Chapter 6
The Early Acheulean ~1.6–1.2 Ma from Gona, Ethiopia: Issues related to the Emergence of the Acheulean in Africa

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Abstract Konso in Ethiopia and Kokiselei in Kenya, both dated to ∼1.7 million years ago (Ma), and FLK West, a recently reported site from Olduvai dated to 1.7 Ma, are the earliest Acheulean sites known in East Africa. Ongoing archaeological investigations at Gona, in the Afar Depression of Ethiopia, have also produced early Acheulean stone assemblages at several sites, estimated to ∼1.6–1.2 Ma. A number of sites, including BSN-12 and OGS-12, have yielded archaeological materials comparable to the earliest Konso artifacts. The stone assemblages from the Gona sites consist of crudely made handaxes, cleavers, and picks, as well as Mode I (Oldowan) cores, and débitage. A variety of raw materials were exploited at Gona, with trachyte, rhyolite, and basalt being the most common.

Our understanding of the behavioral and ecological background for the emergence of the Acheulean is still limited. Preliminary comparisons of BSN-12 and OGS-12 with other early Acheulean sites demonstrate variability in paleoecological settings as well as raw material use. Current archaeological evidence indicates that early *Homo erectus/ergaster* use of this new technology was already in place in East Africa ∼1.75 Ma. At Gona and elsewhere in Africa, continued survey and excavations are needed to document sites with potential for yielding archaeological traces that will help our understanding of the Oldowan–Acheulean transition, the identity of the toolmakers, and the function of the early Acheulean Large Cutting Tools (LCTs).

Keywords Ethiopia • Gona • Technical behaviors • Oldowan–Acheulean transition

6.1 Introduction

Based on current evidence, the Acheulean stone technology emerged in East Africa ∼1.75/1.7 Ma (Lepre et al. 2011; Beyene et al. 2013; Diez-Martín et al. 2015). The preceding Oldowan, the earliest established stone technology, characterized by simple core/flake traditions (2.6–1.7 Ma), is well-documented in the archaeological record in East, North, and South Africa (Leakey 1971; Harris and Isaac 1997; Semaw et al. 1997, 2003, 2009a; de Heinzelin et al. 1999; Plummer et al. 1999; Semaw 2000; Sahnouni et al. 2011; Diez-Martín et al. 2014, 2015; Domínguez-Rodrigo et al. 2014; Páres et al. 2014; Granger et al. 2015, and references therein). Based on a recent discovery made in Ethiopia (Di Maggio et al. 2015; Villmoare et al. 2015), early *Homo* appears to have been present by 2.8 Ma and may be the most

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likely candidate for beginning the systematic manipulation of stones characteristic of the earliest Oldowan industry. According to another recent report from Lomekwi in Kenya (Harmand et al. 2015), the beginnings of ancestral hominin stone manipulation have been pushed back to 3.3 Ma with the discovery of stones with scars and pitting marks interpreted as evidence of "battering activities" by *Kenyanthropus platyops*. According to Harmand et al. (2015), these stones are technologically significantly different from the earliest Oldowan. The Oldowan (2.6–1.7 Ma) is a simple technology, but often made with systematic and patterned stone working techniques employed for creating sharp-edged cutting stones used primarily for processing animal carcasses for meat and bone marrow extractions, and probably other functions (Roche et al. 1999; Semaw et al. 2003; Domínguez-Rodrigo et al. 2005; Cáceres et al. 2017).

Lithic technologies are often described as relatively "simple" or "complex", but it is not always clear what these terms mean. Following Deacon (2012), Stout (2013) identified two dimensions of complexity: diversity and structure. Thus, one lithic technology might be considered more complex than another if it involved a greater variety of technical operations and/or if these operations were related to one another in a more structured way. Perreault and colleagues (2013) recently employed a diversity-based approach counting the number of procedural units (mutually exclusive manufacturing steps) to quantify the increasing complexity of Oldowan, Acheulean, and Middle Stone Age technologies. An example of structural complexity would be the nesting of individual operations in increasingly deep hierarchies of goals and sub-goals. Such structural analysis also indicates the greater complexity of Acheulean over Oldowan technology (Stout 2011).

Whereas Oldowan knapping is clearly a demanding perceptual-motor skill (Bril et al. 2015), there is some debate regarding the structural complexity of action sequences involved (e.g., Delagnes and Roche 2005; de la Torre and Mora 2005; Wynn et al. 2011). We have previously presented evidence (Stout et al. 2010) that Oldowan knappers at Gona displayed group-level biases toward particular reduction strategies (unifacial vs. bifacial), indicating the presence of structure beyond direct reaction to immediate core affordances. However, leaving aside reduction methods such as polyhedral (Roche 2005) and bifacial hierarchical centripetal flaking (de la Torre et al. 2003), which may not actually be characteristic of the Oldowan (de la Torre 2009; Stout et al. 2010), the minimal required structure that may be inferred remains limited to a simple chain in which the location of the next removal is determined from the previous one according to a local rule (e.g., vertically adjacent, horizontally adjacent, alternate face).

