10. Obsidian exploitation and utilization during the Oldowan at Melka Kunture (Ethiopia)

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Abstract

The Oldowan assemblages of Melka Kunture represent the earliest known example of obsidian utilization. The proximity of primary and secondary sources of Balchit obsidian, a high quality raw material easily available in large quantities, is a unique situation among East African Oldowan sites. Obsidian represents a large component of the lithic assemblages at Melka Kunture, not only during the Oldowan but during the Acheulian times as well. Other volcanic rocks are incorporated into the technological system at Melka Kunture such as basalts, ignimbrites, trachytes and trachybasalts, which present completely different characteristics for knapping.

10.1 Introduction

With a few exceptions, the exploitation of obsidian at Melka Kunture can be considered as a leitmotiv for more than 1.7 million years, because it represents the first utilization of this material during the Oldowan. Sites of various entities, including Oldowan sites (Karre I, Gombore I, Garba IV, Gombore Iγ), Acheulian and the Middle Stone Age sites (Garba XIIJ, Simbiro III, Gombore II, Garba III), with ages ranging between 1.7 and 0.2 Ma, show that obsidian was an important component of the lithic assemblages (Figure.10.1a). During the Late Stone Age and in recent times obsidian became the dominant raw material (Chavaillon et al. 1979; Chavaillon and Berthelet 2004; Chavaillon and Piperno 2004).

The obsidian-dominated Oldowan assemblages of Melka Kunture represent the earliest known example of systematic utilization of this raw material. At Balchit, 7 km North of Melka Kunture on the western border of the Main Ethiopian Rift, the primary source of obsidian is a dome-flow which belongs to the Pliocene rift margin silicic centres of the Wachacha Formation. However, Quaternary alluvial deposits constitute rich and numerous secondary sources in the area (Poupeau et al. 2004).

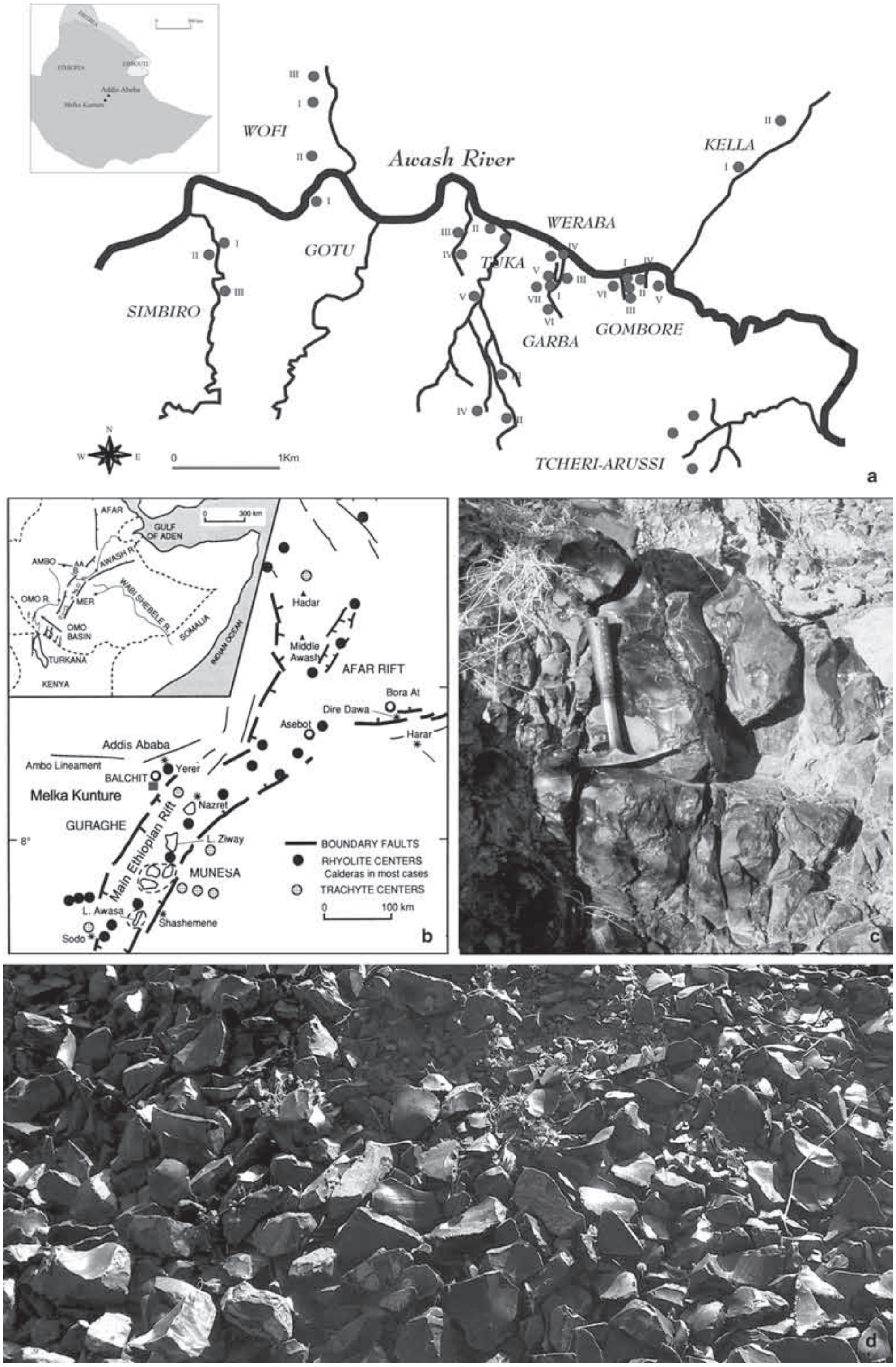

FIGURE 10.1. a: location of the Melka Kunture sites; b: location of the Balchit obsidian outcrops (general setting after Woldegabriel et al. 1992); c: unweathered massive obsidian; d: view of obsidian debris at Balchit locality.

East Africa is one of the few geographic areas with abundant obsidian sources. Apart from the Ethiopian evidence, most of the sources are located in Kenya, close to the Lake Naivasha Basin and Mount Eburru. Potential, but apparently relatively minor sources of volcanic glass are present in the northern portions of Kenya, East of Lake Turkana and in the southern end of the Suguta Valley (Watkins 1981). The southern Kenyan Rift zone and northern Tanzania near Mount Kilimanjaro may also have been a significant source of obsidian (Merrick and Brown 1984).

The exploitation of obsidian is more or less continuous at Melka Kunture throughout the Acheulian. Otherwise it is known from only two other (Acheulian) sites — Kariandusi and Kilombe — around 0.7 Ma. However, even Kilombe only records a few pieces of worked obsidian, and at Kariandusi obsidian represents approximately 15% of the industry (Gowlett 1993; Gowlett and Crompton 1993). From the Middle Stone Age onwards, obsidian was frequently utilized in almost all East African sites (Merrick et al. 1994) and is generally dominant in Late Stone Age lithic assemblages in the region.

The physical properties of obsidian, in particular its mode of fracture, make it particularly suitable for the manufacture of many types of tools. In the case of Melka Kunture, the volcanic rocks utilized for knapping were different types of basalts, ignimbrites, trachytes and trachybasalts on one hand and obsidian on the other hand. These two groups of raw materials present completely different qualities for stone knapping. This unique situation raises a series of questions and could add important information to the current debate on the criteria that identify the Oldowan Industrial Complex (Texier 1995, 2005; de la Torre et al. 2003; Martínez-Moreno et al. 2003; de la Torre 2004; Delagne and Roche 2005; de la Torre and Mora 2005; Stout et al. 2005; Bishop et al. 2006).

10.2 Geological Background

The sites of Melka Kunture are located in a demi-graben depression that belongs to the Upper Awash Basin on the Ethiopian Plateau (Figure. 10.1b). The Basin surface area is around 3,000 km^2 and it is delimited by Pliocene volcanoes. The main volcanic centers are Wachacha and Furi in the North, Boti and Agoiabi in the South. Its eastern limit is marked by the main graben of the Ethiopian Rift belonging to the large East African Rift system (Mohr 1999). The Melka Kunture area is made up of valleys whose inner terraces resisted erosion. The visible thickness of these deposits is around 30 m, but the cumulative thickness of the various levels is about 100 m. A recent structural, tephrostratigraphic and lithostratigraphic approach provides new insights into the evolution of the environmental background for hominin activities in this area (Kieffer et al. 2002, 2004; Bardin et al. 2004; Raynal and Kieffer 2004).

