*Journal of Archaeological Science* (2000) **27,** 1197–1214
doi:10.1006/jasc.1999.0592, available online at http://www.idealibrary.com on IDEAL®

# The World's Oldest Stone Artefacts from Gona, Ethiopia: Their Implications for Understanding Stone Technology and Patterns of Human Evolution Between 2·6–1·5 Million Years Ago

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(*Received 3 February 2000, revised manuscript accepted 11 May 2000*)

The systematic archaeological and geological survey and excavations at Gona between 1992–1994 led to the discovery of well-flaked stone artefacts which are currently the oldest known from anywhere in the world. More than 3000 surface and excavated artefacts were recovered at 15 localities documented east and west of the Kada Gona river. Based on radioisotopic dating ($^{40}Ar/^{39}Ar$) and magnetostratigraphy, the artefacts are dated between 2·6–2·5 million years ago (Ma). EG10 and EG12 from East Gona are the most informative with the highest density, providing the best opportunity for characterizing the oldest assemblages and for understanding the stone working capability of the earliest tool makers. Slightly younger artefact occurrences dated to 2·4–2·3 Ma are known from Hadar and Omo in Ethiopia, and from Lokalalei in Kenya. Cut-marked bones dated to 2·5 Ma from Bouri in Ethiopia are now providing important clues on the function of these artefacts. In addition, *Australopithecus garhi* known from contemporary deposits at Bouri may be the best candidate responsible for the oldest artefacts. Surprisingly, the makers of the Gona artefacts had a sophisticated understanding of stone fracture mechanics and control similar to what is observed for Oldowan assemblages dated between 2·0–1·5 Ma. This observation was corroborated by the recent archaeological discoveries made at Lokalalei. Because of the similarities seen in the techniques of artefact manufacture during the Late Pliocene–Early Pleistocene, it is argued here that the stone assemblages dated between 2·6–1·5 Ma group into the Oldowan Industry. The similarity and simplicity of the artefacts from this time interval suggests a technological stasis in the Oldowan. 

*Keywords:* GONA, OLDEST ARTEFACTS, EARLY PALAEOLITHIC, EARLY HOMINIDS, OLDOWAN, "PRE-OLDOWAN".

## Introduction

The results of the intensive archaeological survey, and systematic excavations between 1992–1994 have firmly established the significance of Gona for understanding the timing and context of the beginning of early stone technology (Semaw *et al*., 1997). The surface and excavated artefacts within the deposits exposed east of the Kada Gona below the level of a tuff named AST-2·75 are now firmly dated close to 2·6 million years ago (Ma) by a combination of Single Crystal Laser Fusion (SCLF) $^{40}Ar/^{39}Ar$ dating and magnetostratigraphy. These are currently the oldest known Late Pliocene stone artefacts, and by definition they are representatives of the earliest archaeology.

The two East Gona localities of EG10 and EG12 yielded close to 3000 surface and excavated artefacts providing the first large data set for analysing the composition and characteristics of the earliest stone assemblages, and for understanding the knapping skills of Late Pliocene hominids. Recent field research from the nearby contemporary deposits at Bouri in the Middle Awash has brought insights to the function of these artefacts by yielding evidence of bones with stone-tool cut-marks and hammerstone fractures dated to 2·5 Ma (de Heinzelin *et al*., 1999). It was argued for a long time that the appearance of flaked stones in the archaeological record signalled the beginning of a novel adaptation by Late Pliocene hominids with the incorporation of substantial meat in their diet (Harris, 1983; Pickford, 1990; Vrba, 1990). Thus, the two contemporary sites of Gona and Bouri are now shedding light on this issue by yielding complementary evidence, the former with abundant stone artefacts and the latter with evidence of use of such artefacts in butchery activities. An important addition from Bouri is also the discovery of *Australopithecus garhi*, the new hominid argued to be the species responsible for making the earliest stone tools (Asfaw *et al*., 1999). A handful of slightly younger Late Pliocene archaeological sites dated between 2·4–2·3 Ma are known from the nearby Hadar, in the Afar region of Ethiopia (Kimbel *et al*., 1996), Member F of the Shungura Formation in the Omo, from southern Ethiopia (Chavaillon, 1976; Merrick, 1976; Howell *et al*., 1987), and the Lokalalei



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sites of West Turkana, from northern Kenya (Roche, 1989, 1996; Kibunjia *et al.*, 1992; Kibunjia, 1994; Roche *et al.*, 1999).