Early Acheulean technology includes all aspects of Oldowan knapping, for example preserving simple débitage on small cores, while adding more structured core reduction and shaping methods (de la Torre 2011; Stout 2011). Thus, early Acheulean technology may be considered more complex in terms of both procedural diversity (e.g., addition of large flake blank production) and structural organization (e.g., superordinate goal of core shaping). Cognitively, this increased structural complexity implies increased abstraction, maintenance, and manipulation of goal representations (Stout 2011), while behaviorally it implies greater contingency between actions (and thus greater skill). Whereas the limited dependency between sequential actions in Oldowan flaking means that unexpected outcomes and sub-optimal choices are easily accommodated if basic requirements for forceful, accurate percussion are met, errors during Acheulean shaping are more liable to compromise the intended outcome. This has been supported in experimental comparisons of Oldowan and later Acheulean-style knapping (Stout et al. 2015; Stout and Khreisheh 2015) which have found that the latter takes longer to learn and is more dependent on abilities to accurately predict action outcomes and make appropriate strategic choices. These abilities are in turn associated with increased neural activity and functional connectivity in the prefrontal cortex (Stout et al. 2015). Further experimental work is needed to test the degree to which these findings apply to early Acheulean technology.

The earliest Oldowan at Gona has been characterized based on thousands of stone artifacts excavated within fine-grained sediments, which have been recovered from ten archaeological sites distributed over a wide area (>4 km apart). All of these archaeological sites at Gona have been securely dated to 2.6–2.5 Ma by a combination of $^{40}Ar/^{39}Ar$ and paleomagnetic dating techniques (e.g., Semaw et al. 1997, 2003, 2009a). Perhaps surprisingly, our understanding of the more recent Oldowan–Acheulean transition remains more limited despite decades of systematic surveys and excavations of many sites dated to 1.8–1.4 Ma across East Africa (see Semaw et al. 2009b for discussions).

At Gona, several early Acheulean sites are documented preserving stone assemblages and associated fossil fauna estimated to ~1.7–1.2 Ma (Quade et al. 2004). Unfortunately, these sites still lack precise absolute radiometric dates, and geological/geochronological studies are underway for securing more precise minimum ages. The early Acheulean sites at Gona are distributed over a wide area within the Dana Aoule North, Ounda Gona South, and Busidima North drainages (Fig. 6.1). A summary of the preliminary geological contexts and general characteristics of the stone assemblages from Busidima North 12 (BSN-12) and Ounda Gona South 12 (OGS-12) (among the most important sites) will be presented here, in the hopes that this continuing work can help shed light on this important watershed in human evolution.

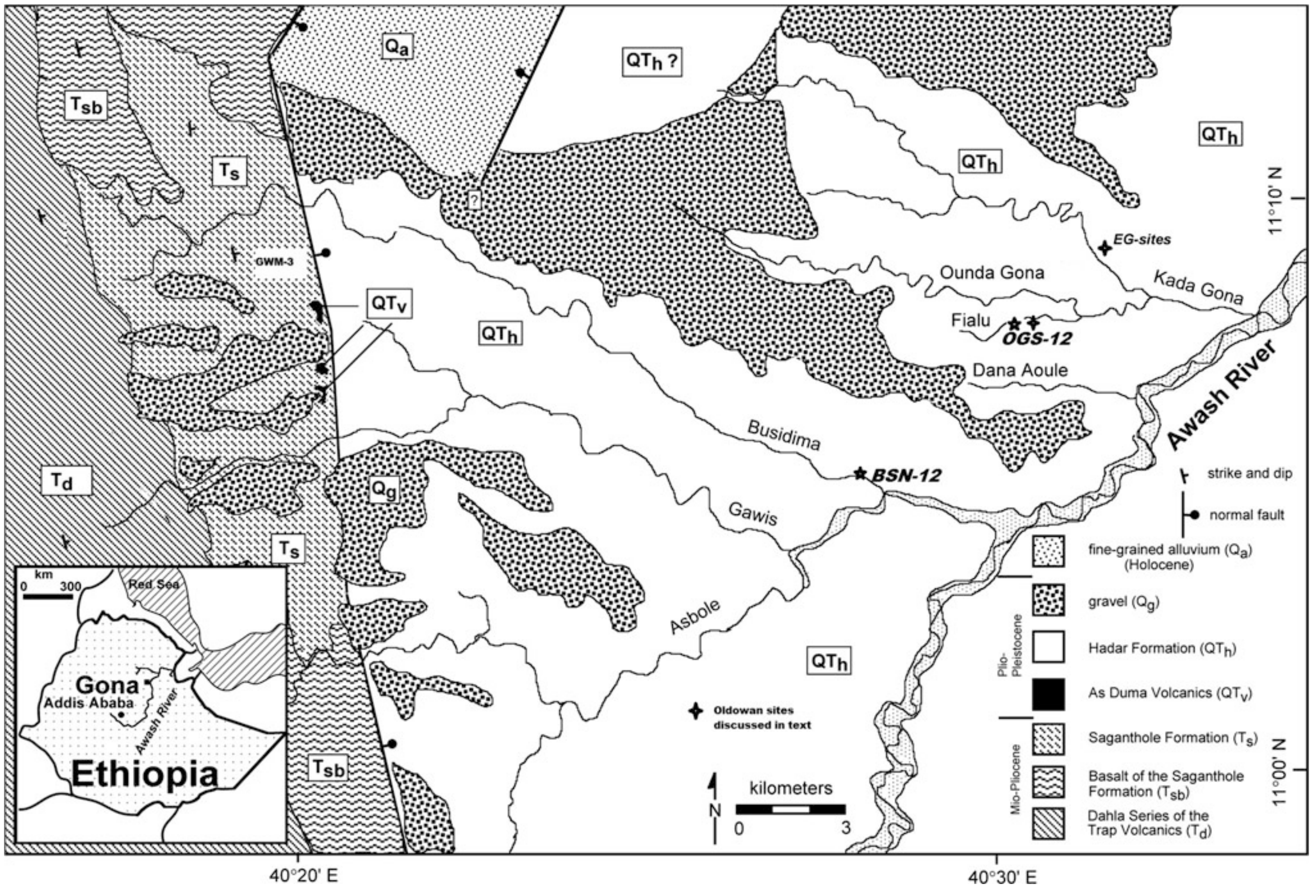

Fig. 6.1 Map of the Gona Project area showing the geology and the location of the Acheulean and some of the Oldowan sites discussed in the text (Figure modified after Quade et al. 2004)