Volcanism in the Melka Kunture region was characterized by multiple eruptions, correlated with the Mio-Plio-Pleistocene evolution of the Ethiopian Rift. Ancient episodes of this event are represented on the landscape as basaltic hills. With the exception of the products of the initial local eruptive manifestations, the secondary basaltic flows originated from volcanoes several tens of kilometres away from the site. The volcanoes were mostly explosive, as indicated by the differentiated nature of the magmas. Beginning about 4 or 5 Ma, these volcanoes underwent multiple eruptions. Some of the pyroclastic material arrived directly to localities that later became occupied by hominins. In particularly various ignimbrites, aerial ash and pumiceous fallouts from repeated phreato—magmatic eruptions fell on the sites. These types of eruptions have a high destructive strength. The periods of human occupation post-date these large eruptions that produced the wide sheets of welded ignimbrites. Nevertheless, very violent late eruptions have on several occasions completely erased any evidence of the presence of hominins along the course of the Upper Awash.

The valley of the Awash River has been a focus of hominin occupation since 4 to 5 Ma. The Awash regularly reestablished its course after each important volcanic episode and each time established a new basal level of erosion. The water flow of this river and its tributaries provided the sedimentary context of reworked volcanic materials that buried and preserved the archaeological sites within the Melka Kunture Formation. This sedimentation was a consequence of the reactivation of the border faults that provoked on several occasions the subsidence of the demi-graben. This process of burial was assisted by the input of pyroclastic materials during eruptions. The influx of sediment considerably increased the river's bed load. However, this cycle was largely controlled by the level of the Awash sill, at the exit of the Basin. This may have remained high for a long period of time, reducing the likelihood of local erosion. Its position upstream of the river gorges separated it until recently from the regressive erosion processes.

The alluvium of the right bank tributaries demonstrates an evolution in time related to the different geodynamic phases of the Melka Kunture fault and the associated volcanism. Those of the left bank recorded the different stages of dismantling of superficial formations covering the part of the valley between Melka Kunture and the Wachacha volcanic center.

10.3 The Volcanic Raw Materials

The lavas found near Melka Kunture are associated with the different volcanic episodes that occurred in the area over the last several million years. These lavas are abundant in the alluvial sediments of the Awash River and its tributaries in the vicinity of Melka Kunture. Moreover, the less fragile facies of the lavas cobbles are preserved in the different archaeological sites. We have identified (Kieffer et al. 2004): aphiric to porphyric basalts, microdoleritic basalts, trachybasalts, trachyandesites, trachytes, rhyolites including obsidian and various welded ignimbrites. We note here a magmatic bimodality, with melanocratic basalts on one hand and trachytes/rhyolites on the other. The intermediary facies seem less well represented, which is consistent with the regional magmatic phases (Woldegabriel et al. 1992; Chernet et al. 1998). The different volcanic rocks have been introduced into the sites as cobbles, fragments or blocks. Rare small-sized flint and opal fragments are known, which are suitable for small tool shaping. These most probably correspond to precipitations of amorphous silica from hydrothermal circulations directly linked to volcanism. Among these different raw materials the use of obsidian is a distinctive feature of the oldowan assemblages of Melka Kunture. The closest primary obsidian sources are known at Balchit, seven kilometres North of the site.

The obsidian dome-flow of Balchit is spotted by extended flaking areas where cores, flakes, blades and debris have been accumulated on several thousands of square metres since prehistoric times. The first studies of the Balchit area and of the obsidian Later Stone Age assemblages were conducted in 1973 and in 1976 (Chavaillon 1976; Hivernel 1976; Hivernel-Guerre 1976; Soulier 1976). Since 1999, special attention was paid to obsidian artifacts and their primary and secondary sources. Analyses were performed on several obsidian samples from various sites including the outcrops of Balchit and reworked debris or pebbles and cobbles from different alluvial formations of the Awash River and its tributaries (Poupeau et al. 2004; Raynal et al. 2005).

The massif of Balchit belongs to the Pliocene Rift margin silicic centres of the Wachacha Formation, located on the western border of the Main Ethiopian Rift, in the Addis Ababa Rift Embayment (Figure. 10.1b). Recently, the age of the massif has been established at 4.37±0.07 Ma by K-Ar measurements (Chernet et al. 1998). It is a flat dome-flow, outcropping over an area of about four square kilometres with a wide variety of eruptive facies. The formation is better exposed at the North-Northeast limit of the outcrop, in a gully a few metres deep. A well developed fluidal structure, almost vertical, could possibly indicate an extrusive flow or represent ramp structures in a flow. Perlites and greyish to white lithophysae are abundant in a sometimes perlitised finely banded lava; the lithophysae are either spherulithic growths of Feldspar or devitrified glass in which the original banding of the lava is still visible.

Amygdales up to 1 meter long of pure and massive obsidian are scattered among the lava dome-flow and preserved among the weathered rock (Figure. 10.1c). The obsidian colour is dominantly black but locally blue, green, red and beige colours have been observed. It corresponds to an obsidian *sensu stricto*, and it is different from other volcanic glasses derived from quick cooling, such as the base of the nearby ignimbrites. The obsidian flow appears *in situ* only in peripheral banded and deformed facies found on the Jimjima Plateau and close to the village of Balchit. The entire structure could have been transformed by pumice formation and devitrification in a bright and fluidal lava, where subsisted amygdales veins and blocks of this obsidian. The unweathered lava that was selected for knapping is massive, uniformly black and very finely banded and breaks easily with conchoidal fracture, giving more or less translucent flakes with excellent cutting edges.

The obsidians from Melka Kunture are of calc-alkaline composition (Muir and Hivernel 1976). Four compositional types were recognized on the basis of concentrations derived from the ICP-MS analysis of 23 to 26 trace elements (Poupeau et al. 2004). Type A composition was isolated from two Balchit obsidians and six nearby samples from alluvial deposit of the Awash River. Three other samples from alluvial deposits have different compositions, labelled B, C and D. While the Type B composition differs from Type A group essentially by the content of rare earth elements (REE); Type C presents in general lower trace element content and Type D has a higher content of some trace elements, especially Y, Zr, Hf and the REE. More recently, Negash et al. (2006) analysed by XRF the composition of 10 Balchit obsidian samples. The contents obtained for Ti, Mn, Fe, Rb, Sr, Y, Zr and Nb are in excellent agreement with our Type A composition.

Thus to date, only one elemental composition was found for the 12 Balchit obsidians recently analysed by Poupeau et al. (2004) and Negash et al. (2006). The same composition was found for 10 artifacts from Gombore I and II and Garba IV (Negash et al. 2006) and two obsidians from alluvial deposits (Poupeau et al. 2003). These comparisons are significant, as an inter-laboratory comparison program in progress shows that these two groups of researchers obtain similar results on obsidians from various volcanic provinces (unpublished results). A comparison with the data by Muir and Hivernel (1976) would be more uncertain, although their results do not seem contradictory with a Type A composition.

Further field sampling and analyses will be necessary to understand if the B and C types of composition reflect only minor variations in Balchit obsidians or if they have to be referred to yet unidentified sources upstream or on the left bank Basin of the Awash River. The obsidian of Type D collected South of the Awash River in the Simbiro creek formation is a grey vitreous fluidal lava with a porphyric microstructure; quartz and feldspar crystals are oriented according to the fluidal structure. This material appears to have an ignimbrite facies and might be a bedsole rapidly cooled when in contact with the substratum. Similar ignimbrite facies were actually observed in this area.

Obsidian debris were widely distributed across the paleolandscape in secondary sources (Figure. 10.1d) as products of erosion from the primary source. Large blocks, cobbles, and gravels are found in Quaternary alluviums and in minor river beds and form secondary sources which were available for prehistoric groups.

