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ORIGINAL ARTICLE

# Deciphering Middle Stone Age Technological Behaviors: An Analysis of the Lithic Technology from Level VI-B at Mumba, Tanzania

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**Abstract** The Mumba rockshelter, located in the northwest of Lake Eyasi is key to understanding the Stone Age in East Africa. The stratigraphy of the site spans the last 130 ka BP and comprises levels from the Middle Stone Age, the Later Stone Age, the Pastoral Neolithic, and the Iron Age. In terms of the Middle Stone Age (MSA), Mumba has helped to define two lithic industries: Sanzako (130 ka BP) and Kisele (90–50 Ka BP) that characterize this techno-complex in northern Tanzania. The Sanzako industry was defined based on level VI-B at Mumba, which was excavated in 1938 by Köhl-Larssen. Here we present the study of the lithic assemblage excavated by Mehlman between 1977 and 1981. Mehlman subdivided this unit into three sublevels (Lower, Middle, and Upper), all of which remained unanalyzed and therefore, unpublished. The main features of the lithic assemblages found in the three sublevels are the presence of discoid, Levallois, and bipolar knapping methods. Additionally, the retouched tools are mainly sidescrapers, denticulates, and notches. This recent research enables us to understand the Sanzako industry in more detail, as well as its nature within the chronocultural framework of the MSA in northern Tanzania.

Archaeological time period: Middle Stone Age. Country and region discussed: Northern Tanzania.

**Supplementary Information** The online version contains supplementary material available at https://doi.org/10.1007/s10437-024-09582-9.

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**Résumé** L'abri sous roche de Mumba, situé au nord-ouest du lac Eyasi, est essentiel pour comprendre l'âge de pierre en Afrique de l'Est. La stratigraphie du site

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s'étend sur les 130 derniers ka BP et comprend des niveaux du Paléolithique moyen, du Paléolithique supérieur, du Néolithique pastoral et de l'âge du fer. En ce qui concerne le Paléolithique moyen (MSA), Mumba a contribué à définir deux industries lithiques: Sanzako (130 ka BP) et Kisele (90-50 Ka BP) qui caractérisent ce techno-complexe dans le nord de la Tanzanie. L'industrie Sanzako a été définie sur la base du niveau VI-B à Mumba, qui a été fouillé en 1938 par Köhl-Larssen. Nous présentons ici l'étude de l'assemblage lithique fouillé par Mehlman entre 1977 et 1981. Mehlman a subdivisé cette unité en trois sous-niveaux (inférieur, moyen et supérieur), qui sont tous restés non analysés et donc inédits. Les principales caractéristiques des assemblages lithiques trouvés dans les trois sous-niveaux sont la présence de méthodes de taille discoïdes, Levallois et bipolaires. De plus, les outils retouchés sont principalement des racloirs latéraux, des denticulés et des encoches. Cette recherche récente nous permet de mieux comprendre l'industrie Sanzako, ainsi que sa nature dans le cadre chronoculturel du MSA dans le nord de la Tanzanie

**Keywords** Middle Stone Age · Lithic technology · Lake Eyasi · Tanzania · East Africa

**MOTS-CLÉS** **Middle** stone age · Technologie lithique · Lac Eyasi · Tanzanie · Afrique de l'Est

## Introduction

The Middle Stone Age (MSA) is the time period linked to the emergence of *Homo sapiens.* It is defined by the deliberate knapping of prepared cores, which exhibit certain characteristics derived from both the Early Stone Age (ESA) and the Later Stone Age (LSA) (Goodwin, 1929; Goodwin and Van Riet Lowe 1929). These two occurrences were not simultaneous given that the appearance of *Homo sapiens* sensu lato took place 400–350 ka BP, whereas the emergence of MSA industries in Africa has been documented in the 500–300 ka BP time period at various sites such as Olorgesailie (Kenya), Gademotta (Ethiopia), Kapthurin Formation (Kenya), Jebel Irhoud (Morocco) and the Victoria West sites in South Africa (Basell, 2013; Brooks et al., 2018; Clark, 1988; Deino et al., 2018; Hublin et al., 2017; Li et al., 2017; McBrearty & Brooks, 2000; Tryon & Faith, 2013; Tryon et al., 2005). The beginning of the MSA is also linked to the earliest evidence of modern behavior (McBrearty & Brooks, 2000; Henshilwood et al., 2002; D'Errico & Stringer, 2011; Marean, 2015).

This chrono-cultural period is linked to the spread of *Homo sapiens* within and outside Africa. This can be viewed as a spatio-temporal mosaic process that ends with the configuration of *Homo sapiens* as a species (Scerri et al., 2018). In this context, Eastern Africa has played an important role in this process, both in terms of the fossil and the archaeological records. In the case of the former, as proved by the fossils of Omo I and II, of Herto, Ndutu, or the Gawis skull, among others (Day, 1969; Fleagle et al., 2008; White et al., 2003; Rightmire, 1983; Quade & Wynn, 2008). In the case of the latter, thanks to the large amount of MSA sites, which are essential to our understanding of certain technological behavioral patterns (Blinkhorn & Grove, 2021).

According to Clark (1988), there is considerable variation in the MSA lithic assemblage in Eastern Africa, which is noted both spatially and temporally. Many authors have studied the origin of this technological variability, which can be explained in terms of site function (Collins & Willoughby, 2010; Maíllo-Fernández et al., 2019a, 2019b; Mehlman, 1989; Osypińska & Osypiński, 2016); raw material economy (Ambrose, 2012; Eren et al., 2014a; Tryon & Ranhorn, 2020); geographical and palaeoenvironmental factors (Basell, 2008; Douze & Delagnes, 2016; Stewart & Stringer, 2012); or cultural transmission linked to territorial proximity or not (Foley & Laht, 2011; Scerri et al., 2014; Creanza et al., 2017; Spinapolice, 2020).

This is also the case for MSA lithic assemblage in northern Tanzania where we find a more diachronic — as opposed to simultaneous — seriation. The Njarasan industry (300–200 Ka) is the oldest, followed by the Ngaloba Beds industry (200–100 ka BP), the Sanzako (131.7 + 6.9 – 6 ka BP), and the Kisele (90–56 ka BP). The Kisele is contemporaneous with the Loiyangalanian industry (64 ka BP). The appearance of the Later Stone Age (LSA) is identified in the region with the emergence of the Mumba industry dated to 69–59 ka BP (Mehlman, 1989; Domínguez-Rodrigo et al., 2007; Prendergast et al., 2007; Mabulla, 2015; Bower et al., 1985, 2012; Bower & Mabulla, 2013; Maíllo-Fernández et al., 2019a, 2019b; Diez-Martín et al. 2009; Gliganic et al., 2012; Solano-Megías et al., 2021).

In the case of Mumba, the Lake Eyasi Basin, where Mumba occurs, is a geological a ramification of the Rift Valley that stretches from north to south (Lake Natron-Manyara), and east to west (Mount Meru-Kilimanjaro) (Dawson, 1992), acting as a pathway for animal migrations and for the movement of human groups.

Throughout the twentieth century, several research projects were undertaken in Lake Eyasi's basin to study its geoarchaeology. These projects include the work of Köhl-Larsen (1934–1939), Reeve (1946), Rafalski and her team (1978); Mehlman (1977 and 1981), Mabulla (1996), Prendergast (2005) (Bräuer & Mehlman, 1988; Mehlman, 1989; Mabulla, 1996; Domínguez-Rodrigo et al., 2007; Prendergast et al., 2007 and 2014; Diez-Martín et al. 2009).

## Mumba Rockshelter

The Mumba rockshelter (35°17′47″ E; 3°32′26 ″ S) is located in the Karatu district in the northwest of the Lake Eyasi basin (Fig. 1). The site is found in an area between the Lag'hangareri-Ishimijega Precambrian hills — which consist of gneiss and diorite deposits — partially buried by Quaternary volcanic sediments and the Gandargh hills (Bräuer & Mehlman, 1988; Mehlman, 1989; Mabulla, 1996; Prendergast et al., 2007; Domínguez-Rodrigo et al., 2007; Bushozi, 2011; Bushozi et al., 2020).

The site is a rockshelter around 1050 m/asl, parallel to Lake Eyasi (Mehlman, 1989; Mabulla, 1996). At present, it is located around 3.5 km from the eastern shore of the Lake and is made up of alluvial, lacustrine, and aeolian sediments that produced a stratigraphy with a base dated to ~ 131 ka BP (Gliganic et al., 2012; Mehlman, 1989). The Mumba rockshelter is among a limited number of sites in East

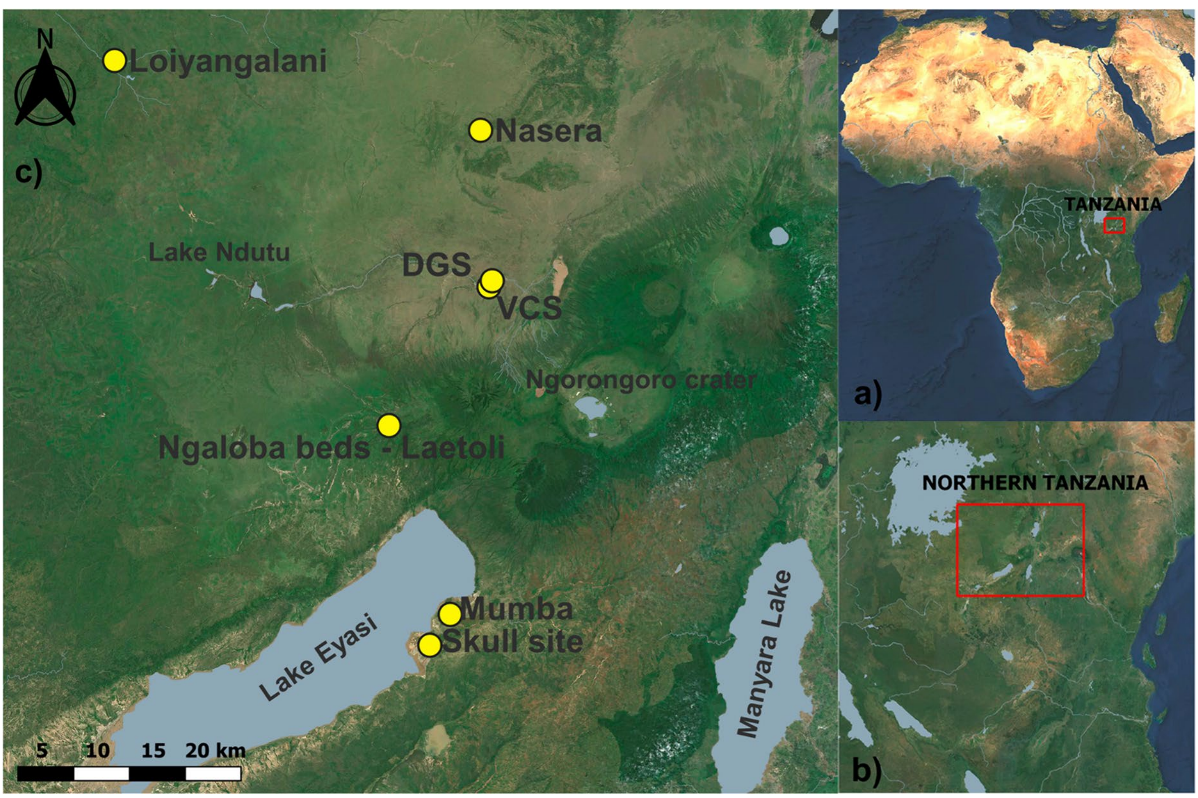


**Fig. 1** Map of northern Tanzania with the sites cited in the text. **a** Africa map. **b** Northern Tanzania. **c** Major sites cited in the text created using http://www.qgis.org

Africa that possess an archaeological sequence comprising the MSA, LSA, Pastoral Neolithic, and the Iron Age (Mehlman, 1989; Prendergast et al., 2007). This stratigraphy encompasses a large portion of all of the phases of African prehistory. This stratigraphy suggests that Mumba during most of the Stone Age was a recurrent place for shelter for the hominin groups in the region.