6.2 The Oldowan–Acheulean Transition

Over the past fifty or so years, a large number of early Paleolithic sites, within the time interval between ~2.6 and 1.5 Ma, have been documented in much of East, North, and South Africa (e.g., Leakey 1971; Howell et al. 1987; Kimbel et al. 1996; Isaac and Harris 1997; Semaw et al. 1997, 2003, 2009a; de Heinzelin et al. 1999; Plummer et al. 1999; Roche et al. 1999; Chavaillon and Piperno 2004; de la Torre and Mora 2005, 2014; Boisserie et al. 2008; de la Torre et al. 2008, 2012; Delagnes et al. 2011; Lepre et al. 2011; Blumenschine et al. 2012; Beyene et al. 2013; Sahnouni et al. 2013a, b; Gallotti 2013; Diez-Martín et al. 2014, 2015; Domínguez-Rodrigo et al. 2014; Granger et al. 2015, and references therein). However, the nature and characteristics of the archaeological transition from the Oldowan to the Acheulean, as well as the identity of the makers of the earliest Acheulean and contemporaneous Oldowan in East Africa, are still poorly understood. The remarkable work by Leakey (1971) could be singled out as the most seminal in attempting to show the behavioral evolution of Oldowan–Acheulean ancestors. Based on the materials she excavated at Olduvai, Leakey saw the "Developed Oldowan" as an intermediary between the two stone industries. However, based on our current state of knowledge (with the ~1.75 Ma Konso and Kokiselei, and the 1.7 Ma FLK West discoveries), it appears that the earliest Acheulean was contemporaneous with, or actually preceded, Leakey's Developed Oldowan (with the earliest such assemblages from Olduvai dated ~1.7 Ma), making this "artifact tradition" unlikely to have been the transitional phase toward the Acheulean (Stiles 1979; de la Torre and Mora 2005; see Semaw et al. 2009b for details).

Beyond questions related to changes in the artifact forms themselves, the question of why ancestral hominins began making purposefully shaped large cutting tools (LCTs) beginning ~1.75 Ma, is also poorly understood (Lepre et al. 2011; Beyene et al. 2013). Although the early Acheulean LCTs are labeled as handaxes, picks, and cleavers, archaeologists are still grappling with basic questions regarding their respective functions. Much of our knowledge of the function of the early Acheulean was primarily derived from experimental butchery studies (e.g., Schick and Toth 1993; Jones 1994). Earlier investigations on microwear studies have shown meat and plant processing on Karari implements dated to 1.5 Ma (Keeley and Toth 1981). Further, woodworking has been proposed based on phytoliths traced on LCTs excavated at Peninj, in Tanzania (Domínguez-Rodrigo et al. 2001). However, exactly the sorts of woodworking/plant-processing activities accomplished either with the Karari or using these LCTs during the early Acheulean, and how these products were utilized, have yet to be unequivocally demonstrated based on the archaeological evidence. Advances in fat-residue and use-wear studies on late Acheulean bifaces and scrapers from Revadim in Israel have shown evidence of elephant butchery for meat (Solodenko et al. 2015).

A recent report from FLK West has provided spatially associated Acheulean stone assemblages and fauna suggesting exploitation of meat resources (Diez-Martín et al. 2015). At Gona, studies on bone surface modifications on faunas associated with early Acheulean LCTs at OGS-12 have shown exploitation of meat from small- and medium-sized animals. Nonetheless, the LCTs we refer to as picks have an indeterminate function, though some have suggested digging. Beyene et al. (2013) have presented diachronic morphological evidence to support the idea that they really are a distinct artifact class, showing little technological change through time (1.75–1.0 Ma).

For a long time the appearance of the Acheulean has been considered to have coincided with a larger-brained hominin, otherwise generally referred to as *Homo erectus/ergaster* (Klein 2009), or "*Homo erectus*-like" hominin, according to Beyene et al. (2013). With recent possible revisions in the age of the earliest *H. erectus/ergaster* fossils (McDougall et al. 2012), the new findings at Olduvai (Domínguez-Rodrigo et al. 2015), and with unresolved issues relating to dating uncertainties and taxonomic status of some fossils (see Antón 2012), the association between the onset of the Acheulean and the emergence of *H. erectus* remains unclear.

6.3 The Early Acheulean at Gona

The Acheulean is clearly distinguished from Oldowan stone technology with the creation of purposefully shaped large cutting tools (LCTs) made with great emphasis on large size and heavy weight. The beginning of the Acheulean marks the onset of human imposition of form on stone artifacts created with intended designs such as handaxes, cleavers, and picks. Acheulean artifacts during the initial phase were crudely worked, but attained symmetry and standardized shapes through time (e.g., Beyene et al. 2013; Sahnouni et al. 2013a, b). Our glimpse into the earliest Acheulean comes mainly from the two sites of Konso and Kokiselei. Now with ongoing studies at Gona, a number of additional excavated sites are yielding important data from ~1.7 to 1.2 Ma. At Gona, the main early Acheulean sites are found within the Busidima drainages, at Dana Aoule North and in the Ounda Gona South area (Fig. 6.1).