10.4 The Oldowan Sites

The Oldowan sites discovered at Melka Kunture are Karre I, Gombore I, Gombore Iγ and Garba IV, dated between 1.7 and 1.4 Ma (Schmitt et al. 1977; Westphal et al. 1979; Cressier 1980). The localities of Karre I and Gombore Iγ have been excavated over limited areas, respectively of around 10 m^2 and 12 m^2. The sites of Gombore I and Garba IV, characterized by several archaeological layers that have been extensively excavated and investigated in greater detail (Chavaillon 2004).

10.4.1 Methodology

In this paper we introduce the general features of the archaeological contexts related to the sites of Gombore I and Garba IV and give details of the preliminary results of a technological analysis of the lithic series of Layer E in Garba IV, which results from the research carried out in 2005. The lithic assemblages of Gombore IB2 and of Garba IVD are presented using Leakey's (1971) typological scheme, subsequently revised by Chavaillon et al. (2004). This scheme has been widely utilized during the eighties and nineties.

In Tables 10.1 and Tables 10.2 the term "shaping" refers to a "knapping operation carried out for the purpose of manufacturing a single artifact by sculpting the raw material in accordance with the desired form" (Inizan et al. 1999:138). The category "shaping products" includes the types classified by Chavaillon et al. (2004) as pebble tools (choppers, polyhedrons, spheroids, heavy end-scrapers, rabots, various pebble tools), handaxes and cleavers. The technological analyses in progress will try to verify if these artifacts were indeed the products of the activities of shaping or, alternately, the results (cores) of the activities of flaking. "Flaking" is used in this paper as "an intentional flaking of blocks of raw material, in order to obtain products that will either be subsequently shaped or retouched, or directly used without further modification" (Inizan et al. 1999:155).

The term "percussion material" refers to pebbles and cobbles with fairly numerous impact marks on one or several faces and to pebbles and cobbles with one, two, three or more fractures (Chavaillon 1979; Chavaillon et al. 2004).

The classification used for Garba IVE lithic assemblage is necessarily different in consideration of the different methodological approach; it considers the description of the structural criteria identifying the reduction process (de la Torre 2003; Delagne and Roche 2005). Until completion of the ongoing technological study, the lithic assemblages of Gombore IB2 and Garba IVD currently are not comparable with that of Garba IVE from a technological point of view.

10.4.2 Gombore I

This site, discovered in 1965 by J. Chavaillon, was excavated up until 1982, reaching an exposure of about 250 m^2. Various Oldowan layers were discovered. Layer B was divided into three sublayers: the most important (B2) is, at various locations, separated from the underlying layer B3 by a layer of volcanic ash. Two limited excavations have been carried out at this site in order to reach layers C and D. A left distal humerus of *Homo erectus* was discovered in 1976 in the southern sector of the excavation (Chavaillon and Coppens 1986). A total of 20,403 archaeological items have been discovered in B2, 10,411 (51%) of which are lithic artifacts, 1,832 (9%) faunal remains and 8,160 (40%) unmodified pebbles.

10.4.2.1 Stratigraphy and environment

The stratigraphy of the Gombore sequence has been recently reexamined (Raynal et al. 2004). The deposits at Gombore I belong to the lowest parts of the Melka Kunture Formation (Raynal et al. 2004), which consists mainly of the accumulation of pyroclastic air-fall and of pyroclastic material in secondary deposition within volcano-derived fluvial systems (Figure. 10.2a). A test pit excavated at Gombore I shows the deposits below archaeological layer B of Chavaillon's (2004) excavations. From top to bottom these consist of:

- Silty coarse sands, very poorly sorted with a multi-modal grain-size curve.
- A tuff unit between archaeological layers B2 and B3 was sampled by J. Chavaillon during his excavations at Gombore I. This silty-sandy tuffaceous material is a rhyolitic air-fall, quasi-identical to the "Grazia tuff" at the bottom of the Garba IV series (Raynal, Kieffer 2004). The magnetic polarity of the tuff itself has not been established but units below and above show reverse polarity (Cressier 1980) corresponding to the Matuyama Reversal Chron.

We assume that earlier units form the bottom of the visible series, even if there is no observed connection between these deposits and those preserved and observed along the Gombore Gully sections.

The palynological analysis, based on several samples from Units IB and IC (Bonnefille 1976), clearly indicates thicket/scrub vegetation (bush) and the presence of a nearby forest. The percentage of *Juniperus* and *Podocarpus* pollens is high and these pollens are associated with those of high altitude thickets. The Gramineae represent 63% of the total pollens and the trees only 29%. Among the trees, *Juniperus* (80%) represents 21% of the total pollens while it accounts for only 1.5% nowadays. This indicates a humid climate, which cooled during the time of Gombore IB. A fragment of liana (*Cesalpinioxilon* sp.) was also recovered at the base of level B2.

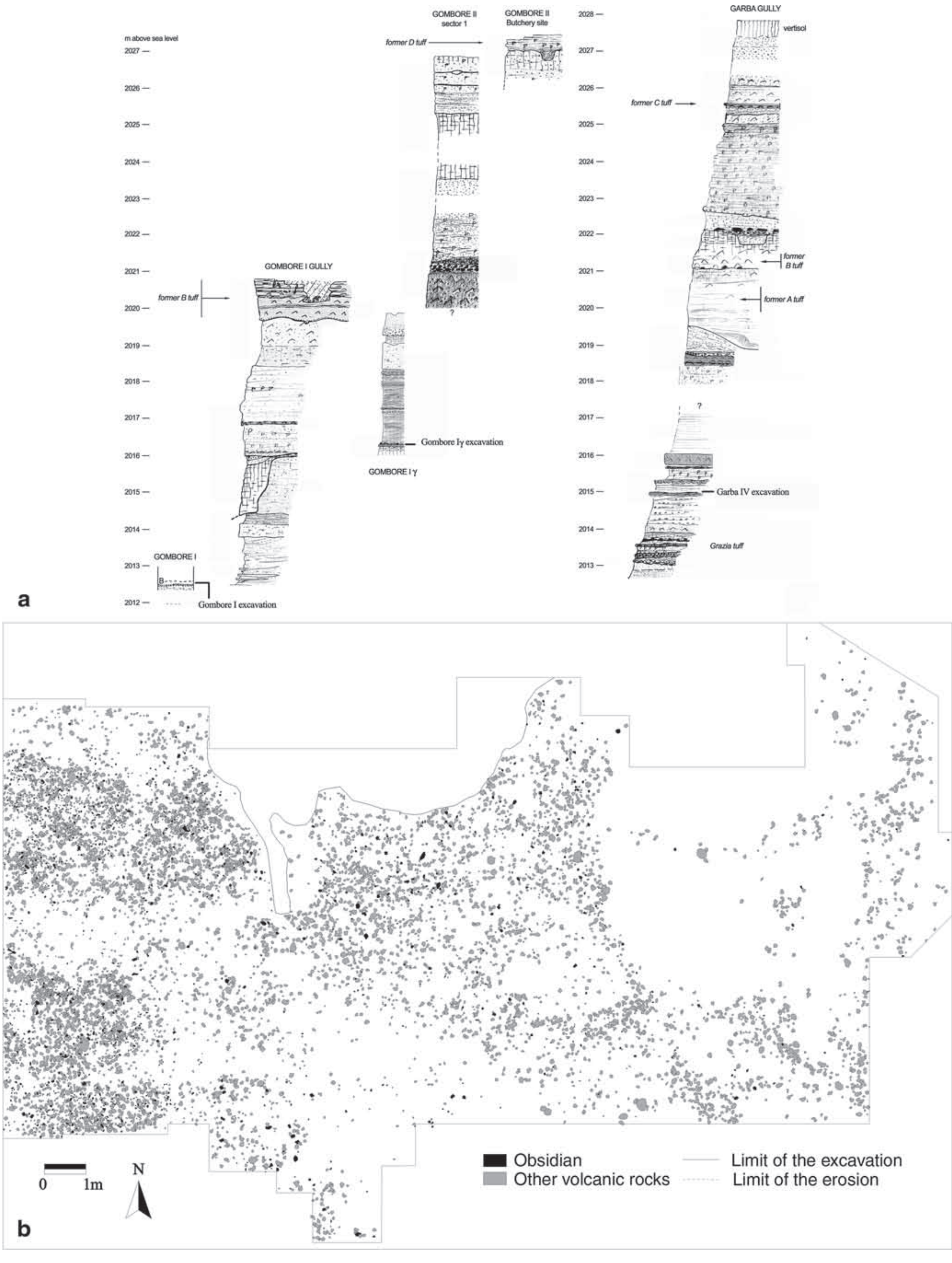

FIGURE 10.2 a: Gombore I series in the context of the Melka Kunture Formation; b: Gombore IB2, plan of the lithic artifacts

Table 10.1. Gombore IB2: lithic assemblage components, excluding percussion material.