Multiple archaeological excavations have been undertaken at Mumba. It was first excavated by Kohl-Larsen in 1933–1939 (Kohl-Larsen, 1943), who initially, established its stratigraphy. However, it was Mehlman who, between 1977 and 1981 (Mehlman, 1989), ultimately established the stratigraphy that we know today. Kohl Larsen excavated during different periods and to different degrees: in 1934, she excavated an 8×4 m test pit (according to Kohl Larsen 1943 in Mehlman, 1989), or 6×7 m with a maximum depth of 5.5 m, according to Kohl Larsen's field notes (in Mehlman, 1989). Later, in 1938, she further excavated a test pit measuring 9×12.5 m and 10.5 m deep (Mehlman, 1989:73). On the other hand, in 1977, Mehlman excavated various test pits inside the shelter, which he named Ex. 1, Ex. 2, Ex. 3 (Mehlman, 1979), and Ex. 4, which he excavated in 1981 (Mehlman, 1989). Various irregular areas were excavated, with a total of 14.1 $m^3$ excavated in one of them (in a 12.5×9×2 m trench) and a further 47 $m^3$ in Ex. 2, in a total area of 2.35 $m^2$ (Mehlman, 1989:78). The excavation works established the six levels and their associated sublevels, which remain somewhat applicable. During the early 2000s, the site was excavated once again, this time by Prendergast and colleagues using a more modern methodology (Domínguez-Rodrigo et al., 2007; Prendergast et al., 2007). Four trenches were excavated: Trench 5 (2×2 m), Trench 6 (2×1 m), Trench 7 (2×2 m) and Trench 8 (2×2 m). Lastly, the site was excavated by Bushozi and colleagues (2020) between 2014 and 2018, with a new trench excavated between Trench 5 and Trench 7 dug by Prendergast et al. (2007).

Here we present the study of the assemblage from level VI-B at Mumba excavated by Mehlman between 1977 and 1981. Notably, this assemblage has remained unstudied and unpublished until now. As is known, the site of Mumba comprises six levels (I–VI), with level VI-B being the oldest, which was divided into Upper, Middle and Lower (Mehlman, 1989). Level VI-B is made up of granulometric clay and sand debris, including clasts of 0.5–1-cm clasts, defined by Melhman as a lacustrine level (Mehlman, 1989; Prendergast et al., 2007; Bushozi et al., 2020). It was dated to 131.7 + 6.9 – 6 ka BP using 230Th/231 Pa (USGS-82–19) and to 109.5 + 44.4 – 23 ka BP using 231 Pa/235U (USGS-82–19) from faunal samples (Mehlman, 1989). Three *Homo sapiens* molars were found in Unit VI-B (Bräuer & Mehlman, 1988).

The fauna published was excavated by Kohl-Larsen and analyzed by Gifford-González. In this limited collection, Gifford-González identified a single specimen each of wildebeest, oryx, buffalo, or warthog (MNI = 1 of each). Additionally, two distinct species of zebra were identified: *Equus burchelli* (MNI = 1), and *Equus grevyi* (MNI = 2). The latter was identified with much uncertainty, the presence of which would indicate the prevalence of arid climatic conditions.

The lithic assemblage excavated by Mehlman is slightly more abundant than the one currently present at the Olduvai Gorge Museum. It is known that Mehlman took a portion of the sample to the USA for analysis (Mehlman, 1989: 115). A thorough review of the literature has revealed the existence of at least, seven more pieces in addition to the 3282 present at the Olduvai Gorge. These seven pieces were taken to the USA and subsequently published by Mehlman in his PhD dissertation (Mehlman, 1989), but have not been found in the collection available to us at the Museum. At present, the total number of exported pieces and their whereabouts are unknown. Our analysis, based on the assemblage stored at the Olduvai Gorge Museum comprises: 2 pieces from sublevel VI-B Lower, 451 pieces from sublevel VI-B Middle, and 2829 pieces from sublevel VI-B Upper.

## Materials and Methods

We analyzed the lithic assemblage using taphonomic and technological criteria (Maíllo-Fernández et al., 2019a, 2019b).

Most of the studies of MSA assemblages have centered on their typological analyses, focusing on the presence of the various types of lithic pieces and where, in many cases, technological and typological concepts are combined (Mehlman, 1989; Merrick, 1975; Nelson, 1973; Clark & Kleindienst, 1974;

Shea, 2008; Yellen et al., 2005). In this paper, we present a detailed study employing a number of methodological approaches (taphonomic, technological, typological) that allow us to generate the necessary synergies to define and contextualize the first MSA industries at Mumba.

Here we analyze the assemblage from level VI-B at Mumba, which was excavated by M. Mehlman between 1977 and 1981. The assemblage was divided into three sublevels, as previously noted: Lower, Middle, and Upper (Mehlman, 1989). Given that sublevel VI-B Lower only has two pieces, it has not been included in the following analyses because it is not statistically-representative. As noted above, this unit has been studied from a taphonomic, technological, and typological point of views (see Supplementary Information 1, 2, and 3 for further information).

### Taphonomic Analysis

In order to interpret a lithic assemblage, it is essential to pinpoint the post-depositional processes undergone by an archaeological site. In the taphonomic analysis, we have paid special attention to the following types of alterations: pseudoretouch; rounding; porcelainization/abrasion; and white patination.

1. Pseudo-retouch. A superficial and mechanical alteration that affects the surface of the stone tools. It is generated by the movement and brushing of the pieces with the sediment because of trampling or hydric processes (Stapert, 1976; Berlirán, 2014). This alteration can be noted by the presence of non-continuous, irregular, alternate, and orderless "retouch". Pseudo-retouch has been classified into three categories: marginal, deep, and very deep.
2. Rounding. A mechanical (fluvial, eolian, lacustrine, or marine) or chemical alteration (diagenetic dissolution) that alters the edges of lithic pieces (Bernaldo de Quirós et al., 1981). Rounding has been classified into three types: marginal rounding, deep, and very deep.
3. Porcelainization/abrasion. Alteration caused by wear on the surface of the lithic tool. It can be produced by a direct/indirect source of controlled heat (Bernaldo de Quirós et al., 1981) or by the brushing of the piece against other sedimentary particles, giving rise to wear, breakage, and micro-detachments (Pedraza, 1996). It can also be produced by hydric processes (Shackley, 1978). This process has been classified into three categories: marginal, deep, and very deep.
4. White patina. This chemical alteration is only found on chert and is produced by quartz grain dissolution in alkaline soils that contain high pH water. This alteration occurs first on the outside part of the piece and then on the inside, leading to a weight reduction (Schmalz, 1960; Fairbairn & Robertson, 1972; Röttlander, 1975; Stapert, 1976; Texier, 1981; Luedtke, 1992). This alteration has been classified into four types: very marginal, marginal, deep, and very deep.

### Technological Analysis

Lithic industries allow us to identify two key aspects that help further our knowledge of human behavior: techno-psychological and techno-economic types of production. Identifying these represents the main objective of any chaîne opératoire analysis (Boëda et al., 1990). To that effect, the chaîne opératoire is the basic analytical tool, representing a set of actions, gestures, and tools that constitute technical processes in a series of predictable stages (Audouze & Karlin, 2017; Karlin, 1992; Karlin et al., 1992). In this study, we will place greater focus on the technological process, that is to say: to the sourcing of raw materials; to the knapping techniques and methods; to the aims of the lithic production; and to the final products, both retouched and unretouched (sensu Maíllo-Fernández et al., 2019a, 2019b).

The lithic assemblage from the VI-B sublevels at Mumba has been studied using both a quantitative and qualitative analytical approach, thus examining the individual characteristics of each of the pieces, such as measurements, platform type, presence/absence of cortex, and number of scars. The general characteristics of the assemblage as a whole have also been noted in terms of the presence and/or absence of the different phases of the chaîne opératoire. Lastly, the alteration of the pieces by retouch has also been studied, and a typological classification has been assigned (Supplementary Information 1, 2, and 3).

On the other hand, the chaînes opératoires characteristic of the Middle Palaeolithic and the Middle Stone Age have been studied to describe the knapping methods and the operational schemes followed when making the lithic tools. These include the discoid (Boëda, 1993, 1995; Guilbaud, 1986; Terradas, 2003); centripetal (Kuhn, 1995; Mourre, 2003); Levallois (Boëda, 1994, 1995; Boëda et al., 1990; Tryon et al., 2005); bipolar (de la Peña & Wadley, 2014; de la Peña, 2015a, b; Díez-Martín et al., 2011; Sánchez Yustos et al., 2012); single platform methods; unipolar; bipolar/bidirectional; polyhedral and opportunistic (Fuertes Prieto, 2004; Delagnes & Roche, 2005) (see Supplementary Information 4).

### Typological Analysis

The typological approach was carried out in broad terms. There is an absence of consensus in the typological study of the assemblages of East Africa (Mehlman, 1989; Merrick, 1975; Nelson, 1973; Clark & Kleindienst, 1974; Shea, 2008, 2020; Yellen et al., 2005). This lack of agreement is an obvious handicap when it comes to comparing the collections, as highlighted by several authors (e.g. Clark & Kleindienst, 2001; Douze, 2012; Will et al., 2019). In this study, we have adopted on a more general approach by grouping the retouched blanks into large typological clusters (sidescrapers, endscrapers, burins, backed pieces, etc.).

## Results

The Mumba assemblage found at the Olduvai Gorge Museum comprises two pieces from sublevel VI-B Lower; 451 pieces from sublevel VI-B Middle; and 2769 pieces from sublevel VI-B Upper (Table 1). Given its small size, sublevel VI-B Lower has not been included in the present study.

The most common raw material used in both sublevels is quartz: 69.67% in the case of sublevel VI-B Middle, and 80% in the case of sublevel VI-B Upper for both retouched and non-retouched pieces (Fig. 2; see Supplementary Information 5). The other types of raw materials used are not abundant enough. The raw materials are local in origin, except obsidian, sourced from the basin of Lake Naivasha in Kenya (Mehlman, 1989). In general, fine-grained raw materials such as quartz, hyaline quartz, and fine-coarse quartzite are more typically utilized.