At Busidima, one of the most important sites is BSN-12, located near the present bank of the Busidima River, about 700 m upstream from its confluence with the Asbole River. In most cases at Gona, archaeological sites (both Oldowan and early Acheulean) are located stratigraphically just above major conglomeratic layers (characterized by a fining-upward sequence), interpreted as axial paleo-Awash gravels (Type I/II gravel, see Quade et al. 2004). At BSN-12, Acheulean artifacts have been found associated with the Boolihinan Tuff, which may date to ~1.2 Ma (Quade et al. 2004). Typical Acheulean artifacts, including picks and handaxes, were collected from the surface at BSN-12. Although Oldowan-type cores/flakes were found buried within the tuff itself, none of the Acheulean handaxes have been recovered *in situ*, except for one pick pulled out of the BHT tuff itself. Several other specimens (of Oldowan character) were collected with the tuff actually adhering on the artifacts as matrix, which we refer to here as "in context" (see Table 6.1 for the composition of the BSN-12 and OGS-12 stone assemblages). The association of the BSN-12 Acheulean site with cobble conglomerates (Type I/II channel) indicates that the makers ranged close to the paleo-Awash river, where stone raw materials and possible food resources would have been plentiful. As shown in Table 6.1, a low density of materials, especially LCTs, was recovered at the site.

In the Ounda Gona South area, Acheulean sites, including OGS-12, were found associated with a small channel (Type II) feeding into the paleo-Awash. At OGS-12 the materials were deposited within and just above such a channel, with a tuff dated to 1.64 Ma situated a few meters stratigraphically below the site (Quade et al. 2004). The site is estimated to 1.6–1.5 Ma, and laboratory work is underway to resolve the age of OGS-12 and other early Acheulean sites at Gona. The OGS-12 stone tool assemblage (Table 6.1), which consists of large flakes and handaxes made mainly of trachyte, rhyolite, and basalt, was found above a small pebble channel fill.

Examples of some of the LCTs from OGS-12 are shown in Figs. 6.2 and 6.3. The reworked pedogenic carbonate nodules and the small size of the channel suggest a small drainage with Type II gravel, a habitat near a stream tributary to the Awash. The recovery of fossil fauna including crocodiles, freshwater clams, and marsh cane rat (*Thryonomys swinderianus*) suggests that the channel was perennial. The location of OGS-12 on a Type II channel indicates that early *Homo erectus* spent considerable time in habitats some

Table 6.1 Composition of the OGS-12 and BSN-12 early Acheulean stone artifact assemblages

	BSN-12		OGS-12	
	Surface	In context	Surface	In context
Handaxes	3	0	12	1
Picks	0	1	11	2
Cleavers	0	0	1	0
Cores/choppers	25	7	10	5
Discoids	5	0	0	0
Whole flakes	95	4	77	31
Broken flakes and Angular fragments	49	0	56	25
Modified flakes	0	0	4	4
Modified cobbles	0	3	3	7
Unmodified cobbles	0	3	0	1
Split cobbles	0	0	1	0
Hammerstones	0	0	2	1
Total	177	18	177	77

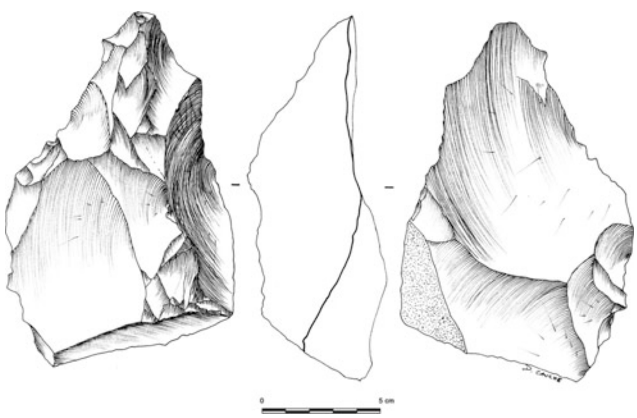

Fig. 6.2 An early Acheulean biface excavated from OGS-12

distance from the main paleo-Awash axial system. This contrasts with the settings for all of the earliest Oldowan sites at Gona dated to 2.6 Ma, which are associated with a Type I gravel interpreted as the paleo-Awash channel (Quade et al. 2004). Such different site distributions, i.e., proximity of the Oldowan sites next to or near the main paleo-Awash channel, and Acheulean occupations ranging close to but also away from the main axial river, was also a pattern documented at Koobi Fora in Kenya (Rogers et al. 1994). Interestingly, the OGS sites represent a geological context, with presence of permanent water in a tributary floodplain setting that is rare in the upper Busidima Formation. This may help explain the scarcity of archaeological materials in these younger deposits. Such isolated and

Fig. 6.3 Dorsal and ventral faces of a biface/handaxe (OGS-12-13) and a unifacial pick (OGS-12-63) collected from OGS-12, both made from side-struck flakes. The LCTs were recovered freshly eroding out of the excavation wall

localized perennial tributaries to the paleo-Awash with possible "wet and mixed open/closed" environments may have been the favored habitats for early *Homo erectus* at Gona. Several early Acheulean assemblages in the BSN and OGS drainages have been excavated, and research is in progress to refine the age of these sites and to precisely date these localities with both radiometric and non-radiometric dating techniques. Further, additional research is needed to understand better the habitat preferences of Acheulean toolmakers.

