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Abstract

The Holocene hunter-gatherers of the Maghreb are characterized by extensive use of wild plant resources; for food and for making containers, weapons and tools, ropes and fabrics. Some of the harvesting and processing operations of these materials can be performed with stone tools that leave traces on the tools. It is therefore possible to get information about the nature of the harvested and processed plants, the technical operations carried out with the tools and the design of the tools themselves. This information has a technological, economic and cultural scope, and is essential for thinking about the links between environmental changes and lithic industry variability. We present here the first data from technological and use-wear studies carried out on collections from Epipalaeolithic sites in Algeria and Tunisia, focusing on unretouched blades and bladelets from the Columnatian, blades and backed blades from the Typical Capsian, and notched blades and bladelets from the Upper Capsian.

1. Introduction

The economy of the last hunter-gatherer societies of the Maghreb, between 12,000 and 7000 BP, is quite well known for hunting activities, through information provided by faunal remains and lithic tools, in which projectile armatures occupy a prominent place. In recent decades, archaeobotanical data (charred remains, phytoliths, pollen) concerning the harvesting of plants for food or artisanal purposes, and the different processing chains of these plants have been published providing new knowledge about the exploitation of plants.

The published data concern, on the one hand, food plants: pine nuts, pistachios, acorns, allium bulbs, sedge tubers, fruits, cereal seeds and wild herbs (Lubell, 2001; Shipp et al., 2013; Morales et al., 2015). On the other hand, we now have some clues for the use of plants to make ropes and baskets or plaiting materials: esparto and other grasses, wood, palm (Carrión et al., 2018; Morales, 2018; Morales et al., 2015). Although actual physical evidence of these technological uses is for the moment unknown in the Maghreb, documents from neighboring regions and other periods can be used to discuss possible achievements. The very dry environment of Takarkori shelter in Libya has preserved remnants of early Holocene rope and baskets mostly made from grasses (di Lernia 2012). The current and/or historical traditional craftsmanship of the Maghreb also shows the importance and diversity of basketry, spinning and rope. Thus, for example, in Morocco and Algeria we know of containers made from cane (*Arundo donax*), palm (*Chamaerops humilis*) and esparto grass (*Stipa tenacissima*), as well as fibers and date palm leaves, wicker and rushes (González and Ibañez, 2002; Ibañez et al., 2007). We can reasonably assume these are also associated with many wooden objects. The exploitation of plant resources thus appears to be very developed since the late Pleistocene-early Holocene.

These plant resources and exploitation strategies by hunter-gatherer groups took place during periods of climate change. Thus, at Aïn Misteheyia (Algeria), a *rammadiya* (also called *escargotière*, see Lubell et al., 2009: 176, n. 1) with a sequence from Typical Capsian to Upper Capsian (Jackes and Lubell, 2016; Hill et al., 2019), the analysis of phytoliths shows a change in livelihood strategies, from preferential harvesting of sedge tubers to more intensive use of grass seeds, along with changes in exploited animal species and in the lithic industry (Shipp et al., 2013). These changes occurred around 8200 cal BP, when the climate became more arid. At El Mekta (Tunisia), climate and environmental change led populations to move from harvesting oriented towards the acorns of *Quercus* sp. during the Typical Capsian, to collection centred on *Pinus halepensis* nuts during the Upper Capsian (Morales et al., 2015).

Exploitation of plant resources, especially the acquisition and preparation of raw materials, can require the use of cutting objects, and thus for prehistoric societies, knapped stone tools, possibly associated with other tools made of stone, wood or bone. The variability of lithic industries, whether chronologically or regionally, technologically, or in types of tools which have been traditionally interpreted in cultural terms, could largely be explained by adaptation to environmental change (Sheppard and Lubell, 1990; Rahmani, 2003; Rahmani and Lubell, 2012). Thus, according to these authors, the stress provoked by the aridification of the environment around 8000 BP would have stimulated an innovation trend in Capsian groups, leading to the introduction of pressure debitage (Tixier, 1976; Rahmani, 2003) which allows the standardization of blanks (Inizan, 1976; Rahmani and Lubell, 2012) and marks the shift from the

Typical Capsian to the Upper Capsian. However, the most recent radiometric data (Perrin et al., 2020) suggest that this transition occurs around 8500-8400 cal BP prior to the 8200 BP climate event. Other factors must therefore be considered: regional traditions; mobility, exchange and dissemination systems; availability and acquisition strategies of lithic raw materials (Sheppard and Lubell, 1990; Rahmani and Lubell, 2012); site function (Rahmani, 2003).

However, hypotheses concerning the link between technological and typological changes in the lithic industry, climate and environmental changes, and environmental exploitation strategies, largely based on the function of lithic tools, must be verified by use-wear analyses (Lubell et al., 1984; Rahmani, 2003), especially concerning the exploitation of vegetal resources. Unfortunately few functional analyses on tools have been carried out so far.

Observations on tools marked by gloss that can be observed with the naked eye were published in the 1970s. Camps (1974:102, 170) reported intense use polish on Typical Capsian backed knives:

> *Les ébréchures fréquentes, les traces d'émoussé, voire un certain lustre sur les marges du tranchant révèlent l'usage de ces lames qui sont des couteaux et non des pointes.*
> *Des lame[s] à bord abattu ou non, portant un lustre parfois très marqué au voisinage du bord et s'étendant sur les deux faces de ces couteaux. (…) De telles lames ont été reconnues dans plusieurs gisements capsiens mais elles restent assez rares. (…) Non seulement le fait de couper des tiges de graminées ne prouve pas que l'on cultive des céréales, mais encore faut-il bien admettre que le « lustre des moissons » peut être provoqué par la coupe de tiges non consommables mais fort utiles comme les roseaux, par exemple, qui pouvaient servir aussi bien à la confection de pièges qu'à la fabrication de vanneries ou à la couverture des habitations*.

Inizan (1976:91), in her thesis on the Capsian, reported in the Typical Capsian of Aïn Metherchem thirty tools that "*offrent, sur un bord denticulé ou non, un lustre très brillant* ". These are backed blades, end-scrapers on backed blades, a scraper and some denticulates.

Tixier (1965) reported five backed blades from the Typical Capsian site of Aïn Zannouch with rounded edges, without describing any gloss.

Observations implementing the methods of use-wear analysis are few. Dauvois (1976) published excellent documentation on a backed blade with gloss from the Typical Capsian of the Tebessa region, clearly showing the distal location of the polish and bifacial distribution of wear, as well as the transverse orientation of striations, from which use for transverse motions rather than longitudinal cutting can be inferred. He also noted the difficulty in establishing the chronology of wear (the striations can be associated with the polish or subsequent to it), and showed that the retouching of the left edge was later than the polish. Some articles have been devoted to the study of impact fractures on projectiles from the Iberomaurusian (Sari, 2014), Columnatian (Dachy et al., 2018) and Capsian (Rahmani, 2007; Gassin and Gibaja 2016; Khedhaier, 2013). Observations were made on tools used for working plants in the Columnatian (Dachy et al., 2018) and Capsian (Beyries and Inizan, 1982; Gassin and Gibaja, 2016; Gassin et al. 2014). These have also highlighted other types of activities.

The objective of the present study is to identify some of the tools and the technological processes for exploiting plant resources through use-wear analysis of the lithic industries. We looked in different contexts for tools used on plant matter; we wondered what were the materials worked by the lithic tools, the technological actions made, and we tried to understand in which operating sequences these technological operations occurred. We also wondered about the design of lithic tools themselves: which supports were chosen, how were the active parts configured, what were the modes of fitting and hafting? Through the identification of these functions and choices, we want to contribute to the appreciation of the importance of the exploitation of the plant world in the economy of Epipalaeolithic hunter-gatherers and to the functional interpretation of the variability of lithic industries.

2. Material and methods

As part of the MeNeMOIA research program (du Mésolithique au Néolithique en Méditerranée occidentale: l'impact africain, IdEx Toulouse), led by Thomas Perrin, we worked on lithic industries from excavations carried out in Algeria and Tunisia, from the 1920s to the 1970s in three cultural contexts: Columnatian, Typical Capsian and Upper Capsian (fig. 1, 2, table 1). Our work, which dealt with the chronology of these occupations as well as technological and functional analyses of the lithic assemblages, made it possible to highlight the implication of the lithics in processing plants.

Two of these sites were the subject of systematic stratigraphic excavations.

Saint Trivier / Chabet el Houidga is located in the city of Mascara in western Algeria. It was excavated in 1955-1960 by Georges Simonnet, a member of the military stationed in Algeria during the Algerian War of Independence, and an amateur prehistorian. He excavated several trenches in a small wadi, with careful recording of the stratigraphic and spatial data and used a fine sieve. He revealed one metre of multiple occupancy levels (layers 6-3) that can be considered Columnatian, and date from the first half of the 10th millennium cal BP; other occupations, older and newer, are less important. This site, which has remained unpublished since the excavation, is currently under study in Toulouse and was the subject of a first publication in 2018, including a technological, typological and use-wear study of a lithic industry sample (Dachy et al., 2018), the results of which are reproduced here in more detail, relating to about fifty pieces used for plant processing.

Kef Zoura D is a rammadiya in a rock shelter located in the Télidjène Basin in eastern Algeria, excavated by David Lubell and Mary Jackes in the 1970s (Lubell, 2016; Lubell et al. 1984; Jackes and Lubell, 2008). A Typical Capsian to Upper Capsian (~10,000 to 6,000 cal BP) stratigraphy was found in deposits at least 2 m thick. The lithic industry has been the subject of technological and typological studies (Sheppard, 1987, 2016; Rahmani, 2003, 2004, 2007; Rahmani and Lubell, 2012). A preliminary use-wear study was conducted on a sample of 350 artefacts (Gassin and Gibaja, 2016). Here we summarize observations on 13 Typical Capsian and Upper Capsian backed blades out of a total of 42, and 57 notched bladelets out of a total of nearly 650 notches and denticulates (Sheppard 2016) in the Upper Capsian levels (units I, II and III).

Other sites were excavated in the past, but poorly controlled with sorted industries (i.e. selected artefacts), thus providing less reliable documentation. However, to the extent that we think about types of tools and types of activities, we can use this truncated information and these materials provide in some cases points of comparison with the better documented series. We have been able to examine selections of tools from four excavations in collections held at the Muséum d'Histoire Naturelle d'Aix-en-Provence (MHN) and the Institut de Paléontologie Humaine in Paris (IPH).

Aïn Metherchem (Tunisia), excavated by R. Vaufrey in the 1930s and studied by M.-L. Inizan (1976), is a rammadiya with a Typical Capsian occupation and indications of Upper Capsian occupation as well (some nuclei with traces of pressure debitage). A series of backed blades and unretouched blades are conserved at the IPH. Their interest for a functional study was noted by Inizan (many blades with gloss). We studied 359 blades, including 30 with intense polish.

El Mekta is a rammadiya located near Gafsa in Tunisia, previously excavated by Vaufrey and Gobert, and recently re-excavated by an interdisciplinary team led by Morales and Mulazzani (Morales et al., 2015). The stratigraphy shows a Typical Capsian to Upper Capsian sequence. Lithics from the earlier excavations are held at the MHN, among which we were able to select one backed blade.

Negrine el Quedim in the Tebessa region of Algeria is attributed to the Upper Capsian. Two backed blades were selected from the Camps collection, kept at the MHN..

Bir Hamaïria is an Upper Capsian rammadiya in Tunisia, excavated by Teste, Gobert and Lacorre (Marty, 1966). A lithic series of 100 pieces from the Gobert excavations is kept at the MHN including the bladelet with multiple notches studied there

Our observations were made with a stereo microscope (x5-x40) and a metallographic microscope (x50-x200). Initial study used the former and if traces of wear were identified, they were examined with the metallographic microscope. The observations concern chipping, blunting, polish and striations, and are interpreted using experimental references, following the methods of use-wear analysis developed from the works of Semenov (1964) and widely developed since (see in particular Marreiros et al., 2014).

To describe the technical action of tools used in machining (transverse cutting of materials), we use the vocabulary developed by woodworking and metal working technicians and craftsmen (see for instance Rigaud, 1972, 2007; or www.minaprem.com), and regularly present in the use-wear analyses field especially in France (e.g., Gassin, 1996; Beugnier, 2006; Guéret, 2013; Langlais et al., 2018; Philibert, 2016) The face of a tool that raises the chip is called the rake face (fig. 3). The opposite face, the one in contact with the new surface created by the removal of chips, is the flank face. The angle formed by the rake face with the surface material is the rake angle. The angle formed by the flank face with the surface is the clearance angle. When the rake face forms an angle with the material of less than 90°, we are dealing with transverse motion with a negative rake angle (scraping). When this angle is greater than 90°, it is a positive

rake angle (whittling). This vocabulary makes it possible to accurately describe the operating mode of the tools.

3. Results

3.1. Plant whittling tools in the Columnatian of Saint-Trivier / Chabet el Houidga (Mascara, Algeria): 1st half of the 10th millennium BP

The lithic industry from this site is dominated by backed bladelets, segments and notched bladelets (Dachy et al., 2018). An exhaustive sorting realized on the huge lithic corpus (25,756 pieces, chips included) has allowed us to isolate 50 both retouched and unretouched bladelets showing very similar macroscopic glosses (61 UZ). A microscopic analysis has concerned a sampling of 18 tools marked by this intense and original gloss (table 2, fig. 4). All are bladelets or blades of good quality raw material, systematically using a thin concave or rectilinear edge. The active parts with gloss were always used unretouched but many artefacts have also modified edges linked with other functional episodes. A significant number of blanks is on rare raw materials that have not been worked on site.

At high magnification, all polishes have very particular and common characters - form and repartition - suggesting a single function for all objects. This is particularly the case for the very invasive polish developed on the lower face (end flank), characterized by the perpendicular orientation of the striations, and the many very regular pits which occur on the flat glossy surface (fig. 5 and 6). On the other hand, there is considerable variability in the more or less grainy character of the surfaces and in the frequency of the striations (fig. 6), but there is clearly a continuum between the two extreme situations, so this does not reduce the impression of a great homogeneity. On the upper surface (rake face), the polish is much less developed, contrary to what was observed on the blades of the Capsian. Its more important and peculiar character is its repartition concerning more the ridges of the upper face that the vicinity of the active edge. All these traces can be attributed to a transverse action with a positive rake angle on plants within the framework of a very precise operational sequence that has yet to be determined (basketry, plastering?).

The analyses were focused on the glossy active parts but the main part of blades and bladelets show a succession of use on other materials, especially several types of abrasive materials, with both modified and unmodified edges. In total, 30 of the 50 glossy tools are also marked by macroscopic abrasive use traces which will be studied more precisely in the future. Still, it is certain that they are the result of different actions on various abrasive materials, including hide, soft mineral materials and very probably different plants than the ones producing the intense polishes described earlier. If one adds the rather frequent breakage of the pieces and the common presence of retouch on the other edges, it seems that these artefacts (and probably all the tools in Saint-Trivier) had rather long cycles of use.

All these characteristics make these tools a very good functional indicator in the sense that they combine rather remarkable blanks with very original and easily identifiable traces.

3.2 Typical Capsian backed blades

The backed blades types 35 to 43 of Tixier's typology (Tixier, 1963) – are one of the dominant tools of the Typical Capsian, but they are also present in the Upper Capsian (Rahmani, 2003). Functional observations published several decades ago by Tixier (1965), Camps (1974), Inizan (1976) and Dauvois (1976) have led us to verify the existence and the nature of these use-wear traces. We have therefore resumed the examination of the Aïn Metherchem series from the excavations of R. Vaufrey, studied by M.-L. Inizan and kept at the IPH.

Among the 359 tools observed and sorted with a stereo microscope, 30 showed wear with lateral gloss. Most were observed quickly but eight unbroken pieces were the subject of close observation, including with the metallographic microscope (table 3).

There is a certain typological diversity concerning these glossy blades. Six are unretouched or only have irregular removals; most, however, belong to two very specific types, arched backed blades (12) and end-scrapers on backed blades with a pointed end opposite the end-scraper (8). There are also four burins on backed blades.

The worn blades, whether unretouched or retouched, are always used on a raw edge. When this edge is retouched, these retouches are posterior to wear and do not show any subsequent use (e.g. burin, microdenticulation, notches) with few exceptions: on blade 31 (fig. 7 C) and 23 (fig.11), a notch is marked by a smooth non-abrasive polish, indicating scraping of plant material.

The glosses visible to the naked eye have varying degrees of development; some are poorly developed, attesting to fairly brief use; others are highly developed, showing more prolonged use. They are always located on the unretouched edge, with an acute angle edge, close to the pointed end when it is present, and developed on both faces, in a halo, with a marked extension towards the interior. The polish, generally smooth and shiny (fig. 7A, 7G; fig. 9) suggests a transverse action on plants rich in silica. Part of the striations appear to be associated with the polish and suggest an abrasive component of the worked material (fig. 7F, G, H; fig. 9). The relative symmetry of the polish on both sides (fig. 8, 9, 11) may correspond to a splitting action, or to a change in tool position, the two faces being alternately the rake face and the flank face for positive rake cutting (whittling). However, the dissymmetry of the traces is quite marked on five tools (fig. 7, 10), indicating cutting with a positive rake angle without alternating position of the two faces.

On the blades where wear is most developed, the orientation of the striations and wear indicates the possibility of more complex actions or successions of different actions, with striations perpendicular and parallel to the cutting edge (fig. 7, 10, 11). Blades 23 (fig. 11) and 31 (fig. 7) also have a mesial notch, with a clearly bending initiation, with vegetal material transversal wear. This diversity of wear can result either from the use of the tool during the same operational sequence, with different actions during the process, or from uses in different operational sequences, as also suggested by the presence of wear related to different materials.

Indeed, some blades have a grainier, more matte, polish without a smooth "vegetal" component. It may be due to working skin or some more abrasive plants (e.g. No. 30, fig. 9). On

some blades (Nos. 22, 23, 29, 30, 31) with a smooth luster resulting from working plants, the edge is blunt with a matte abraded bevel, of transverse or longitudinal orientation (fig. 7E, 8 ACDE, 10ABD, 11DG). This very developed wear is so different from the adjacent luster that it can be assumed to result from a second use in scraping or cutting by the same edge on a very abrasive material. These clues of multiple uses suggest a long duration of use for these tools.

The scraper opposite the tip rarely bears traces of use. On blade No. 23 (fig. 11), the distal end-scraper has a grainy matte polish, oriented perpendicular to the axis of the blade, present only on the upper face, and blunting the right edge of the front of the end-scraper on the underside. It might be traces of hafting, which could be associated with oblique striations on the lower face. Three other end-scrapers (Nos. 22, 24, 25) have a very slight blunting and undiagnosed use (maybe traces of hafting?).

Some other examples of backed blades come from several formerly excavated sites. In uncontrolled contexts, their chronological attribution is uncertain. Two backed blades with transverse gloss of plants, preserved in the Camps collection at the MHN, come from the site of Negrine el Quedim, attributed to the Upper Capsian. One of them has a different polish on the lower face (smoother, more striated) and on the upper face (more matte and less striated). This dissymmetry suggests use with a positive rake angle (whittling). A backed blade from El Mekta (Gafsa, Tunisia)in the Gobert collection (MHN), shows intense distal wear with perpendicular striations, marked blunting and a matte covering polish. These few poorly contextualized examples testify to the fact that the series of Aïn Metherchem is not isolated and that these uses of backed knives are recurrent.

At Kef Zoura D, ten backed blades from the Upper Capsian and three from the Typical Capsian have small bifacial removals distributed intermittently on the raw edges. These tiny scars can result from the cutting of soft materials, for example during butchering operations. No transverse gloss linked with plant working was observed in this limited sample (Gassin and Gibaja, 2016). In the final Capsian and Early Neolithic site of Hergla-SHM1 in Tunisia, backed blades are absent and no traces of plant working have been observed (Khedhaier, 2013).

The complexity of the wear observed at Aïn Metherchem is somewhat disconcerting, and it will be necessary to complete the observations on this material. It can be concluded for the moment that the backed blades / backed knives of the Typical Capsian were used at Aïn Metherchem and probably in other Capsian sites for whittling and/or splitting siliceous plants, and also had other functions, in transverse and in longitudinal motions, either on the same materials, or on more abrasive materials, or in butchery. Unretouched blades have also been used for these plant whittling actions, and we can therefore expect to find others at Aïn Metherchem as in other series.

3 .3 Upper Capsian notched blades and bladelets

Notched blades and bladelets are one of the characteristic tools of the Upper Capsian and are also found in many industries of the Late Mesolithic of Europe (Perrin, 2009). In these contexts, these tools are essentially made on regular bladelets, produced by pressure or indirect percussion; there are also notches on blades or flakes. These are mostly direct notches, but

there are some rare inverse ones. Most of the notches come from a bending fracture. These are intentional, not use removals, as frequently assumed. These bending fractures shape an active edge forming a right angle with the lower face, before bending parallel to the upper face of the flint (fig. 12, n° 16, 17). This particular morphology has been well described (Tixier, 1963; Sheppard, 2016) and reproduced experimentally (Gassin et al., 2013, 2014; Guéret et al., 2014). These fractures are very easily produced by pressing the edge of the bladelet, ventral face downwards, flattened on a convex surface, for example wood. Some notches, however, have a more complex morphology, resulting from a succession of retouching, possibly involving other techniques.

Most of our observations were made on material from Kef Zoura D (Gassin and Gibaja 2016). Notched bladelets have been widely documented in the Upper Capsian, but for the moment we have not seen artefacts of the same morphology and function in the Typical Capsian at Kef Zoura D. We have also seen one notched bladelet with traces of wear from Bir Hamaïria in the series kept at the Muséum d'Histoire Naturelle d'Aix en Provence.