	Obsidian			Others			Total	
Category	*N*	*% in relation to the total of the category*	*% in relation to the total of the obsidian artifacts*	*N*	*% in relation to the total of the category*	*% in relation to the total of artifacts on other volcanic rocks*	*N*	*%*
Shaping products	190	10.0	14.0	1719	90.0	57.9	1,909	44.1
Cores	120	48.0	8.8	130	52.0	4.4	250	5.8
Flakes	726	46.5	53.3	835	53.5	28.1	1,561	36
Retouched flakes	99	53.8	7.3	85	46.2	2.9	184	4.3
Tools on flake	172	48.5	12.6	183	51.5	6.2	355	8.2
Indeterminate fragments	54	77.1	4.0	16	22.9	0.5	70	1.6
Total	**1361**			**2968**			**4329**	

The fragmentary nature of the materials made it difficult to identify all faunal fragments, yet several specimens were identified to family or species level. The site nevertheless yielded well-preserved specimens of hippopotamus (*Hippopotamus amphibius*) and suids (*Metridiochoerus* and *Kolpochoerus*). There are also some remains of giraffe. Elephants (*Elephas recki*) and crocodiles are very rare. Bovids are abundant (*Connochaetes cf. gentryi* and *Damaliscus*) and equids are represented by *Hipparion*.

It is hard to draw precise biochronological estimates from this fragmentary fauna, but the *Connochaetes* is definitely not *C. olduvaiensis*, which appears at Olduvai Bed II, and more reminiscent of *C. gentryi* from earlier levels of Olduvai and the Turkana Basin (Geraads et al. 2004). Based on the magnetostratigraphy and the faunal evidence, we place the age of the site at 1.9–1.6 Ma.

10.4.2.2 Lithic production

The raw materials utilized for the lithic production (Figure. 10.2b) consist of obsidian (19%) and other volcanic rocks previously described (81%).

A large part (58%) of the assemblage consists of percussion materials, namely cobbles and/or blocks of raw material with impact marks or fractures, whose anthropic origin is often difficult to identify. The most commonly used raw materials are the welded ignimbrites, various basalts and trachytes. obsidian is extremely rare. The composition of the remaining part of the lithic assemblage is shown in Table 10.1.

Excluding the percussion material, the obsidian constitutes 31.5% of the total lithic series and around 50% of each category, except for the shaping products (10%). The numbers of obsidian flakes and cores are more or less similar to those of other volcanic rocks. The production of obsidian flakes seems more or less equally related to shaping and flaking. Flakes of other volcanic rocks appear to be mainly the result of shaping. Fifty-one percent of all flakes are retouched and nearly half of them are on obsidian (Figure. 10.3).

10.4.3 Garba IV

The site of Garba IV is located on the right bank of the Awash. The river has destroyed an unknown portion of the northern part of the site. The site, discovered by J. Chavaillon in 1972, was excavated from 1972 until 1982. The excavation and preliminary stratigraphic reconstruction allowed the identification of a sequence composed of five main archaeology-bearing stratigraphic units (C–G). The uppermost ones (C–D) were completely exposed, documented and removed.

In 1982 a 4 m^2 test trench was excavated below D in order to verify the thickness and nature of the underlying levels. Those were until then only seen in natural sections. An occupation level with fauna and lithic industry, corresponding to E, was reached about 60 cm below the base of D (Piperno and Bulgarelli 2004). In this level, a fragmented mandible of a 2/3 years old *Homo erectus* child was discovered (Condemi 2004).

A new series of excavations in 2005 explored E on a surface of 8 m^2 and F on a surface of 6 m^2, allowing the clarification of the lower part of the Garba IV stratigraphic sequence.

10.4.3.1 Lithostratigraphy

Three stratigraphic units (1–3 from the bottom to the top) were recognized within the sedimentary fluvial series (Figure. 10.4a) with a thickness of about 3 m (Kieffer et al. 2002; Raynal and Kieffer 2004; Raynal et al. 2004).

Stratigraphic Unit 1 at the base of the sequence is a layer of greenish silty sands, typical sediment gravity flow deposit, only the top of which has been excavated.

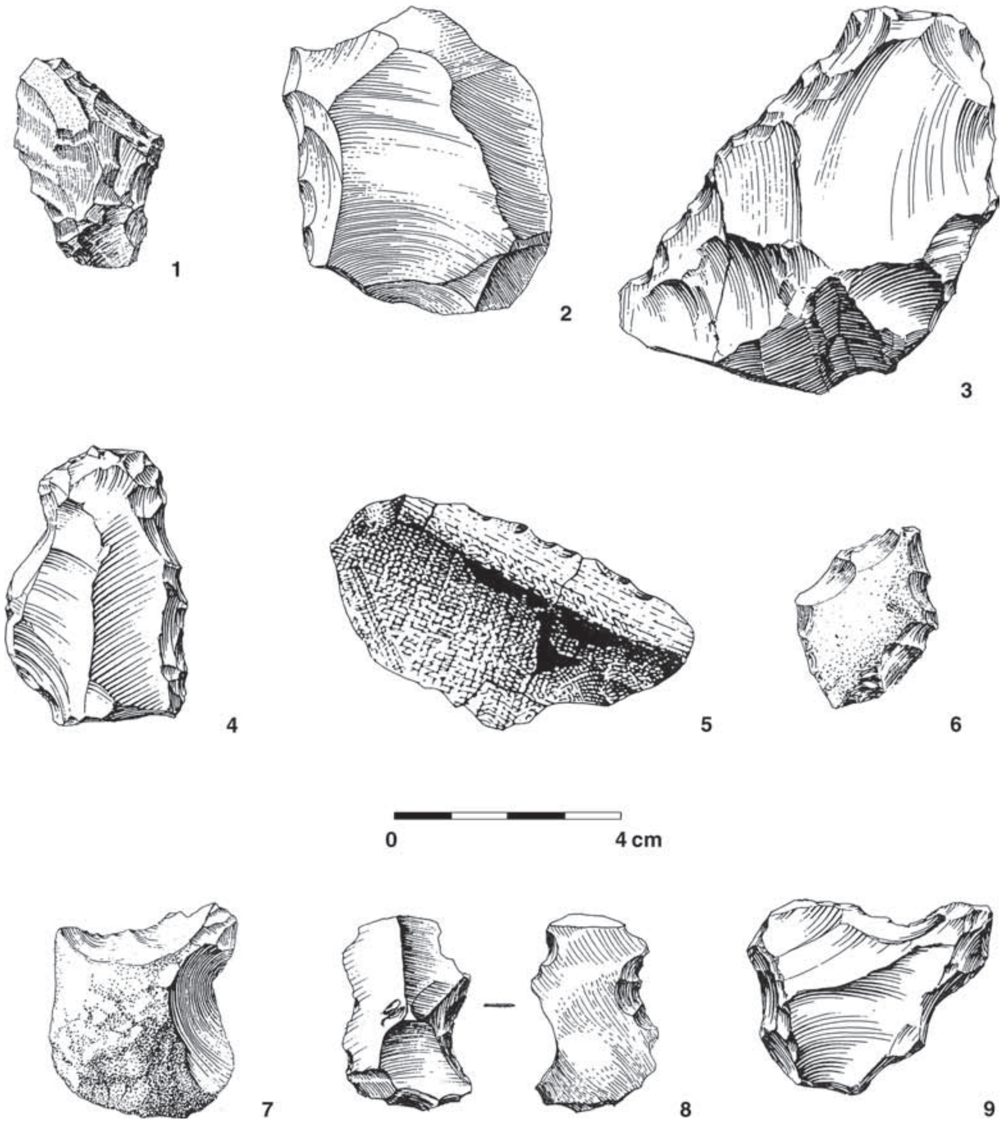

FIGURE 10.3. Gombore IB2. Obsidian. 1-3: straight simple side-scrapers; 4: convex simple side-scraper; 5: transversal convex side-scraper; 6: biconvex convergent side-scraper; 7-9: notches.