6.3.1 The BSN-12 and OGS-12 Stone Tool Assemblages

A total of 195 artifacts (177 surface and 18 "in context") from BSN-12, and a total of 254 (177 surface and 77 *in situ*) stone artifacts were recovered at OGS-12 (Table 6.1). Those referred to as "in context" from BSN-12 are artifacts recovered within the BHT or with the tuff adhering to the specimens as matrix; at OGS-12 the *in situ* artifacts were recovered from a small excavation (4 m × 3 m).

The metric and spatial data from both sites are still being analyzed, and only the assemblage compositions of the early Acheulean stone artifacts and raw material types used are discussed here. The main early Acheulean artifact types at both sites consist of crudely made handaxes, picks, and one cleaver (Tables 6.1, 6.2, 6.3, Figs. 6.2, 6.3). These are the emergent stone artifacts, the earliest of which are documented at 1.75 Ma at Konso and Kokiselei (Lepre et al. 2011; Beyene et al. 2013). Oldowan-type cores, whole and broken flakes, and fragments were recovered along with the Acheulean stone assemblages (Table 6.4). It is important here to note that the Acheulean did not replace the Oldowan; rather, Oldowan-type artifacts co-occurred with the early Acheulean, actually remaining ubiquitous throughout the Paleolithic (e.g., Clark et al. 1994). At the Busidima and Ounda Gona sites and elsewhere in East Africa, handaxes were made on large flake blanks (>12 cm) as well as on large cobbles. Picks (sometimes trihedral) were also made on both large flakes and cobbles.

A majority of the artifacts from BSN-12 and OGS-12 are worked on trachyte and rhyolite, with a substantial representation of basalt at OGS-12 (Tables 6.2, 6.3, 6.4, 6.5, 6.6). Whereas trachyte and rhyolite cobbles were easily accessible from the nearby cobble conglomerate associated with BSN-12, research is ongoing to trace the sources of the stone raw materials accessed by the OGS-12 toolmakers, some distance away. Our identification of the raw material types used for making the stone artifacts was conservative, but most of those included in the indeterminate category, particularly for the OGS-12 handaxes and picks (Tables 6.2, 6.3) were most likely basalt, also clearly reflected on the raw material composition of the cores/choppers, whole flakes,

Table 6.2 Stone Raw Materials, Handaxes, BSN-12, and OGS-12 (surface and "in context" combined)

	BSN-12	%	OGS-12	%
Trachyte	1	33.33	2	15.38
Rhyolite	1	33.33	2	15.38
Basalt	1	33.33	1	7.69
Vitreous volcanic	0	0.00	0	0.00
Other	0	0.00	2	15.38
Indeterminate	0	0.00	6	46.15
Total	3	100.00	13	100.00

Table 6.3 Stone Raw Materials, Picks, BSN-12, and OGS-12 (*Note* there were no picks recovered at BSN-12 from the surface)

	BSN-12				OGS-12	
	In context	%	Surface	%	In context	%
Trachyte	0	0.00	4	36.36	0	0.00
Rhyolite	0	0.00	2	18.18	0	0.00
Latite	0	0.00	0	0.00	0	0.00
Quartz latite	0	0.00	0	0.00	0	0.00
Aphanitic	0	0.00	1	9.09	0	0.00
Basalt	1	100.00	3	27.27	2	100.00
Vitreous volcanics	0	0.00	0	0.00	0	0.00
Other	0	0.00	0	0.00	0	0.00
Indeterminate	0	0.00	1	9.09	0	0.00
Total	1	100.00	11	100.00	2	100.00

Table 6.4 Stone Raw Materials, Cores/Choppers, BSN-12, and OGS-12

	BSN-12				OGS-12			
	Surface	%	In context	%	Surface	%	In context	%
Trachyte	11	44.00	0	0	2	20.00	2	40.00
Rhyolite	3	12.00	0	0	3	30.00	2	40.00
Latite	3	12.00	1	33.33	1	10.00	0	0.00
Quartz latite	0	0.00	0	0.00	1	10.00	1	20.00
Aphanitic	0	0.00	0	0.00	0	0.00	0	0.00
Basalt	5	20.00	0	0.00	3	30.00	0	0.00
Vitreous volcanics	3	12.00	1	33.33	0	0.00	0	0.00
Other	0	0.00	1	33.33	0	0.00	0	0.00
Indeterminate	0	0.00	0	0.00	0	0.00	0	0.00
Total	25	100.00	3	100.00	10	100.00	5	100.00

Table 6.5 Stone Raw Materials, Whole Flakes, BSN-12, and OGS-12

	BSN-12				OGS-12			
	Surface	%	In context	%	Surface	%	In context	%
Trachyte	38	40.00	0	0.00	9	11.69	10	32.26
Rhyolite	19	20.00	2	50.00	3	3.90	5	16.13
Latite	4	4.21	1	25.00	4	5.19	2	6.45
Quartz latite	0	0.00	0	0.00	0	0.00	1	3.23
Aphanitic	3	3.16	0	0.00	1	1.30	2	6.45
Basalt	18	18.95	1	25.00	53	68.83	10	32.26
Vitreous volcanics	3	3.16	0	0.00	0	0.00	0	0.00
Other	8	8.42	0	0.00	0	0.00	0	0.00
Indeterminate	2	2.11	0	0.00	7	9.09	1	3.23
Total	95	100.00	4	100.00	77	100.00	31	100.00