There are fractured pieces in both sublevels: 61.2% in sublevel VI-B Middle, and 36.3% in sublevel VI-B Upper (see Supplementary Information 6). Most of these fractures are due to bending and can be linked to the knapping processes employed. Fractures due to percussion are noteworthy, especially in sublevel VI-B Upper, where they represent 34.69% of the pieces showing fractures. The causes are not fully understood; however, they could be linked to the configuration and knapping of the pieces.

The presence of cortex in the lithic assemblages is thought to represent an in situ reduction of the cores (Andrefsky, 1998), as well as the transportation of rough-out blanks (Dibble, 2005). Most of the pieces in both sublevels lack a cortex, with 83.67% in sublevel VI-B Middle, and 84.48% in sublevel VI-B Upper. The raw materials that show the highest amount of cortex are quartz, fine-grained quartzite, and chert, although this account for a small percentage (see Supplementary Information 7). We can therefore infer that most of the lithic raw materials were brought to the site without cortex, despite proximity to the sources.

### Taphonomy

Pseudo-retouch is the most common taphonomic alteration noted within the assemblage. It is observed in 76.28% of the pieces in sublevel VI-B Middle and in 32.32% of the pieces in VI-B Upper (Table 2). This type of alteration may be biological in origin due to trampling processes, although it might also be linked with quartz's inherent fragility when knapped, given its internal fractures.

Rounding, the second most common type of alteration, is noted in 56.89% of the pieces in sublevel VI-B Middle, whereas in sublevel VI-B Upper, it is found in 25.23% (Table 2). This alteration is mechanical in origin and it appears to have occurred as a result of lacustrine processes associated with the site's geographical location, on the shore of Lake Eyasi.

Porcelainization is found on 48.47% of sublevel VI-B Middle pieces and 2.57% of VI-B Upper (Table 2). This alteration is produced by the direct or indirect controlled heating of the pieces and/or raw material. At Mumba, it seems that this occurred unintentionally; the pieces showing porcelainization were likely left in areas close to heat sources.

**Table 1** General inventory by raw material and by sublevel

| Sub-level/raw material | Fine-grained quartzite | Coarse-grained quartzite | Quartz | Chert | Obsidian | Jasper | Sandstone | Hyaline quartz | Phonolite | Basalt | Indet | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VI-B Lower | | | | | | | | | | | | |
| Flake | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Hammer | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Total | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 |
| VI-B Middle | | | | | | | | | | | | |
| Flake | 33 | 3 | 249 | 37 | 1 | 0 | 0 | 17 | 1 | 14 | 1 | 356 |
| Blade | 1 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| Bladelet | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| Burin blow | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Cobble | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 4 |
| Chunk | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 9 |
| Tablette | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | | 6 |
| Debris/chip | 3 | 1 | 45 | 3 | 1 | 0 | 0 | 2 | 0 | 1 | 1 | 57 |
| Thermic debris | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Total | 42 | 4 | 307 | 43 | 2 | 0 | 0 | 21 | 1 | 17 | 5 | 442 |
| Cores | | | | | | | | | | | | |
| Discoid | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Levallois | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Centripetal | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Bipolar | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| Oportunistic | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Total cores | 1 | 0 | 7 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 |
| VI-B Upper | | | | | | | | | | | | |
| Flake | 46 | 2 | 933 | 54 | 1 | 9 | 0 | 103 | 4 | 0 | 0 | 1152 |
| Blade | 0 | 0 | 4 | 2 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 10 |
| Bladelet | 1 | 0 | 1 | 2 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 7 |
| Hammer | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 23 | 0 | 24 |
| Chunk | 3 | 0 | 77 | 4 | 0 | 3 | 0 | 0 | 0 | 1 | 0 | 88 |
| Debris/chip | 16 | 0 | 1162 | 53 | 0 | 8 | 0 | 194 | 1 | 11 | 2 | 1447 |
| Thermic debris | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Indet | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |

**Table 1** (continued)

| Sub-level/raw material | Fine-grained quartzite | Coarse-grained quartzite | Quartz | Chert | Obsidian | Jasper | Sandstone | Hyaline quartz | Phonolite | Basalt | Indet | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 66 | 2 | 2177 | 116 | 1 | 22 | 1 | 303 | 5 | 35 | 2 | 2730 |
| Cores | | | | | | | | | | | | |
| Discoid | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 |
| Levallois | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| Centripetal | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 |
| Bipolar | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| Unipolar | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Oportunistic | 1 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 |
| Others | 0 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| Total cores | 1 | 0 | 37 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 39 |

Another common alteration, however, which is only found on chert pieces, is white patina, present in sublevel VI-B Middle on 6.63% of the pieces, whereas, in VI-B Upper, it is found on 1.36% (Table 2). Caution should be exercised when considering the occurrence of this alteration, as the proportion of chert is rather small compared to the overall variety of raw materials. The formation of white patina is a result of the interaction between the pieces and water with a high pH level, causing the dissolution of the quartz grains (Schmalz, 1960; Stapert, 1976; Texier, 1981; Röttlander, 1975).

Other types of alterations have been found in much smaller numbers, such as concretion (present in 3.32% of sublevel VI-B Middle and 13.97% of sublevel VI-B Upper). A concretion is formed when calcium carbonate precipitates from the rockshelter and as a result of fossil-diagenetic processes. Thermal extractions, that represent less than 1% in both sublevels and which only affect chert, are caused by the rapid warming and cooling of the pieces (Table 2).

Chips, which account for 13.1% of sublevel VI-B Middle and 52.3% of VI-B Upper, provide very interesting information. These values are well below those recorded during experimental work (Maíllo-Fernández, 1998). The absence of chips in an assemblage may indicate that knapping did not take place at the site or the excavated area, or that they have been lost due to low-intensity water or wind action (Schick, 1986, 1987; Behm, 1985; Dunnell & Stein, 1989). From a theoretical point of view, the absence of chips, in our case might be attributed to two possible reasons: Firstly, not all of them were collected during the excavation; or secondly they may have been eroded or removed by water or wind events.

We do not have data to support the first hypothesis. In terms of the second hypothesis, the small number of chips correlates, in sublevel VI-B Middle, with a greater number of blanks showing alterations due to the action of water. In this case, we are here dealing with a lithic assemblage where there is "fresher" material, and then there is other secondary, rounded stone material (Mehlman, 1989:198), or an assemblage in which only a part was affected by the action of water. In any case, this alteration represents a one-off and low-energy occurrence, given that most of the alterations are marginal (Table 2).

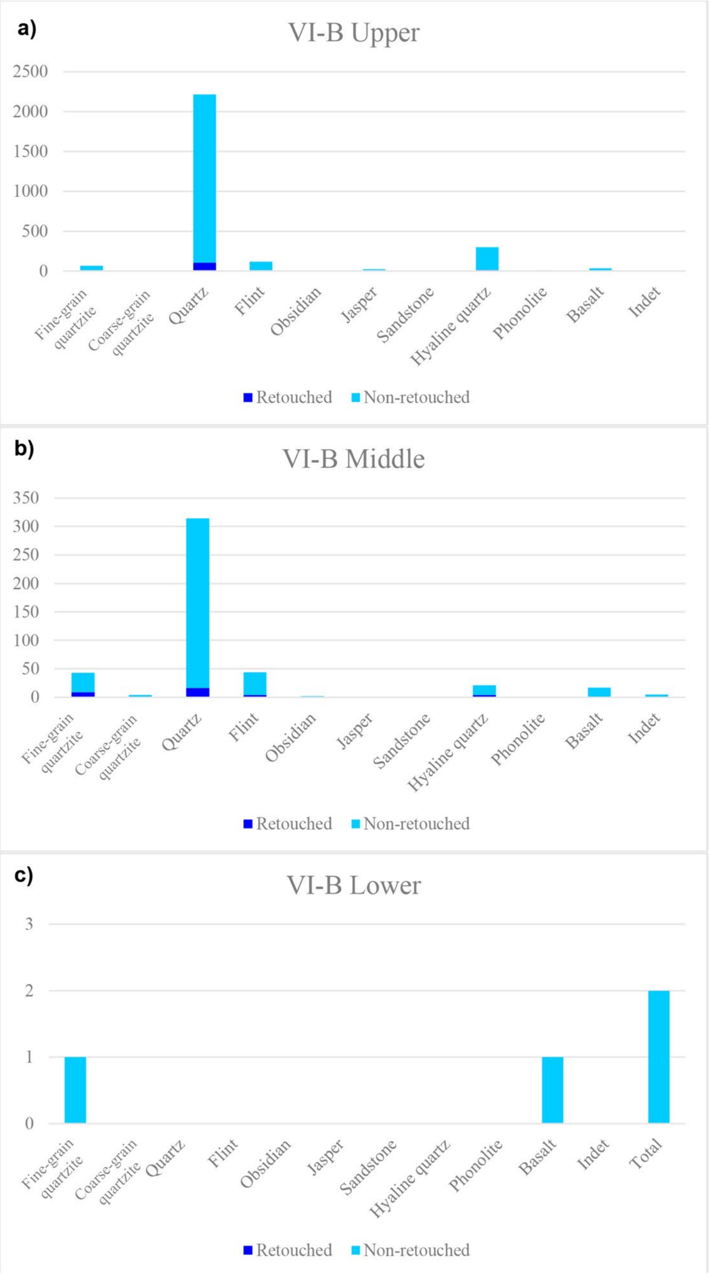


**Fig. 2** Retouched and non-retouched pieces by sublevel and raw material

Techno-Typological Analysis

The most frequent operational schemes employed in sublevels VI-B Middle and Upper at Mumba are mainly the freehand methods (discoidal, Levallois, and centripetal) and the bipolar method on anvil.

*Discoid Operational Schemes*

Discoid methods are the most abundant in both sublevels (VI-B Middle and Upper), both on cores and on flakes (Fig. 3).

**Table 2** Taphonomic alterations

| Taphonomic alteration | VI-B Lower | VI-B Middle | VI-B Upper |
|---|---|---|---|
| Marginal pseudoretouch (PY) | 0 | 269 | 352 |
| Deep pseudoretouch (PM) | 0 | 29 | 76 |
| Very deep pseudoretouch (PR) | 0 | 1 | 0 |
| *Total pseudoretouch* | 0 (0%) | 299 (76.28%) | 428 (32.32%) |
| Marginal rounding (RD1) | 0 | 175 | 210 |
| Deep rounding (RD2) | 0 | 41 | 89 |
| Very deep rounding (RD3) | 0 | 7 | 35 |
| *Total rounding* | 0 (0%) | 223 (56.89%) | 335 (25.23%) |
| Marginal porcelainized (AB) | 0 | 190 | 7 |
| Deep porcelainized (AB1) | 0 | 0 | 23 |
| Very deep porcelainized (AB2) | 0 | 0 | 4 |
| *Total porcelainized* | 0 (0%) | 190 (48.47%) | 34 (2.57%) |
| Very marginal white patina (DS1) | 0 | 6 | 6 |
| Marginal white patina (DS2) | 0 | 6 | 3 |
| Deep white patina (DS3) | 0 | 12 | 6 |
| Very deep white patina (DS4) | 0 | 2 | 3 |
| Total white patina | 0 (0%) | 26 (6.63%) | 18 (1.36%) |
| Shrinkage crack/crazing | 0 (0%) | 4 (1.02%) | 5 (0.38%) |
| Concretion | 0 (0%) | 13 (3.32%) | 185 (13.97%) |
| Thermal chips | 0 (0%) | 3 (0.77%) | 7 (0.53%) |
| Double patina | 0 (0%) | 0 (0%) | 13 (0.98%) |
| Burnt | 0 (0%) | 0 (0%) | 1 (0.08%) |
| Eroded | 0 (0%) | 1 (0.26%) | 0 (0%) |

Sublevel VI-B Middle contains a single discoid core and 65 discoid flakes. The core is a unifacial discoid core fragment on fine-grained quartzite (Table 3). The blank used in its knapping could not be identified. This fragment does not present cortex and we have not been able to observe if a peripheral preparation took place that would have eliminated all of the initial cortex found on the blank. The piece was abandoned because it became fractured during the knapping process.