The sample studied is 57 notched pieces (tab. 4). In almost all cases, these are blades or bladelets (median width 11.8 ± 2 mm) produced by pressure, more rarely slightly irregular blades and in one case an elongated flake (fig. 12). We have observed up to thirteen notches on the same bladelet. The width of the removals is generally less than 10 mm. Other areas of these notched bladelets, such as raw edges, are sometimes used, but the main use is on the notches.

Each notch is an independent use area. It is therefore not a denticulated cutting edge consisting of the entire retouched edge of the bladelet, but a concave active edge a few millimeters in length. Thanks to the difference in the morphology of wear polishes on both sides, it can be established that the negative of the retouch is the rake face, that which is towards the front of the movement (fig. 12, n° 16). On the retouched face, there is a smooth to "snow-melting" marginal polish, without striae. On the opposite face, there is a bevel, most frequently convex and smooth, sometimes with a fluted appearance or with small folds oriented perpendicular to the edge (fig. 13). This polish can be marginal, or extending on the face, with a convex surface, stretched bumps, asymmetric depressions, and fine striations. The polish on the retouched face is produced by the friction of the chip, while the polish on the opposite face results from the pressure exerted on the new surface created by the detachment of the chips. The extension of the polish on this face depends on the hardness of the worked material, the clearance angle and the duration of use.

This association – retouched face / rake face – is systematic, including the rare inverse notches. For example, the bladelet F21 606 (fig. 13) has direct notches on the mesial part of the right and left edges, and inverse ones on the proximal left and distal right edges. This is what makes it possible to establish with certainty the fact that each notch is an independent active zone. It is indeed possible to reconstruct the changes in orientation and gripping of the piece during use, the bladelet being alternately turned flat, keeping the lower face downwards (successive use of the direct notches on the right and left edges), then by rotation around the longitudinal axis, to use the inverse notches.

The polish sometimes has a marked extension on the lower face (end flank), indicating a low clearance angle, and is sometimes more marginal, due to a slightly higher clearance angle. The rake face polish morphology indicates that the active zone has worked in negative rake cutting. This mode of operation is the same as that of the lateral edges of burins. This type of use is well documented by experiments.
The fact that the blade is almost laid flat on the material being worked, with a low clearance angle (Gassin and Gibaja, 2016, fig 20-4), makes it possible to scrape solids having a diameter much greater than the diameter of the arc of the circle which constitutes the notch: with the inclination, the active edge is almost rectilinear. The contact is limited to a few millimeters, which is enough to lift fine chips.

The material is rigid, relatively soft (with little or no evidence of use removals). Most traces are characteristic of the scraping of rigid plants with a variable silica content – e.g. wood or plants like cane. In certain cases, however, the traces are more ambiguous, sometimes suggesting a hard animal matter (shallow narrow ripples on the edge, e.g. fig. 13AG). However, some characteristics of the hard animal matter are lacking: numerous use scars, cracks parallel to the edge on the rake face, deep folds on the end flank. These traces have been found on unretouched flakes from Kef Zoura D used to work bone.

Most of the clues suggest scraping of wood with a negative rake angle. It can only be objects of small diameter (thin rods a few millimeters to 1 or 2 cm in diameter, wooden splints). The limited extent of the polish on the upper face indicates a low thickness of the detached chips, so precision and finesse work.

Evidence for transverse working of wood or plants is also present on the edges of unretouched blades (e.g. fig. 14). Irregular removals are not retouch but represent traces of use on an acute raw edge used for transverse cutting with a positive rake angle.

So, for the moment, we can only interpret the wear of notched bladelets at two Upper Capsian sites. In both cases, these are scraping tools, used mainly on rigid plants for delicate work involving the detachment of fine chips for the shaping or finishing of objects such as arrows, utensils, tools, ornaments, or for the preparation of materials, for example for basketry, for which a fine surface condition is desired.

Contemporary industries of the Second Mesolithic of Western Europe have many notched blades, with identical modes of operation, and a greater variability of observed wear (Guéret et al., 2014). It will therefore be particularly interesting to continue this investigation on Capsian notched blades to assess the variability of uses.

4. Discussion and conclusion

4 .1 What plant processing tasks can be identified for lithic tools?

These three different types of tools (Typical Capsian backed blades, Columnatian unmodified blades or bladelets and Upper Capsian notched bladelets) were all used to work plants with a transverse motion, sometimes with complex actions, sometimes in a repetitive and standardized way. In the three cases, blanks were used several times on different materials,

among which processing plants and/or wood is the dominant activity. These technical operations are very likely associated with producing basketry or shaping of arrows, or other small implements made of wood or plants.

The observed kinds of wear are different in the series we studied. At Saint Trivier, there were blades and bladelets used by straight or concave ca. 2 cm long unretouched acute edges in positive-rake cutting on plants with an abrasive component. At Aïn Metherchem, blades and backed blades were used with 4-6 cm long active zones on acute unretouched edges. They were used in positive rake-cutting and splitting, but also in longitudinal cutting, on plants with a low abrasive component. These different actions may or not be associated during the same work. There are other uses on the same edges, to scrape or cut very abrasive materials. At Kef Zoura (Upper Capsian), blades and bladelets with numerous notches created by bending retouch were used with concave active zones less than 1 cm long, in negative rake cutting of vegetal matter, without any abrasive component, probably wood.

The exact nature of the worked plants is difficult to determine from the available experimental references; for the most part, the Kef Zoura D Upper Capsian notched blades were probably used to scrape wood but we cannot be entirely certain. The importance of plants/wood working and the diversity of tool morphologies and use traces have also been highlighted for artefacts from sites of the Early and Late European Mesolithic, where unretouched blades used on plants, and notched blades, are an important part of the tool kit (Beugnier et Crombé, 2007; Crombé et Beugnier, 2013; Guéret, 2013; Guéret et al., 2014; Gassin et al., 2013, 2014 ; Osipowicz 2019; Vaughan, 1990), and for Middle East blades, from Khiamian to Late PPNB (Ibáñez et al., 2007: 159). Systematic experiments are therefore necessary to further interpret these uses.

Enlarging the sample of studied material will make it possible to document variability or regularity of use-wear patterns and the tools on which they occur. This type of work can also be expected to be found in older industries, for example the Aterian or Iberomaurusian (e.g. Desmond 2019), as archaeobotanical, anthropological (Carrión et al., 2018; Humphrey et al., 2014), and use-wear analysis data (Potì et al., 2019) already suggest.

The increase of data from techno-functional studies on worked bone is a particularly promising avenue. For Kef Zoura D, Petrullo (2016) has shown that a significant proportion of pointed bone tools were used on plants, in a piercing and sometimes rotating movement, perhaps in basket making. These tools are complementary, possibly within the same *chaînes opératoires*, and testify to the importance of the working of plant materials.

4 .2 A typology integrating morphology, technology and use-wear.

Although these tools are clearly dedicated to working plants, their morphology and mode of operation are different; all three are multifunctional blanks. Can we envisage a functional typology, based on the recurrence of associations between functions, morphology of the active edges, techniques used for the production of supports, types of retouching? Given the scarcity of functional approaches in the Maghreb, it is still difficult to know if the type of tools in the Columnatian at Saint Trivier is ubiquitous, or specific to this site, or related to a technological

tradition of a specific period or of a particular culture, or if they are related to the exploitation of particular plants according to the environment of the site. However, some clues could indicate a Columnatian specificity concerning these tools:

- at this stage, this type of wear has not been identified in the Typical and Upper Capsian of Kef Zoura D;

- but, a quick sorting on the only two known Columnatian assemblages from Le Cubitus and Columnata (Cadenat's excavations, Les Eyzies Museum) has shown macroscopic glosses on numerous blades and bladelets. These polishes have only been observed to the naked eye but, at this scale at least, they are strikingly similar to those described in Saint-Trivier.

The backed blades used to whittle plants are found in several Typical Capsian assemblages; it remains to confirm their presence or absence in the Upper Capsian. It also remains to be seen to what extent other tools (e.g. unretouched blades as at Aïn Métherchem) perform the same function, both in Typical Capsian context and others.

Researchers who have published extensive syntheses and studied many Capsian series (Tixier, 1963; Grébénart , 1976; Inizan, 1976; Rahmani, 2003; Sheppard, 1987) did not report glossy blades in the Typical Capsian, with the exception of the glossy tools of Aïn Metherchem published by Inizan who reported none in any of the other sites she studied. The only other mentions lack precision: "*plusieurs gisements capsiens*" (Camps, 1974); " *région de Tébessa*" (Dauvois 1976). The three examples we have described (Negrine el Quedim and El Mekta) may correspond to the Capsian deposits mentioned by Camps. It is possible that conservation problems in open-air deposits exposed to alteration factors explain the rarity of polish on artefacts from these occurrences where, as at Aïn Misteheyia, deposits are affected by deflation and compaction (Lubell et al., 2009). This assumption obviously does not apply to Kef Zoura D, where the traces of use are very well preserved: in this case, the absence of this type of tool and function is one of the characteristics of the site. We have seen that at Kef Zoura D blades with a backed edge were probably used in butchery, and that at Aïn Metherchem these tools are multifunctional. It is therefore possible that the rarity of mention of tools with luster corresponds to an archaeological reality. These tools would only be used to scrape plants at certain sites. Only additional functional studies will better document the nature and frequency of this wear.

The function of the Upper Capsian notched blades is well known only at Kef Zoura D. The absence of notched blades with the same functions in the Typical Capsian remains to be verified, as well as their presence in other Upper Capsian sites. It is known that the notched blades are very abundant in many Upper Capsian sites, with varying proportions (Camps, 1974; Grébénart, 1976; Inizan, 1976; Rahmani, 2003; Sheppard, 1987).
Notched blades are also present in the Saint Trivier Columnatian, but have not yet been fully studied. From a typological perspective, some contrasts can be observed and are probably linked with differences in retouching techniques: thus, Columnatian notches are clearly deeper and more marked than the Upper Capsian ones. Concerning their function, new investigations would be necessary, but the first preliminary observations shows abrasive traces (transverse

motion) in the notches (lower face) which are completely unknown in the Capsian of Kef Zoura D.

The first data on the Epipalaeolithic and the early Neolithic of Morocco constitute on the other hand another avenue to follow, insofar as some notched blades used to scrape plants have been observed (Linstädter et al., 2015).

It is interesting to make long-distance comparisons to verify the existence, at a given time, of types of tools defined by both their function and their morphology. The unretouched blades of the Columnatian have quite strong analogies with those of the early and middle Mesolithic of northern Europe (Beugnier, 2007; Guéret, 2013; Osipowicz, 2019). Upper Capsian notched bladelets are very similar, regarding technology, typology and use-wear, to notched bladelets in Castelnovian and other Second (or Late) Mesolithic in Mediterranean and Northwestern Europe. They appear to be part of a technological package, with pressure or indirect percussion and trapezes, widely distributed in North Africa and Western Europe (Gassin et al., 2014). These similarities can partly be the result of technological convergence, but one can also in some cases suspect diffusion and transfers, including those in quite different environments (Perrin, 2009; Perrin et al., 2020). The verification of these hypotheses will necessitate integration of functional studies with technological studies and chronology.

5. Conclusion

The study of plant-working tools from these sites (Saint Trivier, Kef Zoura D, Aïn Metherchem), aimed to explore the role of lithic tools in the exploitation of plant resources by the last hunter-gatherer societies from the Maghreb, by characterising the design and the action modes of the tools, and the worked materials.

We have identified three types of use that are found on three very different types of tools. In the Columnatian of Saint Trivier, these are blades and bladelets using an acute unretouched edge for a transverse action in positive rake cutting (whittling) of plants containing an abrasive component. In the typical Capsian from Aïn Metherchem, backed blades (and unretouched blades) were used in complex actions (positive rake cutting or splitting, longitudinal cutting) on weakly abrasive siliceous plants, as well as in other functions. In the Kef Zoura D Upper Capsian, notched blades and bladelets were systematically used to scrape rigid plants, mainly wood, in negative-rake cutting. The laminar supports of these tools were also frequently recycled.

These examples show a certain importance of plant-working with lithic tools. The tool designs, their operating modes and the worked plant materials are different. We have probably some occurrences of the same tools with identical functions on other sites, but our knowledge is still very partial and more abundant data are necessary to confirm this.
If we retain the hypothesis of a synchronism between the Columnatian and the typical Capsian, we can suspect different technical choices for plant-working in different regions, whether these are local traditions or environmental constraints in the choice of worked materials.

The transition from the Typical Capsian to the Upper Capsian, documented at Kef Zoura D, is shown in particular by the development of notched blades for scraping wood. It is difficult to suspect a simple adaptation to a drier environment, since woodworking has been attested for a long time. In addition, this typological innovation is also observed in Europe, in very different environmental contexts from those of the Maghreb.

The very partial nature of our work obviously limits the conclusions that we can draw from it. Functional studies on projectile armatures are also few; it will be necessary to develop these studies, insofar as there is a major change in lithic equipment, synchronous with the development of notched blades, without it being known whether there is a direct link between these two elements. Finally, studies of complete lithic series will be essential, beyond the analysis of specific tools, with the aim to explore the different aspects of a complete technical changeover. In addition, only the analysis of complete lithic assemblages or representative samples makes it possible to have a global vision of the functions and management of lithic productions, and therefore to assess site functions in the settlement systems, in conjunction with other analytical approaches. However, we believe that we have shown the need to develop functional studies; especially to search the links between the composition of the assemblages, resource exploitation and adaptative strategies to distinct environments, as well as the identification of certain traditions, invisible from only technological and typological approaches.

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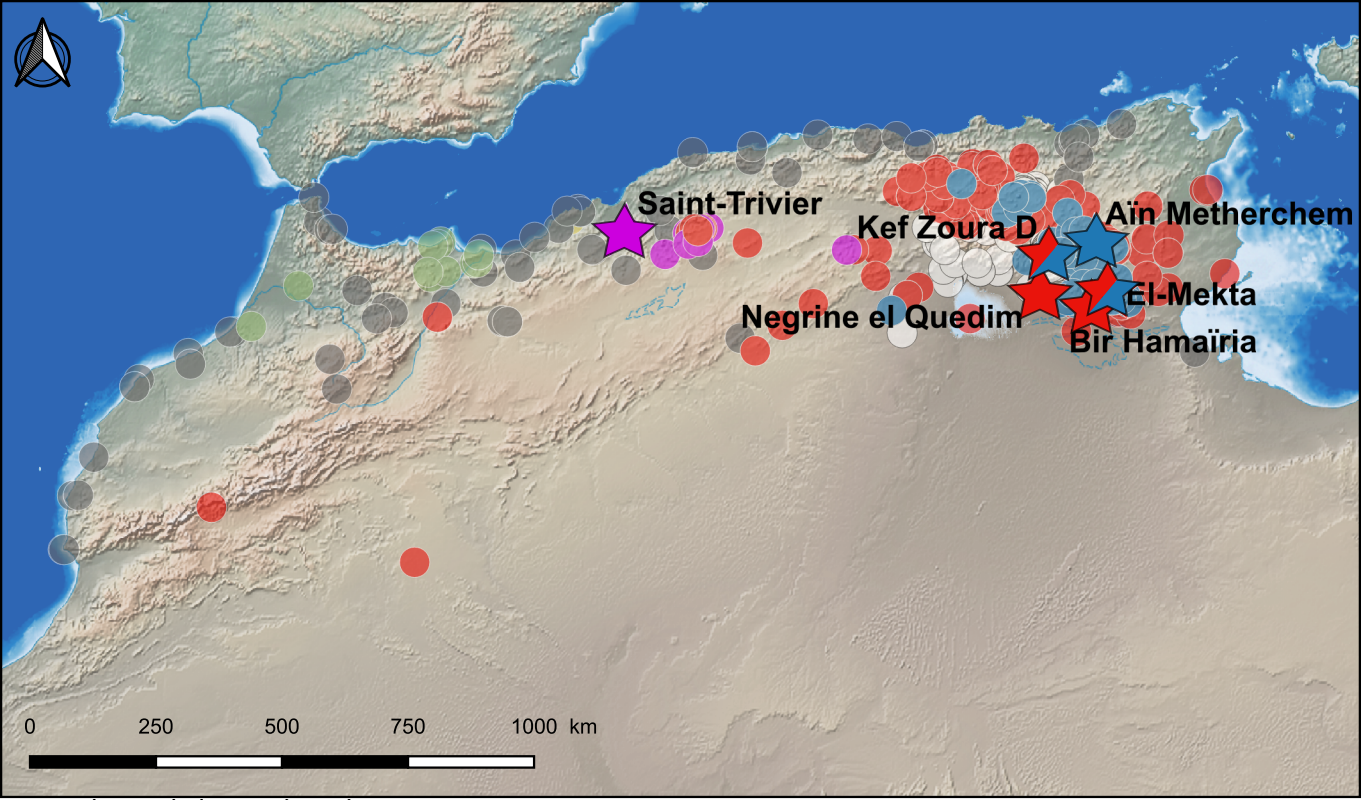
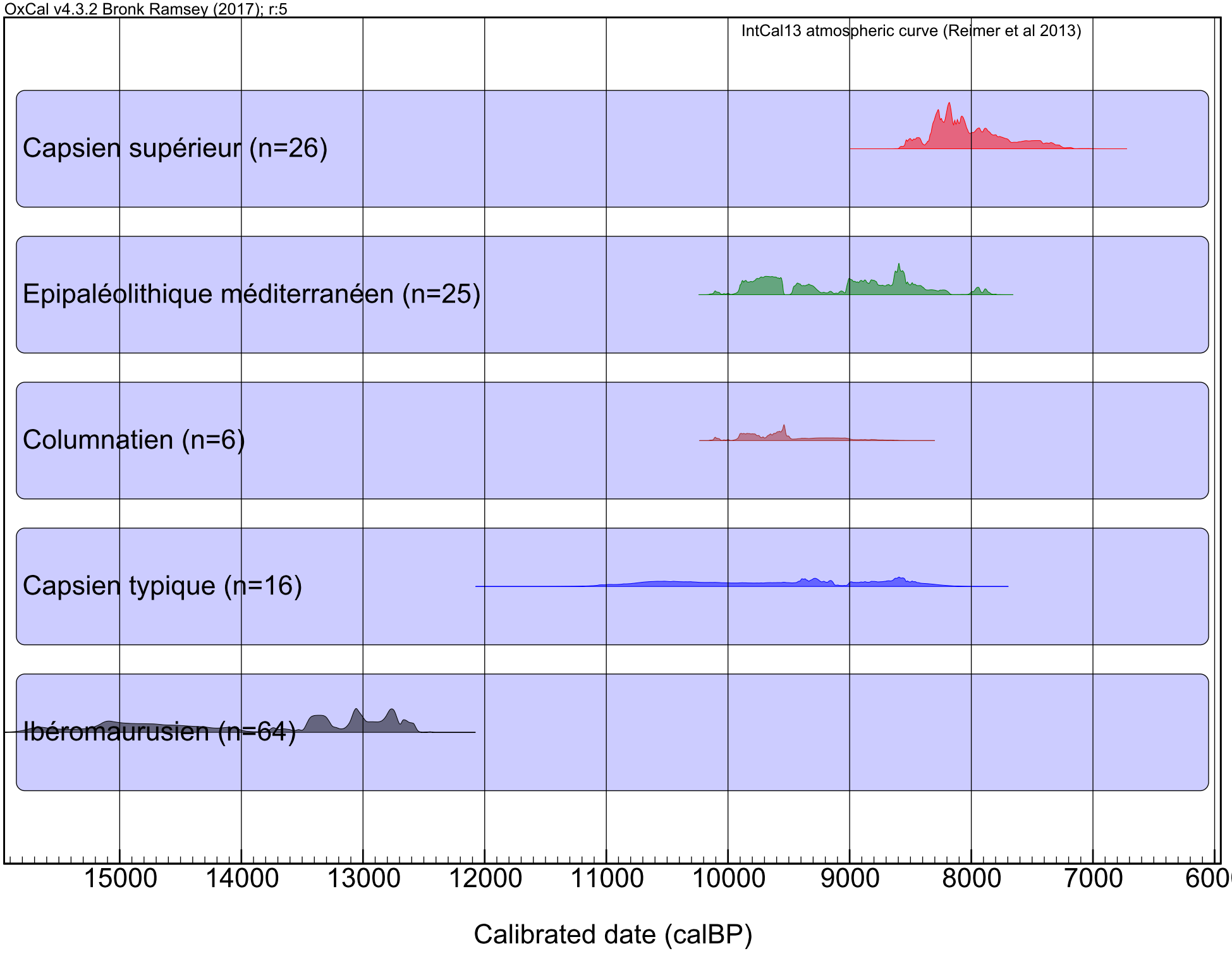
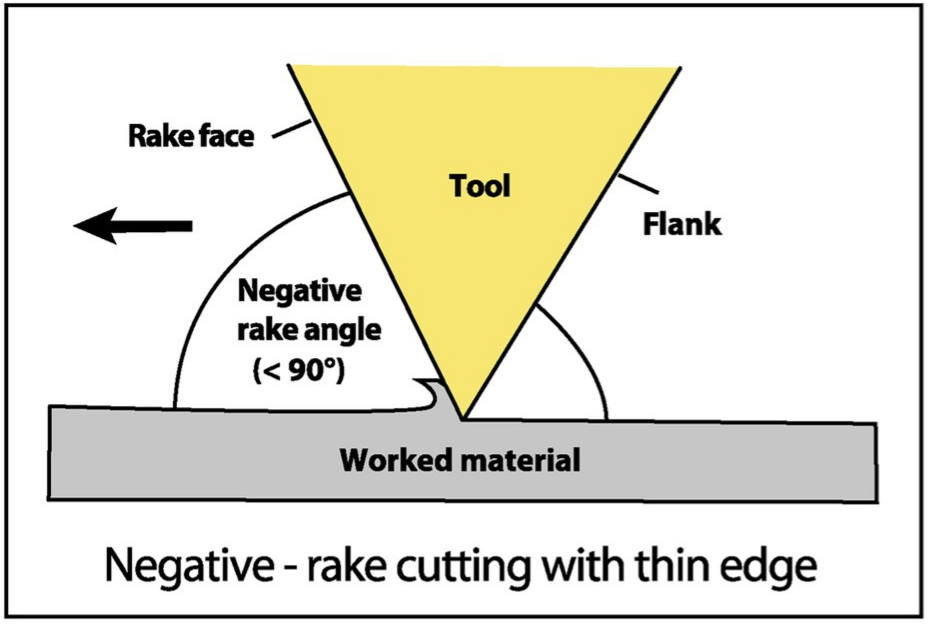
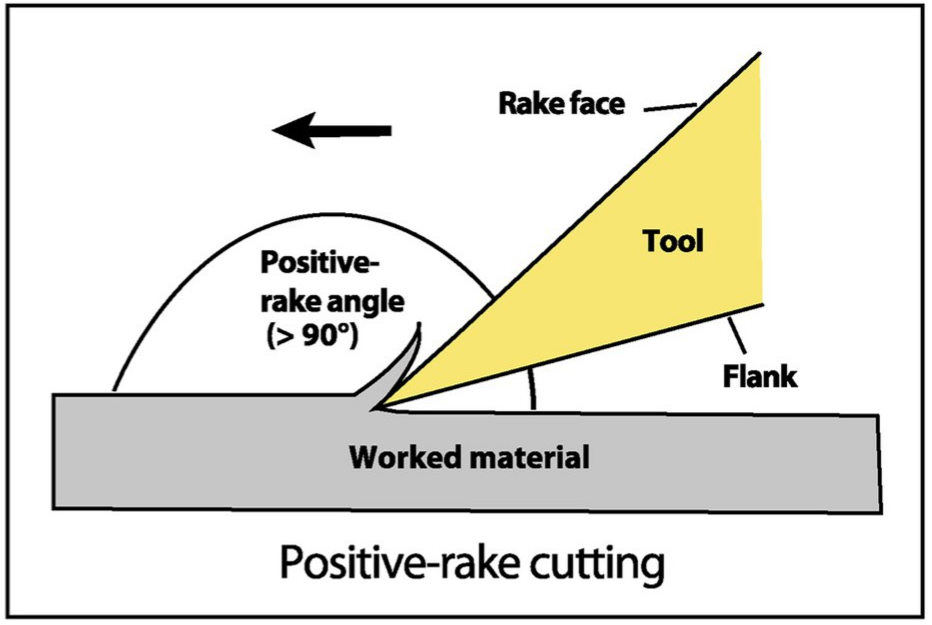