The most informative Plio-Pleistocene archaeological sites in East Africa, providing major evidence for stone technology and the behavioural repertoire of Oldowan hominids between 2·0–1·5 Ma, are Olduvai Gorge from Tanzania (Leakey, 1971) and Koobi Fora from northern Kenya (Isaac & Harris, 1997). There are a large number of additional archaeological sites in this time period in the eastern, northern and southern parts of Africa. The archaeological sites from east Africa include Melka Kontoure, Middle Awash, Gadeb and Fejej from Ethiopia (Chavaillon *et al.*, 1979; Clark & Kurashina, 1979; Clark *et al.*, 1984, 1994; Asfaw *et al.*, 1992) and Chesowanja from Kenya (Gowlett *et al.*, 1981). Well-known sites of this interval with "pebble tools" (*galet aménagé*) from north Africa are Sidi Abderrahman from the Casablanca sequence in Morocco (Biberson, 1961; Clark, 1992) and Ain Hanech from Algeria (Balout, 1955; Sahnouni & de Heinzelin, 1998). Oldowan sites from the southern parts of the continent include Swartkrans Members 1 and 2 (Brain *et al.*, 1988), Sterkfontein Member 5 (Kuman, 1994*a*, 1994*b*) and Kromdraai (Kuman *et al.*, 1997). The ages of the sites from the northern and southern parts of Africa were estimated mainly based on magnetostratigraphy and faunal correlations with the East African sites, particularly with the faunal sequence documented from the well-dated Shungura sequence in the Omo.

The main artefact types found in all of the archaeological sites dated between 2·6–1·5 Ma are cores, whole and broken flakes, angular and core fragments, a small number of retouched pieces and in some instances unmodified stones transported to sites. The two basic Oldowan flaking techniques used were the hand-held percussion (for example on the volcanic rocks found at Gona and Lokalalei), and the bipolar flaking technique (the primary mode of stone working utilized on quartz, for example, at Omo). The 1·89 Ma "KBS Industry" from East Turkana has stone assemblages typical of the Oldowan. The absence of retouched pieces and spheroids/subspheroids was the criteria used for distinguishing the KBS (Isaac, 1976). Assemblages with a greater variety of artefact types including spheroids and retouched pieces become dominant later *c.* 1·5 Ma with the so-called "Developed Oldowan". A few instances of probable retouched pieces were encountered at Gona, and there were some specimens identified into this category at Lokalalei 2C. The most distinctive of all the assemblages are the Karari scrapers from Koobi Fora dated to *c.* 1·6–1·5 Ma. These may be standardized cores probably made from split cobbles or large thick flakes (Harris, 1978).

The stone assemblages dated between 2·6–1·5 Ma conveniently group into the Oldowan Industry (*sensu* Leakey, 1971) because of similarities in the composition and simplicity of the artefacts, and in the knapping techniques practiced by the hominids. The Oldowan lasted for over 1 million years with little or no technological change and it was later replaced by an advanced stone working tradition—the Acheulian *c.* 1·5 Ma in Africa (Isaac & Curtis, 1974; Gowlett, 1988; Asfaw *et al.*, 1992; Clark, 1994). A technological stasis for the Oldowan tradition is suggested because of its long persistency in the archaeological record (Semaw *et al.*, 1997).

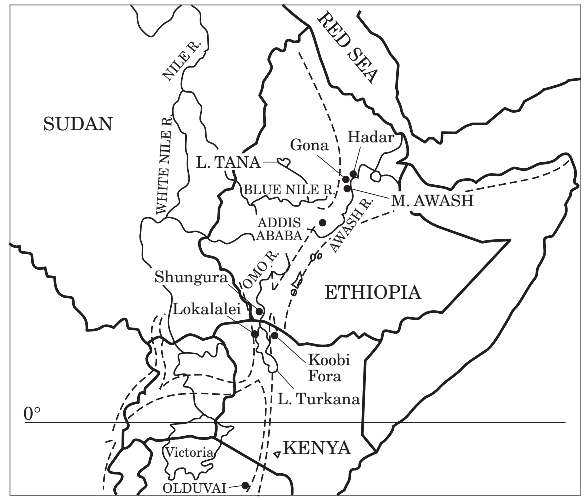

Figure 1. A map showing Gona and Late Pliocene sites dated between 2·4–2·3 Ma.

## The Gona Study Area

The Gona Palaeoanthropological Research Project (GPRP) study area is located in the west-central Afar region of Ethiopia and it encompasses more than 500 km$^2$ area with artefact- and fossil-rich Plio-Pleistocene sediments (Figure 1). The study area is bounded to the east by the Hadar study area, to the north by the Mile-Bati Road, to the south by the Asbole River and to the west by the Western Ethiopian Escarpment. The major rivers within the study area, including the Kada Gona, the Ounda Gona, the Busidima and the Asbole, and associated small feeding streams, drain the surrounding areas flowing seasonally into the Awash River. A wealth of stone artefacts and fossil fauna are currently being exposed by these drainages.

More than 40 m of sediments are exposed along the Kada Gona drainage, with at least two artefact-bearing horizons documented in the time interval between 2·6–2·0 Ma. The deposits contain clays and silts, tuffaceous marker horizons and cobble conglomerates, which are prominent in the sections exposed within the Kada Gona and surrounding drainages. Erosion is rapid at Gona because of the high relief badlands topography, and artefacts and fauna are exposed by torrential rains and rapidly washed into modern drainages.