A total of 65 flakes have been identified (17.61% of the total blanks in the sublevel). These flakes exhibit both chordal and centripetal in direction (Fig. 3 [1–5]): 37 centripetal flakes (57%); 26 chordal flakes (40%); and 2 pseudo-Levallois points (3%; Table 3).

The most common raw material used for these methods is quartz (76.92%), followed by fine-grained quartzite (7.69%), chert (6.15%), or basalt (4.61%). Others like hyaline quartz or coarse-grained quartzite are used more marginally (Table 3). Most of the discoid flakes do not present a cortex (87.7%) or have it marginally (10.8%). Only 1.5% of these flakes are fully cortical (Supplementary information 8). The platforms are plain (56.9%) and dihedral (15.4%), others are broken (7.7%), or do not have a platform due to proximal fractures (7.7%) (Table 4). These types of platforms allow us to infer that the striking surfaces of the cores were roughly prepared prior to knapping. Lastly, most of the flakes had between two (17%), three (47.7%), and four (18.5%) previous scars on their dorsal faces (Supplementary information 9).

In sublevel VI-B Upper, there are nine discoid cores and 226 discoid flakes. Of the nine cores, six are unifacial discoid and three are bifacial discoid, all on quartz (Table 3; Fig. 3 [6–8]). The six unifacial discoid cores have on average dimensions of $33 \times 23 \times 16$ mm, and the blanks used to knap them were pebbles. Although three of them had a small cortical part on the striking surface, they did show surface preparation. On the exploitation surface, the number of flakes removed is between four and 10, and their average length and width is $16.1 \times 17 \times$mm. The abandonment of five of the six cores was due to blank depletion, whereas in the remaining core, it was

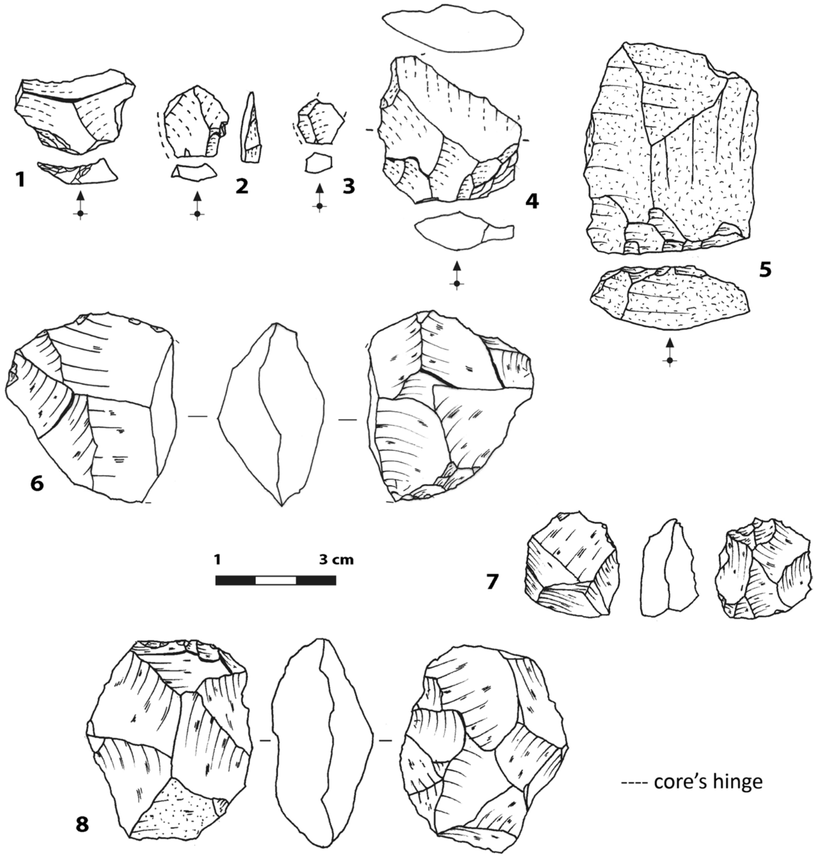


**Fig. 3** Sublevel VI-B Middle (1–5) and VI-B Upper (6–8): 1 Centripetal flake. 2, 3 Chordal flake. 4, 5 Centripetal flakes. 6–8 Bifacial discoid core. 7 Unifacial discoid core. Raw material: quartz (1); quartzite (2, 3, 5–8), basalt (4)

not possible to discern the reason why knapping was abandoned.

The three bifacial discoid cores have average dimensions of 47 × 39 × 26 mm. It was not possible to discern the blanks from the cores except in one case, a pebble, the only to preserve a cortical part. These cores show five, eight, and nine removal scars, with an average length and width of 22.6 × 21 × 6 mm. They were abandoned due to their depletion and fractures.

In general, the bifacial discoid cores are slightly bigger than the unifacial cores, which could indicate that the unifacial cores were used more intensively, as noted in the reasons why each of the pieces was abandoned.

The 226 flakes represent 18.97% of the total blanks in this sublevel. The most common raw material used for flakes is, once again, quartz (79.2%), followed by hyaline quartz (7.08%), fine-grained quartzite (5.75%), basalt (4%), and chert (3.54%) (Table 3). The absence of cortex on flake products is widespread (88.9%), whereas the rest of the discoid pieces show it marginally (11.1%) (Supplementary information 8).

In this level, there are 24 chordal flakes (10.62%) and three pseudo-Levallois points (1.33%) (Table 3). The platforms linked to this kind of method are plain (44.24%) and dihedral (9.3%) (Table 4). 91.2% of the flakes from sublevel VI-B Upper have two, three, four, and five anterior scars with a centripetal direction (Supplementary information 9).

*Levallois Operational Schemes*

The Levallois operational schemes are the second most common in the assemblage (Fig. 4).

In sublevel VI-B Middle, there is one Levallois core and 26 Levallois flakes (7.04% of total blanks). The only documented core here is a recurrent centripetal Levallois core produced on a quartz pebble the dimensions of which are 53 × 48 × 19 mm (Fig. 4 [7]). The core presents the cortex in the central part and shows peripheral preparation of the striking platform

**Table 3** Discoid flakes and cores by raw material

| | Fine-grained quartzite | Coarse-grained quartzite | Quartz | Chert | Obsidian | Jasper | Sandstone | Hyaline quartz | Phonolite | Basalt | Indet | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VI-B Middle | | | | | | | | | | | | |
| Chordal flake | 3 | 0 | 20 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 26 (40%) |
| Pseudo-Levallois point | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 (3%) |
| Centripetal flake with/without cortex | 2 | 1 | 29 | 2 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 37 (57%) |
| Total | 5 (7.69%) | 1 (1.53%) | 50 (76.92%) | 4 (6.15%) | 0 (0%) | 0 (0%) | 0 (0%) | 2 (3.07%) | 0 (0%) | 3 (4.61%) | 0 (0%) | 65 (100%) |
| Core | | | | | | | | | | | | |
| Discoide unifacial | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Total | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| VI-B Upper | | | | | | | | | | | | |
| Chordal flake | 2 | 0 | 20 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 24 (10.62%) |
| Pseudo-Levallois point | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 (1.33%) |
| Centripetal flake with/without cortex | 11 | 0 | 156 | 7 | 0 | 0 | 0 | 16 | 1 | 8 | 0 | 199 (88.05%) |
| Total | 13 (5.75%) | 0 (0%) | 179 (79.2%) | 8 (3.54%) | 0 (0%) | 0 (0%) | 0 (0%) | 16 (7.08%) | 1 (0.44%) | 9 (4%) | 0 (0%) | 226 (100%) |
| Core | | | | | | | | | | | | |
| Discoide unifacial | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| Discoide bifacial | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| Total | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 |

**Table 4** Platform type in discoid material

| Platform type | Cortical | Dihedral | Rectilinear faceted | Convex faceted | Plain | Punctiform | Indeterminate | Broken | Delete | No platform | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| VI-B Middle | | | | | | | | | | | |
| Chordal flake | 1 | 1 | 0 | 0 | 17 | 0 | 0 | 3 | 0 | 4 | 26 |
| Pseudolevallois point | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Centripetal flake | 2 | 8 | 3 | 1 | 19 | 0 | 0 | 2 | 0 | 1 | 36 |
| Centripetal flake with cortex | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| Total | 3 (4.6%) | 10 (15.4%) | 3 (4.6%) | 2 (3.1%) | 37 (56.9%) | 0 (0%) | 0 (0%) | 5 (7.7%) | 0 (0%) | 5 (7.7%) | 65 (100%) |
| VI-B Upper | | | | | | | | | | | |
| Chordal flake | 0 | 0 | 0 | 1 | 19 | 0 | 0 | 2 | 0 | 2 | 24 |
| Pseudolevallois point | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 3 |
| Centripetal flake | 1 | 20 | 8 | 10 | 65 | 1 | 1 | 50 | 1 | 21 | 178 |
| Centripetal flake with cortex | 2 | 1 | 0 | 0 | 13 | 0 | 0 | 3 | 0 | 2 | 21 |
| Total | 3 (1.32%) | 21 (9.3%) | 8 (3.53%) | 11 (4.9%) | 100 (44.24%) | 1 (0.44%) | 1 (0.44%) | 55 (24.33%) | 1 (0.44%) | 25 (11.06%) | 226 (100%) |

