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Comparison of obsidian and chert consumption during the Middle Helladic at Kirrha, Phocis, Greece.

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Abstract

Lithic artifacts were still in use in Bronze Age Europe, in spite of the emergence of a new technology, namely metallurgy, during this period. In fact, stone technology continued to be used everywhere until at least the end of the Early Bronze Age, and even until the end of the Late Bronze Age in specific areas. This is especially true for Greece where lithic raw material and/or tool networks were still operating during the whole Bronze Age. During the Middle Bronze Age in mainland Greece, obsidian and high-quality chert were still widely used, especially in settlements. This raises the question of the necessity of the use of obsidian instead of a stronger or more versatile material (chert or metal). Why was volcanic glass, which required considerable investment in terms of know-how and long-distance transportation, still used in spite of the technological context (where metallurgy was already developed)? The purpose of this paper is to contribute to this debate through the use-wear analysis of obsidian tools. Artifacts from settlement levels of the Middle Helladic site of Kirrha (Phocis, Greece) have been examined. In this domestic-use context, bronze and chert were also found. The main results of this study show an exclusive form and use of obsidian: bladelets were used for cutting soft and siliceous plant matter, with the exception of Graminae harvesting activity. These results point to the specialization of the lithic industry in terms of raw materials, where sharp obsidian artefacts were employed for cutting of soft and flexible materials, depending on the relative brittleness of the rock, at least at Kirrha. Thus, among the numerous propositions concerning continued obsidian circulation during the entire Bronze Age, a functional use (at least) could be proven, if this observation is also made elsewhere in Greece.

Keywords: use-wear analysis, chipped stone tools, obsidian, chert, Bronze Age, Greece.

1. Introduction

The continued presence of obsidian during the Middle Bronze Age, on the mainland Greece in particular (Middle Helladic, hereafter MH, Table 1) remains difficult to explain. Indeed, after an initial period of strong connectivity throughout the Aegean world during the Early Bronze Age, the Middle Helladic, was a period of decline, during which material and non-material exchanges (know-how)

partially ceased (cf Voutsaki, 2010). Yet obsidian, a material deriving mainly from the Cyclades and shared by the whole south Aegean region, is one of the exceptions to this trend (Broodbank, 2000: 317, Dickinson, 2010: 22). The persistent use of this specific material, contrasts sharply with the idea of a useless lithic industry. Middle Helladic societies are still poorly known and are classically interpreted on the basis of pottery production, settlement patterns or funerary practices. However, the study of the lithics allows us to observe cultural changes and continuity, which are essential topics for understanding the MH.

During the course of this period of formation of the Mycenaean substratum and the hierarchized society characterizing the following period, Helladic communities seem to renew with a social organization regulated by kinship, rooted in traditional mechanisms, with no clear social differentiation in burial methods, at least for the beginning of the period (Voutsaki, 2016). The study of the lithic industry could provide elements to confirm or reject this assertion on the social organization of MH societies, especially using cultural technology. Lithic tools can be used as the unit of cultural technology analysis, highlighting relationships between techniques and socio-cultural contexts. Lemonnier (2012: 13) underlines the fact that "some objects, their physical properties, and their material implementations are not only wordless expressions of fundamental aspects of a way of living and thinking; they are sometimes the only means of rendering visible the pillars of social order that are otherwise blurred, if not hidden". In this way, obsidian, as an everyday object, may also indicate different use rationales. The most obvious and the most accessible of these is observable and is brought to light by use-wear studies, which are the focus of this paper. For this purpose, this article presents the preliminary results of an ongoing study, focusing on the use of obsidian tools at the site of Kirrha (Phocis) during the MH through use-wear analysis. The application of optical instruments is a way of casting light on some of the activities conducted by these communities with chipped stone tools, as well as the economic rationales governing these communities. The comparison between obsidian and chert enables to observe if obsidian has a particular treatment in comparison to the other chipped material due to its particular characteristics such as mechanical (easily knapped) and functional (capacity to cut finely and deeply through materials), but also and especially aesthetic (vitreous sheen, color) or even magical. In addition, the reconstruction notably of use techniques, which is necessarily sketchy in view of the partial character of the information, is a way of assessing the social rationales regulating these techniques, as "technical trends are social trends in their own right" (Lemonnier, 2010: 46). Based on this approach, the hope is to finally grasp the significance of obsidian for its users, and the reasons for its continued use, but also attempt to grasp the social ramifications of the use of this distinctive material at Kirrha during the MH.

Up until today, very few functional studies have been carried out on the chipped lithic corpus from Greece, all periods and materials combined. The earlier research was conducted on chert in the 1970s and 1980s (Diamond, 1974; Christopoulou, 1979; Vaughan, 1981; Perlès and Vaughan, 1983), but with very limited results. In parallel, other traditional studies continued to stumble at the functional interpretation hurdle, where several researchers proposed a functional interpretation of the prismatic bladelet as a razor based on observation with the naked eye (Van Horn, 1976; Runnels, 1985; Carter, 1997). Recently, use-wear studies have only been undertaken for the Middle and Late Bronze Age lithic assemblages from Sojvan in Albania for the Ionian region (Kourtessi-Philippakis and Astruc, 2002), and the material from the Early Bronze Age of Troy for the Aegean (Gurova, 2016). Furthermore, the functional analysis of the material from Troy concentrated on the chert objects. The present work will pursue this initiative by applying the methodology also to obsidian.

2. Material and methods

2.1. Case study of Kirrha: a MH settlement in Central Greece

Kirrha Tell is located in southern Phocis on the northern coast of the Gulf of Corinth in the Bay of Itea (Figure 1). It was first excavated in 1930 by a French team (Dor *et al.*, 1960), then underwent rescue excavations during a long period, before a research project was set up in 2008 under the leadership of the Ecole française in Athens and the Ephorate of Delphi. The most recent results indicate that the site of Kirrha may have been settled from the Neolithic (Orgeolet *et al.*, forthcoming), and was definitely occupied during the EH III through to the LH III, that is, from 2300 B.C. to 1070 B.C. based on the recent mainland chronology proposed by Manning (Manning, 2010; Table 1). About 600 m² have been exposed during excavations, dated mainly to the MH (habitation and tombs), the MH-LH transition (necropolis), and LH III (habitation).

| Relative chronological Phase | Dates BC |
|------------------------------|-------------------|
| Early Helladic I | 3100+ to 3000 |
| EHII | 2650-2500 |
| Later EHII/Lefkandi I | 2500-2200 |
| EHIII | 2250-2100/2050 |
| Middle Helladic | 2100/2050- |
| Late Helladic I | 1700/1675-1635/00 |
| LHIIA | 1635/00-1480/70 |
| LHII B | 1480/70-1420/10 |
| LHIIIA(1) | 1420/10-1390/70 |
| LHIIIA(2) | 1390/70-1330/15 |
| LHIIIB | 1330/15-1200/1190 |
| LHIIIC | 1200/1190-1075/50 |

Table 1: Approximate Absolute Chronology for the Aegean Bronze Age, after S.W. Manning (2010: 23). The author notes that for the EH phase, ± 50 years should be allowed as a reasonable guide range, ± 25 years for the MH and LH phases.

Thus, the site of Kirrha is ideal for an in-depth functional study as it contains occupational contexts from recent excavations.