## Previous Field Research at Gona

The palaeoanthropological significance of much of the central Afar rift, including what are now recognized as the Gona, the Hadar and the Middle Awash study areas was first noticed in the late 1960s by Maurice Taieb while conducting a geological survey in the Awash river basin (Taieb, 1974 in Clark *et al*., 1984). More preliminary geological survey of the general area was later undertaken by Kalb (1993 and references therein). The presence of stone artefacts of great antiquity at Gona was known since the early 1970s, but the archaeology and geology of the area received only cursory attention while a wealth of remarkable fossil hominids of *Australopithecus afarensis* were being discovered from the contiguous Hadar deposits (Johanson *et al*., 1978, 1982)

The initial archaeological survey of the early 1970s led to the discovery of a low density scatter of surface artefacts east of the Kada Gona (Corvinus, 1976; Corvinus & Roche 1976, 1980; Roche & Tiercelin, 1977, 1980). The first archaeological locality was named Afaredo 1, and three further localities named Kada Gona 2, 3, and 4 were documented between two conglomerates identified east of the Kada Gona river. The artefacts were estimated to 2·5 Ma based on the age of the BKT-2 tuff from the Kada Hadar Member of the Hadar Formation then thought to correlate with the tuff found underlying the artefact horizon (Roche & Tiercelin, 1977, 1980). Subsequent field research by Harris (1983) in the area west of the Kada Gona resulted in the discovery of a low density of *in situ* artefacts from a small excavation opened at West Gona locality 1 (WG1 for short). There were no archaeological field studies undertaken in Ethiopia during much of the 1980s, and the first Gona field permit was issued in 1987. Two additional Oldowan localities (WG2 and WG3) were documented at West Gona during the brief survey undertaken that year (Harris & Semaw, 1989).

The first round of systematic archaeological and geological fieldwork at Gona was initiated between 1992–1994. The main objectives were to assess the palaeoanthropological potential of the general study area and to firmly resolve the age of the Kada Gona artefacts. Variable densities of surface and *in situ* artefacts were found from 12 new localities distributed east and west of the Kada Gona river (Figure 2(a)). The highest density and the most informative assemblages were those recovered from EG10 and EG12. Details of the results of this research, including the age of the artefacts and their archaeological significance, and their implications for understanding the behavioural evolution of Late Pliocene hominids, are presented here. Further intensive field and laboratory research is necessary to fully understand the geology, archaeology and palaeontology of the entire GPRP study area, and long-term systematic field studies are now under way by a large multidisciplinary team organized in 1999. The results of the new round of field and laboratory research at Gona will be reported in future publications.

## Stratigraphy

The GPRP study area lies within the sedimentary exposures of the Awash River basin. The Plio-Pleistocene Gona deposits are being dissected by the main rivers and their small tributaries which are currently exposing ancient sediments with extremely rich artefacts and fossil fauna. Following a preliminary geological survey of the Afar region, Kalb (1993) assigned the Gona sequence as "unconformable post-Hadar deposits" comparable in age to the Upper Pliocene Matabeitu Formation of the Middle Awash. Subsequent geological studies placed the Gona stratigraphy within the upper part of the Kada Hadar Member of the Hadar Formation (Taieb *et al*., 1976; Aronson *et al*., 1977, 1981; Semaw *et al*., 1997). However, the upper boundary of the Kada Hadar Member is still poorly studied, and its relationship to the Gona stratigraphy is uncertain.

Initially, three major Cobble Conglomerates and four tuffaceous marker horizons were recognized in the stratigraphic sequence exposed at Kada Gona (Roche & Tiercelin, 1977, 1980). Afaredo 1 was stratigraphically placed higher up in the section and Kada Gona 2, 3 and 4 were placed between the two conglomerates labelled as the Intermediate Cobble Conglomerate (*Conglomérat Intermédiaire*) and the Upper Cobble Conglomerate (*Conglomérat Supérieur*). The four marker tuffs from the oldest to the youngest were marked as ashes I–IV (*Cinérites* I–IV) and later three of these tuffs were relabelled by Walter (1980) as Artefact Site Tuffs 1–3 (AST-1, -2 and -3). The Kada Gona artefacts were stratified above the AST-2 tephra (Figure 2(b)). Unfortunately, the three tuffs were contaminated for K/Ar (or SCLF $^{40}Ar/^{39}Ar$) dating and have not yet yielded absolute ages for the artefacts. Geologist Craig Feibel (now at Rutgers University) was invited to work at Gona, and the first systematic and concentrated geological studies carried out between 1993–1994 provided a better resolution in terms of stratigraphic details and tephra chronology for the artefact localities found east of the Kada Gona (Semaw *et al*., 1997; Feibel & Wynn, no date).