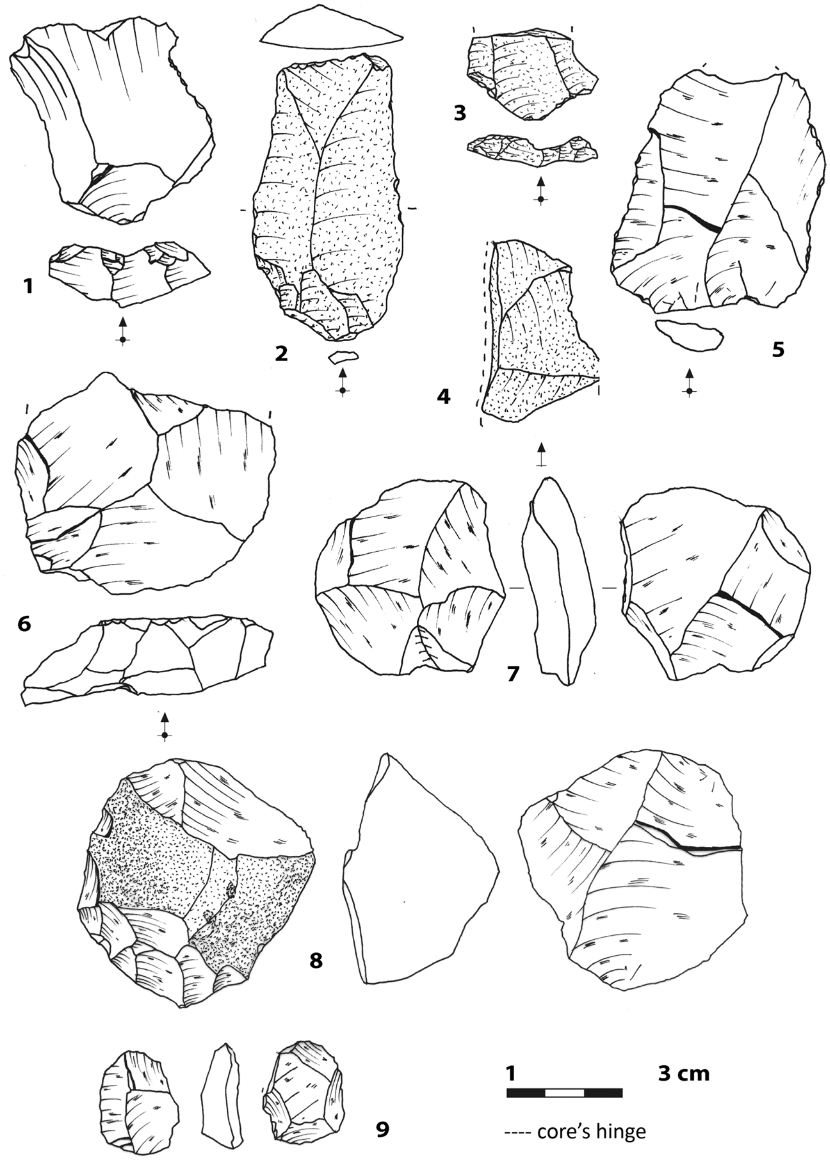


**Fig. 4** Sublevel VI-B Middle (**1**–**7**) and VI-B Upper (**8**, **9**). **1**, **2** Centripetal Recurrent Levallois flake. **3** Unipolar Levallois flake. **4** Bipolar Levallois flake. **5** Preferential Levallois flake. **6**, **7** Centripetal Levallois cores. **8** Unipolar Levallois core. Raw material: chert (**1**); basalt (**2**, **3**); quartz (**4**–**8**)

prior to knapping. The core has six scars from removals on the exploitation surface, the maximum exploitation of which is 25 mm × 24 mm (length and width). The reason for abandonment was that it was completely used up and it was not possible to continue knapping.

The most used raw material was quartz (42.3%), followed by chert (30.77%), basalt (11.53%), and fine-grained quartzite (11.53%) (Table 5). 92.3% of the pieces in this sublevel do not present cortex (Supplementary information 10). Different Levallois flakes have been identified: centripetal recurrent flakes (50%), preferential (23.07%), unipolar (19.23%), bipolar (3.85%) (Table 5; Fig. 4 [1–6]). Half have a dihedral and faceted platform (rectilinear and convex) (Table 6) and present between two and five previous scars (Supplementary information 11). All this variability falls into the array of morphologies that can be obtained using the Centripetal Recurrent Levallois method.

On the other hand, there are three Levallois cores and 60 Levallois flakes in sublevel VI-B Upper. The cores are all made of quartz and their average dimensions are 63 × 53 × 33 mm. Two are knapped on

**Table 5** Levallois flakes and cores by raw material

| Flake type/raw material | Fine-grained quartzite | Coarse-grained quartzite | Quartz | Chert | Obsidian | Jasper | Sandstone | Hyaline quartz | Phonolite | Basalt | Indet | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VI-B Middle | | | | | | | | | | | | |
| Débordant flake | Claro 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 (0%) |
| Levallois indeterminate flake | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 1 | 0 | 1 (3.85%) |
| Preferential Levallois flake | 0 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 6 (23.07%) |
| Unipolar Levallois flake | 1 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 5 (19.23%) |
| Bipolar Levallois flake | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 (3.85%) |
| Recurrent centripetal Levallois flake | 2 | 0 | 6 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 (50%) |
| Levallois point | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 (0%) |
| Total | 3 (11.53%) | 0 (0%) | 11 (42.30%) | 8 (30.77%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 3 (11.53%) | 1 (3.85) | 26 (100%) |
| Cores | | | | | | | | | | | | |
| Centripetal | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| VI-B Upper | | | | | | | | | | | | |
| Débordant flake | 1 | 0 | 23 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 28 (46.6%) |
| Levallois indeterminate flake | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 (3.3%) |
| Preferential Levallois flake | 0 | 0 | 5 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 7 (11.7%) |
| Unipolar Levallois flake | 0 | 0 | 5 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 8 (13.3%) |
| Bipolar Levallois flake | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 (1.7%) |
| Recurrent centripetal Levallois flake | 0 | 0 | 10 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 12 (20%) |
| Levallois point | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 (1.7%) |
| Levallois blade | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 (1.7%) |
| Total | 1 (1.7%) | 0 (0%) | 46 (76.7%) | 5 (8.3%) | 0 (0%) | 0 (0%) | 0 (0%) | 5 (8.3%) | 0 (0%) | 3 (5%) | 0 (0%) | 60 (100%) |

**Table 5** (continued)

| Flake type/raw material | Fine-grained quartzite | Coarse-grained quartzite | Quartz | Chert | Obsidian | Jasper | Sandstone | Hyaline quartz | Phonolite | Basalt | Indet | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Core | | | | | | | | | | | | |
| Centripetal | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |

pebbles, whereas for the third, it was not possible to identify the blank. None of the cores presents a cortex and we observed that there were previous preparations of the striking platforms. The number of scars identified on the cores is four on two of the cores and eight on the third. The reason for abandonment could not be determined, except in the latter case, which was due to depletion of the blank (Fig. 4 [8, 9]).

Among the 60 Levallois flakes, quartz is the most used raw material (76.7%), followed by chert (8.3%), hyaline quartz (8.3%), basalt (5%), and fine-grained quartzite (1.7%) (Table 5). Most of the blanks (93.3%) do not have cortex (Supplementary information 10). The flakes linked to Levallois methods (5.03% of total blanks) correspond, strictly-speaking, to different Levallois methods: débordant flakes (46.6%); centripetal recurrent (20%); unipolar (13.3%); preferential (11.7%); indeterminate Levallois (3.3%); bipolar (1.7%); as well as Levallois blades (1.7%) and points (1.7%) (Table 5). Most of the products are compatible, again, with the Centripetal Recurrent Levallois method. The dihedral and faceted (rectilinear and convex) platforms represent 41.6% of the total, whereas 40% are plain platforms (Table 6). In sublevel VI-B Upper, Levallois flakes present between three and five previous scars (Supplementary information 11).

*Bipolar Operational Schemes*

In terms of cores and flakes, bipolar methods are the third most common type for this assemblage.

In sublevel VI-B Middle, five bipolar cores and 14 bipolar flakes have been recorded (Fig. 5 [1–5]). Only a few raw materials are used in bipolar schemes: quartz (75%), hyaline quartz (18.75%), and fine-grained quartzite (6.25%) (Table 7). The fact that only three raw materials were used for the knapping of this kind of scheme tells us that economic organization was in place. From a total of 10 raw materials identified, only three are used in this case. The availability of raw materials has a great impact on the type of exploitation that takes place; therefore, in general, bipolar methods were used in the knapping of small pebbles of fine-grained raw materials.

On the other hand, 81.25% of the pieces do not present cortex, as opposed to the 18.75% that do (Supplementary information 12). The five bipolar cores documented are made of quartz and are on average 34×24×15 mm. One core was made on plaquettes

**Table 6** Platform type in Levallois material

| Platform type | Cortical | Dihedral | Filiform | Rectilinear faceted | Convex faceted | Plain | Punctiform | Indeterminate | Broken | Delete | No platform | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VI-B Middle | | | | | | | | | | | | |
| Levallois indeterminate flake | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 (3.85%) |
| Preferential Levallois flake | 0 | 0 | 0 | 1 | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 6 (23.1%) |
| Unipolar Levallois flake | 0 | 1 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 5 (19.2%) |
| Bipolar Levallois flake | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 (3.85%) |
| Centripetal Levallois flake | 0 | 3 | 0 | 1 | 3 | 5 | 0 | 0 | 1 | 0 | 0 | 13 (50%) |
| Total | 1 (3.84%) | 4 (15.38%) | 0 (0%) | 2 (7.7%) | 6 (23.1%) | 11 (42.3) | 0 (0%) | 0 (0%) | 1 (3.84%) | 0 (0%) | 1 (3.84%) | 26 (100%) |
| VI-B Upper | | | | | | | | | | | | |
| Débordant flake | 0 | 1 | 1 | 3 | 5 | 12 | | 0 | 5 | 0 | 1 | 28 (46.7%) |
| Levallois indeterminate flake | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 (3.3%) |
| Preferential Levallois flake | 0 | 0 | 0 | 1 | 0 | 5 | 0 | 0 | 1 | 0 | 0 | 7 (11.6%) |
| Unipolar Levallois flake | 0 | 0 | 0 | 0 | 3 | 3 | 0 | 0 | 2 | 0 | 0 | 8 (13.3%) |
| Bipolar Levallois flake | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 (1.7%) |
| Centripetal Levallois flake | 0 | 2 | 0 | 3 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 12 (20%) |
| Levallois point | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 (1.7%) |
| Levallois blade | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 (1.7%) |
| Total | 0 (0%) | 3 (5%) | 1 (1.7%) | 8 (13.3%) | 14 (23.3%) | 24 (40%) | 0 (0%) | 0 (0%) | 9 (15%) | 0 (0%) | 1 (1.7%) | 60 (100%) |

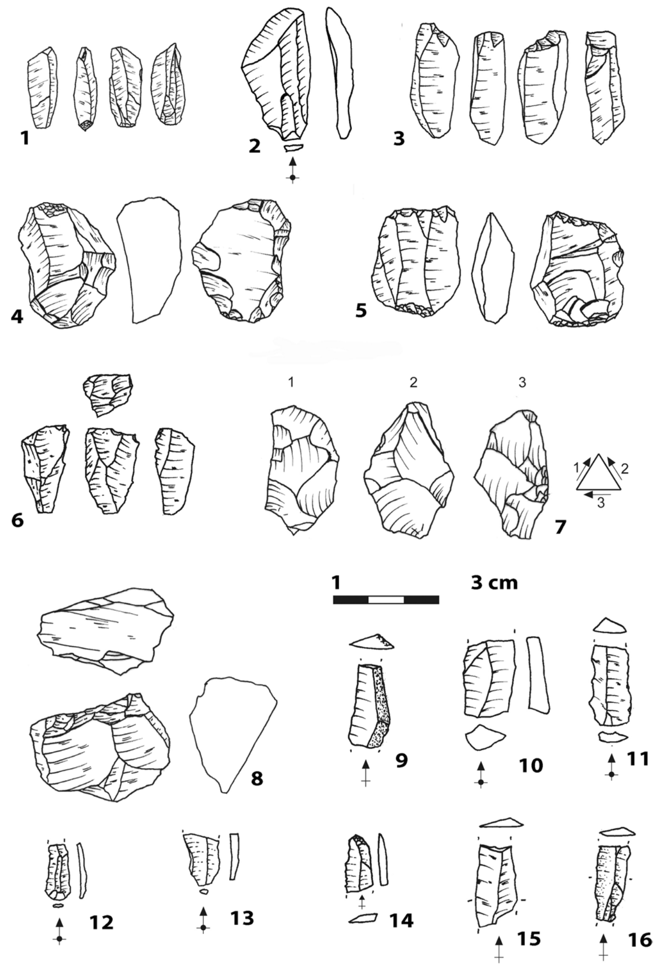


**Fig. 5** Sublevel VI-B Middle (**1**–**5**) and VI-B Upper (**6**–**16**). **1**, **2** Bipolar flake. **3**–**6** Bipolar cores. **7** Trifacial core. **8** Single platform core. **9**–**16** Bladelets. Raw material: Hyaline quartz (**1**, **11**, **12**); chert (**2**, **7**, **9**, **10**); quartz (**3**–**6**, **8**, **15**, **16**); quartzite (**13**, **14**)

and another on flake, whereas it was not possible to identify the blank of the three remaining cores. Three of the five cores show less than 1/3 of the cortex to their surface, whereas the other two have no cortical. No previous preparation of the striking surfaces has been noted. The number of removals varies between four, five, and six. It is worth noting that one of the cores is rotated bipolar (sensu de la Peña & Wadley, 2014), that is to say, it has exploitation scars in five of its six sides. The reason behind the abandonment of four of the five pieces was depletion, whereas the reason for the latter is unknown.