Saint-Trivier
Kef Zoura D
Aïn Metherchem
El-Mekta
Negrine el Quedim
Bir Hamaïria
0
250
500
750
1000 km
niveau de la mer (en m)
0
-30
-60
-90
-120
Ibéromaurusien
Capsien typique
Capsien supérieur
sites étudiés
Columnatien
Epipaléolithique méditerranéen
“post-ibéromaurusien”
indéterminé

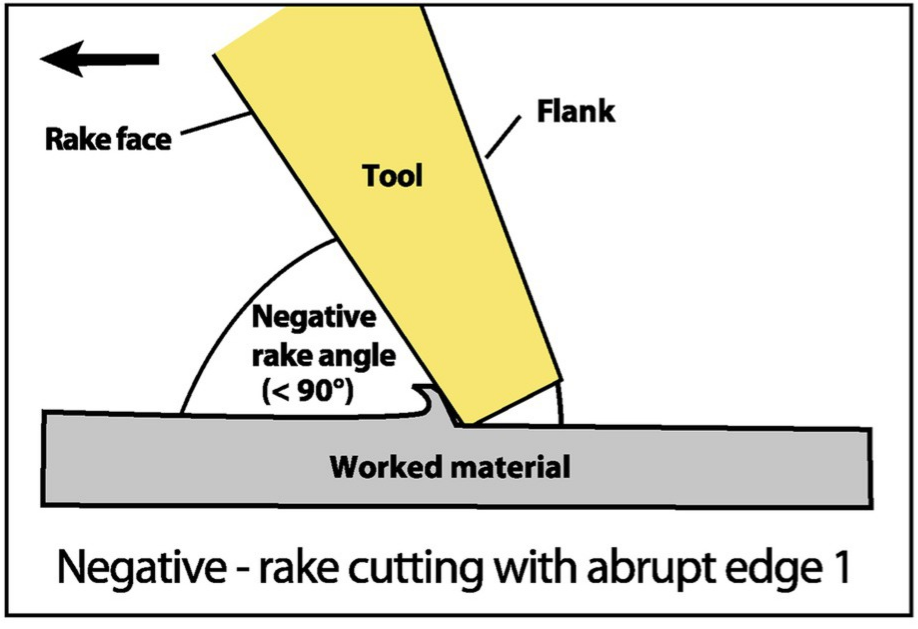

OxCal v4.3.2 Bronk Ramsey (2017); r:5
IntCal13 atmospheric curve (Reimer et al 2013)
Capsien supérieur (n=26)
Epipaléolithique méditerranéen (n=25)
Columnatien (n=6)
Capsien typique (n=16)
Ibéromaurusien (n=64)
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
Calibrated date (calBP)



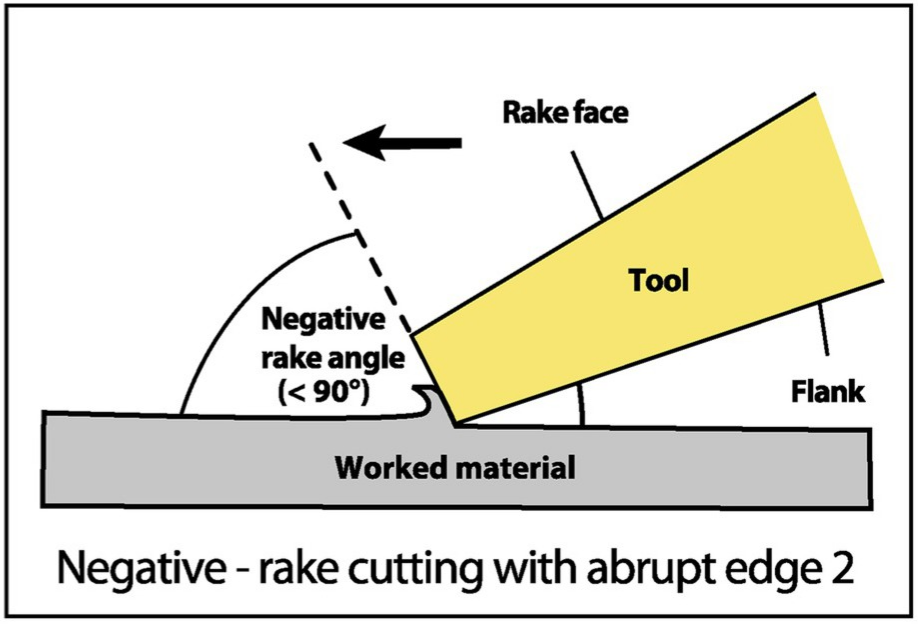
Negative - rake cutting with thin edge



Positive-rake cutting



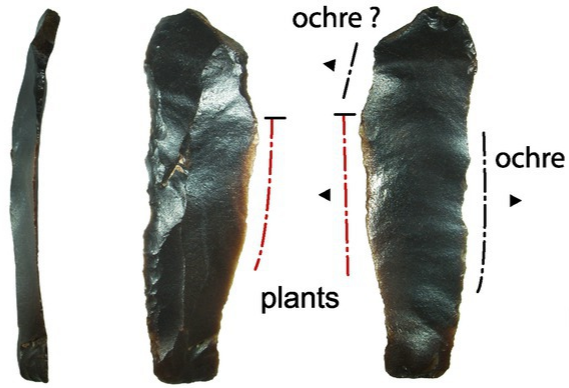
Negative - rake cutting with abrupt edge 1



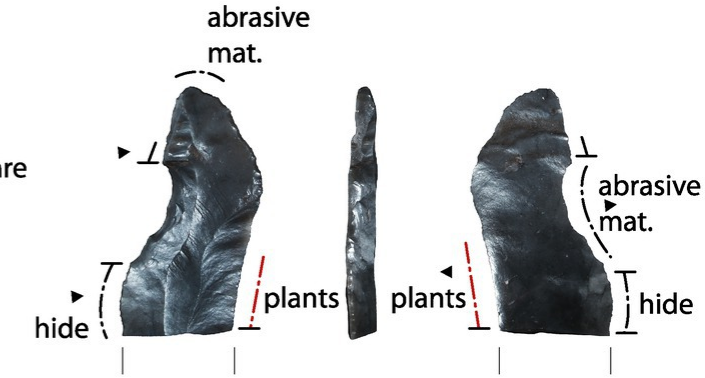
Negative - rake cutting with abrupt edge 2


plants

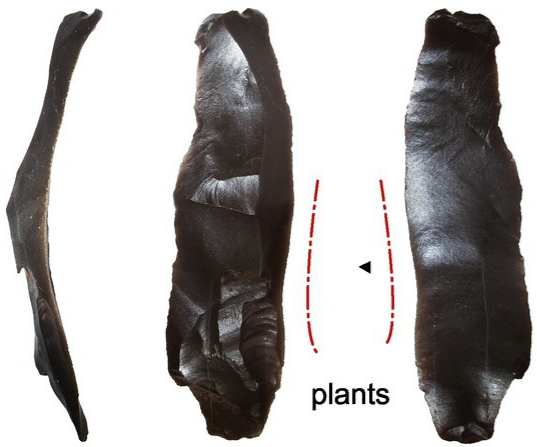
1


ochre ?
ochre
plants

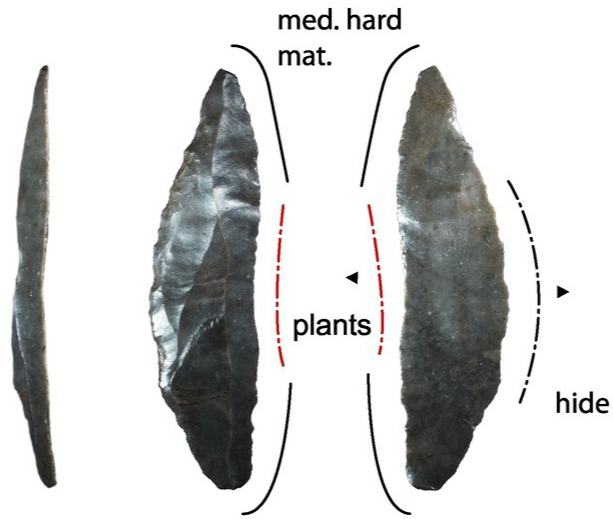
2


abrasive
mat.
hide
plants
plants
abrasive
mat.
hide

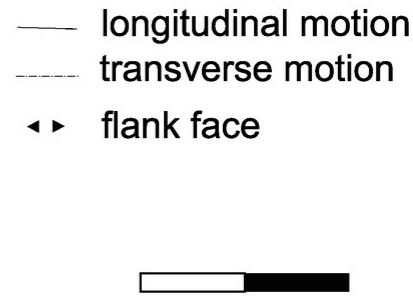
3

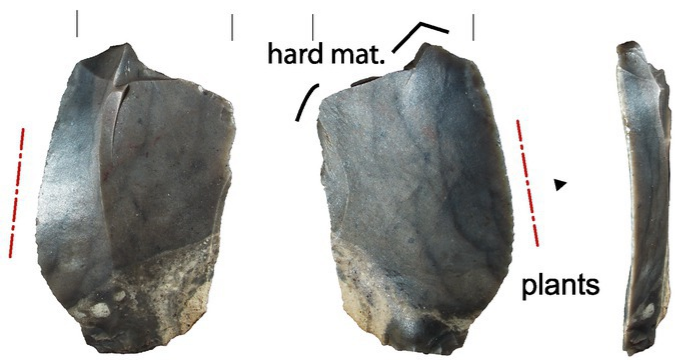

plants

4

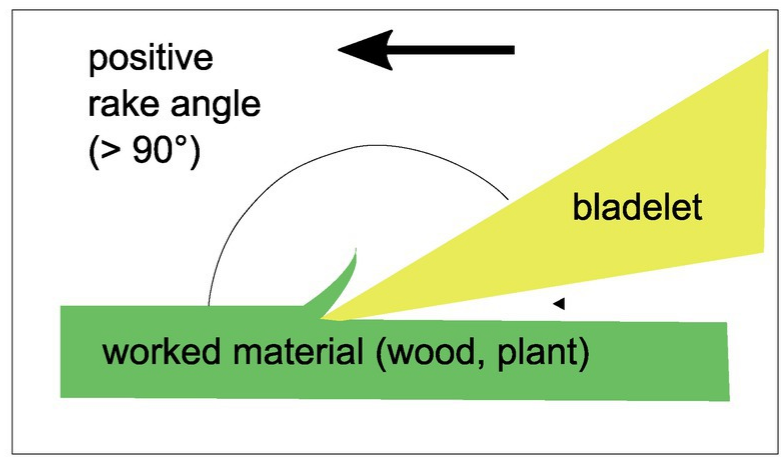

med. hard
mat.
plants
hide

5

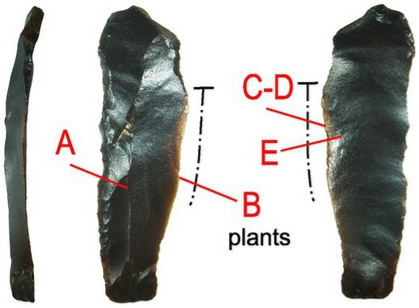

longitudinal motion
transverse motion
flank face


hard mat.
plants

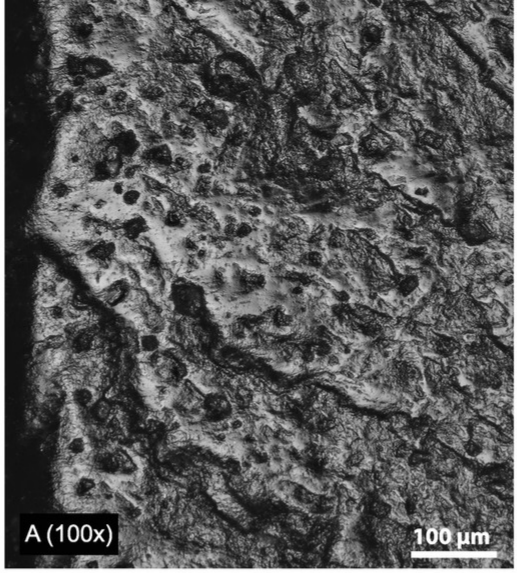
6

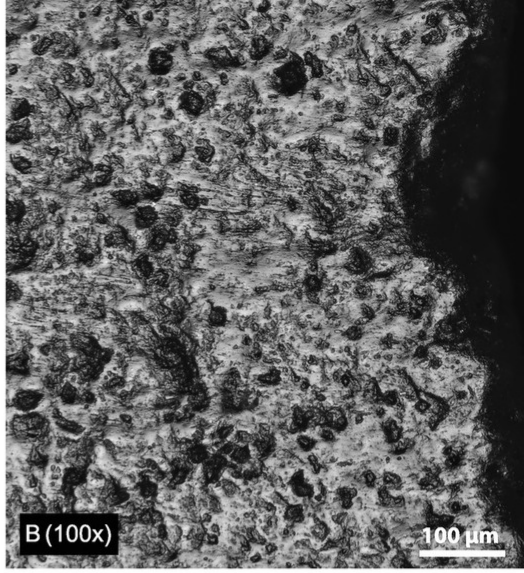

positive
rake angle
(> 90°)
bladelet
worked material (wood, plant)