2.2. The chipped lithic assemblage from Kirrha

In this context, a use-wear study was carried out on the material from the 2009 and 2011 excavations first, as well as material from the more recent excavations (2014-2015). The results presented here are thus only preliminary and will subsequently be compared to those from the ongoing technological study (Kourtessi-Philippakis, forthcoming). For the time being, the lithic assemblage is from the MH occupation and the lower LH III levels.

The lithic industry is not very abundant at Kirrha; the 2009 to 2015 excavations yielded less than 400 objects (less than 200 for 2009 and 2011 campaigns). These figures are rather low in comparison to other sites, like for example Lerna, in southern Greece, where Runnels counted 2900 chipped stone artifacts for the Middle Helladic period alone (Runnels, 1985: 359, Table 1). The situation at Kirrha is midway between that of southern and northern Greece, where the number of lithics from the Middle and Late Helladic levels combined attains than 200 artifacts in the sites of Kastanas and Sojvan (Kourtessi-Philippakis, 2009: 172), and only reaches 100 items in the Middle Helladic levels at Pefkakia (Maran, 1992: 398). Besides the excavated volumes, it is possible to envisage variations in the precision of the different excavation operations. It is also possible that, the consumption of chipped lithic tools at Kirrha may have been lower than in the southern regions of Greece. Again, the reasons behind this could have been very varied: limited access to exchange networks or limited needs, perhaps linked to the presence of metal. One or all of these reasons could explain this trend, but they are beyond the scope of this article.

Here, it only dealt with the material from the 2009 and 2011 excavations. The lithic assemblage is comparable to that from other sites in continental Greece in terms of raw material (Howell, 1973: 77): it is made up of obsidian, good quality chert and chert, a poor-quality chert (Table 1 and Figure 2). Typology and technology also appear to be similar.

2.2.1. Obsidian

Obsidian is represented by 109 objects, or 59.3 % of the total lithic corpus from excavated contexts, which is a lower proportion than at the site of Lerna where it represents 87.8% during the MH (Runnels, 1985: 359, Table 1). Based on macroscopic observation, the Kirrha obsidian seems to come

from the main and well-known sources of Milos, Sta Nichia and Demenegaki. It is opaque, varies in color from dark grey to grey-green, and mid-grey stripes can also be visible. A single artefact is translucent and black and could come from elsewhere.

The majority of the Kirrha assemblage is made up of lamellar pressure-flaked blanks (56%), with a considerable proportion of flakes (31.2%). The bladelets are the usual type for the period, that is the prismatic type described by Cherry and Torrence (1982) as having "tiny platforms, small but bulging bulbs, very straight parallel sided margins and dorsal ridges, and dominantly trapezoidal sections". In parallel, the production of thicker bladelets shows less control of the pressure flaking technique (less parallel ridges, thicker and wider modules), in the same way as Runnel's observations at Lerna for EH III (1985: 375-377). In contrast, only three objects have opposite removals and could come from bipolar debitage, or from use as intermediary objects ("pièce esquillée"). This category of tools with opposite removals is marginal in comparison with the MH series from Lerna, where it attains 41.8 % of the obsidian toolkit and thus represents one of the main traits of the EH III-MH lithic corpus from this site. At Kirrha, the blanks are very rarely transformed, like at Lerna and Agios Stefanos; the cutting edges are left unmodified, and no artefacts bear retouch. However, it is important to note that an obsidian arrowhead has been found in the MH levels in 2015, pointing to the existence of this category of tools in obsidian at Kirrha. Another type of tool, present on mainland sites, but only on chert at Kirrha, is the denticulate (Runnels, 1985; Kardulias 1992; Maran 1992; Karabatsoli, 1997; Karabatsoli and Karimali, 2008). It can be define as a tool made from a flake with one edge bearing large (between 1 and 2mm) notches, more (saw type) or less (common denticulate type), and with long or invasive bifacial retouches.

2.2.2. Chert

Chert corresponds to 37.5% of the assemblage, which is more than twice the proportion at Lerna for the same period (Runnels, 1985: 359, Table 1). Several types of chert have been identified. The "chocolate" or "red-brown radiolarite" chert, is a matt brown to red-brown coloured chert, with grey and beige zones. As this same grey colour is observed on other artefacts, the "chocolate" and the light grey cherts appear to come from the same outcrops. The same is true for several chocolate-coloured chert objects with orange and black veins: a dark grey chert with this element could also come from the same outcrop. The presence of this multi-coloured good quality chert is frequently, although not systematically recorded in all the Helladic sites (Maran, 1992), and could potentially come from the Pindus or diverse locations in Argolis (cf Newhard, 2016). This chert was preferentially used for the production of flake blanks (30%), if bladelets are separated (18.8%) from blades (14.5%). On the other hand, considering the latter to be part of the "laminar-lamellar" category, then this

group becomes predominant (33.3%). Unlike the obsidian, these blanks are often modified: They are retouched on one or two edges, and flakes and blades are transformed into arrow heads or denticulates.

One laminar flake made on secondary Cretaceous chert was also found. It is a honey coloured chert with a matt aspect presenting ooliths. This chert could come from the Balkans or Epirus (cf Parkinson and Cherry, 2010: 4-5 for more details and references).

Lastly, several rare elements in poor-quality, light-grey to medium-grey-coloured and very slightly silicified chert, were found during the excavation in the form of small bladelets. For the flakes, however, it is difficult to distinguish between “intentional” or “accidental” debitage, as this rock is part of the local substratum.

2.2.3. Sampling

As stratigraphic data were not available when this study was carried out, this sampling was based on typological factors. This selection was carried out not only on tools (that is, on blanks presenting retouch or macro use traces), but also on blanks with no apparent use-wear, as well as on several waste products apart from flakes and debris (crested bladelets, etc.). The aim was to explore the idea of the raw material economy and to find out whether only tools and blanks were used, or whether, conversely, all the available cutting edges were used.

The studied types are representative of those present in the assemblage, although the emphasis was on tools and blanks. Badly-preserved objects and those too small for the microwear study were excluded from sampling.

| Raw Material | Denticulated | Arrow head | Blade | Bladelet | Flake | Esquille | Waste by-product | Und. | Total | %Total |
|---------------|--------------|------------|-------------|-------------|-------------|------------|------------------|-------------|------------|--------------|
| Obsidian | | | 9 | 52 | 34 | 6 | 6 | 2 | 109 | 59.2 |
| Chert | 7 | 1 | 10 | 13 | 20 | | | 18 | 69 | 37.5 |
| Quartz | | | | | | | | 2 | 2 | 1.1 |
| Undetermined | | | | | 2 | | | 2 | 4 | 2.2 |
| Total | 7 | 1 | 19 | 65 | 56 | 6 | 6 | 24 | 184 | 100.0 |
| <i>%Total</i> | <i>3.8</i> | <i>0.5</i> | <i>10.3</i> | <i>35.3</i> | <i>30.4</i> | <i>3.3</i> | <i>3.3</i> | <i>13.0</i> | <i>100</i> | |

Table 2: Kirrha chipped stone tools from 2009 to 2011 excavations.

| Raw Material | Denticulated | Blade | Bladelet | Flake | Und. | Total |
|--------------|--------------|----------|-----------|----------|----------|-----------|
| Obsidian | 0 | 2 | 20 | 5 | 1 | 28 |
| Chert | 12 | 5 | 8 | 3 | 3 | 31 |
| Total | 12 | 7 | 28 | 8 | 4 | 59 |

| | | | | | | |
|---------------|------|------|------|------|-----|-------|
| <i>%Total</i> | 20.3 | 11.9 | 47.5 | 13.6 | 6.8 | 100.0 |
|---------------|------|------|------|------|-----|-------|

Table 3: Chipped stone tools sample presented in this study

2.3. Methods

2.3.1. Use-wear analysis

Use-wear analysis is the study of traces. These traces are of different types and vary depending on the worked material, the movement applied, the type of hafting and the lithic economy (reuse, sharpening, etc.). Reference to one or more experimental collections helps to evaluate the impact of the variation of these parameters on the traces left on the tools. In this way, based on analogy, it is possible to interpret the archaeological collections. If there are no equivalent traces in the experimental collections, then it is essential to reproduce them through experiments, thus creating constant interaction between the analysis of archaeological objects and experimentation.