Stratigraphic Unit 2 is divided into 10 subunits. From bottom to top it consists of:

1. Silty sands of a sediment gravity flow deposit containing the lower archaeostratigraphic unit G.
2. Light-gray ashy sands indicative of sediment-gravity to plane-bed flow deposit.
3. Silty sand layer of plane-bed flow deposit.
4. More or less coarse sands.
5. Grey pumiceous silty sand layer which includes archaeostratigraphic units F and E.
6. Gravel layer with obsidian granules.
7. Pumiceous sand layer with coarsely stratified Pumice, probably derived from a distant airfall ash.
8. White tuff of a distal direct airfall ash.
9. Fine sandy layer.
10. Green silty sands of sediment gravity flow deposit.

Stratigraphic Unit 3 is composed of eight subunits. From bottom to top those are:

1. A clast supported massive gravel deposit that constitutes archaeostratigraphic unit D.
2. Upward refining (from coarse to fine) bedded sands.
3. Coarse massive sand containing archaeostratigraphic unit C.
4. Coarse sands and gravels with fine interbedded stratification, craddle and lenses, which indicate a lateral evolution of ephemeral shallow channels.
5. A cineritic layer of irregular thickness.
6. A layer of redeposited white tuff, muddy flow coulee type with surf structures.
7. A layer of obliquely stratified sands indicative of low flow regime.
8. A white sandy tuff (8).

Subunits five to eight form a single reworked tuff unit.

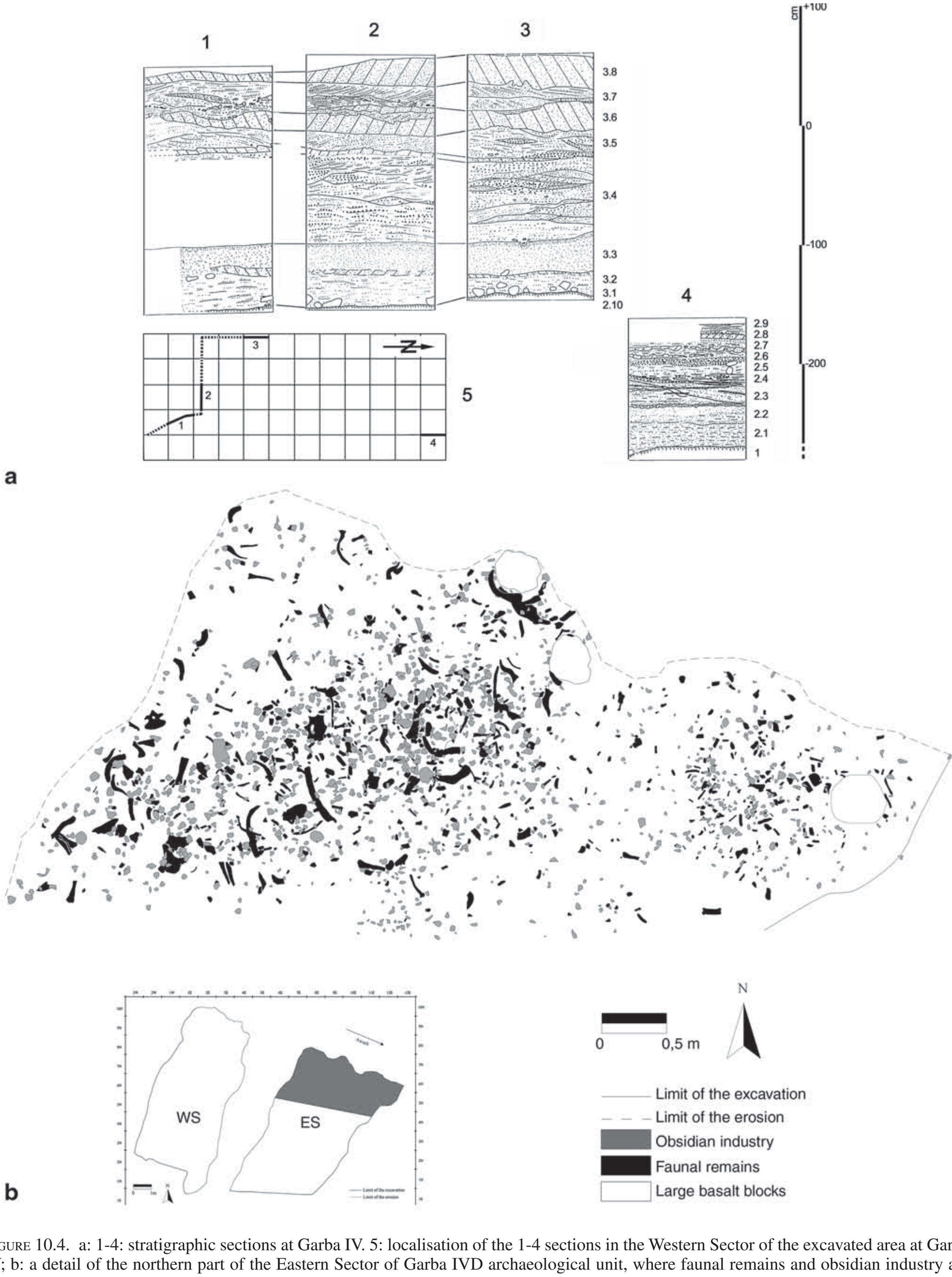

FIGURE 10.4. a: 1-4: stratigraphic sections at Garba IV. 5: localisation of the 1-4 sections in the Western Sector of the excavated area at Garba IV; b: a detail of the northern part of the Eastern Sector of Garba IVD archaeological unit, where faunal remains and obsidian industry are concentrated around some large basalt blocks.

10.4.3.2 Archaeological Unit D

Archaeostratigraphic Unit D represents the most important paleo-surface of the entire sequence. The area, which was excavated systematically over about 100 m^2, is divided into two sectors, a western (WS) and an eastern one (ES), separated by an erosion channel formed when a tributary of the Awash River destroyed the central part of the deposit. Of the total number of 19,055 finds, 2,580 are faunal remains and one coprolite, 6,654 are unmodified pebbles and cobbles and 9,821 are lithic artifacts.

The most frequently identified animals (Geraads et al. 2004) are bovids (*Pelorovis* sp., *Connochaetes gentryi, Damaliscus strepsiceras, Gazella* sp.), equids (including *Hipparion* sp.), suids (*Kolpochoerus* and *Metridiochoerus*), giraffe (including *Sivatherium*), hippopotamus, elephant, and a primate related to the modern Gelada Baboon (*Theropithecus*). Some of the bovids differ little from those of Gombore I and suggest that the two sites are not much different in age. The *Connochaetes* is an endemic subspecies of the wildebeest found at Olduvai Bed I to lowermost middle Bed II, later replaced by *C. taurinus*. The striking abundance of its horn-cores, together with the extreme fragmentation of most bone remains, precludes natural deposition and implies anthropic intervention.

Our hypothesis for the genesis of the archaeological unit in the Garba IV D case is that of an anthropic intervention on a lag deposit which contained unmodified cobbles of ignimbrites or other volcanic rocks, including obsidian pieces. The hominins settled on the lag deposit where they used the raw material available on the spot to manufacture lithic tools, after the water had receded. The bone remains belong to animals hunted or scavenged by hominins and consumed at this locality. All elements abandoned on the site have been partly reworked when sands of unit 3.2 deposited (Raynal et al. 2004).

Superficially the spatial distribution of the finds appears totally random. Nevertheless, in contrast to Gombore IB2, when a detailed analysis of the spatial trends is applied to the different categories of finds, it appears possible that some zones of paleo-surface D may harbour a kind of "memory", if not of their original distribution, at least of some associations attributable to anthropogenic action (D'Andrea et al. 2002; Gallotti and Piperno 2004). Although the zones with high and low concentrations of objects remain more or less constant regardless of both raw material and object category, variations in frequencies could provide some interesting information.

