each tool category can have its individual history of development, sometimes with a considerable time depth. A balanced view of different tools as well as the tasks in which they served is necessary for understanding the complex links between human technologies and the ecological and social factors that have shaped them.

6 Conclusions

The in-depth study of functional wear on a sample of pointed tools and related resharpening flakes allowed us to establish that butchering knives were frequently made and used at Maisières-Canal and were hafted almost without an exception. Many of the butchering knives are tanged, which means that this design partly served the purposes of knife hafting. We have shown that these tools had extended use-lives, unmatched by any other tool category examined from the site thus far. This proves that they were an integral part of the lithic toolkits and influenced blank production and shaping strategies significantly. The two retouching techniques characteristic of the assemblage, the invasive direct retouch and the tranchet blow, were both recurrently used in shaping and rejuvenating the working edges of these tools. Our results show that instead of a narrow focus on projectile points, the understanding of lithic production systems and the evolution of technology as a whole requires a holistic view of hunter-gatherer toolkits and the tasks they were involved in.

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