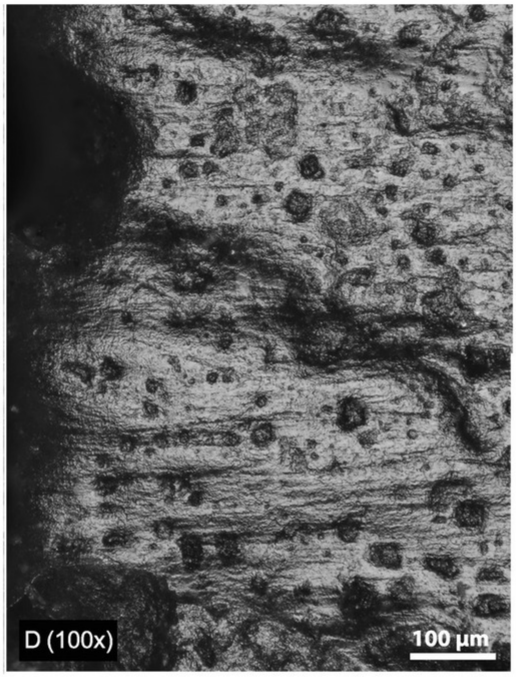
7

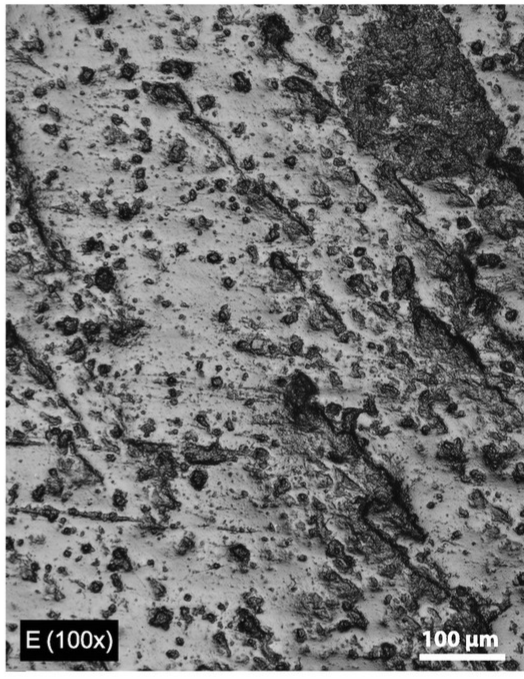


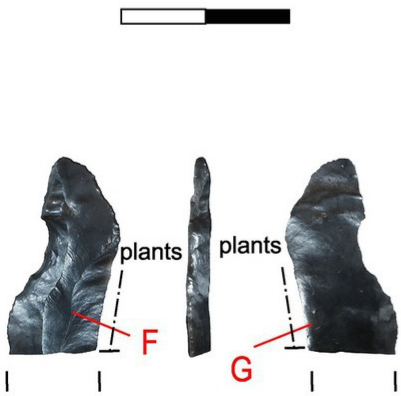
Saint-Trivier - Tr SE1 “dallage” n°3



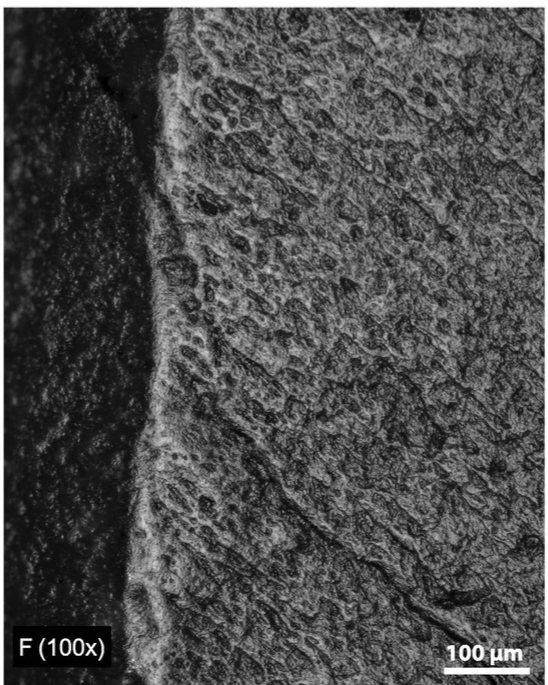


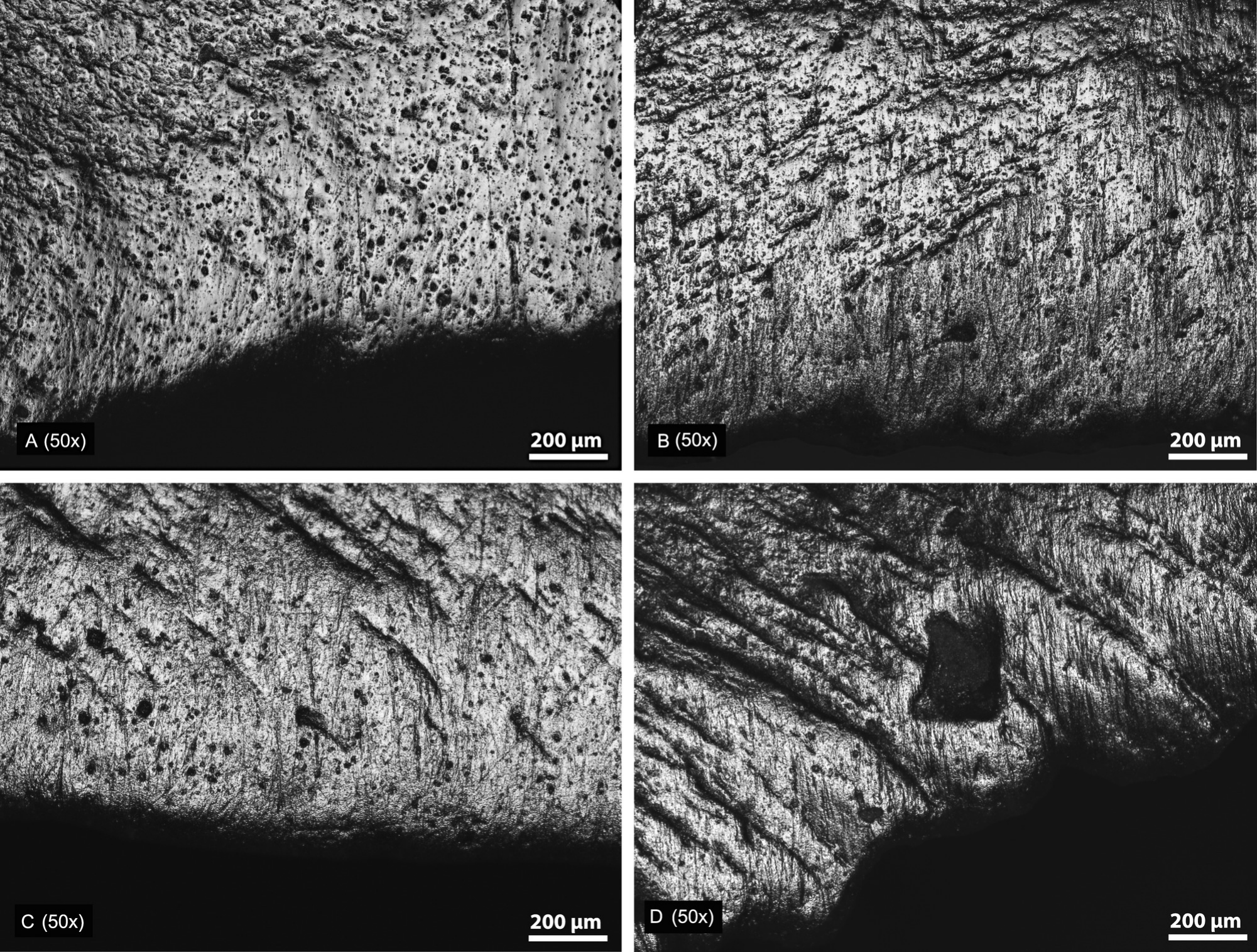


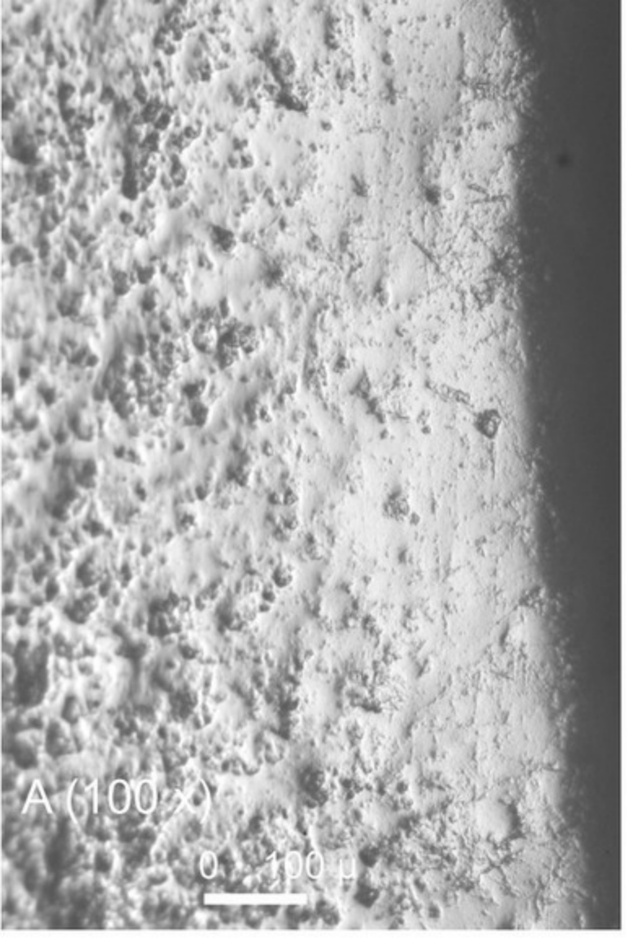


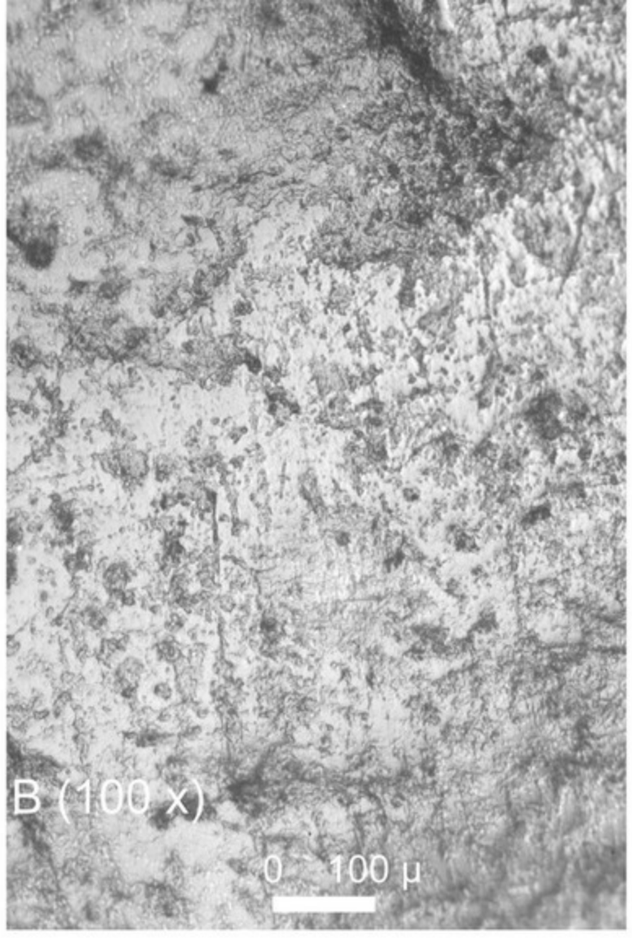


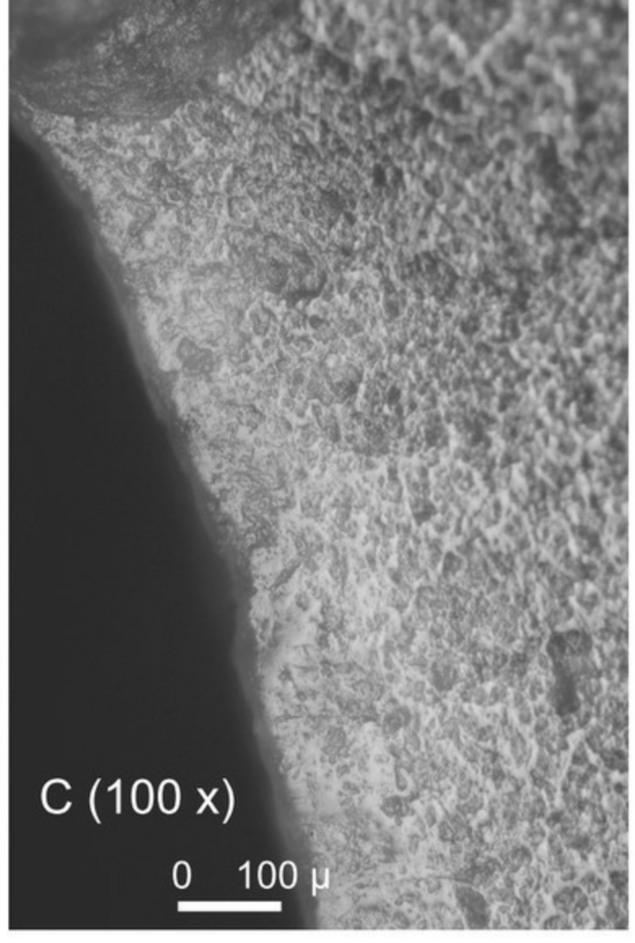
Saint-Trivier - Tr SE1 “dallage” n°2

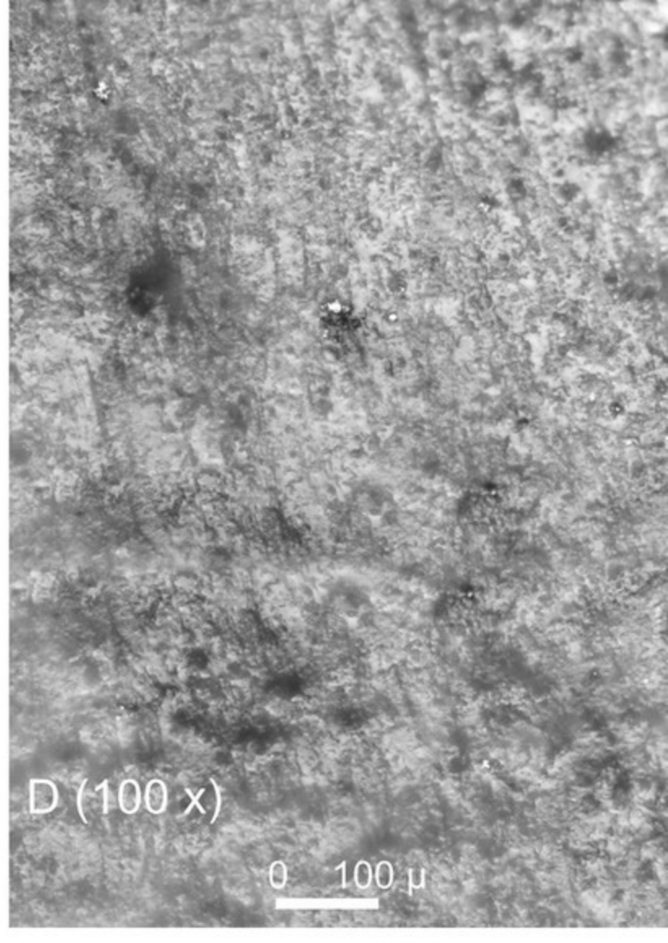


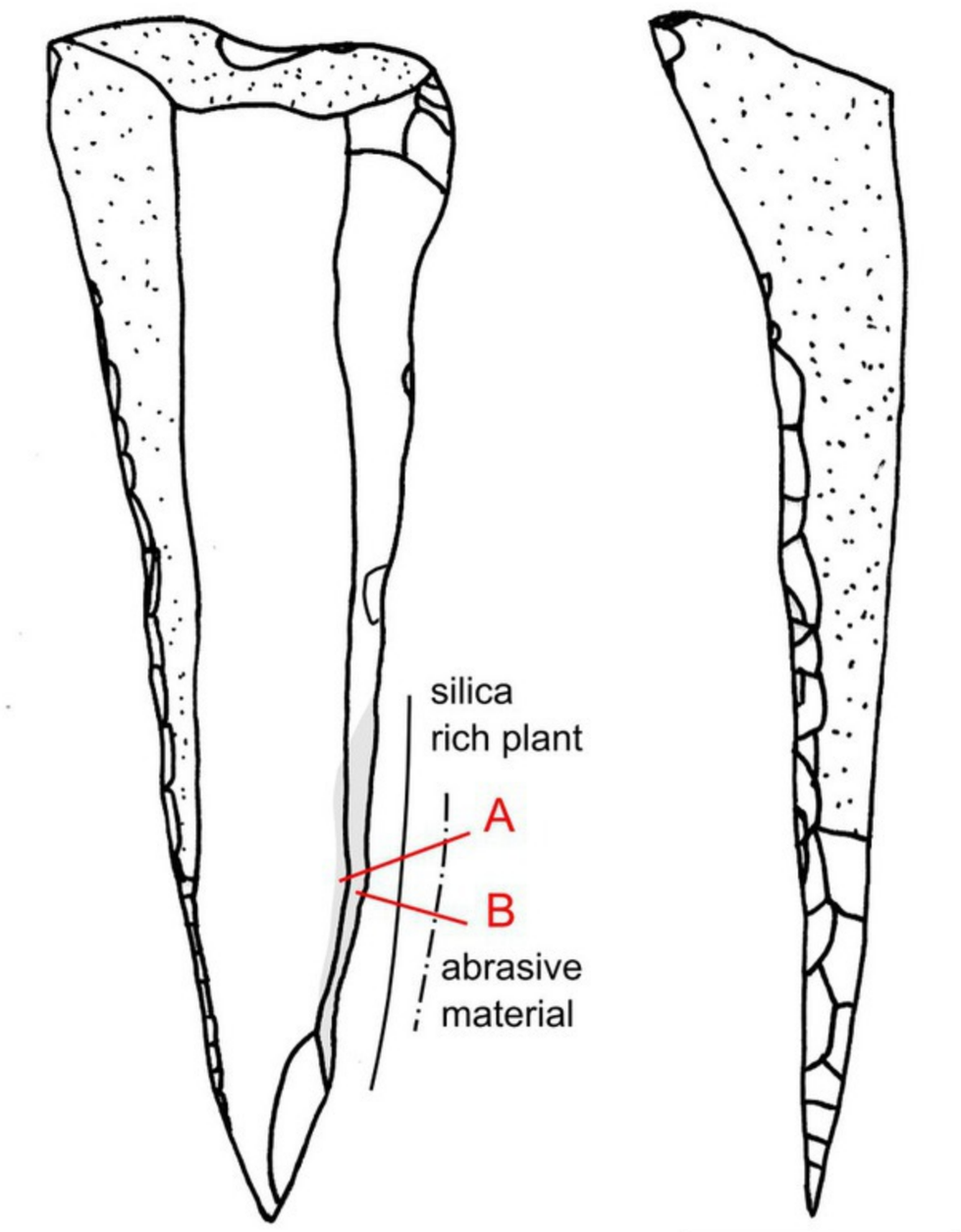

A (50x)
200 µm
B (50x)
200 µm
C (50x)
200 µm
D (50x)
200 µm











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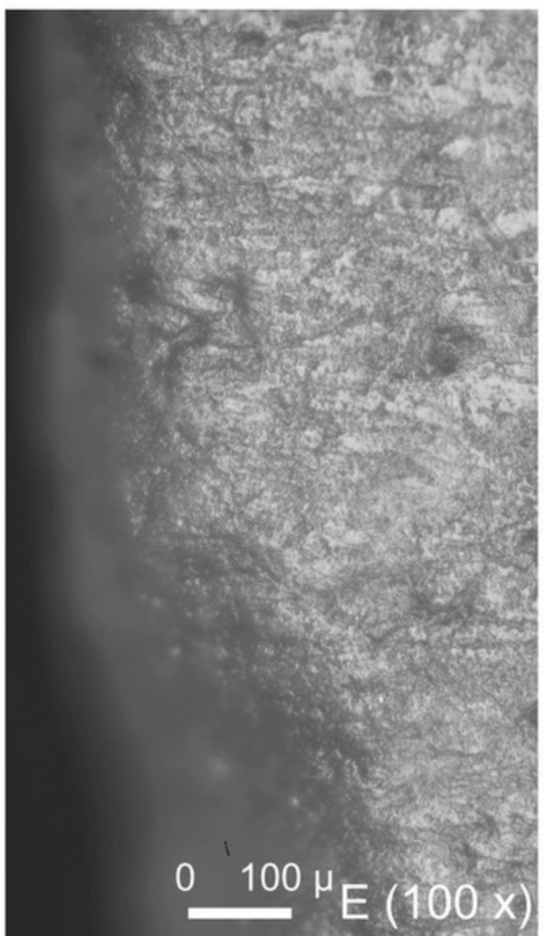
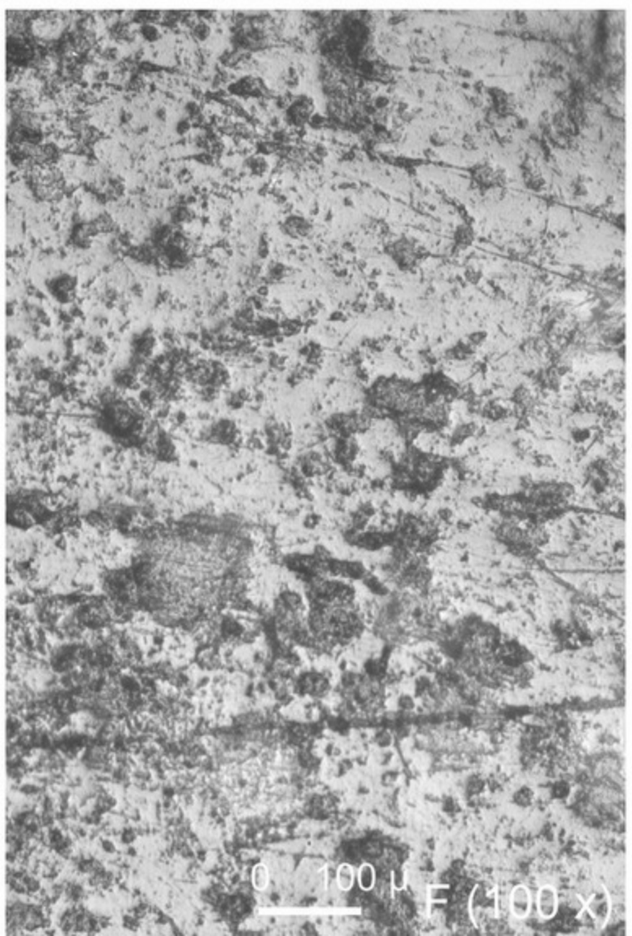
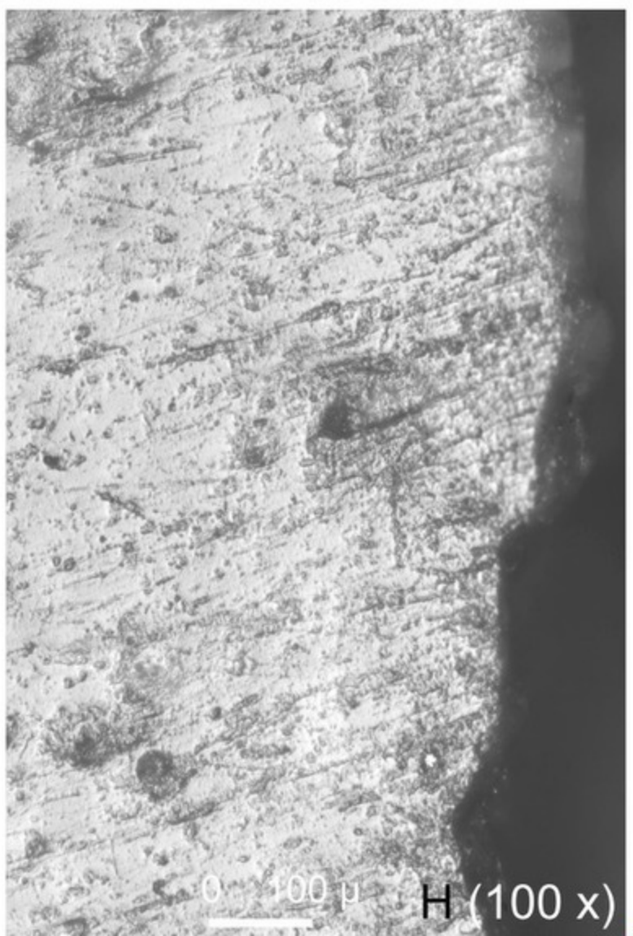
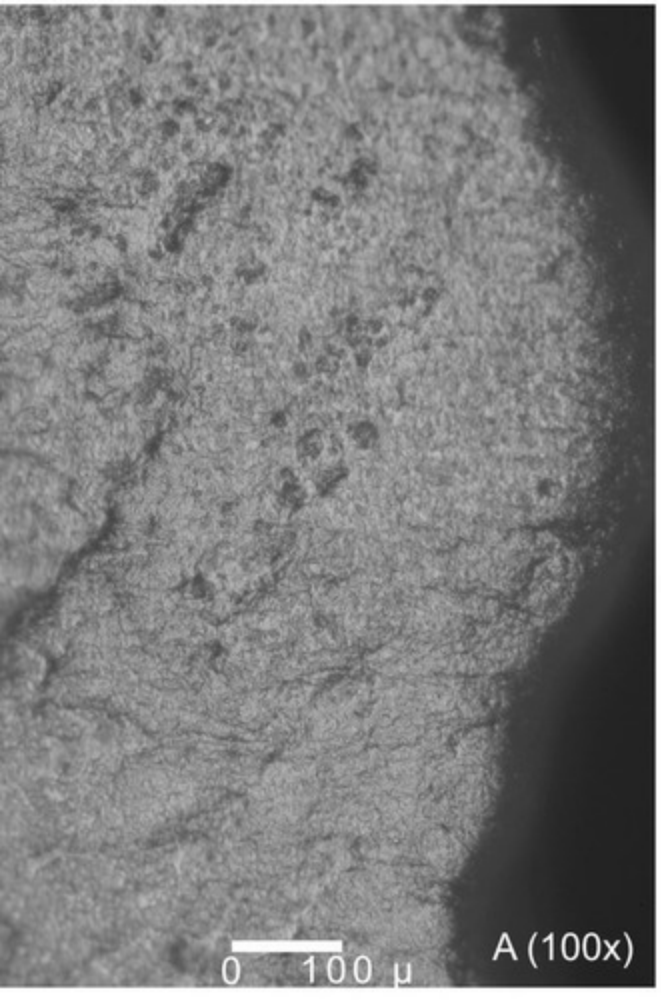
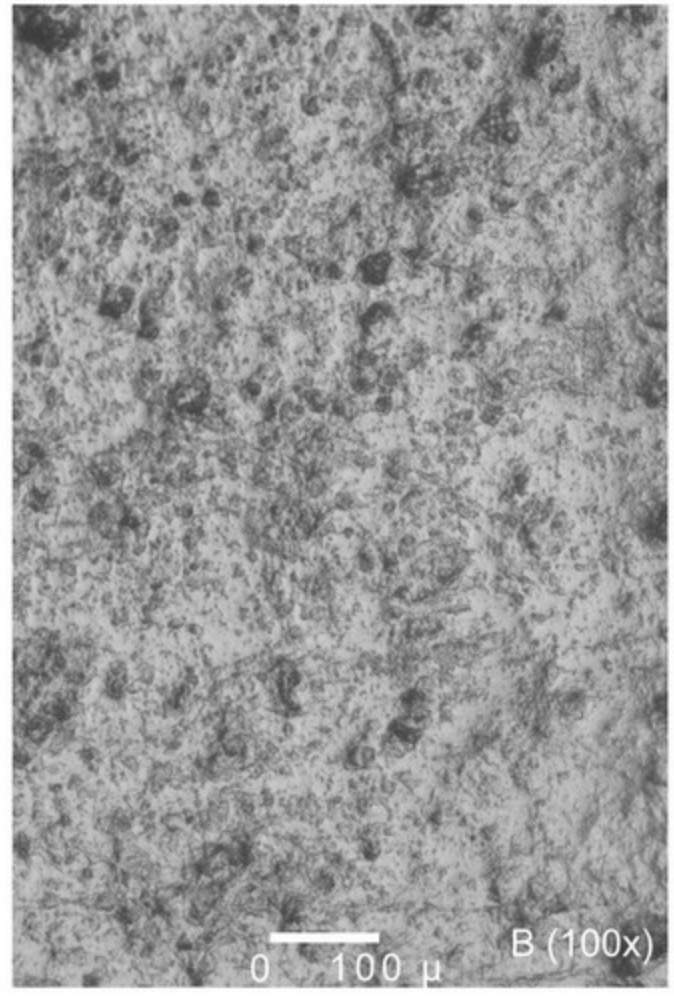
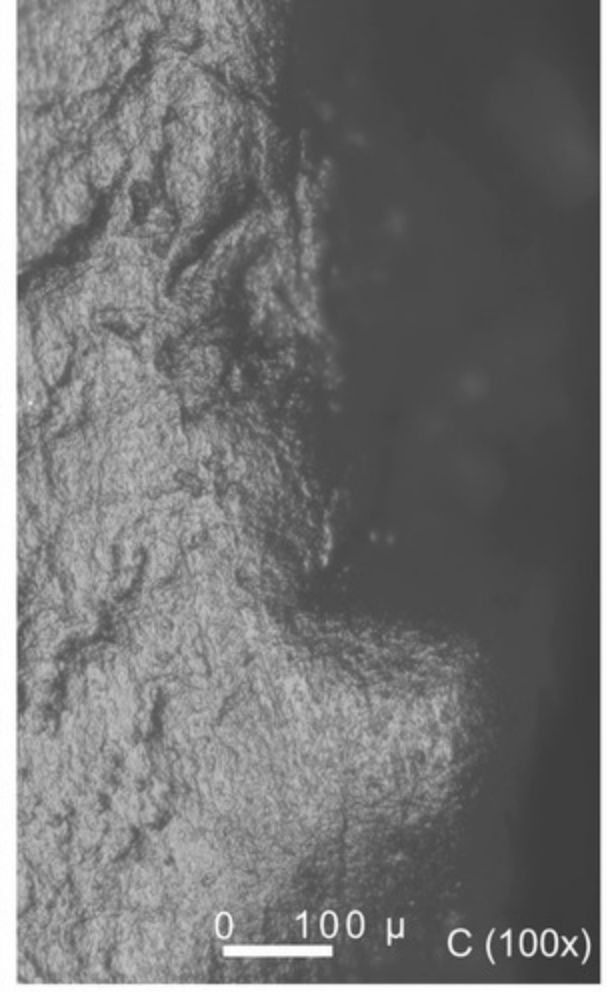