The Kada Gona stratigraphic sequence can be separated into three intervals. At the base of the sequence are the lacustrine sediments with mollusc layers, a Green Marker Tuff, (a possible equivalent of the BKT-2$L_1$ of Hadar well-exposed near EG10), and an overlying tuff which may be a possible chemical correlate of the BKT-2L of Hadar. Above these are the

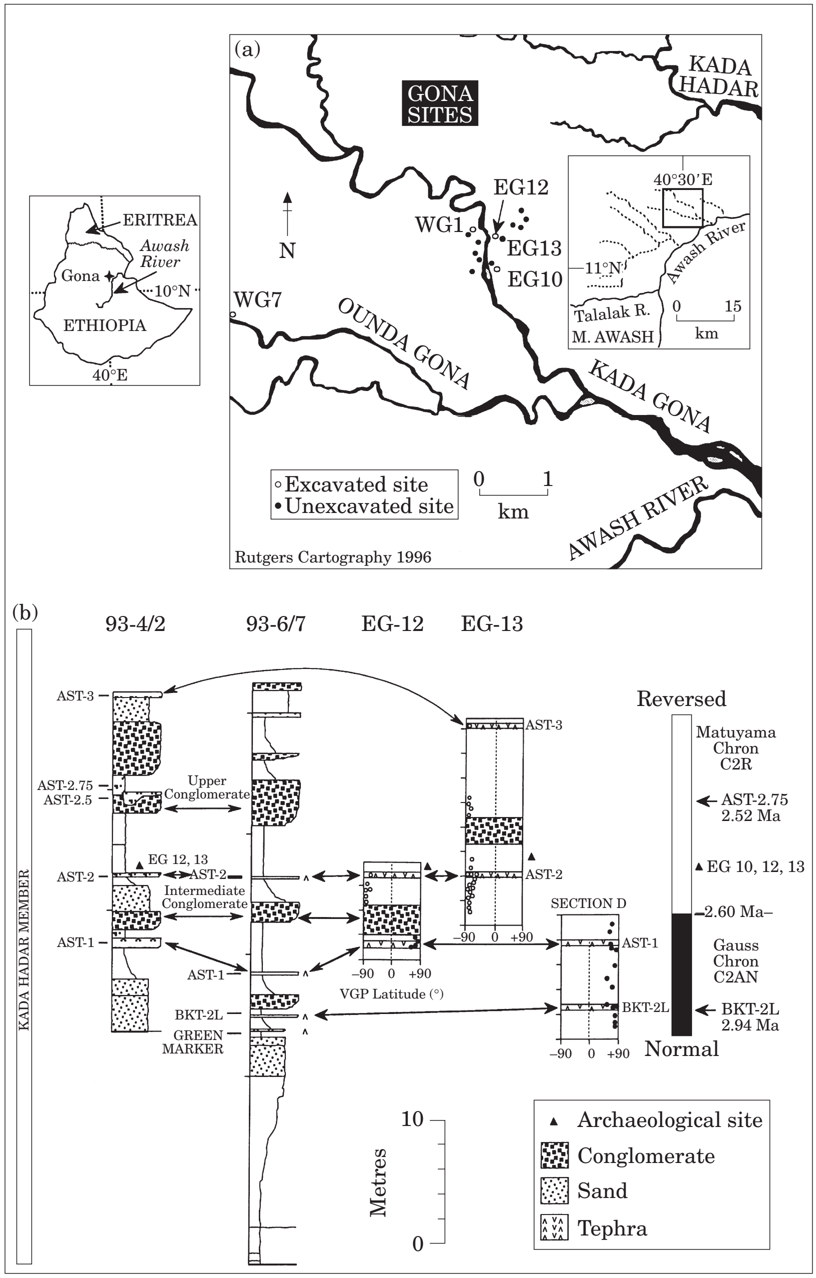


Figure 2. (a) A map showing the excavated and surface-sampled Kada Gona localities. The excavated localities are shown with open circles. (b) Stratigraphy of the Kada Gona sites. Lithostratigraphy and markers from East Gona. The composite sections (93–4/2 and 93–6/7) are correlated with the magnetostratigraphy of EG12 and EG13. Stratigraphic markers are indicated next to the columns and correlations shown with solid lines. Normal polarity is indicated by filled circles, and reversed polarity by open circles. Absolute dates are provided with units of the magnetic polarity timescale (MPTS) on the right (Figure after Semaw *et al*., 1997).

six fluvial cycles with the three major conglomerates (and three additional less prominent ones), and the artefact-bearing layers containing the oldest artefacts and the interbedded marker tuffs (labelled from bottom to top as AST-1, -2, -2·5, -2·75 and AST-3). Uppermost in the sequence at East Gona are the capping strata characterized by fine-grained sediments and consolidated sand layers. The two new tuffs named AST-2·5 and AST-2·75 were identified in 1993 in the stratigraphic sequence exposed near EG10 and EG12. The AST-2·75 (discussed below) proved to be significant for absolute age determinations of the two excavated localities. The oldest Gona artefacts are exposed stratigraphically below the AST-2·75 and above the AST-2 tuffs. Slightly younger artefact occurrences, estimated to be *c*. 2·0 Ma are widely distributed within the capping strata. AST-2 is the only marker thus far identified west of the Kada Gona, and it is found variably exposed below the artefact occurrences documented there.