Based on the size of the cores and the surfaces exploited, we can conclude that these were knapped intensely. It is worth noting that these schemes have been suggested as optimal in the knapping of this type of raw materials, which present many internal fissures (Díez-Martín et al., 2011), as is the case here.

The number of flakes for this method is 16 (3.79% of the total blanks). These flakes have punctiform (31.25%) or plain platforms (25%) or, otherwise, they do not have a platform (18.75%) (Table 8). The flakes in this sublevel have between two and five previous scars (Supplementary information 13) and 71.4% of these scars are unidirectional, whereas 21.4% are bidirectional.

In sublevel VI-B Upper, there are three cores and seven flakes, which represent 0.58% of total blanks. Here, the number of raw materials narrows down to two: quartz (84.62%) and chert (15.38%) (Table 7).

In bipolar pieces, 61.54% do not present cortex as opposed to the 38.46% that do (Supplementary information 12). Most of the flakes do not have a platform (53.84%) because they are either broken or omitted (Table 8). Bipolar flakes have between one and seven previous bidirectional scars.

**Table 7** Bipolar flakes and cores by raw material

| | Fine-grained quartzite | Coarse-grained quartzite | Quartz | Chert | Obsidian | Jasper | Sandstone | Hyaline quartz | Phonolite | Basalt | Indet | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VI-B Middle | | | | | | | | | | | | |
| Bipolar flake | 1 | 0 | 10 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 13 (81.25%) |
| Bipolar flake with cortex | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 3 (18.75%) |
| Total | 1 (6.25%) | 0 (0%) | 12 (75%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 3 (18.75%) | 0 (0%) | 0 (0%) | 0 (0%) | 16 (100%) |
| Core | | | | | | | | | | | | |
| Bipolar | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| Total | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| VI-B Upper | | | | | | | | | | | | |
| Bipolar flake | 0 | 0 | 9 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 (76.92%) |
| Bipolar flake with cortex | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 (23.08%) |
| Total | 0 (0%) | 0 (0%) | 11 (84.62%) | 2 (15.38%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 13 (100%) |
| Core | | | | | | | | | | | | |
| Bipolar | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| Total | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |

**Table 8** Platform type in bipolar material

| Platform type | Cortical | Dihedral | Filiform | Rectilinear faceted | Convex faceted | Plain | Punctiform | Indeterminate | Broken | Delete | No platform | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VI-B Middle | | | | | | | | | | | | |
| Bipolar flake | 1 | 1 | 0 | 0 | 0 | 4 | 5 | 2 | 0 | 0 | 3 | 16 |
| Total | 1 (6.25%) | 1 (6.25%) | 0 (0%) | 0 (0%) | 0 (0%) | 4 (25%) | 5 (31.25%) | 2 (12.5%) | 0 (0%) | 0 (0%) | 3 (18.75%) | 16 (100%) |
| VI-B Upper | | | | | | | | | | | | |
| Bipolar flake | 0 | 0 | 0 | 1 | 0 | 5 | 0 | 0 | 3 | 1 | 3 | 13 |
| Total | 0 (0%) | 0 (0%) | 0 (0%) | 1 (7.69%) | 0 (0%) | 5 (38.46%) | 0 (0%) | 0 (0%) | 3 (23.08%) | 1 (7.69%) | 3 (23.08%) | 13 (100%) |

**Table 9** Centripetal cores

| Centripetal cores | Quartz | Total |
|---|---|---|
| VI-B Middle | 1 | 1 |
| VI-B Upper | 7 | 7 |
| Total | 8 | 8 |

The three cores from this sublevel are made of quartz pebbles and their average dimension is smaller than that in sublevel VI-B Middle (24 × 16 × 13 mm). Two of the cores do not have a cortex, whereas one presents it marginally. They do not have prior preparation on the striking surface. The cores have three, four, and eight previous scars. One of the cores has unidirectional removals (Fig. 5 [6]), whereas the other two present bidirectional knapping. It is worth highlighting that the scars from one of the cores are bidirectional bladelets. Lastly, the reason for the abandonment of the three was core depletion.

### *Centripetal Operational Schemes*

Centripetal schemes are one of the least abundant in the assemblage and are only identified from cores, given that flakes can be confused with other methods.

In sublevel VI-B Middle, one quartz core-on-flake has been documented (Table 9). This core presents 50–75% of the cortex. The core is centripetal but shows little organization and with no prior preparation of the surfaces. It has four scars on its exploitation surface, with the last removal measuring 34 mm × 35 mm. Lastly, the reason for its abandonment was the depletion of the angular links between the striking and exploitation surfaces.

On the other hand, in sublevel VI-B Upper seven cores have been documented, all on quartz, two on pebble, whereas it was not possible to identify the rest of the supports (Table 9). Only one core presents cortex and it is present mostly on the striking surface. None of the cores show prior preparation of the platforms. The cores have between three and six scars. The reasons why they were abandoned are varied: incorrect angular links, depletion of the blank, or fractures.

**Table 10** Other operational schemes by raw material

| Flake type/raw material | Fine-grained quartzite | Coarse-grained quartzite | Quartz | Chert | Obsidian | Jasper | Sandstone | Hyaline quartz | Phonolite | Basalt | Indet | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VI-B Middle | | | | | | | | | | | | |
| Single unipolar flake | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 (100%) |
| Total | 0 (0%) | 0 (0%) | 1 (50%) | 1 (50%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 2 (100%) |
| Cores | | | | | | | | | | | | |
| Oportunistic | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 (100%) |
| Total | 0 (0%) | 0 (0%) | 0 (0%) | 1 (100%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 1 (100%) |
| VI-B Upper | | | | | | | | | | | | |
| Single unipolar flake | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 5 (100%) |
| Total | 0 (0%) | 0 (0%) | 4 (80%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 1 (20%) | 0 (0%) | 0 (0%) | 0 (0%) | 5 (100%) |
| Cores | | | | | | | | | | | | |
| Unipolar | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 (13.31%) |
| Trifacial | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 (6.67%) |
| Polyhedral | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 (6.67%) |
| Oportunistic | 1 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 (73.35%) |
| Total | 1 (6.67%) | 0 (0%) | 13 (86.66%) | 1 (6.67%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 15 (100%) |

*Other Operational Schemes*

There is a variety of additional operational schemes present in both levels (Table 10).

In sublevel VI-B Middle, single unipolar platform knapping is only represented by two flakes made of quartz and chert (Table 10). On its part, in sublevel VI-B Upper, we find two unipolar cores produced on quartz, and five single platform flakes, four on quartz and one on hyaline quartz (Table 10) (Fig. 5 [8]). Several bladelets have also been documented, and these may have been obtained using single platform methods, but also from prismatic cores, the latter absent in the assemblage (Fig. 5 [9–16]).

Opportunistic cores are very rare. In VI-B Middle they are represented only by one core on chert (Table 10). They are slightly more abundant in VI-B Upper ($n=11$), where 10 were knapped on quartz and one on fine-grained quartzite.

Lastly, a trifacial core on chert (Fig. 5 [7]) and a polyhedral one on quartz have been identified in VI-B Upper (Table 10). It has not been possible to identify flakes linked to these schemes given that they tend to be ordinary flakes, not easily distinguishable.

Typological Analysis

From a typological point of view, 40 retouched pieces have been documented in sublevel VI-B Middle (Table 11), seven of which are from drawings in M. Mehlman's PhD dissertation (Mehlman, 1989:187–191). These represent 8.87% of the total number of pieces in this sublevel. The most used raw materials are quartz (42.5%), followed by fine-grained quartzite (35%), hyaline quartz (10%), chert (10%), and obsidian (2.5%) (Table 12). 69.7% of retouched pieces were made on flakes using indeterminate methods; 21.2% on discoid flakes; and 9.1% on Levallois flakes (Table 13). Most of the retouched pieces are simple sidescrapers (20%), denticulates (17.5%), notches (17.5%), retouched flakes (12.5%), and bifacial pieces (10%). The percentage represented by pieces such as the ecailléé, points, endscrapers, truncated pieces, and various other pieces is below 5% (Table 13; Fig. 6 [1–7, 16]).

Sublevel VI-B Upper has 125 retouched pieces (Table 11; Fig. 6 [8–15]), which represents 4.42% of the total assemblage. Quartz is here also the most used raw material (81.6%). The rest of the raw

**Table 11** Retouched pieces. The numbers in parentheses are the number of pieces drawn in Mehlman's (1989) thesis that are only included in the total counts

| Tool/level | VI-B Middle (1977/1981) This study | VI-B Upper (1977/1981) This study | VI-B (1938) (Mehlman., 1989) |
|---|---|---|---|
| Denticulate | 7 (17.5%) | 44 (35.2%) | 0 (0%) |
| Ecaillée | 1 (1) (5%) | 1 (0.8%) | 0 (0%) |
| Retouched flake | 5 (12.5%) | 8 (6.4%) | 0 (0%) |
| Retouched blade | 0 (0%) | 1 (0.8%) | 0 (0%) |
| Notch | 7 (17.5%) | 24 (19.2%) | 0 (0%) |
| Point | (2) (5%) | 2 (1.6%) | 4 (3.25%) |
| Sidescraper | 7 (1) (20%) | 27 (21.6%) | 47 (38.21%) |
| Endscraper | 1 (1) (5%) | 1 (0.8%) | 0 (0%) |
| Burin | 0 (0%) | 1 (0.8%) | 0 (0%) |
| Heavy-duty | 0 (0%) | 3 (2.4%) | 13 (10.57%) |
| Bifacial piece | 3 (1) (10%) | 5 (4%) | 24 (19.51%) |
| Divers | (2.5%) | 5 (4%) | 29 (23.58%) |
| Truncature | 0 (0%) | 2 (1.6%) | 0 (0%) |
| Perforator/Bec | 2 (5%) | 1 (0.8%) | 6 (4.88%) |
| Total | 40 (100%) | 125 (100%) | 123 (100%) |

materials, such as hyaline quartz, chert, fine-grained quartzite, and phonolite show values below 10% (Table 12). In terms of the débitage method, 61.6% of the retouched pieces are produced on indeterminate flakes; 26.4% on discoid flakes; 9.6% on Levallois flakes, and 2.4% on bipolar flakes (Table 13). In this sublevel, denticulates are the most abundant tool type (32.5%), followed by sidescrapers (simple and double, 21.6%) and notches (19.2%, in one case, it appears a piece with hafting notches). The rest of the tools, such as retouched flakes, bifacial pieces, the diverse, heavy-duty pieces, points, truncated pieces, the ecaillée, retouched blades, endscrapers, burins, and borers are only found in very small numbers (Table 11).