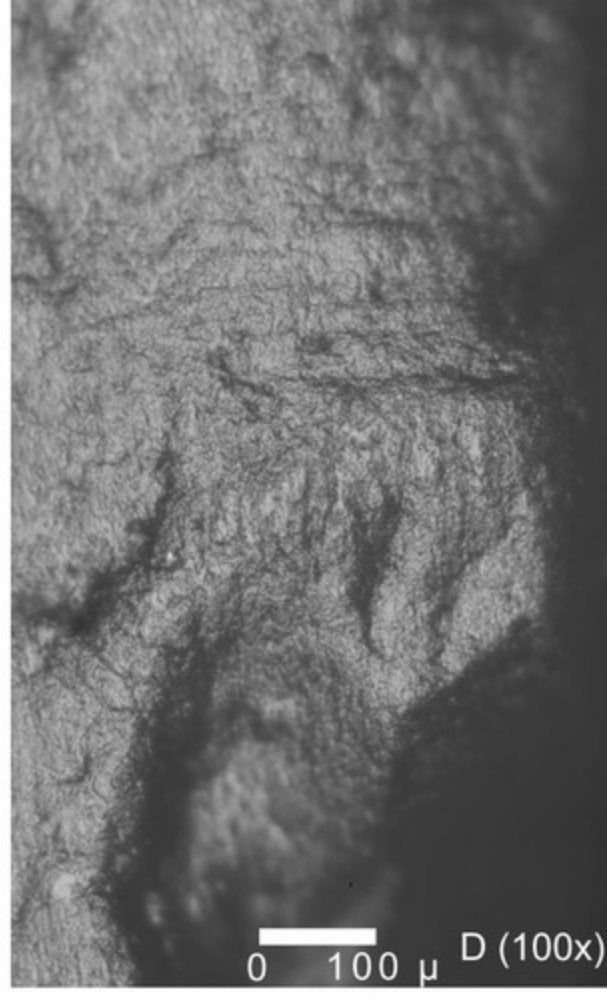


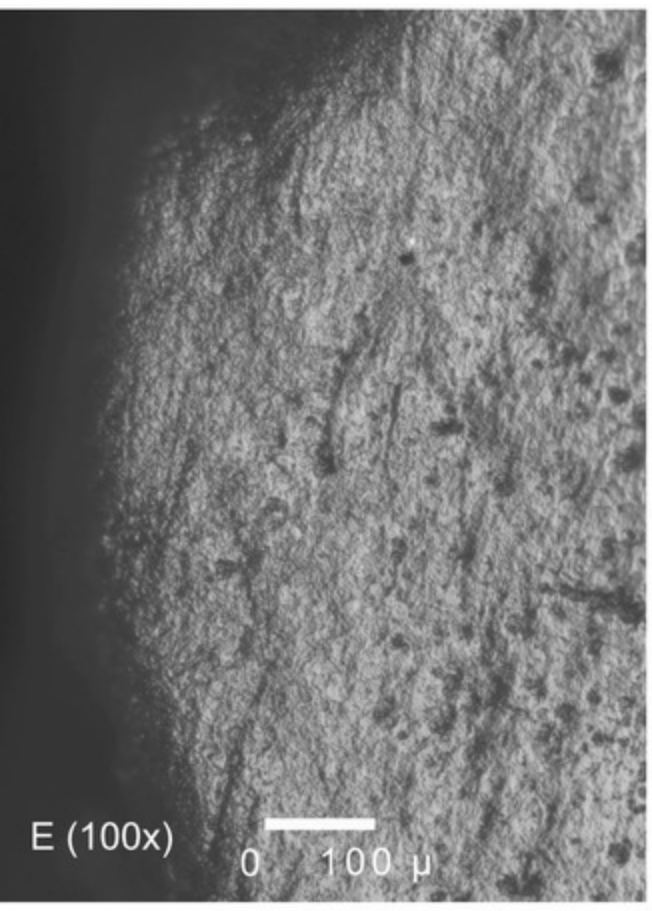


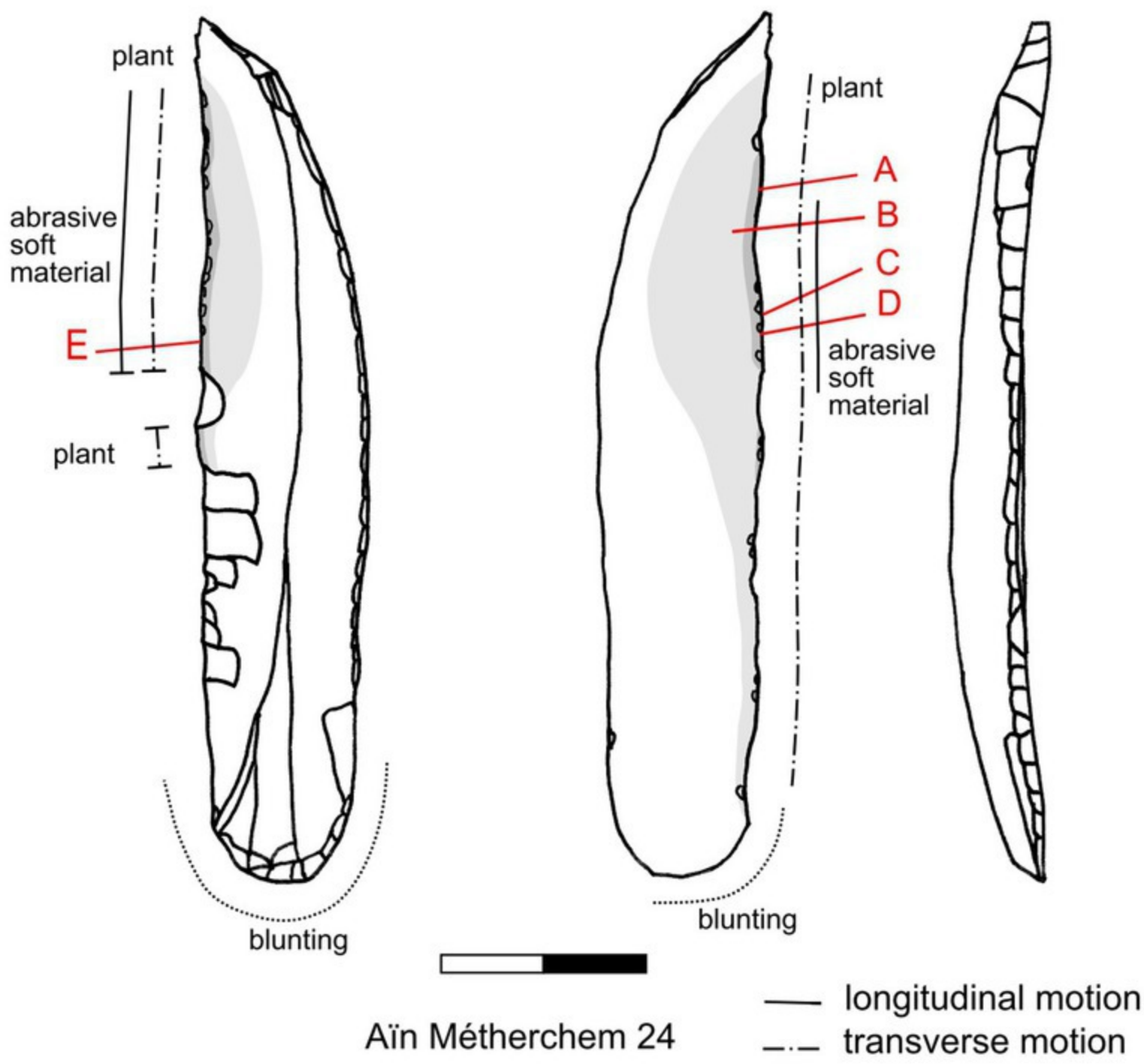

0 100 µ
A (100x)


0 100 µ
B (100x)


0 100 µ
C (100x)


0 100 µ
D (100x)


E (100x)
0 100 µ


plant
abrasive soft material
E
plant
blunting
plant
A
B
C
D
abrasive soft material
blunting
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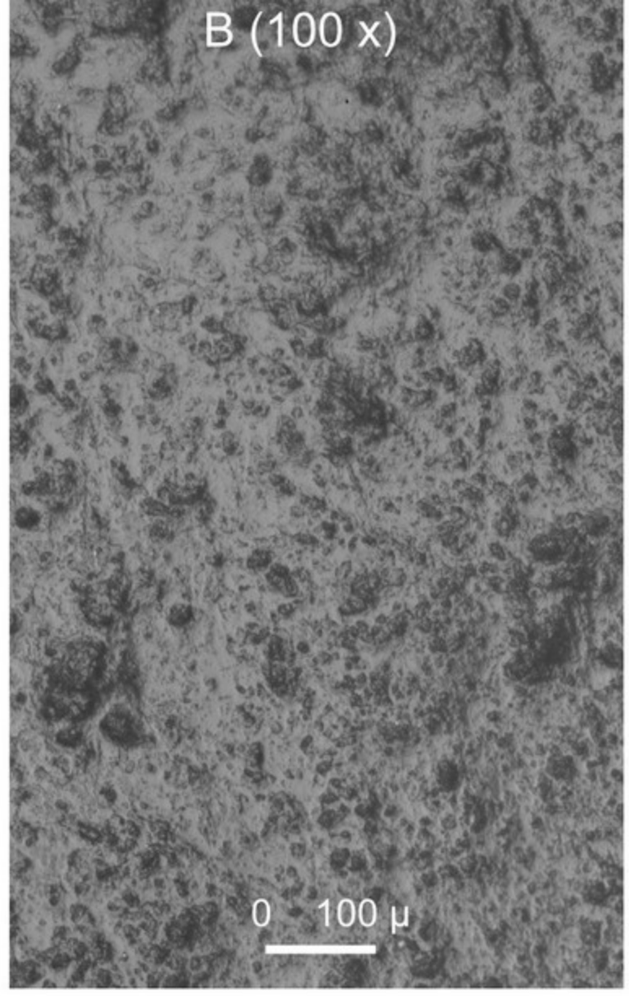
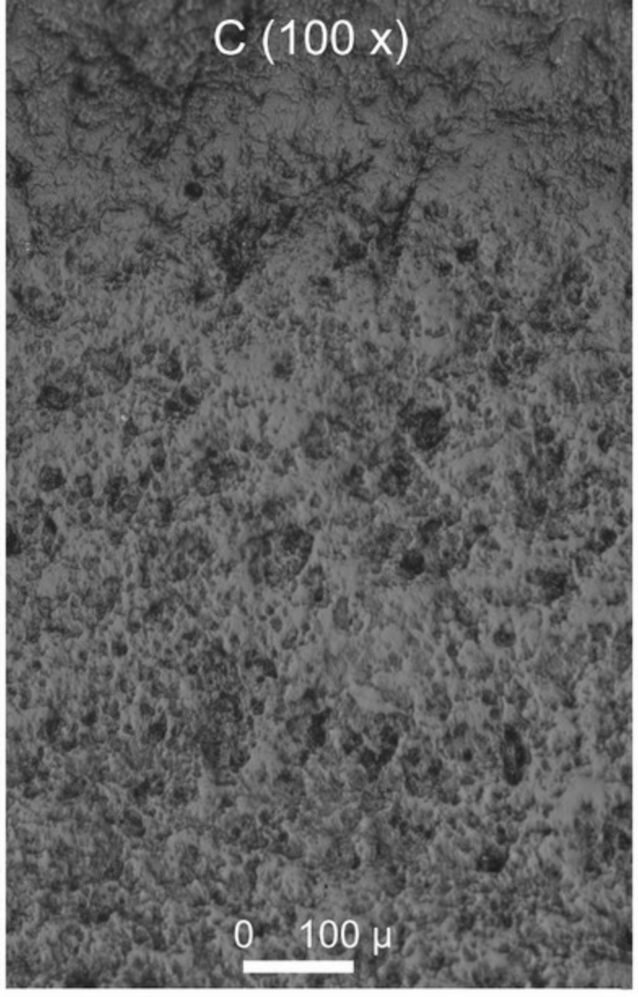
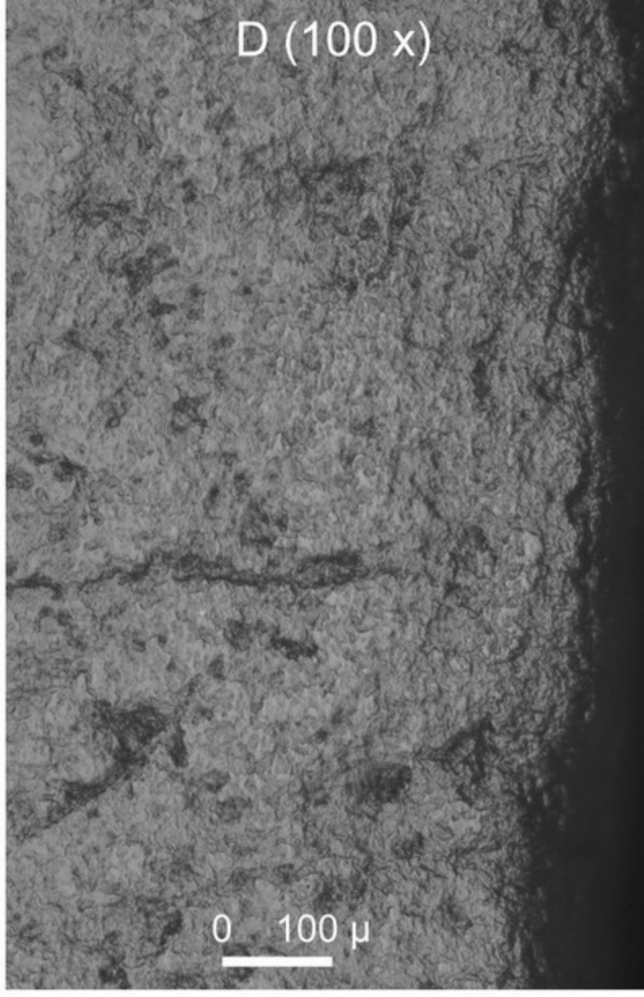
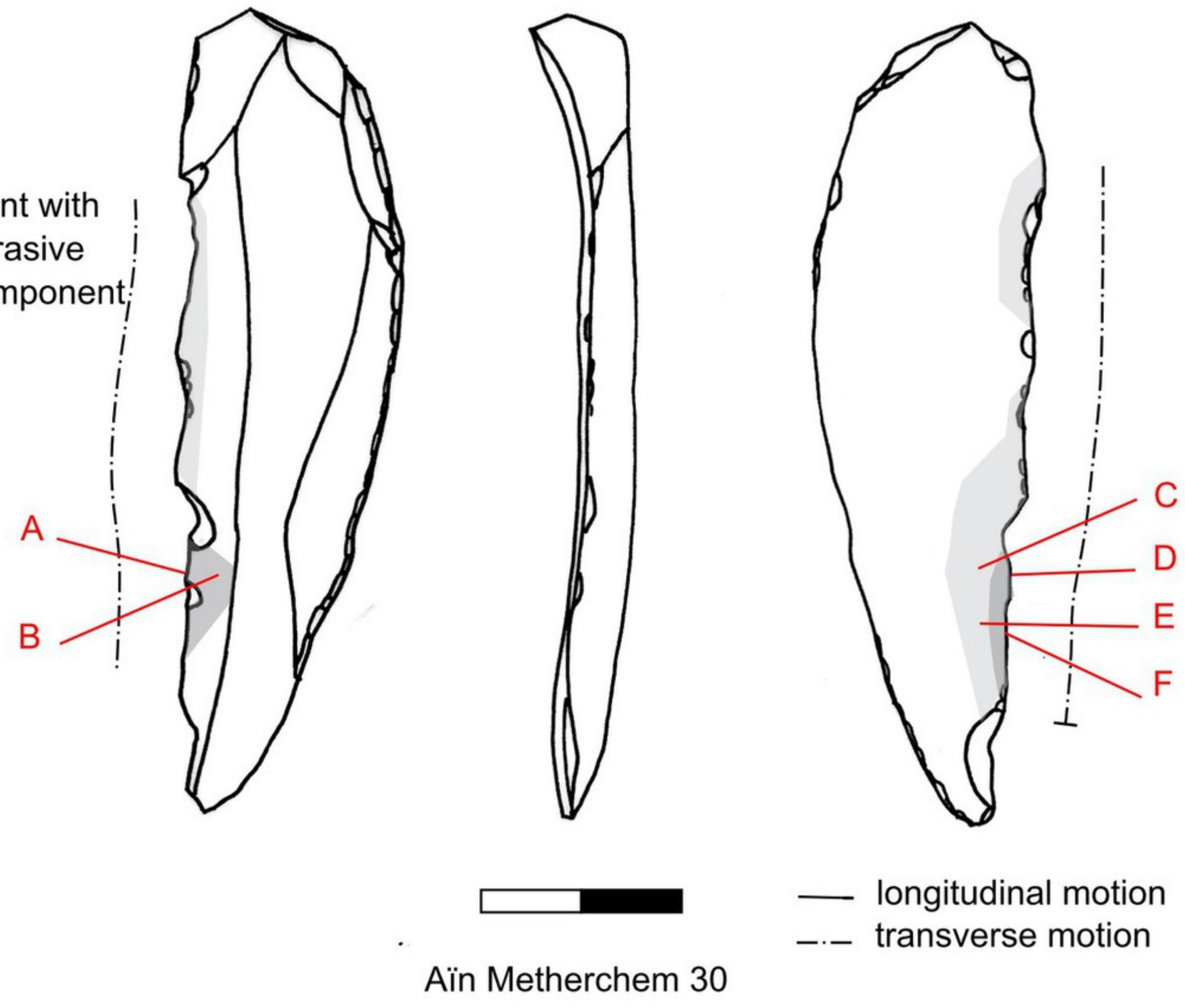
longitudinal motion
transverse motion