Observations are led at different scales, from the naked eyes to the stereomicroscope and then the metallographic microscope. When more detail is required for specific questions, scanning electron microscopy (SEM) or the laser scanning confocal microscope (LSCM) can also be use additionally (see Marreiros *et al.*, 2014: 11-12). These increasingly detailed allow to understand the tool function as a whole and to establish links with the traces observed at a microscopic scale. This method, now currently applied (Marreiros *et al.*, 2014: 11), is essential for interpreting use-wear.

The methodology of use-wear analysis employed in this paper follows the one presented on my master dissertation (Montagné 2014). Use-wear attributes observed are scarring, striation, smoothing/abrasion and polish (for more details, see Montagné 2014: 44-50).

These criteria follow the work of obsidian specialists (Ayoama, 1995; Fullagar, 1986; Hurcombe, 1992; Kononenko, 2011; Setzer, 2004, 2012) but also the ones of notably chert specialists (Gassin, 1996; Mansur-Francomme, 1983, 1988; González Urquijo et Ibañez, 1994; Plisson, 1985). The reference book in use-wear analysis is very useful as example of synthesis of all the aspects of this methodology (Marreiros *et al.*, 2015), with a chapter concerning obsidian use-wear analysis (Clemente Conte *et al.*, 2015: 71-81).

Obsidian and chert, as any kind of raw material, react differently to use, show differential formation and development of use-wear traces. This is a consequence of their mineralogical composition, thus as their homogeneity or heterogeneity (see Clemente Conte *et al.* 2015: 59). These differences also apply within chert and obsidian types, as their composition varies according to provenance or even lava flows, in the case of obsidian. However, general comparisons between use-wear on obsidian and chert can be made. Obsidian is homogeneous, very brittle, and thus, very sensitive to post-

depositional damage related to soil composition, water content and thermal variations (Clemente Conte *et al.* 2015: 73); the most brittle varieties seems to be the most sensitive to mechanical damages. But traces also form more quickly on obsidian, making the identification of use on soft material or short use duration easier than with chert raw materials. However, under the microscope obsidian is shiny, rendering the polish more difficult to identify precisely. The opposite applies to chert, more or less homogeneous depending on the chert type, but still harder than obsidian. Chert can be affected by more intense or longer post-depositional alteration process than for obsidian, and still readable. Also, use-wear takes more time to develop on chert, but is easier to observe as the surface is less shiny than obsidian - except for very fine grained chert, which also has shiny surface. Fully-developed use-wear (Vaughan, 1981: 29) is quite similar for both obsidian and chert. These differences in use-wear formation and development require chert and obsidian experimental collections.

As it was mentioned in the introduction, obsidian will be compare to chert in order to observe whether the lithic industry is treated as a whole for the activities carried out with chipped stone, or activities or techniques are different depending on the material and the form of the tool. This method allows to bring to light the search for certain qualities in each material, or conversely, a certain indifference demonstrating that obsidian is just like any other material.

2.3.2. Material used for the study

2.3.2.1. Technical material

For this study, the microwear analysis was carried out in the Malcolm H. Wiener Laboratory for Archaeological Science (Athens, Greece) using a Leica DM LM microscope and a Leica M10 stereo zoom microscope. A Leica microscope (DM 2700M) was also provided by the Laboratoire Méditerranée Préhistoire Europe-Afrique (Lampea). Magnifications range from 8X to 80X for the stereomicroscope and from 50X to 500X for the microscope, which also provide the possibility of using inferential contrast, which can be very useful, particularly for the study of obsidian. All photos were taken with a Canon 500D, and combined with the help of the Combine ZP software. The data were collected using an Access database.

An ultrasonic bath was used to wash the tools for the first time. The tools were then washed only with water and soap.

2.3.2.2. Comparative material

The experimental references used for the present study are made up of a personal collection built up gradually in response to the questions raised by the study. It consists of obsidian from two Sardinian lava flows and Milos obsidian, essentially from the Sta Nichia flow (see below). An experimental chert collection was already available at the LaMPEA laboratory was also studied, as well as part of collections in obsidian and chert compiled by different researchers, with their authorization. In addition, published references were also used (e.g., Hurcombe, 1992; Kononenko, 2011; Gassin, 1996; Astruc 2002; Vaughan 1981).

3. Preliminary results

3.1. Preservation

The preservation status of the sample is excellent, even at a microscopic scale. The chert is particularly well preserved (30 out of the 31 objects are very well preserved), in comparison with the obsidian (only half of the artefacts are very well preserved), and the overall conservation status is very good. The better conservation of chert in comparison to obsidian has been observed elsewhere, as obsidian is more sensitive to chemical and mechanical weathering (e.g. Hurcombe, 1992: 71; Hurcombe, 1997; Kononenko, 2011: 38; Clemente *et al.*, 2012). It is shown that removals, abrasion and blunting of the working edge, abrasive components, and increased opacity are the most frequent post-depositional wear observed on this type of material (Clemente *et al.*, 2012). These types of weathering are relatively rare or not very marked in our series.

3.2. Obsidian and chert

Out of the 59 studied items, the worked material could not be determined for 16 items, six showed no use, and the 37 remaining artifacts present a total of 54 Used Zones (UZ). The number of Used Zone differs for obsidian and chert tools: obsidian tools seems to have been preferentially used on two edges, while chert was only used on one (Table 4).

| Types/Number of Used Zone | 0 | | 1 | | 2 | | 3 | | Ind | | Total |
|------------------------------|----------|-------|----------|-------|----------|-------|----------|-------|----------|-------|-------|
| | Obsidian | Chert | Obsidian | Chert | Obsidian | Chert | Obsidian | Chert | Obsidian | Chert | |
| Denticulated | | | | 11 | | 1 | | | | | 12 |
| Blade | | | | 2 | 1 | 1 | | 1 | 1 | 1 | 7 |
| Bladelet | 2 | 1 | 3 | 2 | 7 | 3 | 1 | | 7 | 2 | 28 |
| Flake | 2 | | | 2 | | 0 | | | 3 | 1 | 8 |
| Undetermined | 1 | | | 2 | | | | | | 1 | 4 |
| Total number of UZ | 0 | 0 | 3 | 19 | 16 | 10 | 3 | 3 | | | 54 |

Table 4: Number of Used Zones (UZ) depending on tool type and raw material.

As for the worked materials for the whole sample, obsidian and chert combined, plant matter is the most represented material. The ratio between worked plant and animal matter is comparable for both rock types, with in addition, worked mineral matter for obsidian, but not for chert (Figure 3).