## Dating

Attempts were made earlier to tie the Gona AST tuffs to the three Bouroukie Tuffs (BKT-1, -2 and -3) identified within the Kada Hadar Member (Aronson *et al*., 1977). Initial age estimates for the Gona artefacts were made based on the age of the Hadar BKT-2 tuff. The age of the BKT-2 tuff was problematic because of several revised dates that ranged between 2·65–3·14 Ma, implying the approximate age of the artefacts to be anywhere between 2·5–3·0 Ma (Aronson *et al*., 1977, 1980, 1981; Walter, 1980; Walter & Aronson, 1982; Hall *et al*., 1985). Correlation and dating efforts were further complicated because the BKT-2 tuffs are exposed as duplets and triplets named BKT-2u, BKT-2L and BKT-$2L_1$ (Walter, 1980). The Gona AST-1 and -2 tuffs were suggested to be equivalent to the Hadar BKT-2L and BKT-2u tuffs, respectively (Walter, 1980; Tiercelin, 1986). Because of the wide margin of the dates for the BKT-2, the Gona artefacts were loosely and conservatively estimated to *c*. 2·5 Ma with no firm dates (Harris, 1983). Because of the lack of absolute dates for the Gona deposits, the 2·5 Ma age suggested for the artefacts was received with caution (for example, Isaac, 1984; Toth & Schick, 1986; Kibunjia, 1994). Therefore, resolving the age of the Gona deposits was among the major priorities of the field research undertaken during the early 1990s.

The plagioclase-phyric bentonite AST-2·75 tuff identified above the AST-2 marker at East Gona played a critical role in determining the age for the two excavated localities of EG10 and EG12 (Figure 2(b)). Volcanic crystals from AST-2·75 were dated by $^{40}Ar/^{39}Ar$ to 2·517+0·075. This tuff is stratigraphically placed *c*. 5 m above EG10 and EG12 (and directly above locality EG13), providing a minimum age of 2·52 Ma for the oldest Gona artefacts. A detailed palaeomagnetic analysis of the sediments sampled in 1993 from the stratigraphic sections exposed at the surface and excavated East Gona localities revealed that the 2·6 Ma Gauss-Matuyama polarity transition (McDougall *et al*., 1992) occurred within the Intermediate Cobble Conglomerate, which is stratigraphically located just below the artefact horizon and the AST-2 marker tuff. Therefore, the palaeomagnetic analysis gave a maximum age for the EG10 and EG12 artefacts, also corroborating the minimum 2·52 Ma $^{40}Ar/^{39}Ar$ date obtained for the AST-2·75 (Semaw *et al*., 1997). Stratigraphically, the artefacts are actually closer to the reversed magnetozone identified as the lowermost Matuyama chron (2·6 Ma). An $^{40}Ar/^{39}Ar$ analysis of the unnamed tuff (a possible chemical correlate of the Hadar BKT-2L), sampled from the base of the Kada Gona sequence stratigraphically below EG10, yielded an age of 2·940+0·006 Ma (Semaw *et al*., 1997). This date is consistent with the 2·95 Ma $^{40}Ar/^{39}Ar$ age reported for the main BKT-2L from the Kada Hadar Member (Kimbel *et al*., 1994; Walter, 1994). In addition, the BKT-2u from Hadar was dated to 2·92 Ma. The older date for the tuff sampled below EG10 is consistent with the stratigraphy of the Kada Gona sequence. The stratigraphic relationships between the Gona and Hadar deposits have yet to be resolved. The 1992–1994 research has shown that except for the possibility of the BKT-$2L_1$ and BKT-2L, there appears to be no apparent lithochronological or geochemical correlations between the AST Kada Gona tuffs and the BKT Hadar tuffs (Semaw *et al*., 1997).

## The Gona Artefact Localities

A total of 12 new archaeological localities were identified at East and West Gona between 1992–1994. These are in addition to the previous Afaredo 1, Kada Gona 2, 3 and 4 localities of Roche and Tiercelin (1977, 1980), the WG1 locality discovered by Harris (1983), and the West Gona localities of Harris & Semaw (1989). During the 1992 survey, hundreds of stone artefacts were found eroding down steep slopes at EG10 and EG12, and the high density of the artefacts and their very fresh nature indicated that the materials had been exposed from the overlying sediments very recently. The surface artefacts exposed at EG10 and EG12 consisted of cores, flakes and a large number of smaller size angular fragments indicating a high probability of recovering undisturbed primary context assemblages through further excavations. Nearly 3000 artefacts were recovered from surface and systematic excavations carried out at the two localities (Table 1). Additional artefact concentrations were documented at several localities distributed within laterally extensive deposits traced above the AST-2 tephra. Surface occurrences with cores, flakes and angular fragments were sampled at several localities from the east and west sides of the Kada Gona. Most of the archaeological localities exposed on the east side of the Kada Gona were clearly associated with the AST-2 marker tuff and the Intermediate Cobble Conglomerate. Therefore, they are the same age as EG10 and EG12. Further detailed geological work is necessary to determine the age of the archaeological localities exposed within the capping strata. Localities WG1 and WG7 are the only excavated assemblages from west of the Kada Gona. WG7 was the furthest Oldowan locality documented at the time from the Ounda Gona, and its stratigraphic relationship to EG10 and EG12 needs further investigation.