As can be seen in Table 11, in level VI-B from Kohl Larsen's collection, M. Mehlman identified 123 retouched pieces. It is worth noting that this assemblage was not divided into three sub-levels so the number of retouched pieces in the 1938 collection is smaller ($n=123$) than that of the 1977–1981 collection ($n=40$ and $n=125$). There is also greater piece variability in the 1977–1981 collection. The absence and presence of different piece types are remarkable in both collections. For example, the small presence

**Table 12** Retouched pieces by raw material

| Type/raw material | Fine-grained quartzite | Coarse-grained quartzite | Quartz | Chert | Obsidian | Jasper | Sandstone | Hyaline quartz | Phonolite | Basalt | Indet | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VI-B Middle | | | | | | | | | | | | |
| Denticulate | 2 | 0 | 4 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 7 (17.5%) |
| Ecaillée | 0 | 0 | 1 (1) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 (5%) |
| Retouched flake | 1 | 0 | 2 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 5 (12.5%) |
| Retouched blade | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 (0%) |
| Notch | 3 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 (17.5%) |
| Point | (2) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 (5%) |
| Sidescraper | 1 (1) | 0 | 3 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 8 (20%) |
| Endscraper | (1) | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 (5%) |
| Burin | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 (0%) |
| Heavy-duty | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 (0%) |
| Bifacial piece | 2 (1) | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 4 (10%) |
| Divers | 0 | 0 | 0 | 0 | (1) | 0 | 0 | 0 | 0 | 0 | 0 | 1 (2.5%) |
| Truncature | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 (5%) |
| Perforator | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 (0%) |
| Total | 14(35%) | 0 (0%) | 17 (42.5%) | 4 (10%) | 1 (2.5%) | 0 (0%) | 0 (0%) | 4 (10%) | 0 (0%) | 0 (0%) | 0 (0%) | 40 (100%) |
| VI-B Upper | | | | | | | | | | | | |
| Denticulate | 3 | 0 | 37 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 44 (35.2%) |
| Ecaillée | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 (0.8%) |
| Retouched flake | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 8 (6.4%) |
| Retouched blade | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 (0.8%) |
| Notch | 2 | 0 | 21 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24 (19.2%) |
| Point | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 (1.6%) |
| Sidescraper | 0 | 0 | 22 | 2 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 27 (21.6%) |
| Endscraper | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 (0.8%) |
| Burin | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 (0.8%) |
| Heavy-duty | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 (2.4%) |
| Bifacial piece | 0 | 0 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 (4%) |
| Divers | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 5 (4%) |
| Truncature | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 (1.6%) |
| Perforator | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 (0.8%) |

**Table 12** (continued)

| Type/raw material | Fine-grained quartzite | Coarse-grained quartzite | Quartz | Chert | Obsidian | Jasper | Sandstone | Hyaline quartz | Phonolite | Basalt | Indet | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 5 (4%) | 0 (0%) | 102 (81.6%) | 6 (4.8%) | 0 (0%) | 0 (0%) | 0 (0%) | 11 (8.8%) | 1 (0.8%) | 0 (0%) | 0 (0%) | 125 (100%) |

of heavy-duty tools in the 1977–1981 collection ($n=3$) as opposed to the large number in the 1938 assemblage ($n=13$). Or the small number of bifacial pieces in the 1977–1981 collection ($n=4$ and $n=5$), whereas in the 1938 collection, there is a large number ($n=24$). These differences may be due to the assemblages being studied using different methodologies, the differences in piece numbers in both assemblages, pieces going missing, the selection of diagnostic pieces, etc.

## Discussion

There is no doubt that the Mumba rockshelter has been a recurrent place for the inhabitants of Lake Eyasi since the MSA. In this paper, we have here presented the technological analysis from the beginning of its occupation, level VI-B, termed as the Sanzako industry (Mehlman, 1989).

This industry was known from the assemblage recovered during Kohl-Larsen's excavations in 1934 and 1938, published by Mehlman (1989). However, it is important to note that working with these old collections poses certain challenges. The data pertaining to this industry have now been updated through the analysis of the previously unpublished assemblage from M. Mehlaman's excavations.

The raw materials utilized in both sublevel VI-B Middle and VI-B Upper were predominantly sourced locally, with a particular emphasis on quartz (Bushozi et al., 2020; Mehlman, 1989). The only exogenous material present is obsidian which, although very scarce ($n=3$ between both levels), plays an important role given that it originates in the basin of Lake Naivasha (Kenya), around 320 km north of Mumba (Mehlman, 1989). Recently, it has been suggested that its origin might be in Monduli, around 110 km east of Mumba, although this remains to be confirmed (Bushozi et al., 2020). This fact opens up an interesting debate on the territories and intergroup networking of MSA groups in north Tanzania and south Kenya (Merrick & Brown, 1984; Merrick et al., 1994), given that at Nasera Rockshelter, located between Mumba and Naivasha, obsidian from this latter locality was also found. It raises the possibility that practices like the *hxaro* or *nexure*, which are currently observed among groups like the ¡ko or the ¡kung (Heinz, 1972; Wiessner, 2002), may have also

**Table 13** Retouched material by knapping method

| Retouched piece/method | Discoid | Levallois | Bipolar | Others | Total |
|---|---|---|---|---|---|
| VI-B Middle | | | | | |
| Denticulate | 2 | 0 | 0 | 5 | 7 (21.2%) |
| Ecaillée | 0 | 0 | 0 | 1 | 1 (3%) |
| Retouched flake | 1 | 1 | 0 | 3 | 5 (15.2%) |
| Retouched blade | 0 | 0 | 0 | 0 | 0 (0%) |
| Notch | 0 | 1 | 0 | 6 | 7 (21.2%) |
| Point | 0 | 0 | 0 | 0 | 0 (0%) |
| Sidescraper | 2 | 1 | 0 | 4 | 7 (21.2%) |
| Endscraper | 0 | 0 | 0 | 1 | 1 (3%) |
| Burin | 0 | 0 | 0 | 0 | 0 (0%) |
| Heavy-duty | 0 | 0 | 0 | 0 | 0 (0%) |
| Bifacial piece | 0 | 0 | 0 | 3 | 3 (9.1%) |
| Divers | 0 | 0 | 0 | 0 | 0 (0%) |
| Truncature | 0 | 0 | 0 | 0 | 0 (0%) |
| Perforator | 2 | 0 | 0 | 0 | 2 (6.1) |
| Total | 7 (21.2%) | 3 (9.1%) | 0 (0%) | 23 (69.7%) | 33 (100%) |
| VI-B Upper | | | | | |
| Denticulate | 16 | 3 | 1 | 24 | 44 (35.2%) |
| Ecaillée | 0 | 0 | 1 | 0 | 1 (0.8%) |
| Retouched flake | 2 | 0 | 0 | 6 | 8 (6.4%) |
| Retouched blade | 0 | 0 | 0 | 1 | 1 (0.8%) |
| Notch | 4 | 5 | 0 | 15 | 24 (19.2%) |
| Point | 0 | 0 | 0 | 2 | 2 (1.6%) |
| Sidescraper | 7 | 2 | 1 | 17 | 27 (21.6%) |
| Endscraper | 0 | 1 | 0 | 0 | 1 (0.8%) |
| Burin | 0 | 0 | 0 | 1 | 1 (0.8%) |
| Heavy-duty | 1 | 1 | 0 | 1 | 3 (2.4%) |
| Bifacial piece | 0 | 0 | 0 | 5 | 5 (4%) |
| Divers | 2 | 0 | 0 | 3 | 5 (4%) |
| Truncature | 0 | 0 | 0 | 2 | 2 (1.6%) |
| Perforator | 1 | 0 | 0 | 0 | 1 (0.8%) |
| Total | 33 (26.4%) | 12 (9.6%) | 3 (2.4%) | 77 (61.6%) | 125 (100%) |

taken place during that time, or we may even consider the possibility of the existence of ethnolinguistic unit groups in the region (Tryon, 2019). If this is the case, this common territory would not only run N-S (Naivasha-Nasera rockshelter–Mumba rockshelter) but also E-W given the presence of Naivasha obsidian at Lake Nyanza during the Late Pleistocene (Faith et al., 2015) or Kilombe obsidian at sites with similar dates to Mumba (Hoare et al., 2020).

The most often employed débitage methods are the discoid type, both the unifacial and bifacial methods (Supplementary Information 14). In sublevel VI-B Middle, 17% of the knapping products are carried out using discoid methods, whereas in sublevel VI-B Upper, the percentage for this method increases to 19.4%. The Levallois methods are the second most used in both sublevels: in sublevel VI-B Middle, they represent 6.9% of the total, whereas in sublevel VI-B Upper, this percentage decreases to 5.2%. Lastly, bipolar methods are, percentage-wise, greater in sublevel VI-B Middle, with a 4.9% ($n=19$) of bipolar pieces, whereas in sublevel VI-B Upper the percentage of bipolar debitage pieces decreases to 1.4% ($n=17$). This technological scenario aligns with the description provided by Mehlman (1989) and distances itself from that put forward by Conard and