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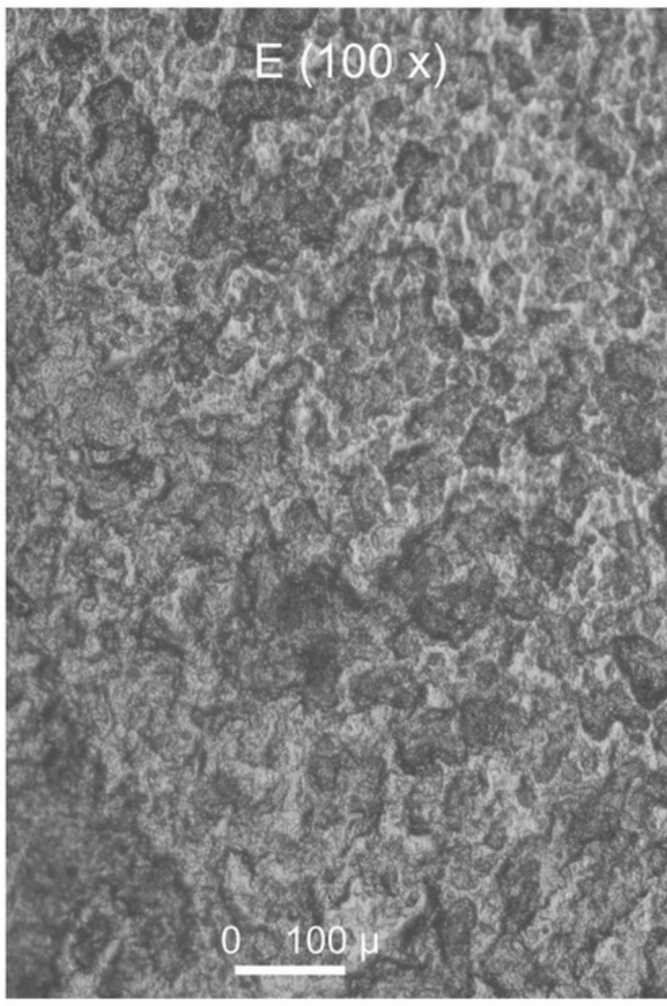
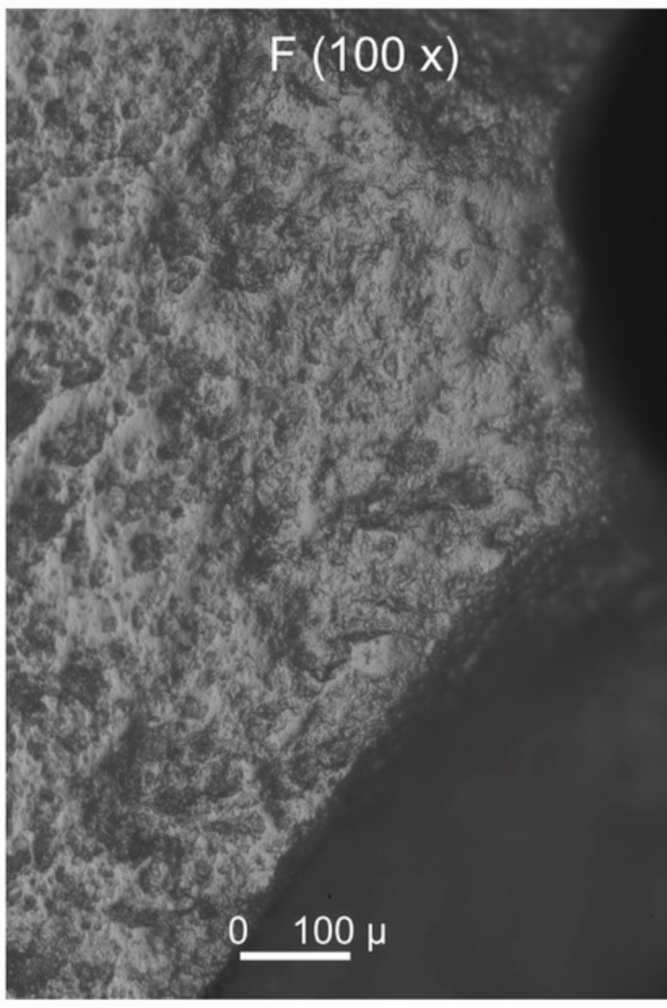
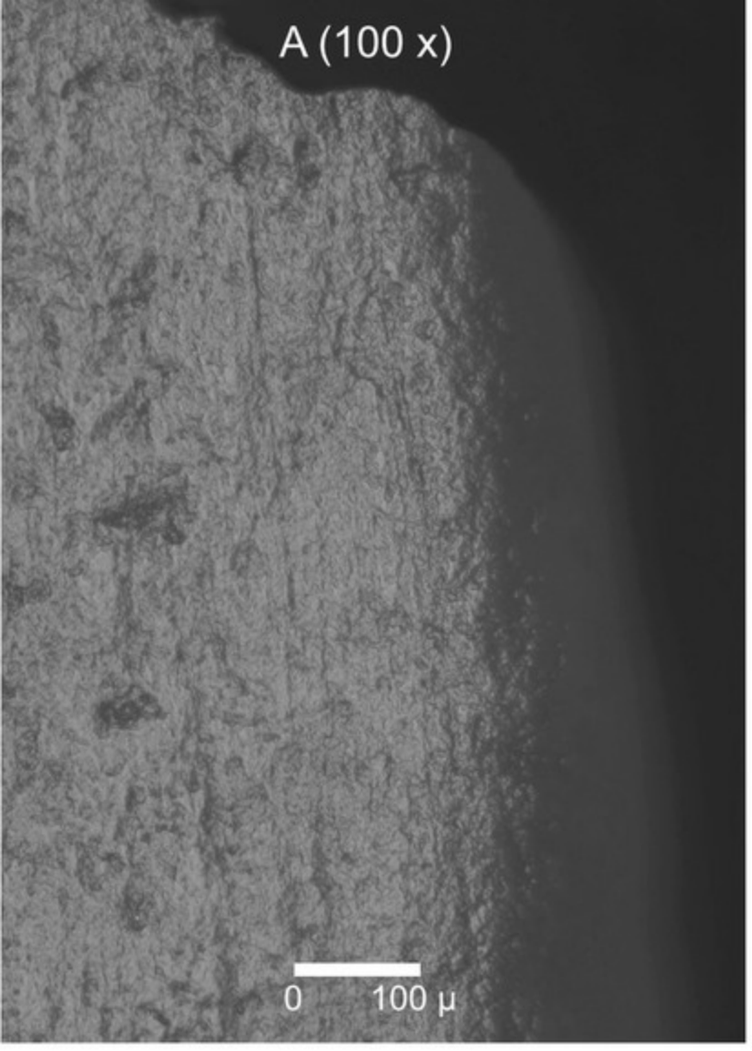
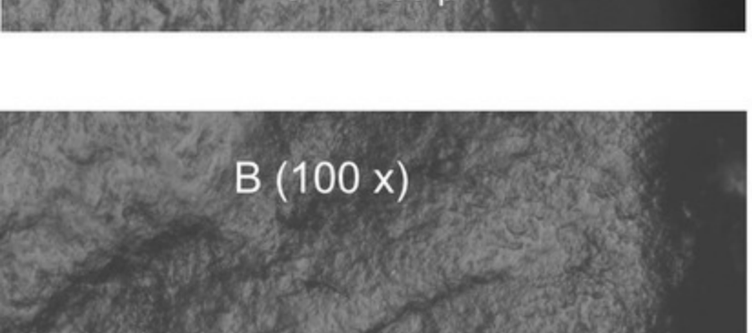
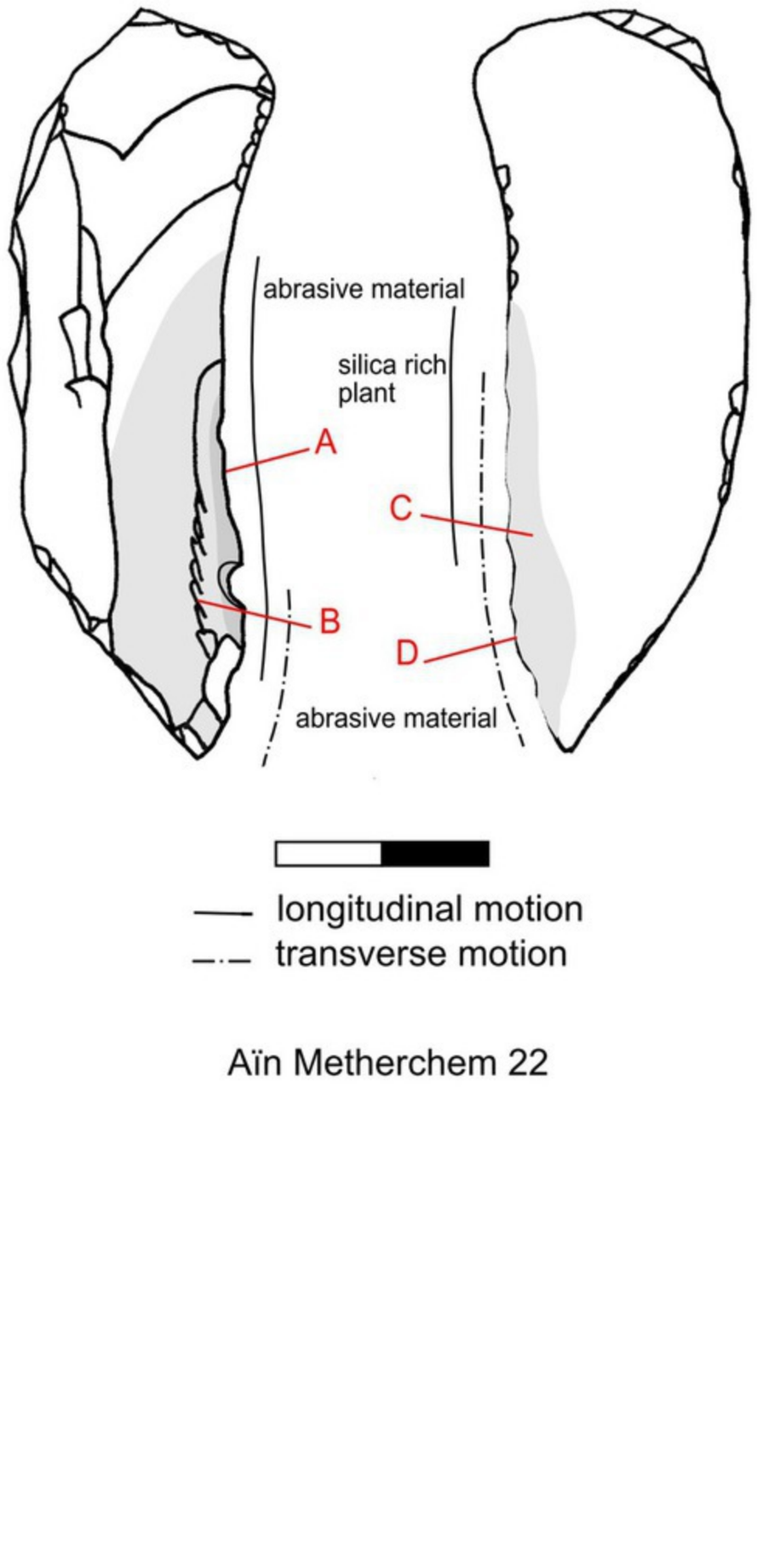





A (100 x)
0 100 µ


B (100 x)
0 100 µ


abrasive material
silica rich plant
A
C
B
D
abrasive material
longitudinal motion
transverse motion
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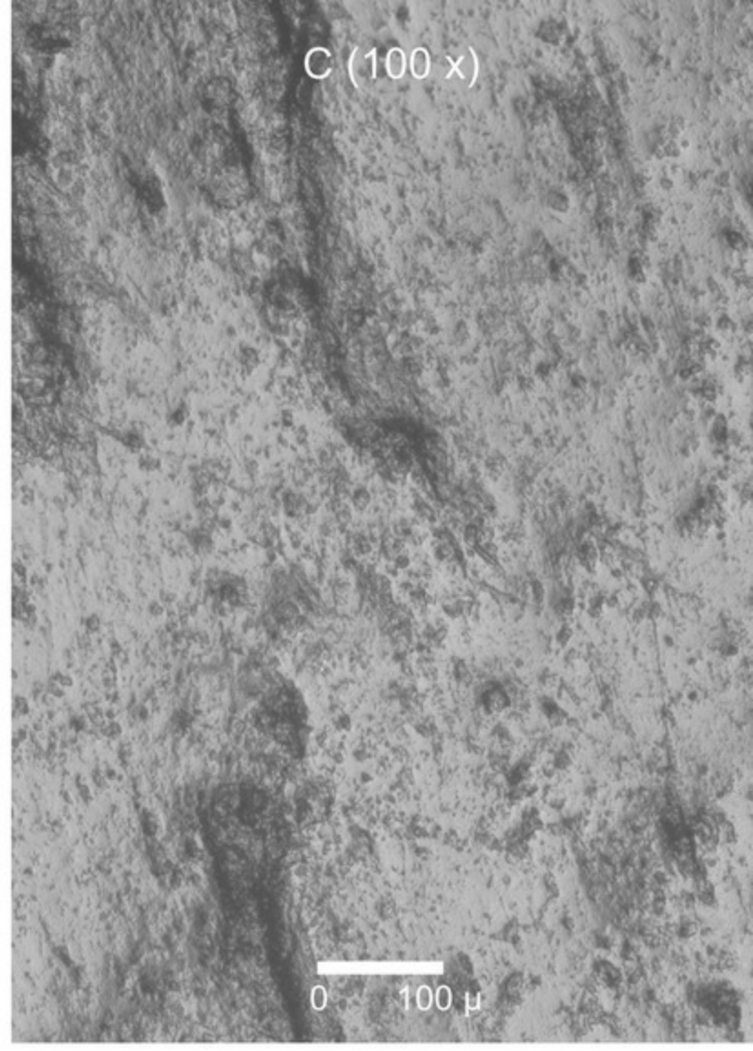
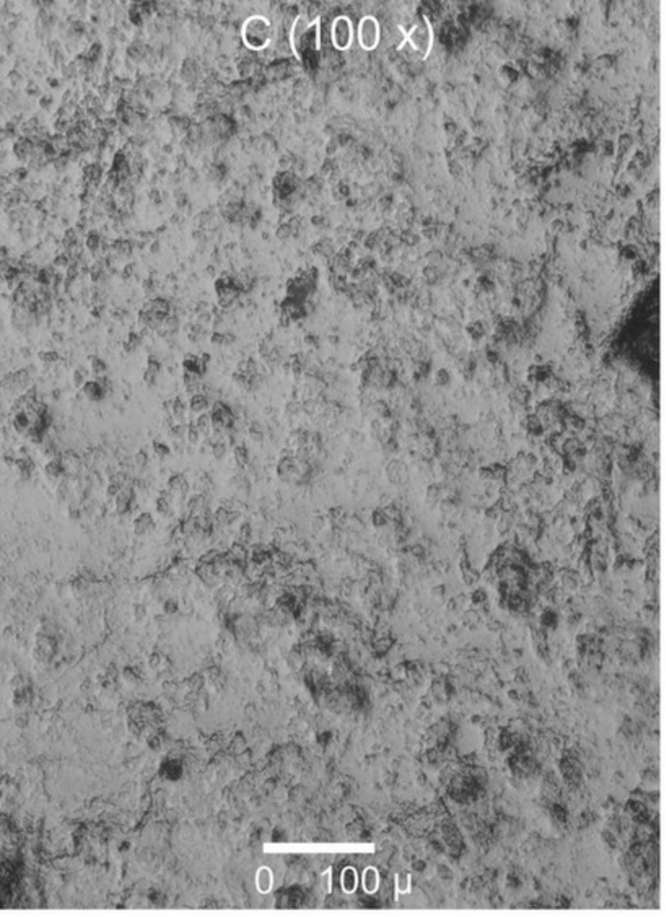
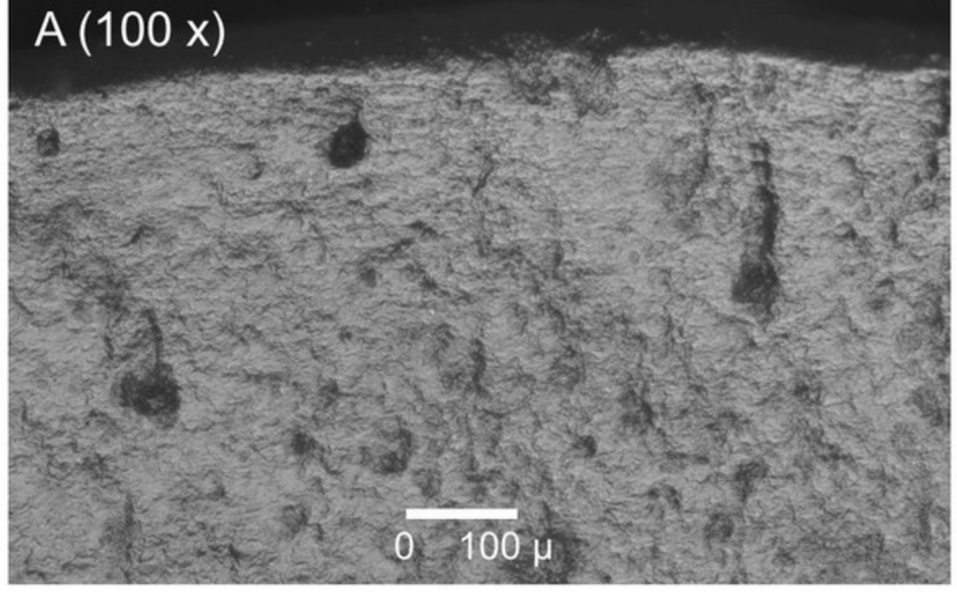
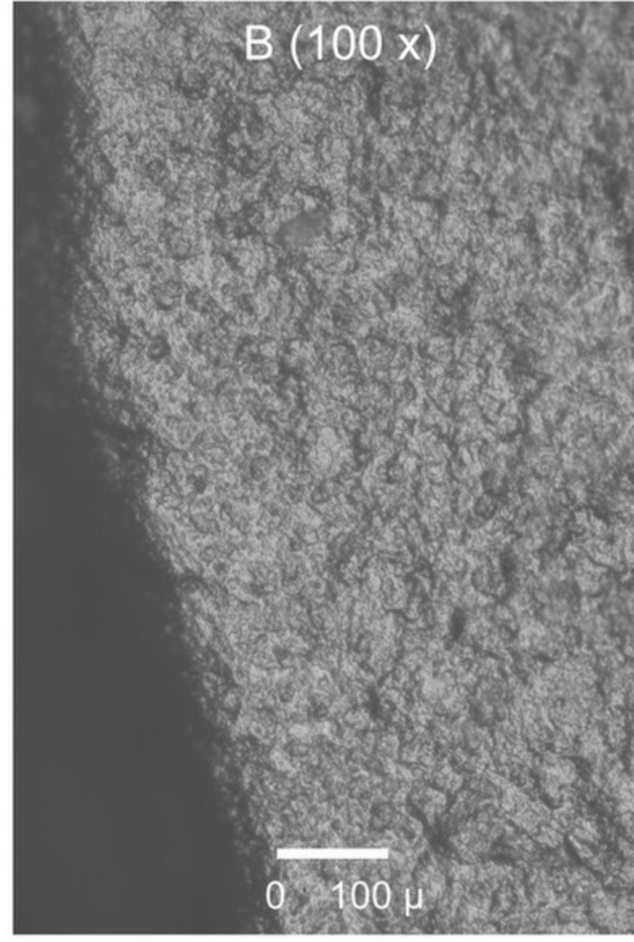
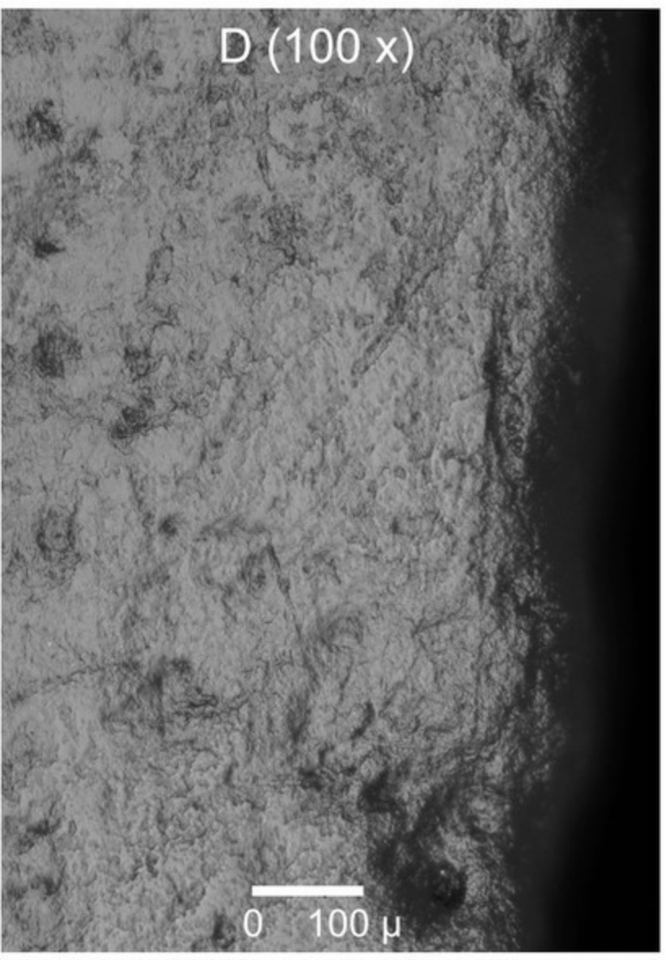