3.2.1. Obsidian use

3.2.1.1. Blanks with no use-wear

Half of the obsidian blanks do not bear any traces of use, whereas for the other half, it is not possible to determine the traces of use. The indeterminate obsidian blank was not used either.

3.2.1.2. Use on plant matter

About one third of the use-wear traces on obsidian are related to working plant matter, exclusively on blades and bladelets (Figure 4). The edge shows pronounced rounding and the polish appear to be bumpy. Striations are numerous, thin, long, smooth and rough bottomed. Slight variations can occur, and most are related to the hardness and the flexibility of the worked material. These plant materials are represented by several types: semi-hard/rigid, soft/semi-rigid or soft/flexible, and do not appear to include grasses, except perhaps for one object (Figure 5). The artefacts used on semi-hard/rigid materials present traces of cutting plant matter and may be branches of trees or bushes. Considering the acute angle of the working edges and the length of the used zones (between 15 and 29 mm), it can be inferred that these obsidian cutting edges were used for detailed tasks on thin wooden branches or rods, to create notches on arrow shafts or decorations on handles (e.g. Noël and Bocquet, 1987; Gassin, 1996: 83). This work was meticulously carried out and would be related to finishing tasks rather than to acquisition (Gassin, 1996: 83).

The soft/semi-rigid non-woody plant matters concern two UZ. These plants were cut up with obsidian and indicate harvesting pulses, such as the grass pea (*Lathyrus sativus*), as identified at Kirrha (C. Pagnoux, personal communication).

The soft/flexible plant materials may be grasses, for example cut during weeding in the fields, maintaining paths or cultivated areas. One obsidian blade of 5 cm may have been used for harvesting (object number : KIR 1027.50, Fig. 4b), but it is not possible to be certain.

3.2.1.3. Other uses

Four UZ on two bladelets (KIR 2021.51 and KIR 2019.50) indicate scraping operations: one bladelet presents two dry hide scraping UZ while the other bears two pottery scraping UZ. Their small size suggests that they were used to scrape dry hide strips and small ceramic objects (figurines, miniature vases, etc.). The identical frequencies of use on both working edges of the bladelets imply that they were used successively, over a relatively short period of time.

3.2.2. Chert use

Most of the chert flakes were used (4 out of 5), as were the indeterminate blanks (6 out of 7) (Figure 6). Only one bladelet in chert has no ZU.

3.2.2.1. Denticulates

The denticulates are associated with working plant materials, in particular with harvesting (8 out of 15), like the same category of tools in the Early Bronze Age at Troy observed by Gurova (2016). This use as a harvesting tool, *contra* Van Horn's (1977: 391) affirmation that the denticulate could not be an agricultural tool, but rather an adze. The latter author argue that the denticulation seems to be worn squarely, instead of showing a rounding as it could be expected for harvesting - but Van Horn (1977) did not take into account the constant reshaping of the denticulation. He also states that the size of the edge can be too short and the angle of the edge too obtuse for such action. Experimentations I conducted show the contrary (not published). Above all, up until now, all of the denticulates in our study only bear traces of cutting actions and not of percussive actions that would result from use an adze. Although this latter use cannot be excluded, here, use-wear provides proof of the use of this type of tool for purely agricultural activities. For the denticulates used as harvesting tools, gloss is often parallel to the working edge. Several objects could been used together and inserted into a curved haft, or used separately, held in the hand. I note, like Gurova, that the smallest and shallowest denticulations identified on certain objects could only be the result of use (Gurova, 2016: 384; Figure 7a). On the other hand, some deliberate retouch seems to have been produced a long time after the abandonment of a tool, covering an older UZ in some cases. This observation is important for the economy of the tool, but also for the form in which it was brought to the site. This element has already been noted for the same category of tools at Sovjan in Albania (Astruc, 2001: 81), and also for the obsidian arrow heads from Mitrou in Greece (L. Rousseau, personal communication).

The denticulate tools with no traces corresponding to harvesting are more difficult to interpret at the present time. Indeed, activities seem to be related to cutting soft, flexible and abrasive materials that cannot for the moment be linked to any of the activities in our experimental corpus. Thus, the use of denticulate objects reflects a range of functions and not restricted to harvesting alone.

3.2.2.2. The lamino-lamellar elements and flakes

The blades are predominantly associated with working animal matter, particularly butchery or dry hide working activities. One blade was used for cutting grasses, hafted in a straight position (object number: KIR 2147.12). Bladelets and flakes used for cutting *Graminae* were hafted in a straight

position too, except for a single object showing herringbone-pattern hafting (object number: KIR 1107.7).

The elements included in this work only underwent initial analysis, and further experiments are required to confirm, and in some cases, to refine the diagnosis. The experimental reproduction and use of tools for the assumed activities is in process.

4. Discussion

4.1. Contribution of the method

This analytical method allows the observation of relatively short durations of use (depending on the hardness of the worked materials), which are not visible with the naked eye for a non-experienced observer. In general, it is only possible to observe use-wear with the naked eye when the tool has been used on hard materials for a prolonged period. Even when lithics undergo very meticulous technological studies, only use-wear studies can confirm or refute the absence of use, particularly for obsidian bladelets. Indeed, a lot of obsidian bladelets from Bronze Age series in mainland Greece are categorized as unusable (Runnels, 1985; Karabatsoli, 1997; and others). Runnels (1985: 367) suggested that they were stocked for future needs, or to be exchanged for finished chert products; the other possibility is that their shape would be suitable for making razors (Bosanquet, 1904: 221; Van Horn 1976: 170; Runnels, 1985: 372, Carter, 1997). Indeed, speculations abound as to the use or absence of use of obsidian during the Bronze Age, but no solid proof has been provided up until now.

Now, it is possible to prove that even the obsidian bladelets which can be considered as blank, that is to say "unused", are used on soft material. This shows that it is essential to be cautious before proposing exchange models. At Kirrha at least, no evidence for shaving has been found, in spite of the fact that experiments have been conducted and that this activity thus be recognisable.

4.2. Tools and raw materials: optimization linked to the technique and worked material

While at first sight there does not appear to be any difference in the way raw materials were used, and the general spectrum of worked raw materials appears to be almost identical, activities are not distributed in the same way for the different tool types (Figure 3). When artefact typology is taken into consideration, and when the traces can be interpreted, the chert denticulates were used for cereal harvesting. The raw material, shape and delineation of the active part of the tool seem to have been part of a specific harvesting technique. This particular morphology involves cutting the plant stem by friction (Goldscheider, 2007: 24), and not by striking or pressure like for harvesting tools with smooth working edges or resharpened denticulates. On the other hand, small bladelets with

obtuse edges were used for plant matter. These bladelets present a precise but a fragile angle which was preferentially use. This advantage and technical constraint were applied to the preferential use of obsidian and chert, for cutting soft and flexible plants (for weeding or maintaining outdoor areas, for example), or finishing more robust materials, such as wood (shaping, decoration, etc.).

The obsidian blade (KIR 3210.8, Fig. 4a) was used for this same type of activity, whereas those in chert, which were probably sturdier, were used on animal matter for butchery activities or scraping dry hide. In the sample, only the chert flakes were used on the same materials as those worked by bladelets, that is for cutting different types of plant matter.

Thus, not only the morphology of the tool, but also the raw material, are decisive for tool use for different types of activities: pointing to the consideration and optimization of the physical properties of tool raw materials.