The lower half of the WS is the largest high-density zone. Here, all the categories of finds (unmodified materials, lithic artifacts and faunal remains) are present in significant quantities, but without noteworthy differences in their spatial distribution. There is slightly less material in the upper half of the area, but it does not show any significant spatial patterns. The only noteworthy element — with the exception of a semicircular barren area — is the recurrent spatial association of large basalt blocks with large faunal remains. This association is also observable in the ES, but here one also finds a very high number of obsidian cores, modified and unmodified flakes, and especially obsidian tools on flake and small debris (Figure. 10.4b). Indeed, the two areas in the ES with the highest densities seem to be connected to, and possibly determined by, the presence of the large basalt blocks more directly than in the WS. In the same zones one also finds many unmodified pebbles strewn all over the surface of the WS, while pebble tools and broken and battered pebbles are extremely rare.

The obsidian industry represents 41% of the total assemblage, which is a higher frequency than seen at Gombore IB2. Excluding the percussion material that is less abundant (27%) than at Gombore IB2, the obsidian artifacts constitute 55% of the total lithic assemblage.

Table 10.2. Garba IVD: lithic assemblage components, excluding percussion material.

	Obsidian			Others			Total	
Category	*N*	*% in relation to the total of the category*	*% in relation to the total of the obsidian artifacts*	*N*	*% in relation to the total of the category*	*% in relation to the total of artifacts on other volcanic rocks*	*N*	*%*
Shaping products	50	4.3	1.3	1,110	95.7	34.6	1,160	16.2
Cores	338	55.1	8.5	275	44.9	8.6	613	8.5
Flakes	2,558	64.3	64.3	1,420	35.7	44.1	3,978	55.3
Retouched flakes	212	73.9	5.3	75	26.1	2.3	287	4.0
Tools on flake	405	78.5	10.2	111	21.5	3.5	516	7.2
Debris	414	65.2	10.4	221	34.8	6.9	635	8.8
Total	**3,977**			**3,212**			**7,189**	

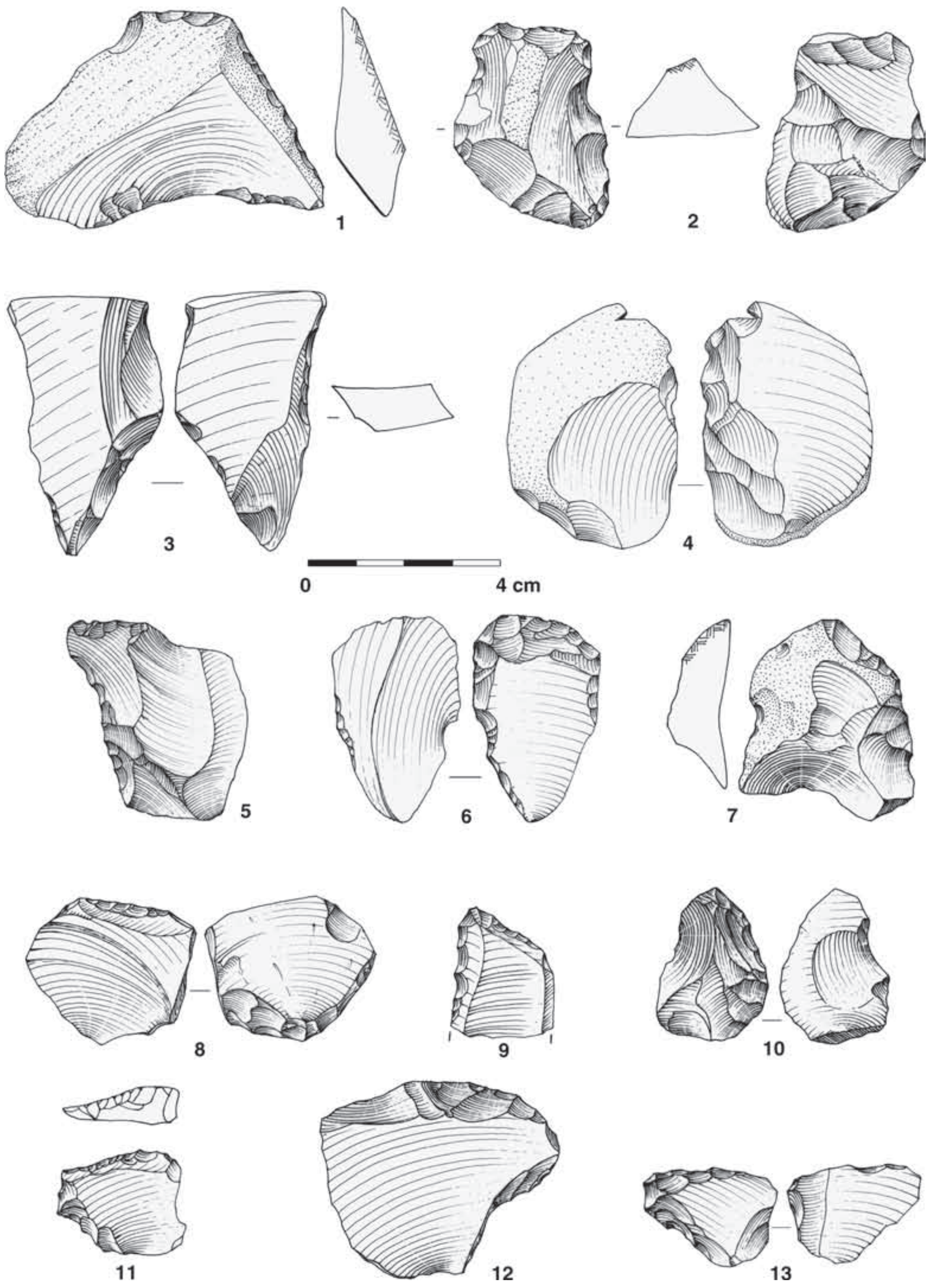

FIGURE 10.5. Garba IVD. Obsidian. 1: simple straight side-scraper; 2, 6, 8, 11, 12: transversal side-scrapers; 3: side-scraper with alternate retouch; 4: inverse side-scraper; 5: simple concave side-scraper; 7, 10: simple convex side-scrapers; 9: convergent side-scraper; 13: déjeté side-scraper.

As shown in Table 10.2, obsidian was used almost exclusively for flake production and only sporadically for pebble tools (rare obsidian choppers). The number of obsidian flakes is almost twice that of other volcanic rocks. Given the small number of shaping products, the flakes in this assemblage seem to be the result of flaking activities, compared to Gombore IB2. Moreover, while at Gombore IB2 the number of the retouched flakes (as defined by Chavaillon et al. 2004) and tools on flakes (e.g. side-scrapers, denticulates and notches) is not very different for obsidian compared to the other raw materials, at Garba IVD 75% of such artifacts are of obsidian. Compared to Gombore IB2, artifacts from Garba IVD are often surprisingly small with intense retouch (Figure. 10.5).

Table 10.3. Garba IVE: lithic assemblage components.

Category	Obsidian	Others	Total
Flakes	26	11	37
Retouched pieces	2	1	3
Indeterminable fragments	5	12	17
Cores	15	6	21
Bolas	0	1	1
Modified pebbles and cobbles	0	18	18
Modified blocks	0	7	7
Broken pebbles and cobbles	0	11	11
Unmodified pebbles and cobbles	4	105	109
Unmodified blocks	0	1	1
Natural fragments	0	9	9
Total	**52**	**182**	**234**

10.4.3.3 Archaeological Unit E

Archaeostratigraphic Unit E was explored in 1982 on a surface of 4 m^2. At this locality 78 finds were discovered, of which 50 were faunal remains, 27 were lithic artifacts and one was a fragmentary mandible of a 2/3 years *Homo erectus* child (Condemi 2004; Piperno and Bulgarelli 2004). In 2005, a new series of excavations explored E on a surface of about 8 m^2**,** where 429 pieces were brought to light. Of these 194 were faunal elements.

The palaeontological material is extremely fragmentary and only 30% of the assemblage could be identified to families. Hippopotamus is the best represented genus with 55 finds, mostly dental fragments, followed by bovids, among which *Connochaetes* sp. and *Kobus* sp. were identifiable. Two metatarsal fragments of *Kobus*, discovered in the same square meter, could be refitted. Equids are represented by *Equus* sp.

The composition of the lithic assemblage from the 2005 excavation is shown in the Table 10.3.