C (100 x)
0 100 µ

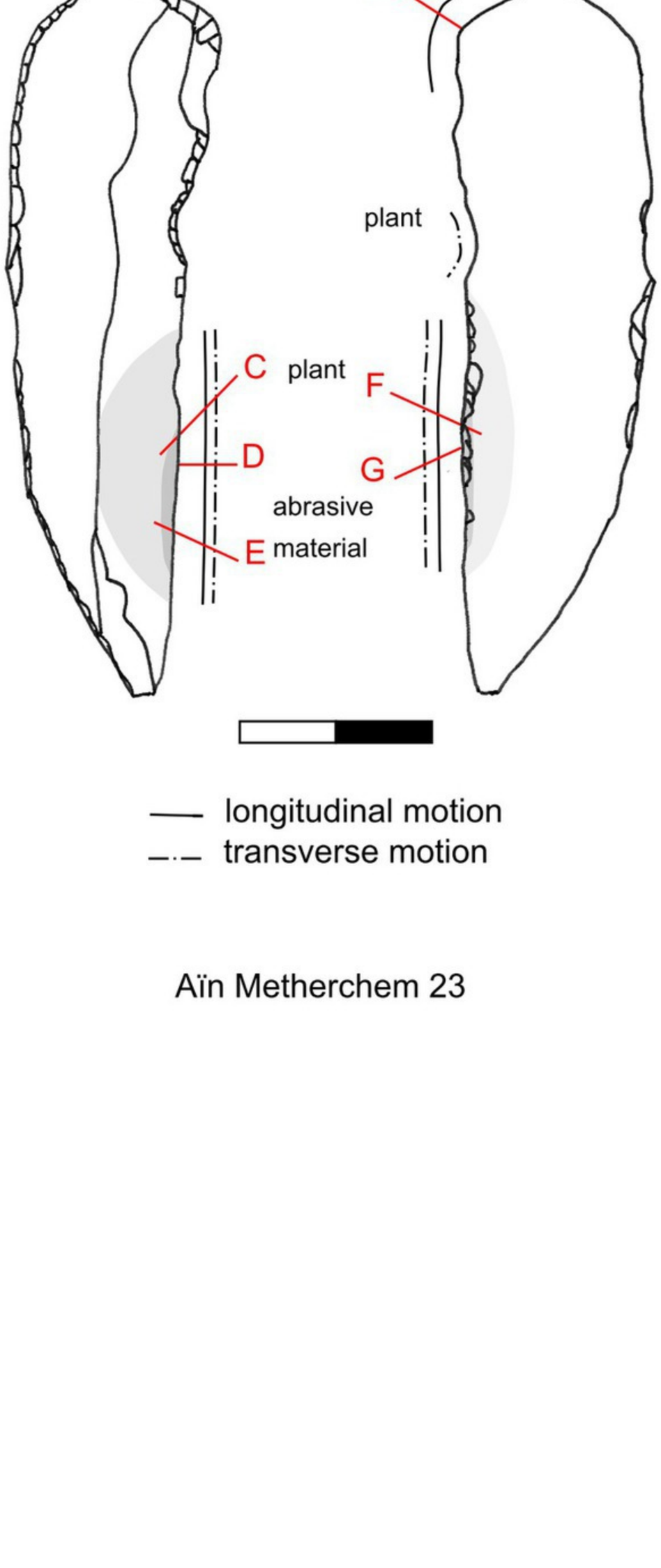

D (100 x)
0 100 µ











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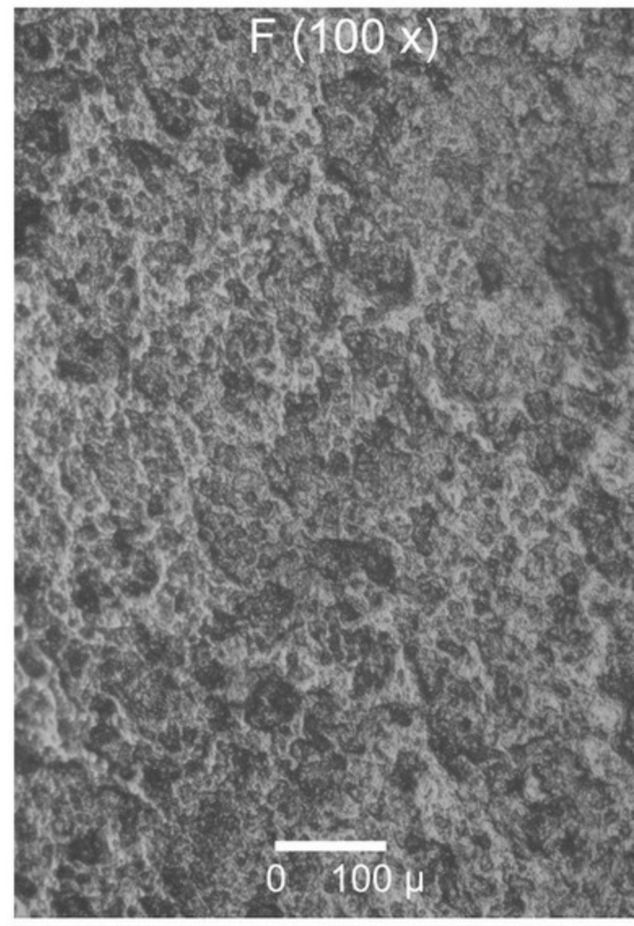