*Table 1. Composition and % of artefact types, the 2·5 Ma Gona and Late Pliocene archaeological sites dated to 2.3–2·4 Ma*

| | East Gona | | | | West Turkana | | | | Omo | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | EG10 | | EG12 | | Lokalalei 1 | | Lokalalei 2C | | FtJi1 | | FtJi2 | | FtJi5 | | Omo 57 | | Omo123 | |
| Artefact category | Exc. | Surf. | Exc. | Surf. | Exc. | Surf. | Exc. | Surf. | Exc. | Surf. | Exc. | Surf. | Exc. | Surf. | Exc. | Surf. | Exc. | Surf. |
| Cores | 0·97 | 2·40 | 0·97 | 2·03 | 11·99 | 6·12 | 2·61 | 2·91 | 0·26 | | | | | 3·90 | | 3·68 | 1·56 | 2·37 |
| Whole flakes | 17·82 | 24·44 | 30·42 | 33·11 | 17·51 | 12·24 | 16·88 | 27·71 | 4·50 | 7·00 | 1·35 | 4·60 | 4·20 | 7·80 | 23·34 | 25·15 | 38·86 | 34·12 |
| Flake fragments | 6·13 | 7·65 | 12·62 | 11·71 | 55·63 | 81·64 | 57·14 | 55·62 | 2·10 | 11·10 | 1·79 | 10·80 | | 1·30 | | | | |
| Angular fragments | 73·53 | 63·27 | 54·05 | 50·90 | 11·99 | | 16·06 | 12·02 | 93·30 | 81·85 | 96·90 | 84·60 | 95·80 | 87·00 | 70·00 | 65·03 | 56·45 | 56·31 |
| Retouched pieces | | | | | | | 0·44 | 0·78 | | | | | | | | | | |
| Piece* | | | | | | | | | | | | | | | 6·66 | 9·81 | 0·26 | 0·30 |
| Core fragments | 1·55 | 2·25 | 1·62 | 2·25 | | | 0·44 | 0·19 | | | | | | | 6·66 | 6·14 | 2·35 | 6·90 |
| Hammerstones | | | | | | | 0·82 | | | | | | | | | | | |
| Modified pebbles | | | | | 2·88 | | 3·34 | 0·78 | | | | | | | | | | |
| Unmodified pieces | | | 0·32 | | | | 2·27 | | | | | | | | | | | |
| Total number of artefacts | 1549 | 667 | 309 | 444 | 417 | 49 | 2067 | 516 | 375 | 270 | 223 | 130 | 24 | 77 | 30 | 193 | 767 | 1014 |

Exc. = Excavated, Surf. = Surface artefacts.
*The meaning of this category is not clear, and exists only in the inventory of Chavaillon (1976) (in Howell *et al.*, 1987).
Source for the Omo artefacts, Howell *et al.* (1987: p. 679).
Source for Lokalalei 2C, Roche *et al.* (1999: p. 59). Broken flakes and small flakes are included together, all the core categories are included together, and broken cores are listed as core fragments. Worked pebbles and broken pebbles are included together. Unmodified pebbles are listed under Unmodified pieces.
Source for Lokalalei 1, Kibunjia (1994: p. 164). Artefacts from both the 1987 and 1991 excavations are included together.
Data not yet available for Hadar.

Figure 3. A photo showing the EG10 excavation and the Kada Gona River.

## The Two Excavated Localities of EG10 and EG12

*East Gona 10 (EG10)*

A high density of fresh stone artefacts were found eroding down in the section exposed east of the Kada Gona approximately 5–7 km upstream from its confluence with the Awash river. Locality EG10 and the Kada Gona river are shown in Figure 3. The artefacts consisted of cores, whole and broken flakes and a high density of angular fragments. The volcanic tuffs including the Green Marker, the unnamed tuff (the possible equivalent of the BKT-2L from Hadar), the AST-1, and -2, and the Lower and the Intermediate Cobble Conglomerates are well exposed in the section (Figure 2(b)). An area of 38 $m^2$ was gridded at EG10 following the edge of the outcrops and 1549 artefacts were collected from the surface and surface scrapes. A total of 667 artefacts were excavated from an area of 13 $m^2$ (9+3 $m^2$ extensions added to the north and 1 $m^2$ to the southeast). The horizontal and vertical distribution of the excavated artefacts are shown in Figure 4. There were no fossilized bones retrieved from the excavations. The sediments were fine-grained with well consolidated brown clay and glass shards from the altered AST-2 tephra chemically identified within and below the artefact levels. There were two artefact levels at EG10 separated by 40 cm thick deposits. The artefacts from both levels were restricted within 10 cm thick layers each suggesting minimal or no vertical displacement after discard. In addition, the fresh nature of the artefacts, and the absence of discernible size sorting indicated a primary geological context. The presence of two horizontally discrete artefact levels may hint at repeated occupation at this locality which may be a result of its close proximity to raw material sources and water. The excavation was extended into a geological trench towards the north down to the level of the Intermediate Cobble Conglomerate, but there were no artefacts recovered from the underlying sediments. The fact that the artefact density is high in the south and southeast portion of the excavated area, and the presence of artefacts still eroding down the slope some 100 m to the south suggests that there may still be a high density of artefacts buried under the overburden.