4.3. Raw material economy

Chert artefacts generally only bear one UZ, whereas most of the obsidian artefacts bear use marks on two edges. This could imply that obsidian was more intensively used as it is not a local material, but this is not really the case as chert was often sharpened and reused, sometimes a long time after initial use. Thus, all of the lithic artefacts were used economically. For obsidian artefacts, the use of two working edges may represent the pursuit of sharpness by using both of the available edges, as cutting edges cannot be resharpened by retouch. In addition, the presence of a single cutting edge for chert tools, particularly for denticulate pieces, could signify the absence of specialists in a position to extend the life of the tool by shaping a similar cutting edge on another part of the artifact, or a predetermination of the tool, making it impossible to modify it.

Durations of use are also different. it would be expected obsidian to be used to its full potential, for longer periods of time, as it is not resharpened or refractured. However, working edges are just used for their initial activity, and not for any other types of action, and they are only rarely used to their maximum potential. This behaviour follows a purely techno-functional rationale, and appears to be in keeping with a local provenance of the raw material, which would allow less cost-efficient use in terms of energy. However, obsidian is not a local material, and these tools are produced by specialists. The maintenance of the original tool form and its limited use cannot be explained just by purely economical and function reasons. Conversely, chert, which is also not a local material but it was acquired from less distant outcrops rather than obsidian, was used for prolonged periods, resharpened and reknapped in some cases (personal observations). Thus, it was treated as a distant material with limited access, and generally used until depletion. However, very small bladelets on

glassy obsidian are not suited to being reshaped or sharpened. On the other hand, it would have been possible to use them for other types of activities involving different actions (initially for cutting and then for scraping, for example). In spite of the large size of the obsidian blade in comparison to the bladelets, the latter were only used for a single kind of activity with no subsequent modification of edges. This can be considered as a deliberate will to preserve the working edges and the sharpness of tools on volcanic glass. This choice could be similar to the precautions taken with the use of some of our present-day tools. For example, Japanese knives made on metal or ceramic, with particularly sharp but fragile cutting edges, are treated in a particular way in present-day urban Western cuisine. In order to preserve the qualities of their sharp edges, they are used for delicate tasks, on soft to mid-hard materials, but always just for cutting actions. Another comparison can be made between the obsidian bladelet and the Japanese knife: both of them bear the same type of sharpening, i.e. asymmetric or “chisel grinding” (Figure 8). This particular type of edge shape is also conducive to meticulous transverse cutting actions on relatively soft materials for optimal precision and accuracy. Moreover, the care taken of Japanese knives today also shows that certain values are associated with them: they come across as aesthetic and exotic objects, which are two potential and significant attributes of Aegean Bronze Age obsidian bladelets. For this period, the social (exchange mechanisms, belonging to a group) and even symbolic aspects should also be considered. They cannot be assessed here but they are nonetheless an integral part of the way in which obsidian was used.

5. Conclusion

The widespread use of diverse lithic artifacts peaks during the Middle and Late Helladic and continues to represent the “common basis” of domestic units (Moundrea Agrafioti, 2002: 93), but these artifacts are nonetheless generally given little consideration as they are viewed as obsolete by its own users. Yet, it is at that period that chipped lithics are fully integrated in the domestic sphere, apart from arrow heads which are also placed in tombs. Obsidian continues to be used, although it declines to some extent, probably due to the fact that it is no longer used in the funerary sphere, where it is replaced by bronze. In addition, the decrease in the amount of obsidian tools could be linked to changes in circulation networks (Rutter, 2001: 122). No competition with bronze is visible in the domestic sphere, whereas there is clearly growing competition with chert, which probably becomes more competitive from this period onwards. These changing relationships may indicate the maintenance of certain traditions, or conversely, cultural shifts. Through these preliminary studies, it is possible to sketch the first outlines of the economic uses and the social conception of tools during the Middle Helladic at the site of Kirrha.

It was clear from the outset that obsidian and chert were treated differently at the procurement and production stages, but we now know that they were also used in different ways (in terms of the activities carried out and possible recycling). Indeed, in this dataset, these two materials were used for distinctive activities, in keeping with their inherent capacities and constraints. In addition, the economy of these two materials is radically different. In most cases, chert is deliberately used in the same way as a limited and long-distance resource, whereas the working edges of obsidian artifacts are preserved and underwent limited use. From a purely functional viewpoint, it is possible to consider that obsidian, which is fragile and increasingly rare, is treated in a particular way in order to preserve the sharpness of the working edge for as long as possible. But the functional aspect alone can never explain the reasons for use: these practices, these “ways of doing things”, – in this case, the use of obsidian, prismatic bladelets and maintaining the initial cutting edges – are constraints determined by the social, economic and ideological functioning of a human group (Perlès, 2009). It may be suggested for the MH, that the presence of obsidian could reveal a wish to show affiliation to a group, to maintain intra-community links through non-verbal communication. On the other hand, leaving part of the production in the hands of specialists signifies a resolve to maintain extra-community links. These hypotheses are important as this period is characterized by marked regional withdrawal and external links seem to be strained. Finally, although, in the absence of written texts it is not possible to grasp the ideological representations operating during these activities, like through ethnographic studies, it is possible to assume that the parsimonious use of the prismatic bladelet corresponds to a quest for efficacy and precision to carry out specific activities. The continued use of obsidian prismatic bladelets could perhaps signify a particular connection, possibly linked to rural community traditions, which is not provable or explainable in detail. Considering the context, these considerations are not irrelevant, as other, more significant elements of the material culture, such as pottery, indicate a rather simple (Voutsaki, 2010: 105), conservative and local production with little circulation. Continuity in the shape of obsidian products, which seem to be affected by a partial de-specialization, denotes certain stability in the cultural configuration at Kirrha, which would not have been revealed by other types of artefacts. Thus, the use of obsidian during the MH at Kirrha, in all aspects, reveals that this material did not by any means become banal or insignificant, contrary to modern biases with regard to prehistoric societies.

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Table:

Table 1: Approximate Absolute Chronology for the Aegean Bronze Age.

Table 2: Kirrha chipped stone tools from the 2009 to 2011 excavations.

Table 3: Chipped stone tool sample presented in this study.

Table 4: Number of Used Zones (UZ) depending on tool type and raw material.

Figure 1: Map of sites mentioned in this article and obsidian outcrops.

Figure 2: Bladelets and tools from Kirrha.

Figure 3: General consumption of obsidian and chert tools.

Figure 4: Obsidian tool types depending on detailed raw material type.

Figure 5: Various obsidian uses.

Figure 6: Chert tool types depending on detailed raw material type.

Figure 7: Various chert uses.

Figure 8: Flat and chisel grindings.