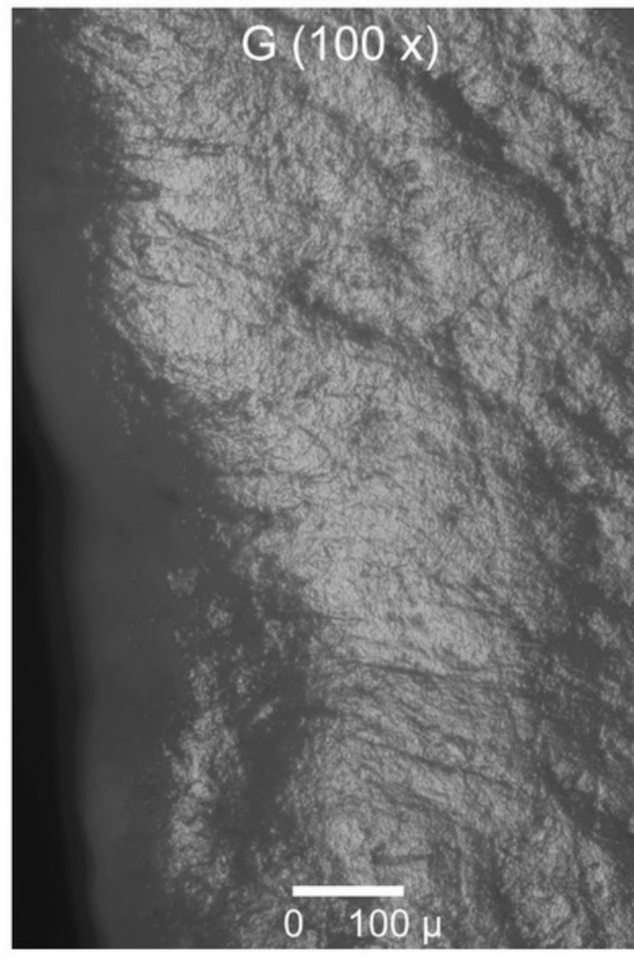

1

2

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12

13

14

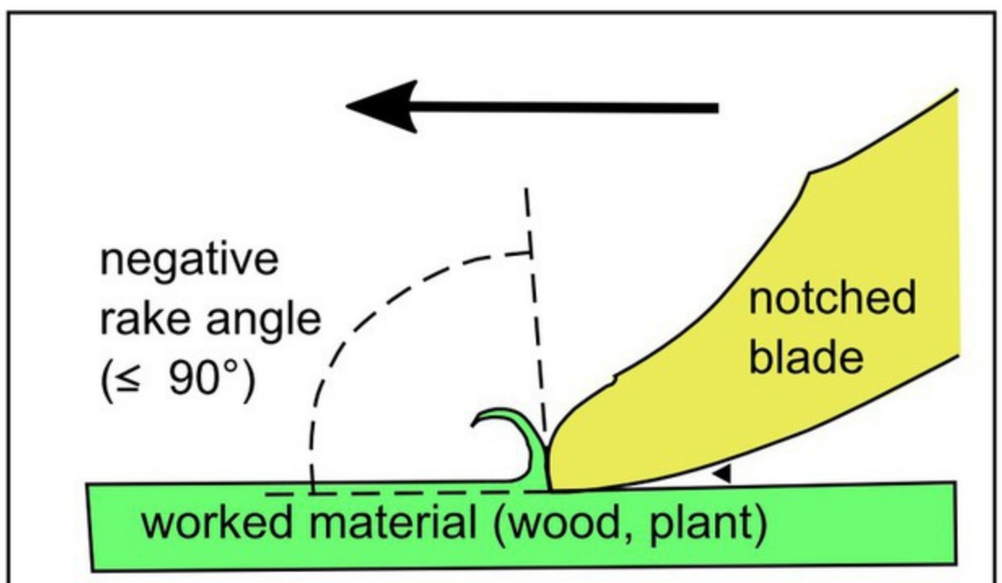
15

longitudinal motion

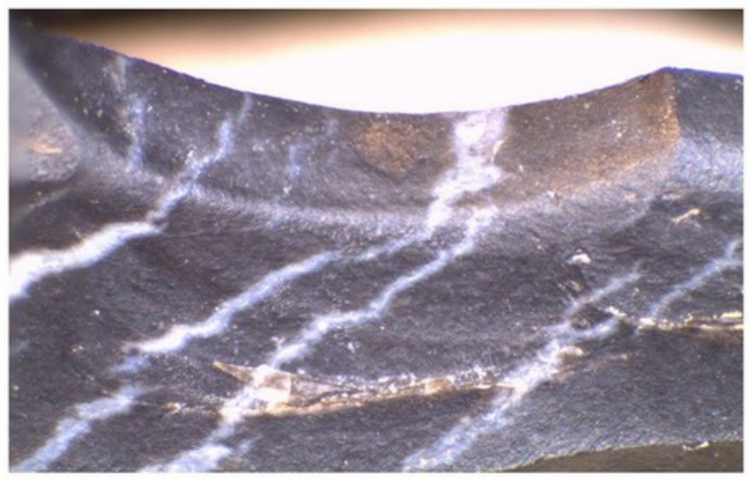
transverse motion

transverse motion in a notch

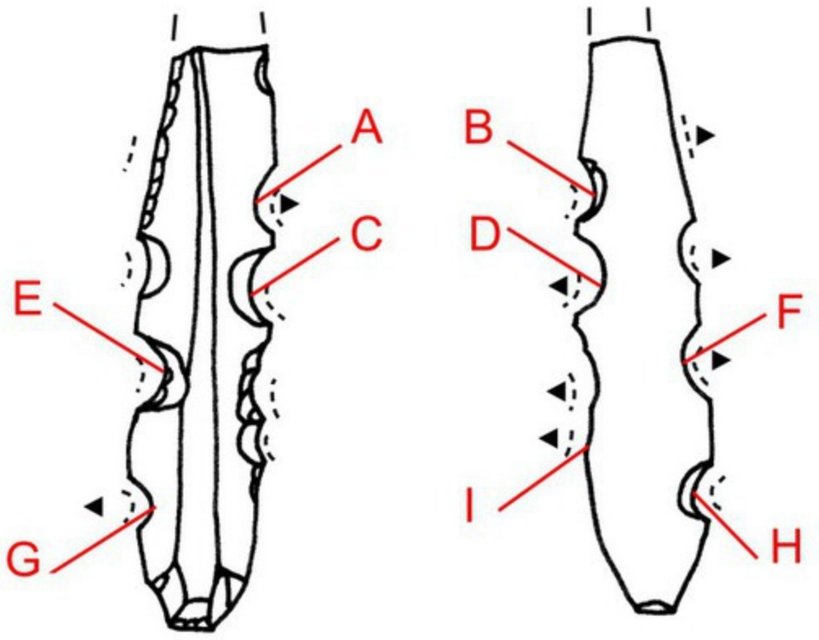
flank face



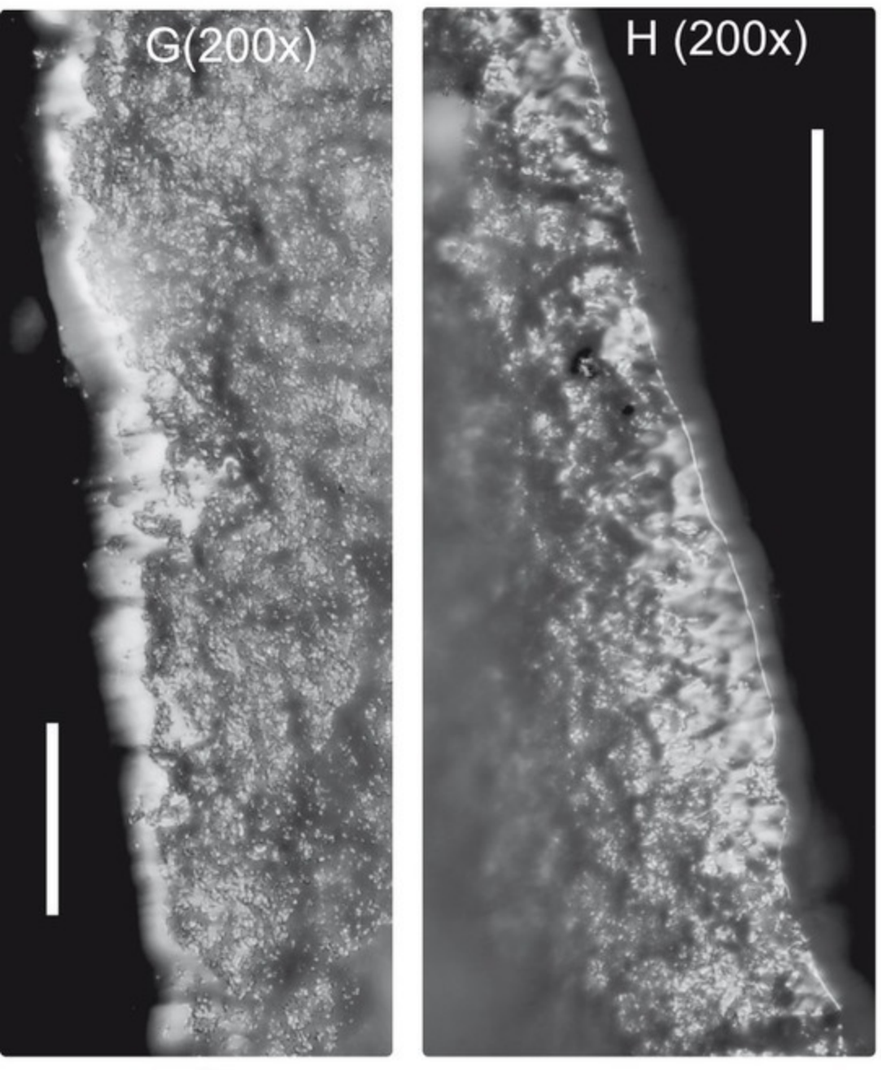
16

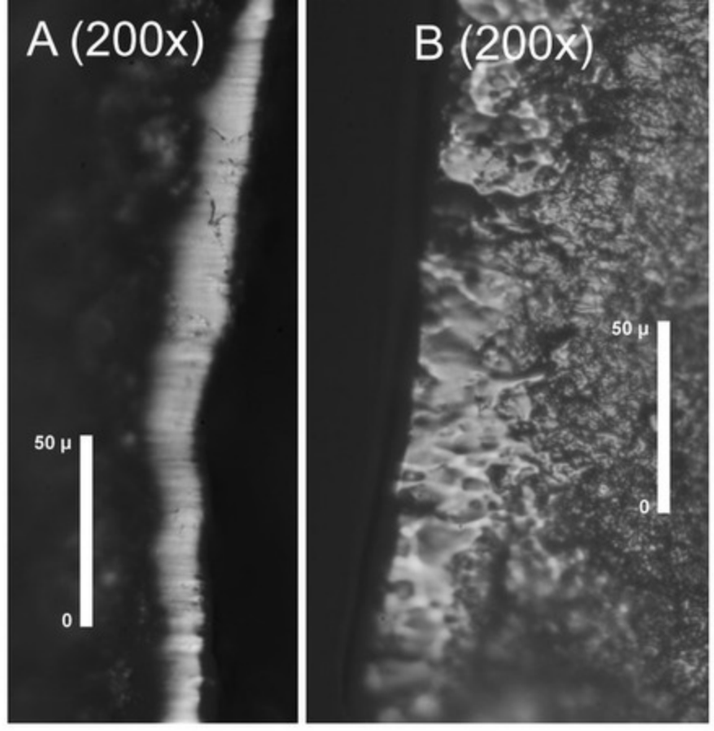


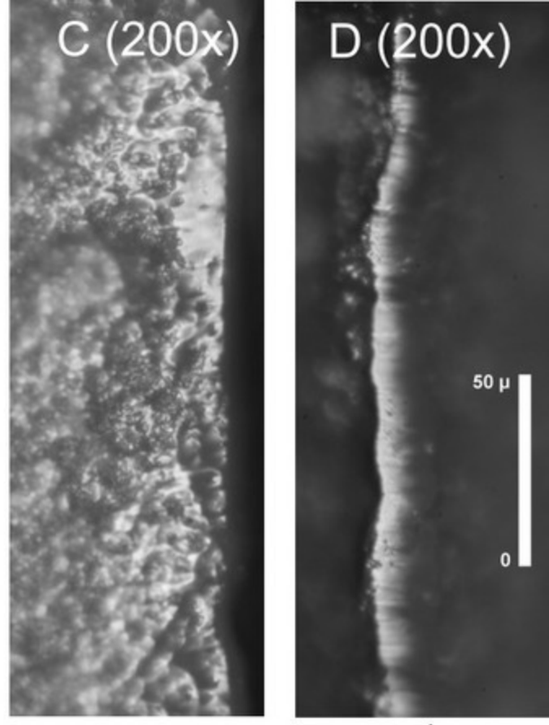
17



Kef Zoura D F21 - 606

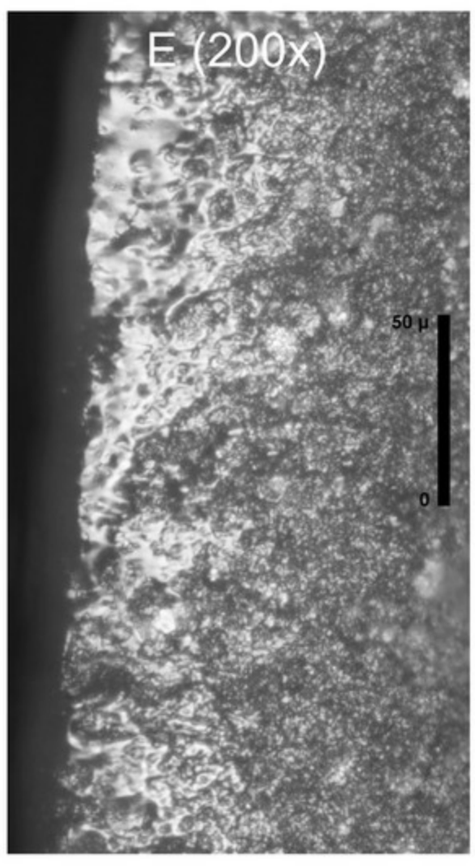


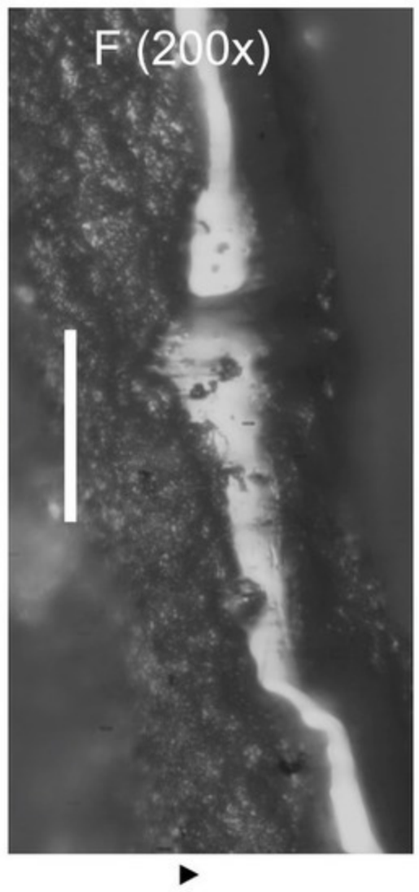


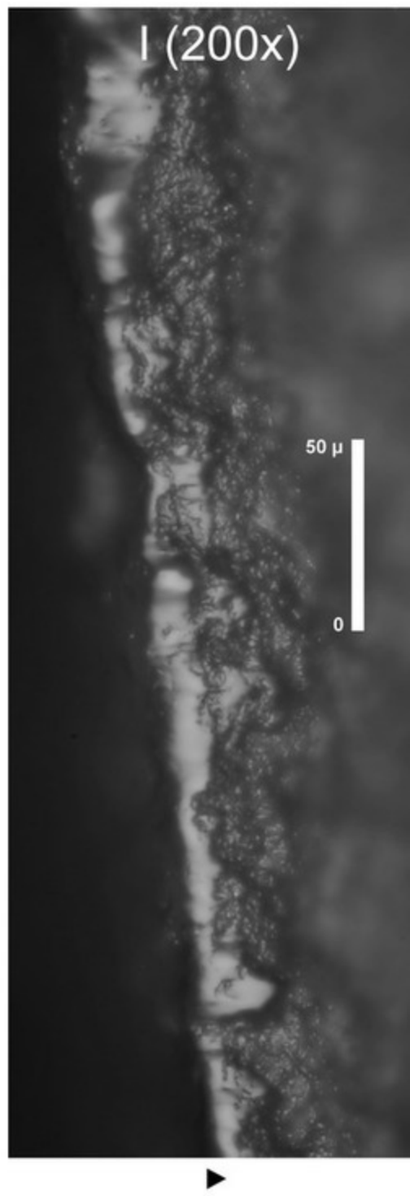


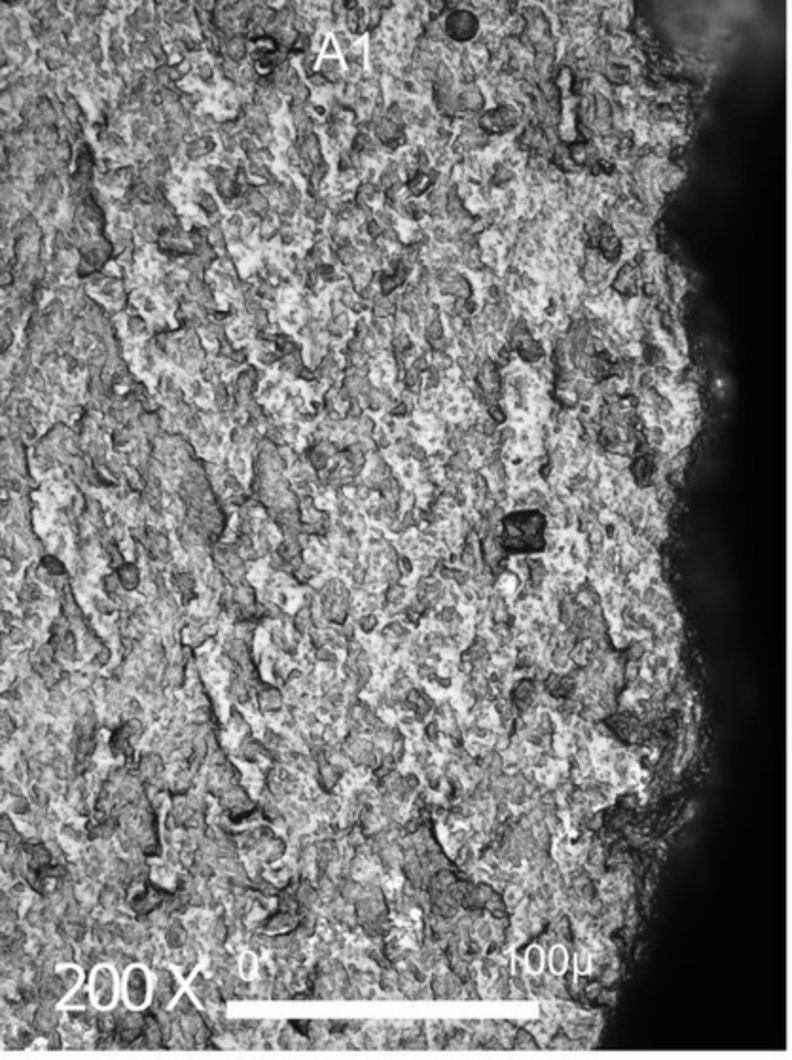
transverse motion in a notch

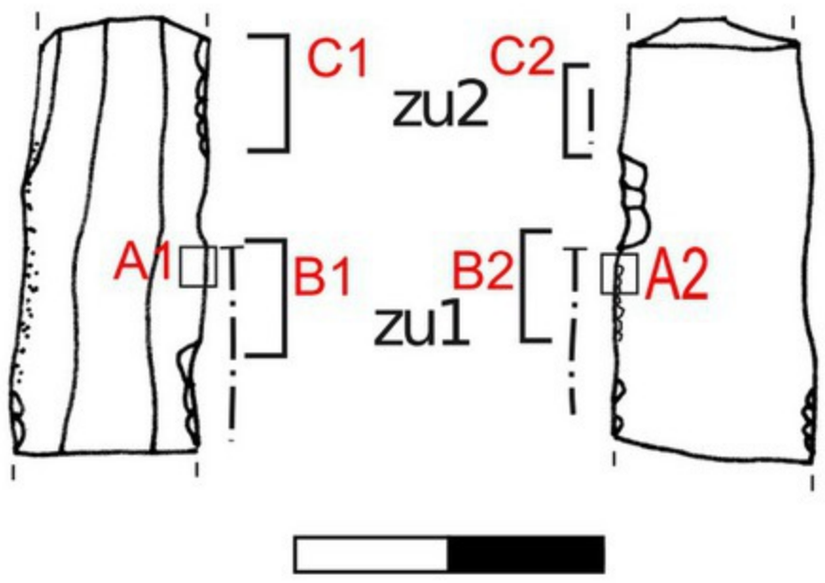
flank face

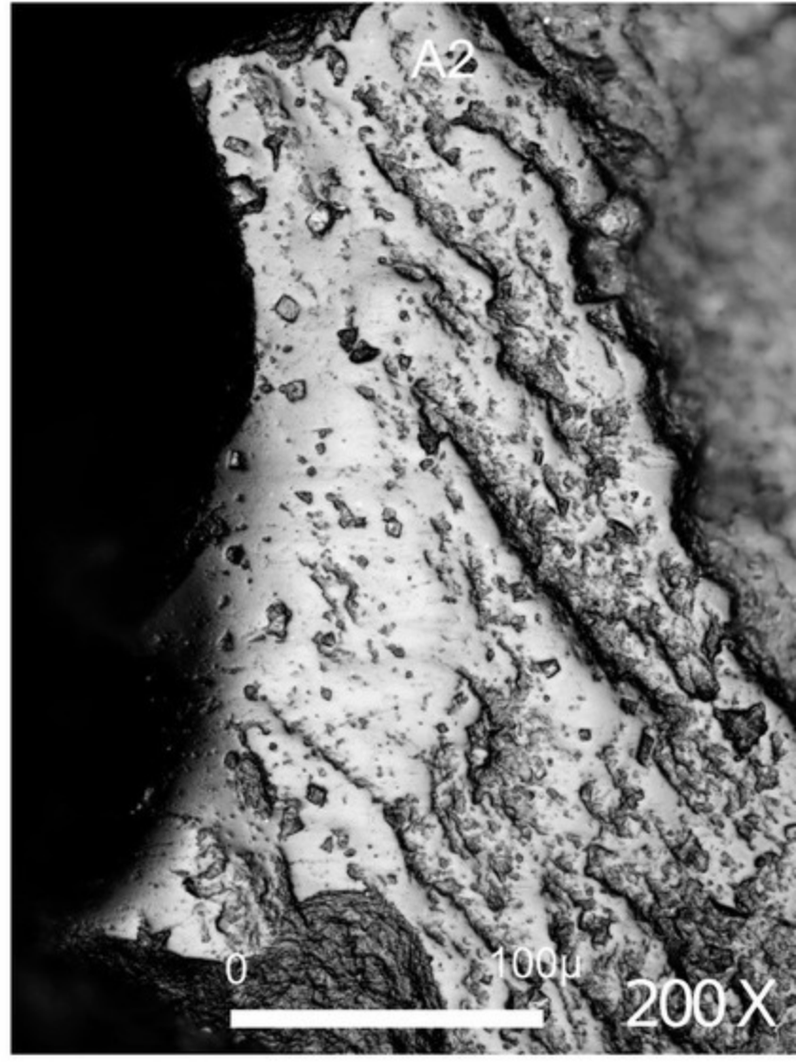







A1
200 X
0
100µ


C1
C2
zu2
A1
B1
B2
A2
zu1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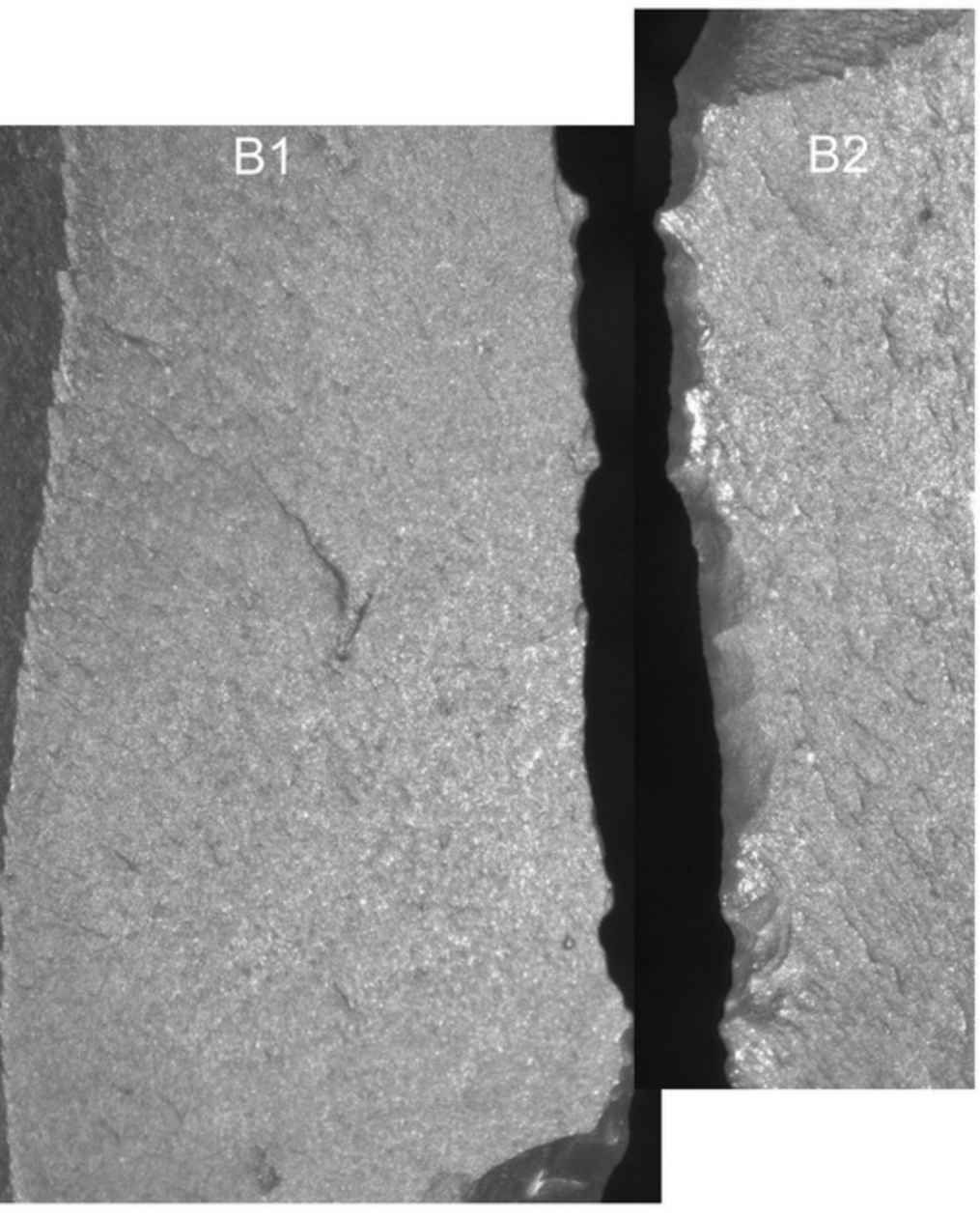
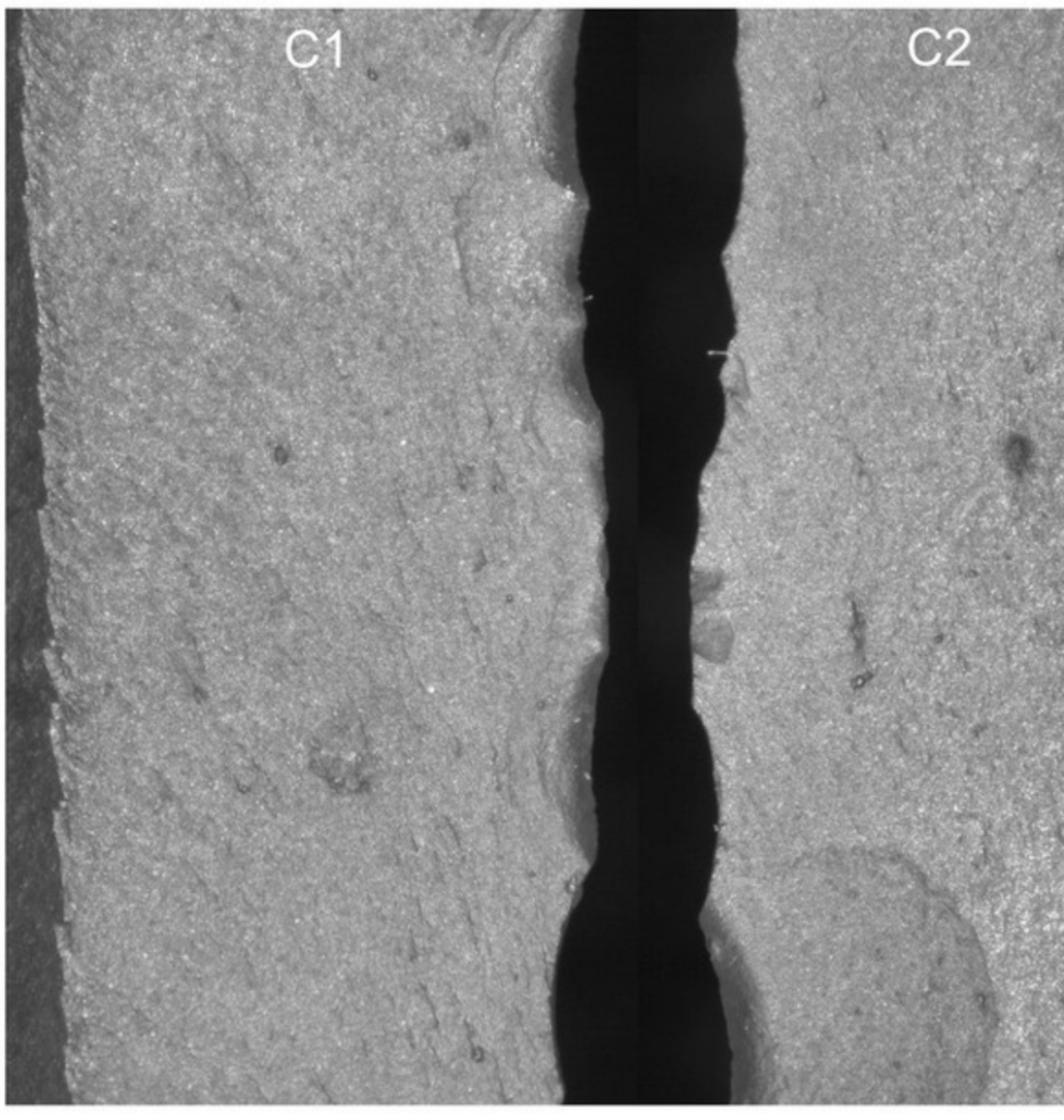
0
100µ
200 X


B1
B2


C1
C2

Corpus	Excavator	Chronology of studied tools
Saint-Trivier	G. Simonnet	Columnatian
Aïn Metherchem	R. Vaufrey	Typical Capsian
El Mekta	R. Vaufrey/E. Gobert	Typical Capsian
Negrin-el-Kedim	G. Camps ?	Typical Capsian
Kef Zoura D	D. Lubell/M. Jackes	Upper Capsian
		Typical and Upper Capsian
Bir Hamaïra	E. Gobert/F. Lacorre/M. Teste	Upper Capsian

Use-wear specialist	Tool types	Sorting strategies
C. Guéret	retouched and unretouched bladelets with glosses	macroscopic observation of the complete corpus (25756 pieces) to isolate the glossy tools
B. Gassin	backed blades	macroscopic observation in a sample of 359 pieces
B. Gassin	backed blades	typological sorting
B. Gassin	backed blades	typological sorting
B. Gassin/J. Gibaja/C. Guéret/	notched blades	typological sorting with macroscopic observation in a sample of 350 pieces
B. Gassin / J. Gibaja	backed blades	
B. Gassin	notched blades	typological sorting

Number of studied tools	
macroscopic	microscopic
50	18
30	7
1	1
2	2
57	57
13	13
1	1

Trench	Square	Level	Type description	Macroscopic observation	Microscopic observation	Transverse plant working with unretouched edge (in UZ)
SE 2		-10/-15/-18	Retouched bladelet	x		1
SE 2		-10/-15/-18	Bladelet	x		1
	9A	13 Est	Backed bladelet	x		1
SE 2		-5/-10	Backed bladelet	x		2
SE		0/+10	Notched bladelet	x		2
SE		0/+10	Bladelet	x		2
	9A	96-88 + 16 6 E	Notched blade	x	x	1
SE - 1		0/-10	Notched bladelet	x		1
SE-1		-20/-28-30	Retouched bladelet	x		1
	16D 18sud	+10/+15	Notched bladelet	x		1
	7A 6N	-20-25/-12-20	Bladelet	x	x	1
SE-1		-35/-40	Backed bladelet	x		2
"reboisement	"foyer noir"		Notched bladelet	x		2
"reboisement	"foyer noir"		Notched bladelet	x		1
"reboisement	"foyer noir"		Notched bladelet	x		1
SE 2		0/+10	Notched bladelet	x	x	1
	8A 4W		Retouched flake	x		1
SE-1		"dallage"	Backed bladelet	x	x	1
2	19H	+5/+15	Bladelet	x	x	1
	16C 196		Bladelet	x	x	2
	20H or 19H	-10/-15	Blade	x	x	2
	7A 5S		Notched bladelet	x		1
	7A 5S		Retouched flake	x		1
	10A	"Terre rouge"	Bladelet	x		1
	10A	"Terre rouge"	Scraper	x		1
	7A 3N	+3-3/+10+5	Bladelet	x		2
	8A 8		Retouched bladelet	x		1
	16E	1à4 Sud +80/1	Notched bladelet	x		1
	16E	1à4 Sud +80/1	Bladelet	x		1
	8A6W		Notched bladelet	x		2
SE 2		0/-5	Bladelet	x		1
	8A 4Est		Notched bladelet	x		1
	8A 6 est		Notched bladelet	x	x	1
TR2	22K	"dallage"	Retouched bladelet	x		1
	7A 6N	-20-21/-12-20	Burin	x		1

	9A 5 est		Notched bladelet	x	x	2
	8A 4W		Notched bladelet	x		1
TR2	20H	"dallage" sup.	Retouched bladelet	x		1
	19H	1/2 sup "dalla	Notched bladelet	x		1
	19H	1/2 sup "dalla	Notched bladelet	x		1
	19H	-10/-15	Notched bladelet	x	x	1
SE		0/-10	Backed bladelet	x	x	1
SE		0/-10	Backed bladelet	x	x	1
SE 1		"dallage"	Retouched bladelet	x	x	1
SE 1		"dallage"	Notched bladelet	x	x	1
SE2		-15/-18 à -20/	Notched bladelet	x		1
SE2		-15/-18 à -20/	Flake	x	x	1
SE2		-15/-18 à -20/	Retouched blade	x	x	1
SE2		-15/-18 à -20/	Bladelet	x	x	1
SE2		-15/-18 à -20/	Bladelet	x	x	2

Notches with scraping of abrasive material	Hide scraping	Other use zones
		x?
		x?
		x
x		
x		
x		
		x
x		
		x
		x
x?	x	x
x	x	x
x		x
		x
x		
		x
		x
		x
x		
x		
		x
	x	
x		
x		
		x
		x

		x
x		
x	x	x
x		x
	x	x
		x
x	x	x
		x
		x

Blade	Type description	Figure	Microscope	Gloss from plant working	Transverse plant working	Transverse matte abrasive usewear	Notches with traces of vegetal material
31	Backed blade	7	X	X	X	X	X
24	Arched backed blade	8	X	X	X	X	
30	End-scraper on backed blade	9	X	X	X	X	
22	End-scraper on backed blade	10	X	X	X	X	
23	End-scraper on backed blade	11	X	X	X	X	X
29	End-scraper on backed blade		X	X	X		
3	Blade with irregular removals		X	X	X		
35	Arched backed blade		X	X	X		
8	Backed blade			X			
9	Proximal fragment of backed blade			X			
10	Proximal fragment of backed blade			X			
11	Distal fragment of backed blade			X			
12	Distal fragment of backed blade			X			X
19	Backed blade			X			
32	Fragment of backed blade			X			
33	Backed blade			X			
34	Backed blade			X			
25	End-scraper on backed blade			X	X		
26	End-scraper on backed blade			X			
27	End-scraper on backed blade			X			
28	End-scraper on backed blade			X	X		
36	Burin on backed blade			X			
37	Burin on backed blade			X			
38	Burin on backed blade			X			
20	Burin on backed blade			X	X		
40	Blade			X			
4	mesial fragment of blade			X			
5	Blade with irregular removals			X			
6	Blade with irregular removals			X			
21	Proximal fragment of blade with irregular removals			X	X		

Kef Zoura D	Notched blade(let)s
analysed blanks	57
used tools	46
notches used to scrape rigid vegetals	94
notches used to scrape rigid materials (little developed wear or with ambiguous characters)	44
used zones situated outside the notches	44