Table 6.6 Stone Raw Materials, Broken Flakes and Angular Fragments (*Note* there were no "in context" broken flakes and angular fragments recovered from BSN-12)

	BSN-12				OGS-12	
	Surface	%	In context	%	Surface	%
Trachyte	16	32.65	9	16.07	7	28.00
Rhyolite	4	8.16	2	3.57	3	12.00
Latite	3	6.12	2	3.57	0	0.00
Quartz latite	0	0.00	0	0.00	0	0.00
Aphanitic	0	0.00	3	5.36	4	16.00
Basalt	18	36.73	30	53.57	6	24.00
Vitreous volcanics	2	4.08	1	1.79	0	0.00
Other	5	10.20	0	0.00	0	0.00
Indeterminate	1	2.04	9	16.07	5	20.00
Total	49	100.00	56	100.00	25	100.00

and angular fragments recovered at the site (Tables 6.3, 6.4, 6.5, 6.6). Also interesting is the fact that the single pick pulled out of the BHT at BSN-12 was also worked on basalt.

Trachyte, rhyolite, and basalt were equally represented among the OGS-12 handaxes (Table 6.1). Remarkably, a large number of picks (~50% of the LCTs) were recovered at OGS-12, with only one cleaver collected at the site from the surface (Table 6.1). At BSN-12, a substantial number of cores/choppers (Table 6.4) as well as a piece identified as a polyhedron (Flaked Pieces of Isaac et al. 1981) were found "in context", i.e., recovered within the BHT or with the tuff adhering on the pieces as matrix. Trachyte, rhyolite, and basalt are well represented in both the BSN-12 and OGS-12 stone assemblages (Tables 6.3, 6.4, 6.5, 6.6), with more artifacts made of basalt identified at OGS-12. The Gona handaxes and cleavers appear to be equally worked on large cobbles as well as large flake blanks, although identifications of the original blanks for several of the specimens were difficult to determine.

6.3.2 Taphonomic Approach to OGS-12 Bone Assemblage

The fauna at BSN-12 includes numerous articulated fossils, suggesting that the Boolihinan ashfall may have led to their death. Further examination and analyses are in progress for this site. Here we present preliminary results from bone surface modification studies of the archaeofauna recovered in association with OGS-12. About 315 faunal remains (bone, teeth, and horn) have been recovered at OGS-12. The taphonomic and zooarchaeological analysis took into account the anatomical and taxonomic identification, grouping fossils by size and weight categories using the six classes provided by Bunn (1986). To assess the integrity of the assemblages, several quantification methods have been used: number of identified specimens (NISP), minimum number of elements (MNE), minimum number of individuals (MNI), and skeletal survival rate (%SSR) (Brain 1981). Fossils were analyzed microscopically to identify taphonomic bone modifications. The main bone alterations include anthropic activity (with evidence of cutmarks and bone breakage), carnivore tooth marks, and presence/absence of post-depositional modifications (manganese oxide, root etching, cracks, and cementation). Casts with silicone (Provil Novo Heraeus Light) and polyurethane resin (Feropur PR-55/E-55) have been made to analyze some modifications with scanning electron microscope (SEM Jeol-6400) and Hirox KH-8700 (Table 6.7).

The cutmarks identified were slicing marks. We took into account the location on bone surfaces, distributions, and orientations (Blumenschine et al. 1996; Lyman 2008; Domínguez-Rodrigo et al. 2009) to identify the activity of butchery processes carried out by hominins. Hominin-induced bone breakage has been identified by the presence and location of percussion pits (Blumenschine and Selvaggio 1988), percussion notches (Pickering and Egeland 2006), conchoidal scars, and bone flakes (Díez et al. 1999; Fernández-Jalvo et al. 1999). Carnivore tooth marks have been analyzed following the methodology established by several authors that consider the type of marks (pits, scores) and types of tissues (cancellous or cortical tissue) and their dimensions in maximum and minimum axis (Selvaggio and Wilder 2001; Domínguez-Rodrigo and Piqueras 2003; Delaney-Rivera et al. 2009; Andrés et al. 2012; Saladié et al. 2014).

The faunal assemblage is taxonomically dominated by Bovidae (40.3%) and unidentified fossils (50.8%). The remaining 8.9% comprise remains of Rodentia (3.5%), Crocodylidae (1.6%), Elephantidae (1%), Carnivora (1%),

Table 6.7 OGS-12 Faunal Assemblage NISP and MNE grouped by size, and weight categories following class size of animals established by Bunn (1986). [a]Crocodile, fish, and turtle remains are not included