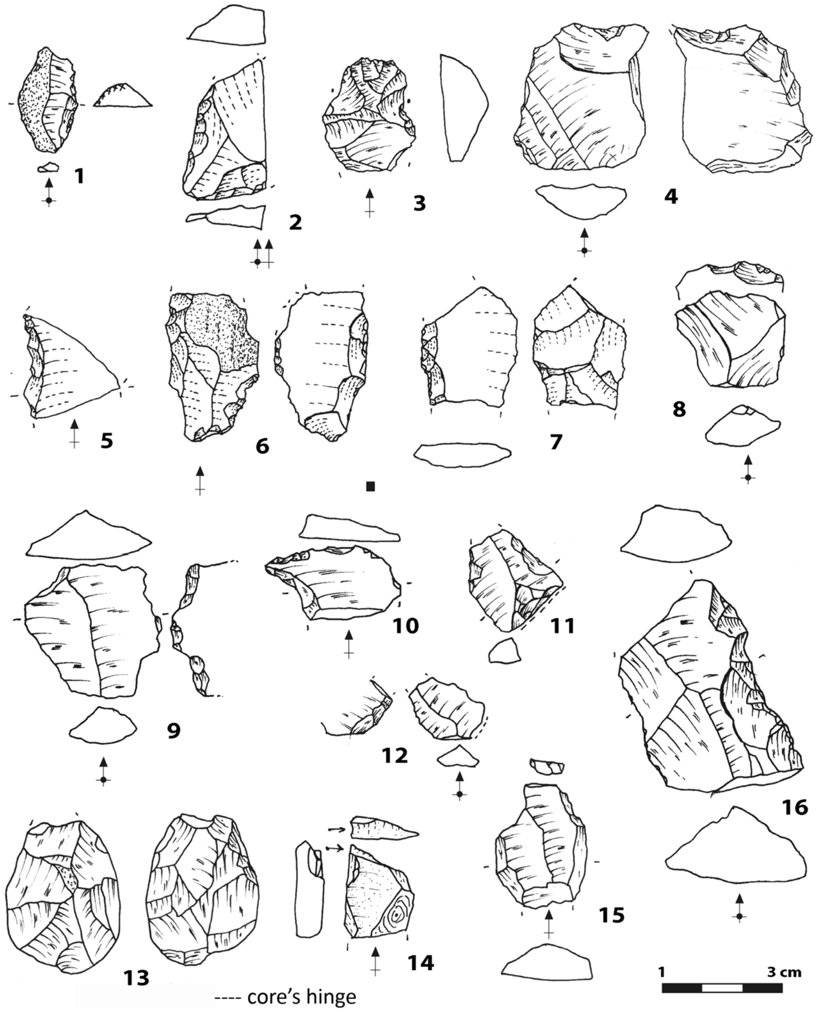


**Fig. 6** Sublevel VI-B Middle (**1**–**7**) and VI-B Upper (**8**–**15**). **1**, **2**, **12**, **16** Single sidescrapers. **3** Carinated endscraper with two notches. **4**, **10** Borers. **5**, **8**, **9** Denticulates. **6**, **7**, **15** Bifacial piece fragments. **11** Notch. **13** Bifacial point. **14** Burin. Raw material: Hyaline quartz (**1**); quartzite (**2**, **5**–**7**); quartz (**3**, **4**, **8**–**12**, **13**, **16**); phonolite (**14**). Technological blanks: Ordinary flakes (**1**–**7**, **14**, **15**); centripetal flakes (**8**–**10**, **16**); pseudo-Levallois point (**11**, **12**); indeterminate (**13**)

Marks, who note a high percentage of Levallois methods in Kohl-Larsen's collection (Marks & Conard, 2008).

Retouched blanks are scarce, 7.3% in sublevel VI-B Middle, and 4.64% in sublevel VI-B Upper. These percentages are lower than the 13.8% recorded by Mehlman in Kohl-Larsen's assemblage (Mehlman, 1989). Both cases reinforce the hypothesis of the small percentage of retouched pieces in the MSA assemblages of East Africa (Tryon & Faith, 2013). This could be attributed to the use of unretouched edges, as suggested for other MSA sites (de la Peña & Wadley, 2017; Scerri et al., 2021; Will & Conard, 2020).

Traditionally, the characteristics of the Sanzako industry have been a high percentage of heavy-duty pieces, bifacial pieces, and a small percentage of points (Mehlman, 1989: 183). From our study, in both sublevels, the most common types of retouched blanks are sidescrapers, notches, denticulates, and bifacial pieces. However, heavy-duty pieces are not very numerous in this assemblage, nor are points, the latter already noted in Kohl-Larsen's collection (Mehlman, 1989). These conclusions have been reached from the analysis of the collection found at the Olduvai Gorge Museum and the published illustration by M. Mehlman. However, it is uncertain whether this represents the total number of retouched pieces because the number transported to the USA for analysis remains unknown.

The Sanzako industry represents one of the oldest MSA industries in northern Tanzania. It should be compared to other industries such as the Njarasan in Lake Eyasi itself, the Ngaloban in Laetoli, and to a lesser extent, with the Ndutu Bed from Olduvai Gorge. It should also be compared to later industries like the Kisele or Loiyangalanian.

The Njarasan industry is known from the surface materials collected by Kohl-Larsen, Mehlman (1989), and Domínguez-Rodrigo and colleagues (2007) from the Middle Beds at Lake Eyasi, and it is linked to remains of archaic Modern Humans (Braüer & Mabulla, 1996bulla 1996; Domínguez-Rodrigo et al., 2008; Mehlman, 1984). Lava is the most common raw material used, and the industry is characterized by the presence of sidescrapers, heavy-duty pieces (mostly nonexistent in Mehlman's collection), and a lithic technology based on discoid methods. It took place around 200 ka BP (Mehlman, 1989). This industry, which has been described as facies of the Sangoan, is different from the Sanzako in that it uses different raw materials, it shows less diversity in the types of sidescrapers, the scarcity of Levallois methods, and the presence of heavy-duty pieces (Mehlman, 1989: 548).

On its part, the Ngaloban industry, found from the upper Ngaloba Beds at Laetoli, is documented by two assemblages found during survey works (Mabulla, 2015; Masao & Kimambo, 2022). The upper Ngaloba Beds dated between 240 and 100 ka BP (Manega, 1993) is associated with LH18, considered to be an early Modern Human (Day et al., 1980; Magori & Day, 1983). The industry employs discoid methods and typologically, is characterized by the presence of scrapers, heavy-duty pieces, unifacial and bifacial points, and a small number of core axes. These distinguishing characteristics distance it completely from the industry in sublevels VI-B at Mumba.

The studies of the MSA at Olduvai Gorge have linked its occurrence to older stages of the MSA, in particular those linked to the Ngaloban industry (Eren et al., 2014b; Leakey et al., 1972). However, it is important to note that these materials, despite their "ancient" in appearance, cannot be directly compared for several reasons. Firstly, the inability to accurately determine the stratigraphic location of the sites studied by M. Leakey, and the fact that the lithic assemblage comprised materials from two different sites, but was presented as one assemblage (Leakey et al., 1972). Secondly, given our current state of knowledge, it is not possible to definitely confirm such ancient occupations at Olduvai Gorge.

The industry placed stratigraphically above Sanzako at Mumba rockshelter is the Kisele. It is the most abundant MSA industry in the region and the one with the greatest time span (108–50 ka BP). Its lithic technology is based on discoid and Levallois methods, as well as the presence of unifacial and bifacial points, sidescrapers (Mehlman, 1989), and dorsal pieces (Bushozi et al., 2020). Although, from a technological point of view, it might be linked to Sanzako, the constant presence of points and dorsal pieces distances the Kisele industry from the Sanzako.

Lastly, Loiyangalani is an open-air site in the Serengeti dated to 64 ka BP. It uses discoid and bipolar methods, with sidescrapers and denticulates representing the most common tool types (Bower et al., 2012; Maíllo-Fernández et al., 2019a). Its techno-typological characteristics are very different to those described here for the Sanzako industry.

Therefore, we can consider Mumba VI-B's Sanzako industry as independent from the rest of industries or known sites in northern Tanzania, both from a chronological and from a techno-typological point of view. However, we must bear in mind that the oldest regional industries (Ngaloba and Eyasi) are mostly found in surface assemblages, and therefore, only limited conclusions can be drawn from them.

Widening the geographical scope, Mumba VI is found within the final stages of the Early MSA, where the lithic assemblages are less abundant and with limited chronological control (Sahle, 2020). However, some of them are of great significance. Thus, there are some assemblages from the beginning of the MSA, such as Gademotta or Olorgesailie, which present Levallois methods and numerous points (Deino et al., 2018; Sahle et al., 2014). Others show a combination of MSA characteristics with some abundance of Large Cutting Tools (LCTs), such as the Kapthurin Formation or the Upper Herto Member (Tryon, 2003; White et al., 2003), whereas other assemblages, like Koimilot or Omo Kibish, present great variability in the discoid and Levallois methods and no LCTs (Shea, 2008; Tryon, 2003; Tryon et al., 2006). We therefore observe a mosaic in the techno-typological composition of the EMSA assemblages, and later in the Late MSA, as discussed on numerous occasions (for example, Clark, 1988; Scerri & Will, 2023; Tryon & Faith, 2013; Will et al., 2019). The assemblage of Mumba VI needs to be placed within this context. In its assemblage, there are no points, the most common *débitage* methods are the discoid, and LCTs are residual.

Modern Behaviour has been identified in the MSA archaeological record through the use of necklace beads, the systematic use of pigment or decorated ostrich eggshells (McBrearty & Brooks, 2000; Scerri & Will, 2023, among others) or through the systematic use of hafting (Barham, 2013). This evidence pushes aside the Eastern Africa Early MSA, especially all the MSA from northern Tanzania, from modern debates on social complexity or the flexibility of ecological responses. Perhaps, these must be looked at from other angles of the MSA prism, such as the use of distant raw materials at Mumba and the social implications that this entails, at least, in modern hunter-gatherer populations (Wiessner, 2002).

With all this, Mumba is one more site in the melting-pot of regional Early MSA assemblages where techno-typological variability may reflect the sociocultural and economic changes that the MSA entailed. These changes may become blurred due to the small number of sites with sufficient resolution; in northern Tanzania, only Mumba has a stratigraphy and defined dates, which is not the case in other superficial assemblages.

This variability has been discussed from ecological and social points of view (see Scerri & Will, 2023 and references therein), but other factors such as the economy of raw materials (sensu Pèrles, 1992) have not been fully considered. It is here where we must add the availability of quality raw materials as distorting elements to this variability, given that Mumba VIB shows a predominance of quartz. A type of quartz that provides very sharp edges, but not a very elaborate débitage given the internal cracking of the nodules (Díez-Martín et al., 2011).

## Conclusion

The lithic assemblage recovered from sublevels VI-B Middle and Upper appears to be the result of *Homo sapiens* group settlements at Lake Eyasi during the first part of MIS5 (131.7–109.5 ka BP; Bräuer & Mehlman, 1988; Mehlman, 1989). The industry in both sublevels, termed Sanzako, comprises discoid, Levallois, and bipolar knapping methods, as well as the presence of tools such as sidescrapers, denticulates, and notches. It is worth noting the small presence of Levallois methods and the absence of points in both assemblages (VI-B Middle and VI-B Upper).

The raw material management is very similar to the patterns observed in the upper levels of the rockshelter (VI-A and V), indicating that raw material procurement took place in a consistent manner across time. It focused on local raw materials, with just a small percentage (obsidian), indicating evidence of long-distance contacts.

The techno-typological variability in the MSA industries of northern Tanzania is still being seen. The relationship between this variability and the postulated regionalization process suggested by the MSA in East Africa (Clark, 1988; Mirazón-Lahr & Foley, 2016) remains unknown, as does its potential association with environmental or economic factors.

The Sanzako industry, like the Ngaloban and Njarasan industries, resembles the industries found in eastern Africa during MI6 and MI5. These industries are characterized by a scarcity of assemblages and a general lack of non-lithic cultural material (Tryon & Faith, 2013; Will et al., 2019).

Based on all the results obtained thus far, we should continue to consider the Sanzako as an industry characteristic of the Early MSA in northern Tanzania for the period 131.7–109.5 ka BP.

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### Declarations

**Conflict of Interest** The authors declare no competing interests.

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