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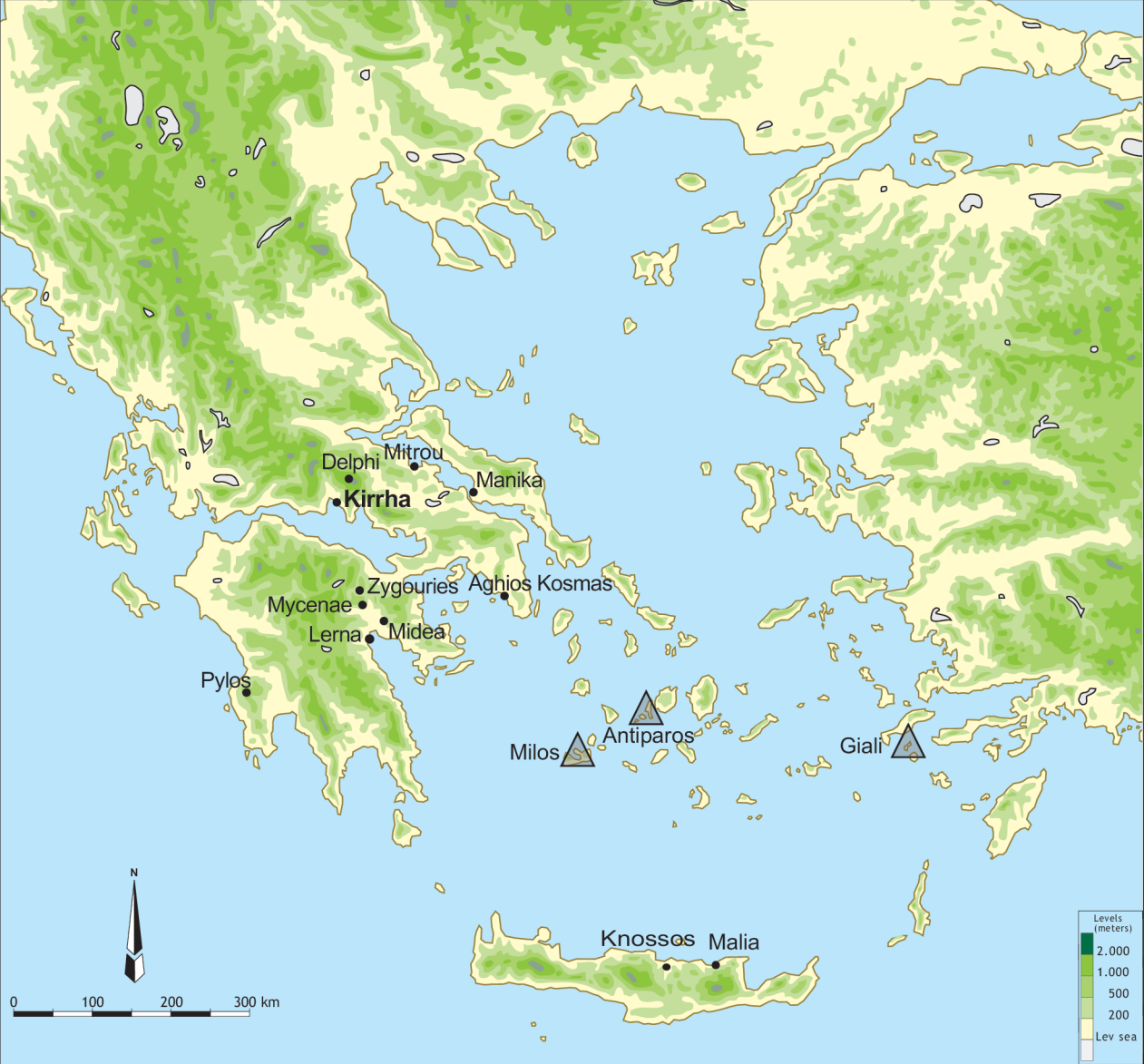
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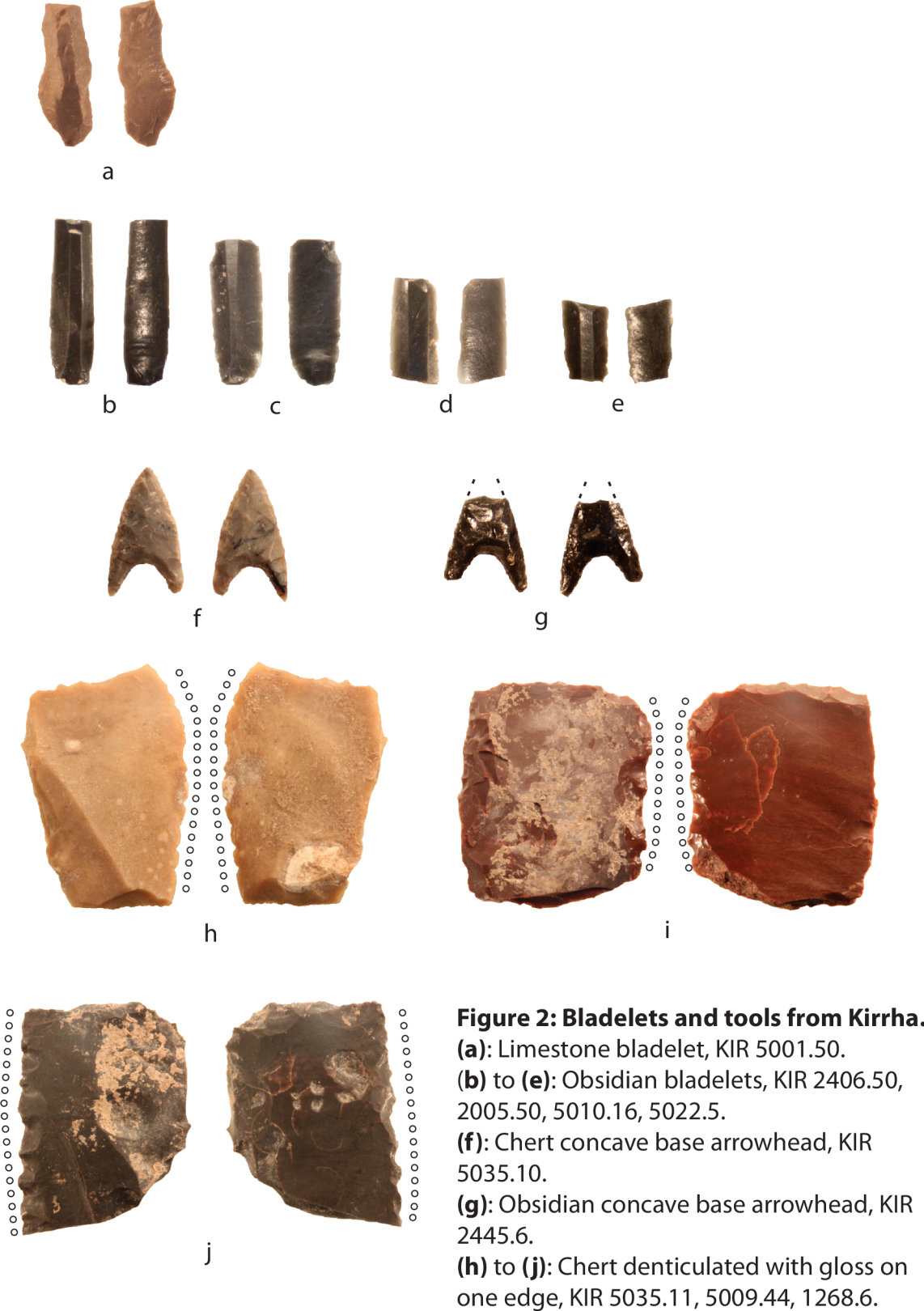
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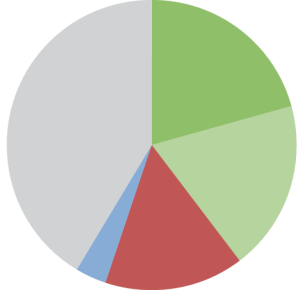
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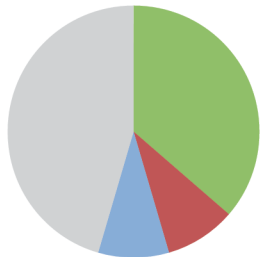




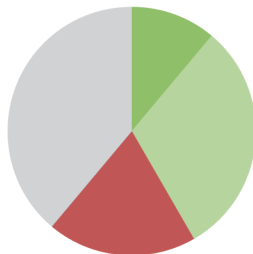


Total obsidian and chert

- Vegetal - Except *Graminae*
- Vegetal - *Graminae*
- Animal
- Mineral
- Undetermined



Obsidian



Chert

Figure 3: Type of worked raw material.