Besides an angular block and nine natural fragments of welded ignimbrites, most of the lithic objects are unmodified cobbles: 96 are of welded ignimbrites, 23 of various basalts, four of obsidian, two of trachybasalt, one of trachyte and 10 of a still undetermined lava. The median size of unmodified cobbles is 74.5x 64x 44.5 mm for welded ignimbrite, 107.5x 77x 61 mm for basalts, 97x 87x 60 mm for other lavas and 75x 52x 48 mm for obsidian. Apart from the unmodified material, 11 broken pebbles, 18 modified pebbles and seven modified blocks are present and more than half are of welded ignimbrites (62%). In this case, the word "modified" is used to identify pebbles, cobbles and blocks presenting discrete and dispersed impact marks, but no percussion zone that would enable them to be defined as hammerstones.

Even if the welded ignimbrite is abundantly available in the alluvium at a close range to the site, it has not been used for knapping activities, except for four cortical flakes and the production of a bola stone, a unique testimony of shaping activity in this unit.

A classification of the cores has been carried out with the following criteria: identification of the number of the flaking platforms (unifacial=one flaking surface; bifacial=two flaking surfaces; multifacial=more than two flaking surfaces); the direction of flaking, which allows a distinction between unipolar, bipolar, centripetal (from a continuous peripheral striking platform) and multipolar (from separate striking platforms) exploitation, and the presence or absence of a distinct prepared striking platform. Considering these attributes, the core analysis allowed us to identify exploitation modalities, the management of volumes and the presence or absence of a hierarchical organization of the surfaces. The following flaking strategies have been identified for the two most commonly used raw material groups, namely obsidian and other volcanic rocks.

Six flaking strategies have been distinguished for obsidian (Figures 10.6, 10.7)

- Unifacial bipolar flaking. A single surface of the core has been flaked through two series of bipolar removals. Flaking is carried out from an unprepared striking platform on the cortical surface of a reworked pebble.
- Unifacial centripetal flaking. These cores present a single flaked surface by series of centripetal removals. The original blank consists of a reworked cobble whose cortical surface acts as the striking platform.
- Unifacial centripetal flaking with a prepared striking platform. These cores are characterized by a single flaked surface, through one or two series of centripetal removals which originate from a prepared striking platform generated by unipolar removals.
- Bifacial centripetal flaking. Two options have been recognized:

1) Flakes are alternatively removed from the two flaking surfaces which are convex and share an intersection plane; no hierarchical organization of the surfaces can be seen. This option fits the basic criteria first outlined by Boëda (1993) for the identification of the bifacial discoid method;
2) These cores present two parallel flaking surfaces with centripetal exploitation and several removals intended to rectify a peripheral striking platform rather than to create a hierarchical organization of the surfaces. In one case, in the final phase of core exploitation, a change in the role of the surfaces is obvious: the last removal is localized on the previous striking platform.

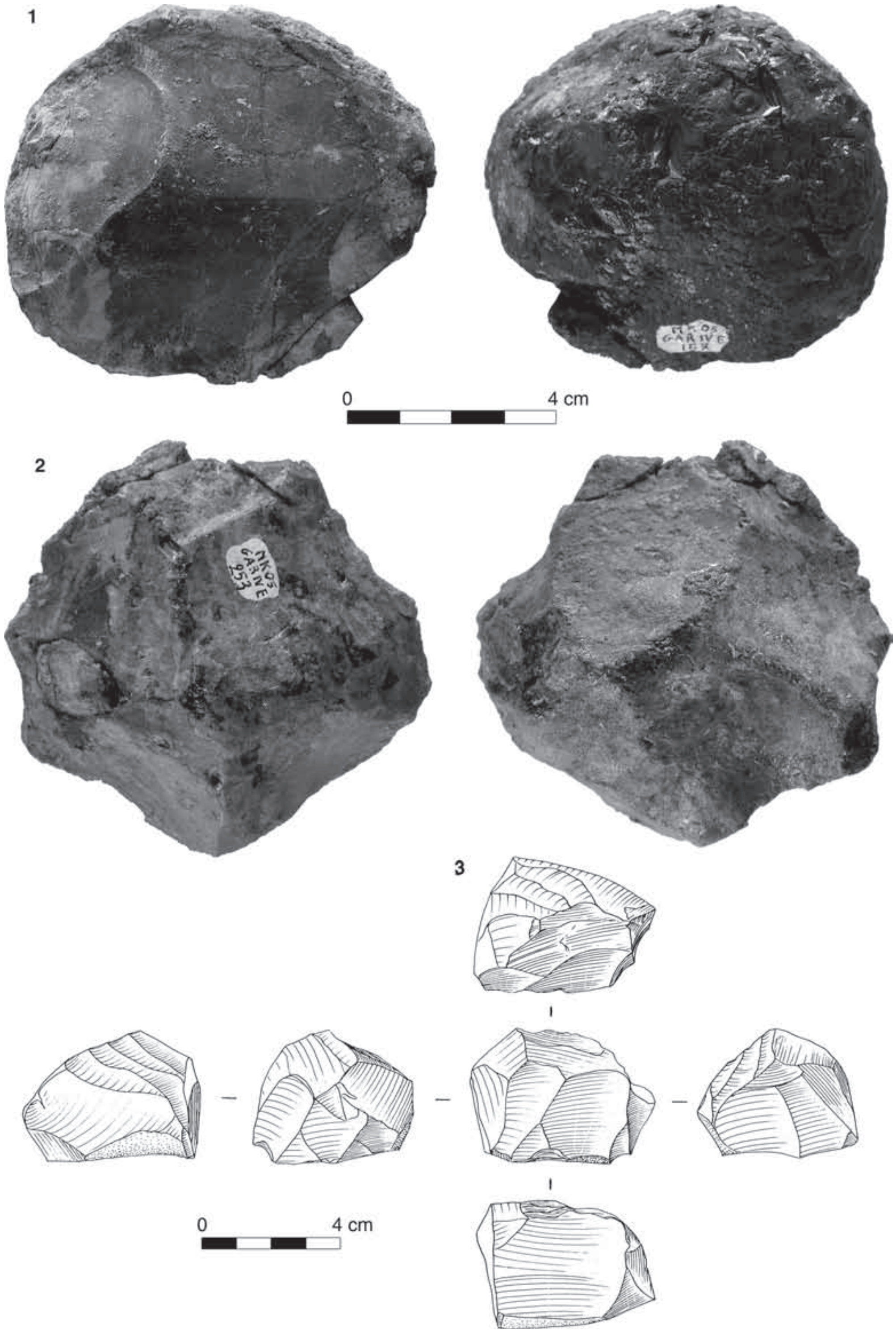

FIGURE 10.6. Cores from Garba IVE. Obsidian. 1: unifacial centripetal flaking; 2: bifacial centripetal flaking with alternate series of removals; 3: multifacial multipolar irregular flaking.