NISP/(MNE)	Class 1 (MNI = 4)	Class 2 (MNI = 2)	Class 3 (MNI = 3)	Class 4 (MNI = 1)	Class 5 (MNI = 2)	Class 6 (MNI = 1)	Indeterminate	Total
Horn		1 (1)	2 (2)					3 (3)
Skull		1 (1)	2 (1)		2 (−)		3 (−)	8 (2)
Maxilla		2 (1)	1 (1)					3 (2)
Mandible	3 (3)	5 (3)	5 (5)		1 (1)		4 (−)	18 (12)
Hioides			1 (1)					1 (1)
Isolated teeth	3 (−)	3 (−)	8 (−)		4 (−)	1 (−)	18 (−)	37 (−)
Vertebra	2 (2)	12 (10)	5 (2)				15 (−)	34 (14)
Rib	2 (1)	10 (3)	3 (1)	1 (1)	1 (1)		12 (1)	29 (7)
Scapula		2 (2)						2 (2)
Humerus		1 (1)	1 (1)				1 (−)	3 (2)
Radius	1 (1)	3 (3)	3 (2)	1 (1)			1 (−)	9 (7)
Ulna		1 (1)	2 (2)				1 (−)	4 (3)
Carpal		1 (1)						1 (1)
Coxal	1 (1)							1 (1)
Femur		4 (3)	2 (2)					6 (5)
Tibia		6 (4)	1 (1)					7 (5)
Tarsal	7 (7)	5 (5)	2 (2)	1 (1)				15 (15)
Metapodial	3 (3)	5 (4)	4 (2)				1 (−)	13 (9)
Phalanx	4 (4)	11 (10)	3 (3)				2 (−)	20 (17)
Long bone	3 (−)	3 (−)		1 (−)			31 (−)	38 (−)
Indeterminate		1 (−)	2 (−)				52 (−)	55 (−)
Total	29 (22)	76 (53)	47 (28)	4 (3)	8 (2)	1 (−)	141 (−)	307[a] (108)

Rhinocerotidae (0.3%), Hippopotamidae (0.3%), Cercopithecidae (0.3%), Testudines (0.3%), and two fish remains (0.6%).

According to NISP (and MNE) (Table 6.7), most of the remains belong to small- and medium-size animals, with size Class 2 (24.4%), Class 3 (14.9%), and Class 1 (9.2%) comprising the majority of identifiable remains, in descending order of abundance and skeletal completeness. The large classes (4, 5 and 6) were rare, with the most abundant element being isolated teeth. The %SSR shows the incompleteness of the individuals recovered. In a general view, the small and medium classes (1, 2, and 3) have a high skeletal bias with low percentages. Thus, Class 1 has a %SSR of 4.4% similar to Class 3 (5.6%), while Class 2 has provided a higher value (10.4%).

Most of the skeletal elements belong to appendicular segments (37.5%) followed by cranial (24.1%) and axial (20.3%) elements. A majority of the appendicular remains are assigned to the lower limbs (metapodial, phalanx, carpal/tarsal) with a 15.6% of representation, while upper limbs (femur, humerus) and intermediate limbs (tibia, radius/ulna) show lower values, with 3.5% and 6.3%, respectively. The isolated teeth are the elements better represented on cranial segments.

In general, the bone assemblages were well-preserved and the main post-depositional modifications were manganese oxide pigmentations (74.6%), cracks (18.4%), cementations (12.3%), and chemical corrosion related to plant activity (4.1%). These modifications have allowed us to distinguish natural taphonomic damage from bone damage related to carnivore and hominin activities.

Carnivore tooth scores on cortical bone have been identified in two ribs and one long bone, and pits in cancellous bone in one indeterminate fragment. Six scores show dimensions for major axis (max = 3.52 mm; min = 1.55 mm; mean = 2.26 mm; s.d. = 0.73 mm) and minor axis (max = 0.82 mm; min = 0.17 mm; mean = 0.42 mm; s.d. = 0.24 mm) that suggest the intervention of a small carnivore. Only one pit was identified, which is insufficient to identify the carnivore responsible for the damage, but the dimensions (2.6 × 2.55 mm) suggest a small size.

Hominin activities have been identified in nine fossils (Fig. 6.4), six with cutmarks, and three bones showing evidence of intentional bone breakage. The cutmarks are slicing marks and are characterized by linear striae with V-shaped cross-section and internal microstriations. The fossils with cutmarks belong to small bovids (Class 2) and indeterminate fragments: one mandible with an isolated and transversal slicing mark on the ascending ramus; one vertebra with two cutmarks with transversal and oblique orientation concentrated close to the caudal articular process; one rib with two oblique marks concentrated on the ventral face; one mid-shaft tibia fragment with an isolated transversal mark on the diaphysis; and finally two indeterminate long bones with oblique marks concentrated on the mid-shaft.

The evidence of hominin marrow exploitation was identified by the presence of percussion pits on long bone

Fig. 6.4 Bones with cutmarks from OGS-12

fragments of Class 4-sized animals, one bone flake and a radial element of a Class 2 animal with medullary extraction. The evidence for hominin exploitation of meat may be limited, but this study has identified numerous activities related to butchery. Carcass-processing activities identified at OGS-12 include: evisceration, disarticulation, defleshing, and marrow exploitation. Evisceration has been identified through cutmarks identified on small bovid ribs. The location of marks on the ventral side of bones relates unequivocally to the consumption of viscera (Nilssen 2000). The marks on vertebrae, mandible, and limb bones, mainly on small bovids (Class 2), clearly indicate disarticulation and defleshing activities.

The evidence from OGS-12 suggests that hominins exploited animal resources from all skeletal segments (skull, trunk, and limbs). Furthermore, the cutmarks identified suggest that hominins had early access to prey at least on small bovids. Considering that viscera are among the first portions consumed by carnivores, they must have been consumed at an early stage (Domínguez-Rodrigo et al. 2005). Moreover, the location of marks in mid-shafts of limb bones is probably related to the butchery of fully fleshed bones, and as a result, also implies early access to carcasses (Bunn 1986, 2001; Domínguez-Rodrigo and Pickering 2003; Pickering and Domínguez-Rodrigo 2006; Pickering and Egeland 2009; Sahnouni et al. 2013a, b).