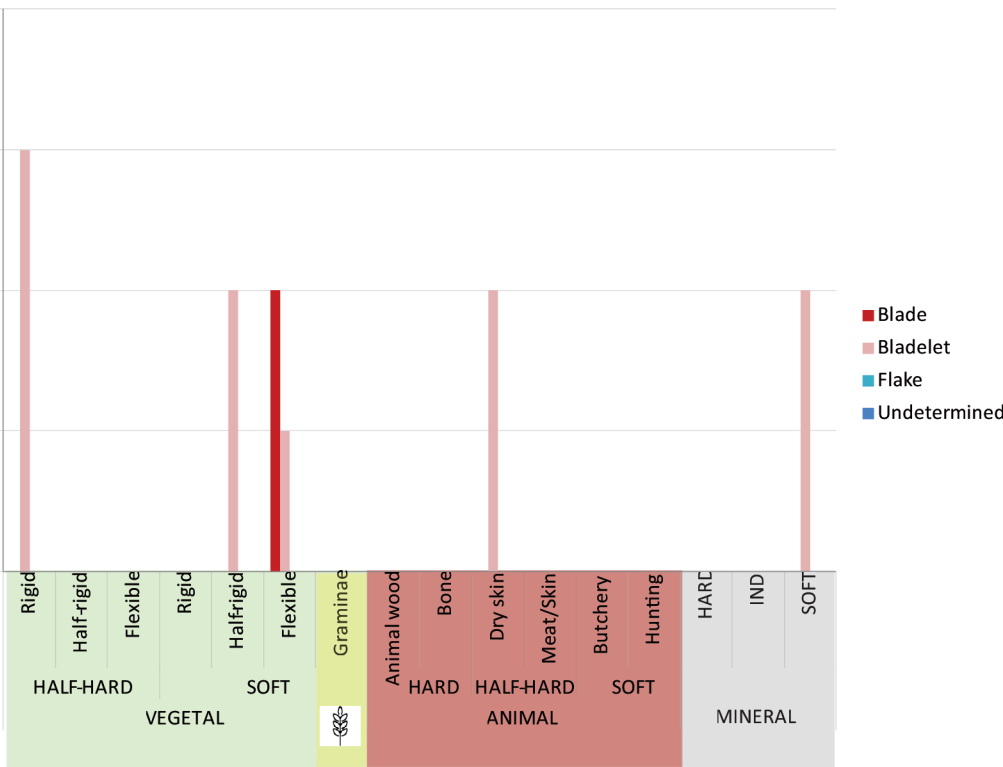


Figure 4: Obsidian tool types depending on detailed raw material type

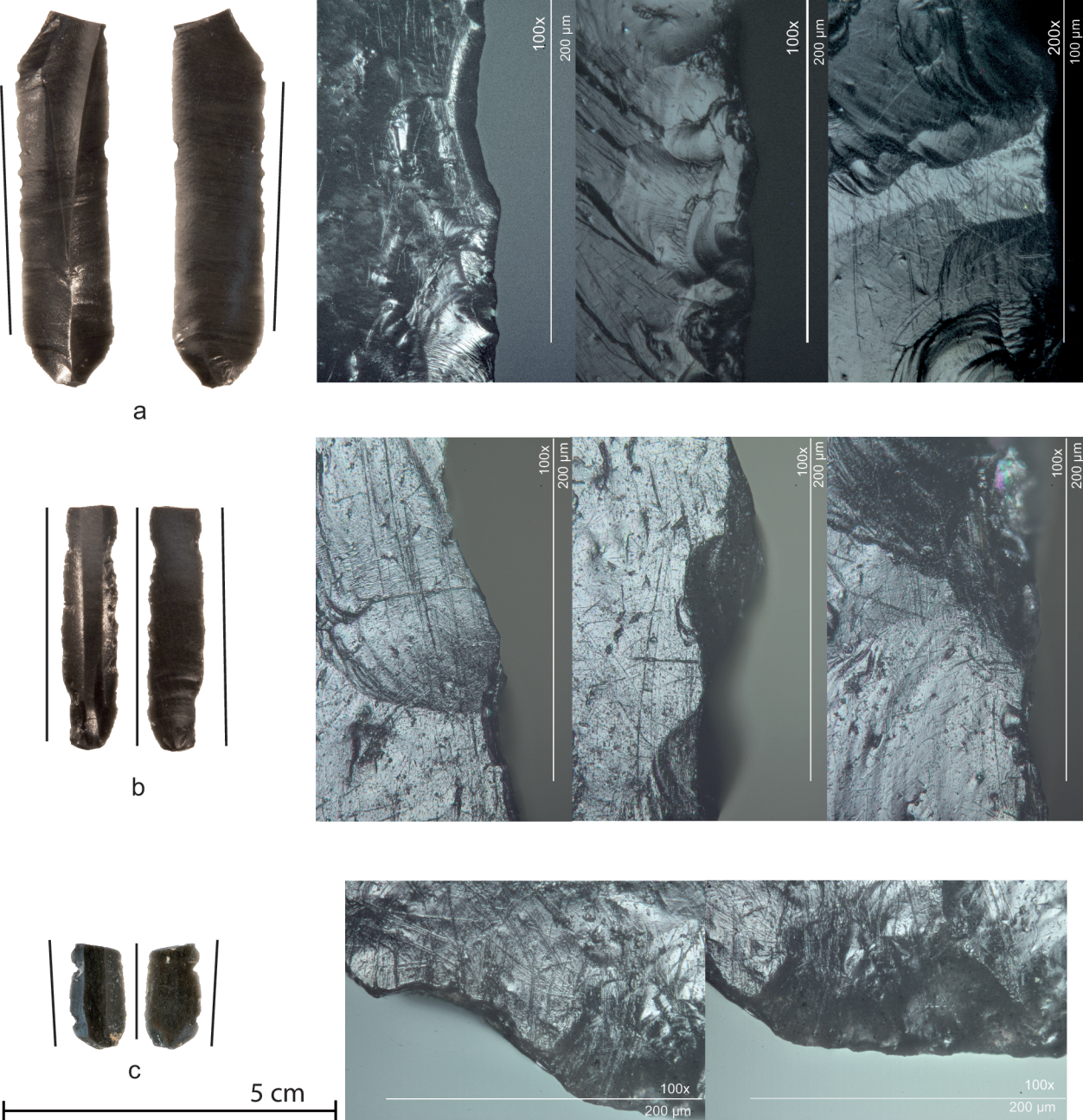


Figure 5: Various obsidian uses.