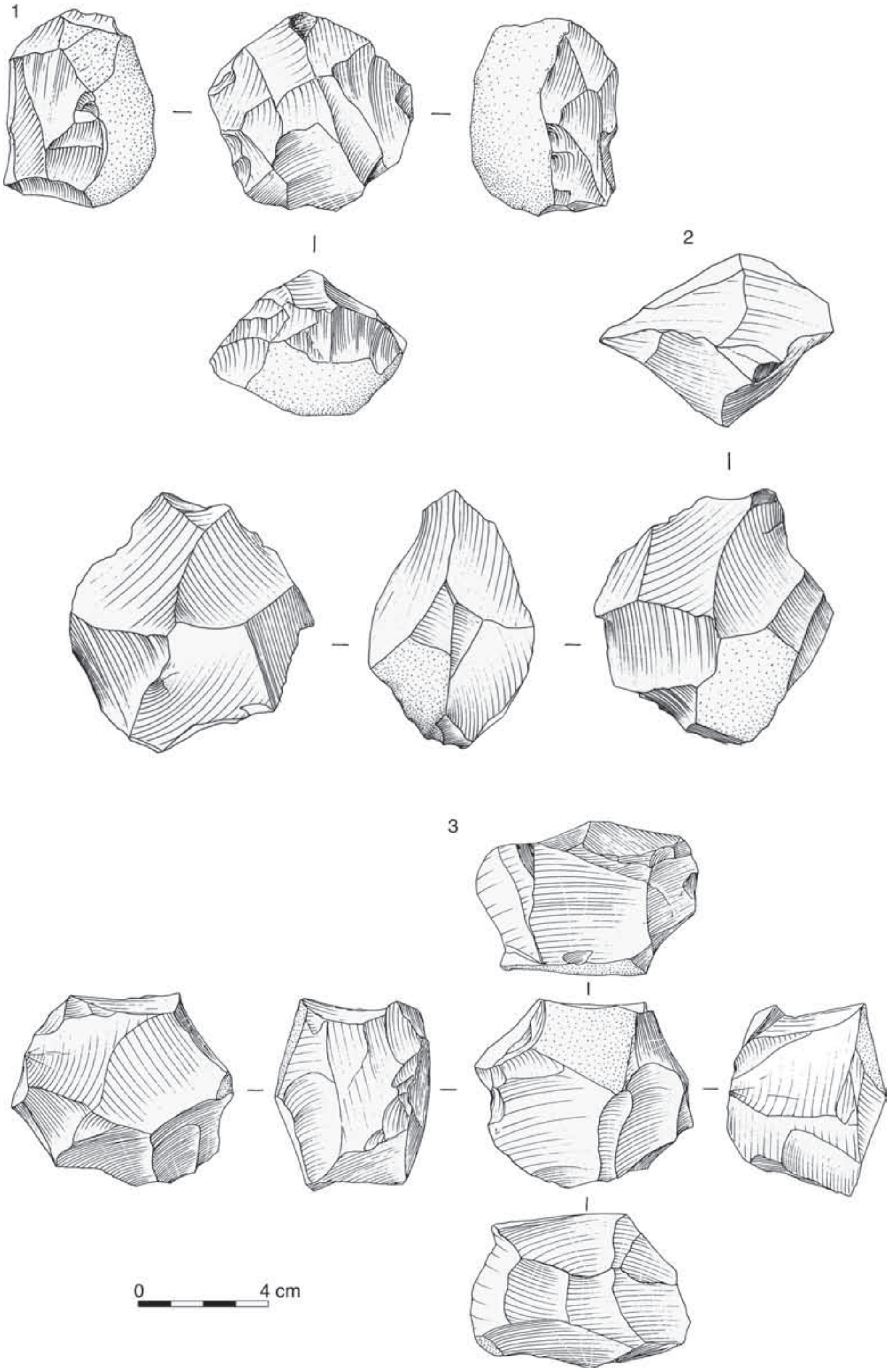

Figure 10.7. Cores from Garba IVE. Obsidian. 1: unifacial bipolar flaking; 2: bifacial centripetal flaking. The removals alternate on the two convex flaking surfaces which share an intersection plane; no hierarchical organization of the surfaces can be seen; 3: bifacial centripetal flaking with two parallel surfaces and several removals to rectify a peripheral striking platform; no hierarchical organization of the surfaces. In the final phase of core exploitation, a change in the role of the surfaces is visible: the last removal is localised on the previous striking platform.

- Partial bifacial flaking. Flaking starts from an unprepared striking surface, which is the cortical surface of a cobble, and continues alternatively from the negative scar.
- Multifacial multipolar irregular flaking. These cores present several independent flaking surfaces. In one case the natural blank is an angular block.

The median size of obsidian cores is 63x 51x 41 mm, consistent with the size of the available cobbles.

Three flaking strategies have been identified for other volcanic raw materials:

- Unipolar partial peripheral flaking. One core shows two series of perpendicular removals in relation with a striking platform on a pebble's natural surface.
- Partial bifacial flaking. The process is identical to the one described for obsidian.
- Multifacial multipolar irregular flaking. The cores are of relatively small size and present a great number of removals, suggesting that they were overexploited.

In the case of the multifacial multipolar irregular flaking on different volcanic rocks, the relatively small dimensions of the cores (58x 55.4x 43 mm) could be explained by the intensity of their exploitation.

The number of flakes is not in agreement with the mean number of negative scars observed on the cores (16 for obsidian and eight for other volcanic rocks), especially if we consider that the total number of scars does not realistically reflect the number of flakes detached and that some cores have been heavily exploited, as already pointed out by other authors (Braun et al. 2005, 2006; see also Kimura 2006). Flakes with cortical surface are the more abundant (62%) and indicate the prevalence of the initial reduction stage. In the case of obsidian, the flakes of full reduction stage present almost three negative scars on the dorsal face and the butts, generally cortical ones, are facetted for five items. Only three flakes have been retouched: one of them is a transversal side-scraper of small dimensions.

10.5 Conclusions

Obsidian represents a large, even major, component of the Oldowan lithic assemblages: 31.5% at Gombore IB2 and 55% at Garba IVD, when the percussion material is excluded from the artifact inventories. The data are not statistically significant for level E of Garba IV, due to the insufficient sample size from the small excavated area.

Generally, the patterns of raw material utilization during Oldowan times were determined by local resource availability. In fact, almost all obsidian cores were produced from small to medium sized cobbles and in only a few cases are the original blanks represented by angular blocks, suggesting preferential use of secondary sources. In the case of two obsidian handaxe-like artifact from Garba IVD, the original blanks were large flakes, whose manner of supply is difficult to explain based on the size of obsidian cobbles and blocks currently available in the alluvial deposits.

The utilization of the other volcanic rocks follows the same supply modalities; the only difference being the quantitative availability in the alluvium of unmodified cobbles and pebbles, of which very few specimens are obsidian.

On the basis of the general typological information from Gombore IB2 and Garba IVD, the detached pieces are the most abundant artifact type. In particular, the number of obsidian flakes at Garba IVD is almost twice that of other volcanic rocks. In contrast to Gombore IB2, these flakes seem to be the result of flaking rather than shaping activities. The relative importance of obsidian use at Garba IVD compared to Gombore IB2 is highlighted by the number of retouched pieces, 75% being in obsidian.

We would like to reemphasize that the technological analysis for these sites is forthcoming and that this article is essentially focused on describing the unusual early use of very high-quality raw materials. Nevertheless the data presented concerning the lithic assemblage of Garba IVE permits some tentative conclusion and suggests interesting directions for future research.

Preliminary results of the technological analysis of the lithic assemblage from Garba IVE demonstrate that the raw material composition is the major source of technological variation in contexts where the supply modalities are not dependent on the type of utilized volcanic material.

The differential flaking strategies identified for the two raw material types are characterized by some essential features. First of all, the variability of the obsidian flaking strategies is more significant compared to that on other volcanic rocks. This variability is not linked to the morphological and dimensional variability of the obsidian original blanks. Furthermore, a hierarchical organization of the surfaces is generally lacking, except in the case of unifacial centripetal flaking with prepared striking platforms. The variability of the flaking strategies identified the presence of prepared striking platforms and the change in the role of the surfaces, indicate a good control of the volumes of the obsidian cores.

The completion of the technological analysis of the Gombore IB2 and Garba IVD lithic assemblages will add further information about exploitation strategies in the context of the Oldowan of eastern Africa. In particular, these data allow a quantitative approach to define how the enormous availability of raw material determined a human response to the specificities of each of the lithic resources recognisable within the exploitation strategies.

Finally, the abundance and availability of raw material in the alluvium systems of Melka Kunture, the proximity of the primary supply source of Balchit obsidian and the high quality of this material, could explain the extensive use of obsidian in the lithic assemblages of Gombore IB2 and in particular

Garba IV. The local supply modality is in accordance with the evidence from the East African Oldowan sites of Olduvai (Hay 1976), Koobi Fora (Isaac et al. 1997), Peninj (de la Torre et al. 2003), Nyabusosi (Texier 1995) and Kanjera South (Plummer et al. 1999), which indicate that Oldowan tool-makers systematically used raw materials abundant in local channels. The few documented exceptions are known at Olduvai (Hay 1976; Potts 1988) and at the Late Pliocene KS1 and KS2 Beds at Kanjera South (Plummer et al. 1999; Braun et al. 2008), where the high quality raw material derives from non-local sources. In this framework the availability of a high quality raw material such as the Balchit obsidian in a primary source and in the alluvium system represents a further exception in the Oldowan context.

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