The intentional bone breakages for marrow exploitations have been identified only in animals belonging to size Classes 3 and 4. In these medium and large ungulates no cutmarks have been identified. Breakage marks on the bones were scarce, and thus did not provide adequate understating of the role of marrow consumption for these hominins. Since no carnivore tooth marks have been observed in these carcasses, we can suggest that carnivores were not involved in large animal acquisition and we can point out that hominins occasionally could have had access to large animal carcasses.

6.4 Issues Pertaining to the Earliest Acheulean

The nature of the archaeological transition from the Oldowan to the Acheulean—e.g., either gradual or abrupt—is still among the least understood issues in early Paleolithic studies. Some suggest the inception of the Acheulean could be traced back to the beginning of discoidal/spherical shaping documented ~1.9–1.8 Ma (Roche et al. 2009). Although few in number, some of the exhaustively worked cores made of fine-grained raw materials (e.g., vitreous volcanics) at Gona (2.6 Ma) could be identified as discoids, throwing some doubt on such a possibility. For example, a majority of the specimens identified as discoids and spheroids at Olduvai and at Aïn Hanech were made of quartz/quartzite, and experimental work has shown that with continuous flaking and use as a hammerstone, quartz/quartzite angular pieces tend to attain a rounded shape (Schick and Toth 1994; Sahnouni et al. 1997). Therefore, further experimental work is needed to determine the impact of raw materials on Mode I artifact forms for understanding whether any such relationship could have been possible between discoidal/spherical shaping and the emergence of the Acheulean. Isaac (1969) proposed that the emergence of the Acheulean was abrupt, and this remains a probable interpretation of current evidence, and we believe that such a rapid transition was likely. Such a conclusion, however, should await further field and laboratory investigations. Among the questions currently being investigated at Gona are issues related to understanding the nature and characteristics of the technological transition from the Oldowan to the Acheulean industry in Africa.

The remarkable number of fossil hominins dated to 1.8 Ma discovered in the Caucasus in Georgia were initially assigned to *H. ergaster/erectus* and recently to *Homo e. e. georgicus* (Lordkipanidze et al. 2013, and references therein). The artifacts associated with the Dmanisi hominins are simple core/flake Mode I (Ferring et al. 2011; Mgeladze et al. 2011), and the evidence for the arrival of early *H. erectus* in the Caucasus is broadly contemporaneous with the earliest Acheulean in Africa. Thus, the Acheulean provided no adaptive role in the expansion of early *Homo* out of Africa, contrary to earlier views on the initial hominin expansion outside Africa.

6.5 Discussion

Regarding the co-occurrence of Oldowan-type cores/flakes with Acheulean tool types, Lepre et al. (2011) hypothesize that different hominin groups may have been engaged in different tool activities. According to Beyene et al. (2013) the same early *Homo* species responsible for the early Acheulean could have also made and used Oldowan-type artifacts, which seems a plausible scenario. Oldowan-type cores/flakes co-occurred with the Acheulean, and actually persisted throughout the Paleolithic in the form of “expedient tools”. The Acheulean LCTs are the new emergent tools, while Oldowan-type artifacts remain ubiquitous throughout the Paleolithic (e.g., Clark et al. 1994). As suggested by Beyene et al. (2013), the Acheulean represents an advanced stone industry, with LCTs utilized for new activities or created for providing a more efficient exploitation of the same activities in which early hominins engaged. The role that Mode 1 cores and flakes had within the Acheulean toolkit, and therefore the technological distinction between Oldowan and Acheulean, will be much better understood once the functions of the various stone tools are determined.

The rare small carnivore activity and the absence of damage related to large carnivores within the OGS-12 faunal assemblage suggests that carnivores had minor impact on the OGS-12 assemblages. We can suggest that hominin-carnivore competition for animal resources was rare or null, at least at this site. As some authors have suggested (e.g., Domínguez-Rodrigo et al. 2007; Pickering and Egeland 2009), hominins from 1.8 Ma were successful with regard to acquisition and processing of animal carcasses, indicating early and regular access to animal resources. OGS-12 shows that hominins around 1.6–1.5 Ma may have had greater cognitive and/or social capacities for accessing meat resources. The Acheulean technology also likely provided hominins the capabilities needed to gain an advantage over other predators for obtaining animal resources.

Compared to the Oldowan, the Acheulean is technologically advanced showing greater hierarchical planning depth and skilled execution of stone crafting (e.g., Stout 2011). The Oldowan is a core/flake tradition created by using the hand-held, direct percussion/bipolar stone working techniques for creating sharp-edged cutting flakes, primarily used for processing animal carcasses. In contrast, the making of the Acheulean demands increased motor skills and cognitive control for executing complex operational sequences involving knocking off large blanks (>12 cm, from our observations) from giant cores or large cobbles and then purposefully shaping these into handaxes with preconceived form (Sharon 2008; Stout et al. 2008, 2015; Stout 2011; Sahnouni et al. 2013a, b). This added complexity would have been associated with increased learning challenges, potentially implicating enhanced self-control for deliberate practice (Stout 2011) and more robust social support for learners (Stout 2002), possibly including intentional teaching (Morgan et al. 2015). This in turn could have important implications for the coevolution of language and technology (Morgan et al. 2015), as well as more direct influences on brain evolution through phenotypic accommodation (the "Baldwin effect"; Hecht et al. 2014). Our ongoing studies at Gona have great potential for answering some of the pressing questions on the mode and tempo of the transition from the Oldowan to the Acheulean, the paleoecological background for the emergence of the Acheulean, and its adaptive role in hominin lifeways.

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