*East Gona 12 (EG12)*

This locality is found in the Aybayto Dora stream, a small drainage feeding into Kada Gona from the east. EG12 is located *c*. 300 m north of the EG10 excavation and *c*. 100 m west of locality EG13. The two localities of EG12 and EG13 hold similar stratigraphic positions. All the volcanic marker tuffs and Cobble Conglomerates found in the section exposed at EG10 are also present here. The AST-2 tephra at EG12 is stratigraphically less than 0·5 m below the artefact horizon. The Upper Cobble Conglomerate is well-exposed *c*. 15 m above EG12. A high density of surface artefacts were found exposed on a very steep-sided slope at EG12. The composition of the artefacts was similar to EG10. Following the edge of the outcrops,

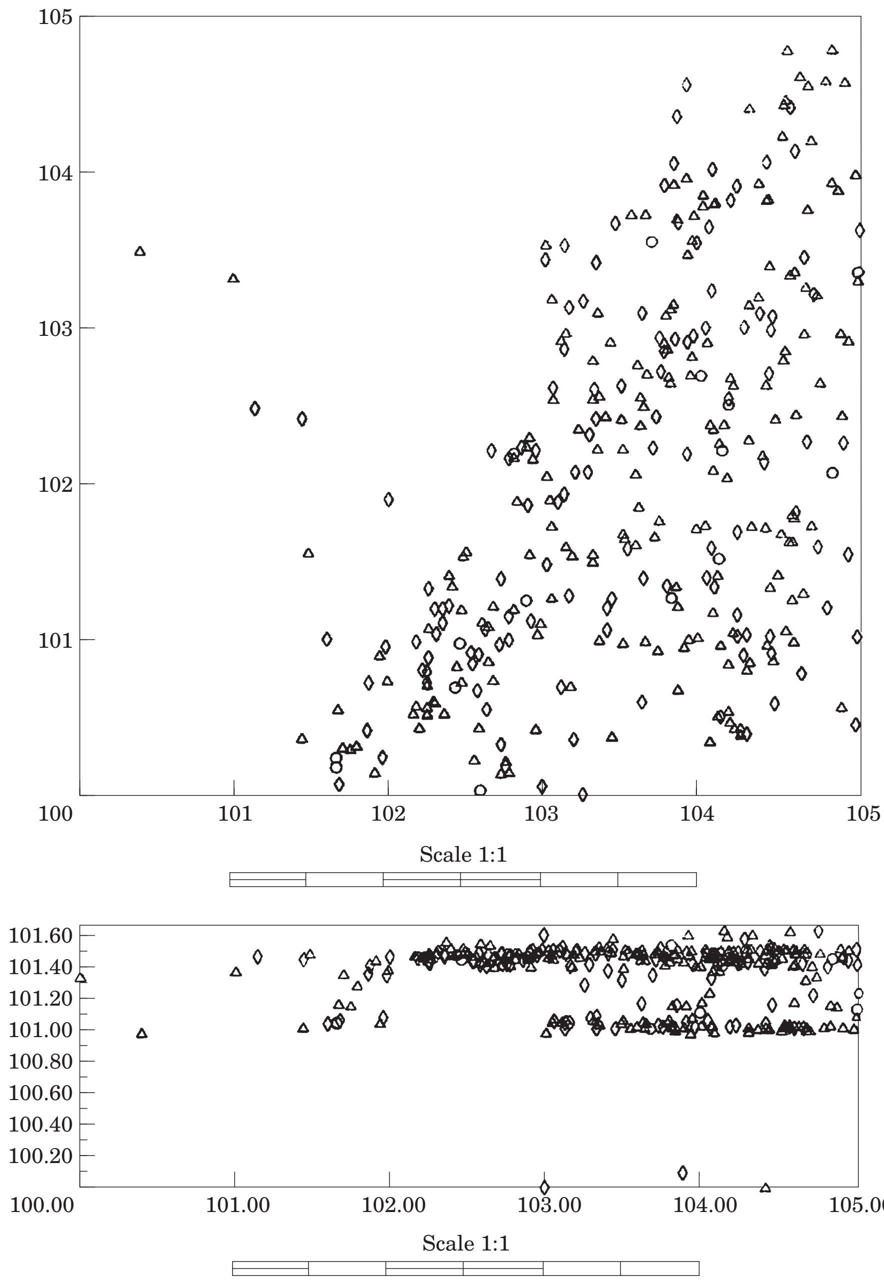


Figure 4. Horizontal and vertical distribution of the EG10 excavated artefacts.

an area of 26 $m^2$ was gridded down to the level of the Intermediate Cobble Conglomerate. The horizontal and vertical distribution of the excavated artefacts are shown in Figure 5. A total of 309 artefacts were retrieved from surface and surface scrapes. About 1 m of overburden was removed before reaching the artefact horizon and an area of 8 $m^2$ (with additional 1 $m^2$ to the southwest) was excavated within fine-grained floodplain sediments yielding a total of 444 artefacts *in situ*. The artefacts were tightly clustered within 40 cm thick well-consolidated brown clay. Preservation and sediment characters were similar to EG10 and there were no fossilized bones recovered at EG12.