(a) KIR 3210.8, blade used on one edge to cut a soft and flexible vegetal, which looks siliceous.

(b) KIR 1027.50, bladelet on both edges used for cutting a soft semi-rigid vegetal, slightly abrasive.

(c) KIR 2019.50, bladelet used on both edges for scrapping a soft and abrasive material, probably pottery.

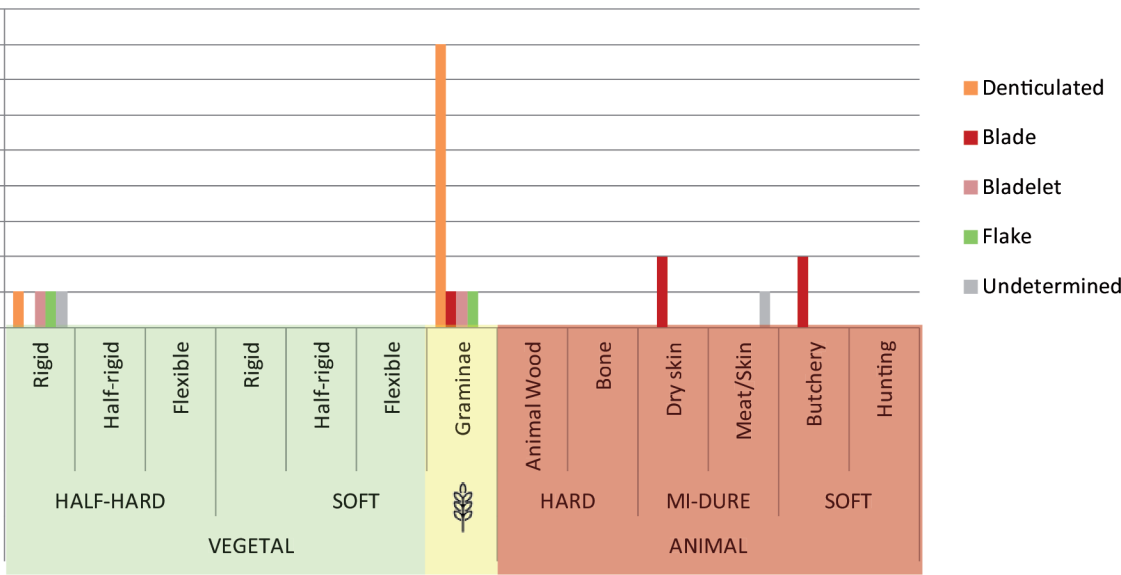


Figure 6: Chert tool types depending on detailed worked raw material types.

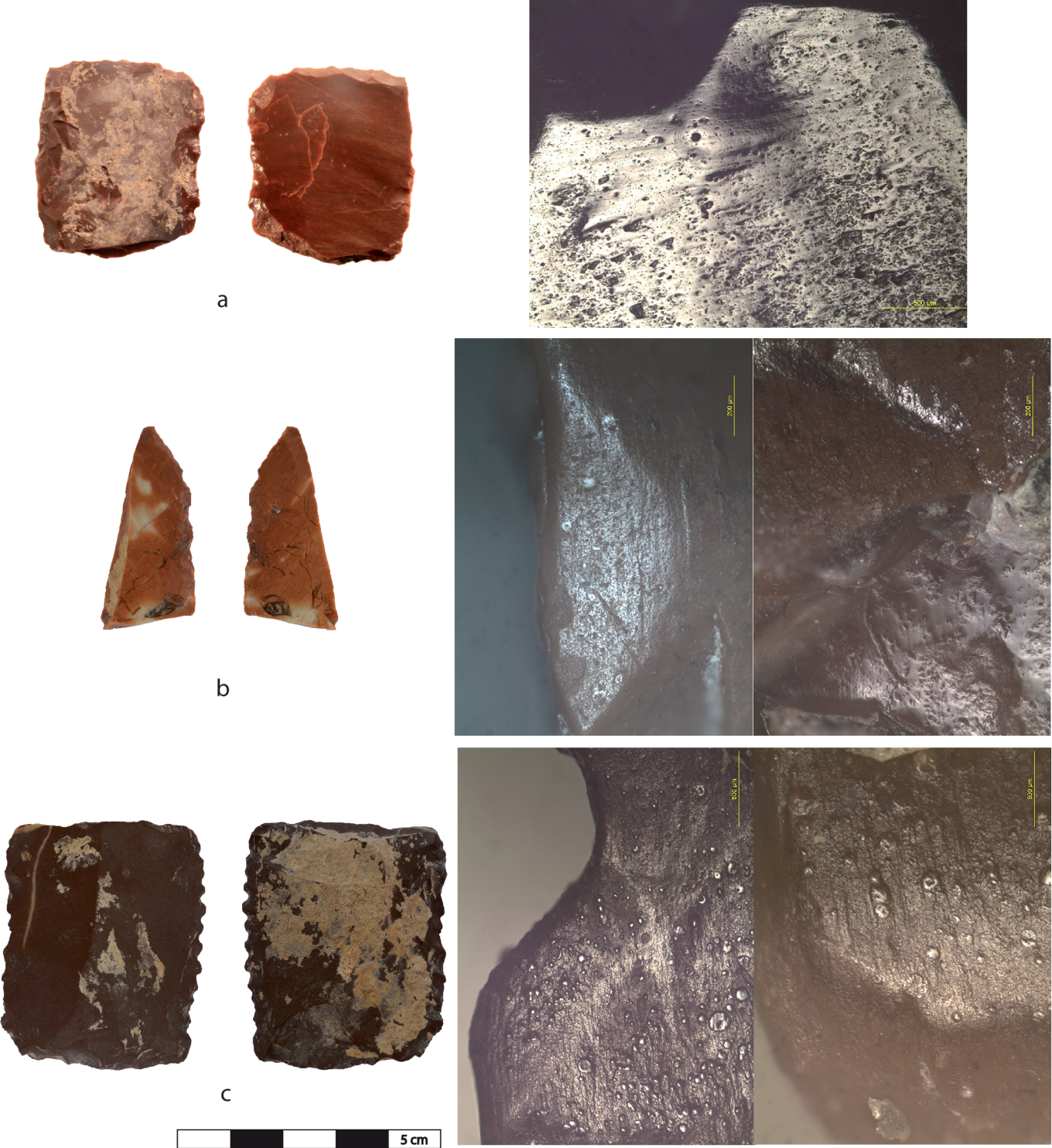


Figure 7: Various chert uses.

- (a) KIR 5009.44: Denticulated used for harvesting, 50X magnification
- (b) KIR 1020.50: Retouched blade fragment, used for harvesting (a), then for cutting a flexible, soft and abrasive material, 100X magnification,
- (c) KIR 1189.6: Denticulated used for cutting a flexible, soft and abrasive material, 50X magnification.

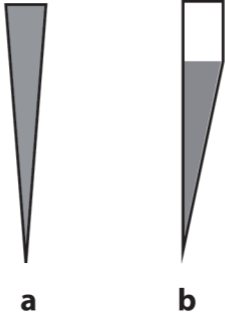


Figure 8: Flat and chisel grindings

(a) Flat grinding, the more multi-skillet.
Common ground in the Western World.

(b) Chisel grinding, sharper but more fragile.
Ground type of actual Japanese knives and Neck-Knives, but also prehistoric prismatic obsidian blades.

In gray, surface used.