## Assemblage Characteristics

The composition and characteristics of the artefacts from EG10 and EG12 are broadly similar to other Plio-Pleistocene Oldowan assemblages known in Africa from deposits dated between 2·6–1·5 Ma (Table 1). The Gona assemblages consist of cores,

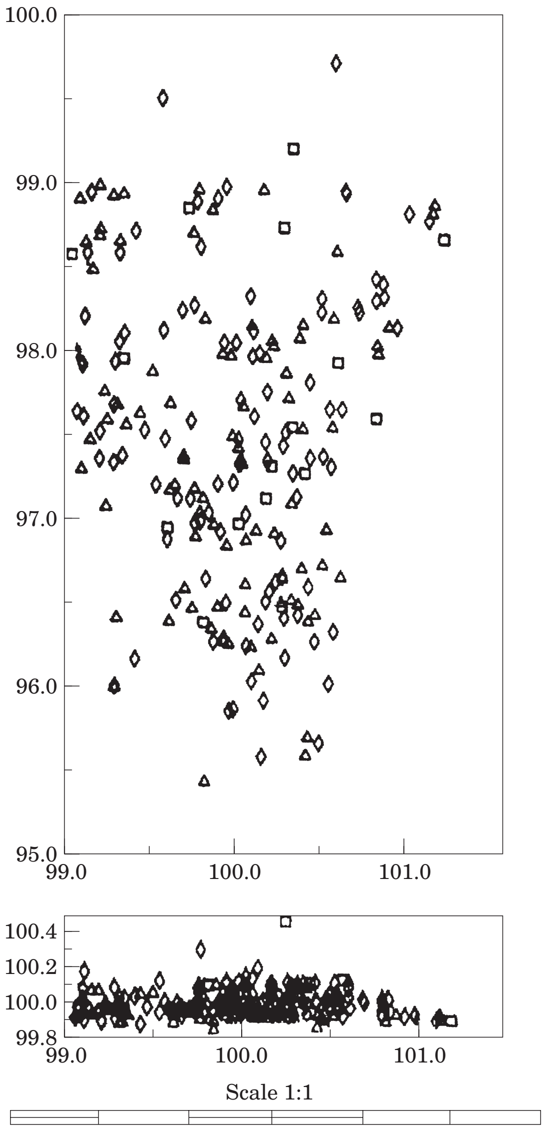


Figure 5. Horizontal and vertical distribution of the EG12 excavated artefacts.

whole and broken flakes and a high density of angular fragments. Using criteria developed by Leakey (1971) for Olduvai Gorge Bed I and Lower Bed II, the Gona cores can be classified as choppers, discoids, polyhedrons and heavy duty core scrapers (Table 2, Figure 6). Almost 99% of the artefacts fall into the category of *débitage* which include whole and broken flakes, and angular and core fragments. A majority of the whole flakes from Gona show prominent bulbs of percussion and smooth release surfaces. Retouched pieces are very rare. There are no specimens identified as manuports except for one split cobble collected from the surface at EG12. Pitting and bruising marks identified on some of the cores may hint to repeated bashing of the cobbles during the process of flaking or may be a result of utilization for pounding activities, for example as hammerstones for breaking bones for marrow. However, one has to exercise caution because field observations have shown that weathering may also mimic these features as a result of exfoliation of the cortex on some of the surface exposed cores.

Although a majority of the Gona cores were unifacially worked, they were very well-flaked, suggesting experienced knapping skills and mastery of the mechanics of conchoidal fracture by their makers (Figure 6). Following Leakey (1971), some of the bifacial cores made of elongated cobbles could have been classified as proto-bifaces. Current understanding of the Oldowan technology strongly suggests that Plio-Pleistocene hominids were mainly after the production of sharp-edged flakes for use as cutting implements, with no predetermined design intended for the shape of the end product (Toth, 1982, 1985, 1987). For example, experimental replication of the artefacts from Koobi Fora has shown that the final shape of the Oldowan cores and flakes were dictated mainly by the size and morphology of the clasts available, the flaking quality of the raw materials and the extent of flaking afforded during the course of reduction of the cores (Toth, 1982, 1985, 1987). In order to avoid the functional implications inferred from Leakey's (1971) elaborate typology,

*Table 2. Gona, unifacially and bi/multifacially flaked pieces*

| | EG10 | | | | EG12 | | | |
|---|---|---|---|---|---|---|---|---|
| | Surface | | Excavated | | Surface | | Excavated | |
| | Uni | Bi/Multi | Uni | Bi/Multi | Uni | Bi/Multi | Uni | Bi/Multi |
| Side choppers | 3 | 2 | 8 | 0 | 1 | 0 | 4 | 1 |
| End choppers | 3 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| Side and end choppers | 2 | 2 | 2 | 1 | 0 | 0 | 0 | 3 |
| Discoids | 1 | 0 | 1 | 2 | 1 | 0 | 0 | 0 |
| Core scraper | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 1 |
| Polyhedron | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Total | 9 | 6 | 11 | 5 | 3 | 0 | 4 | 5 |
| % | 60·00 | 40·00 | 68·75 | 31·25 | 100·00 | 0·00 | 44·44 | 55·55 |

Uni=Unifacially worked, Bi/Multi=Bifacially or Multifacially worked.

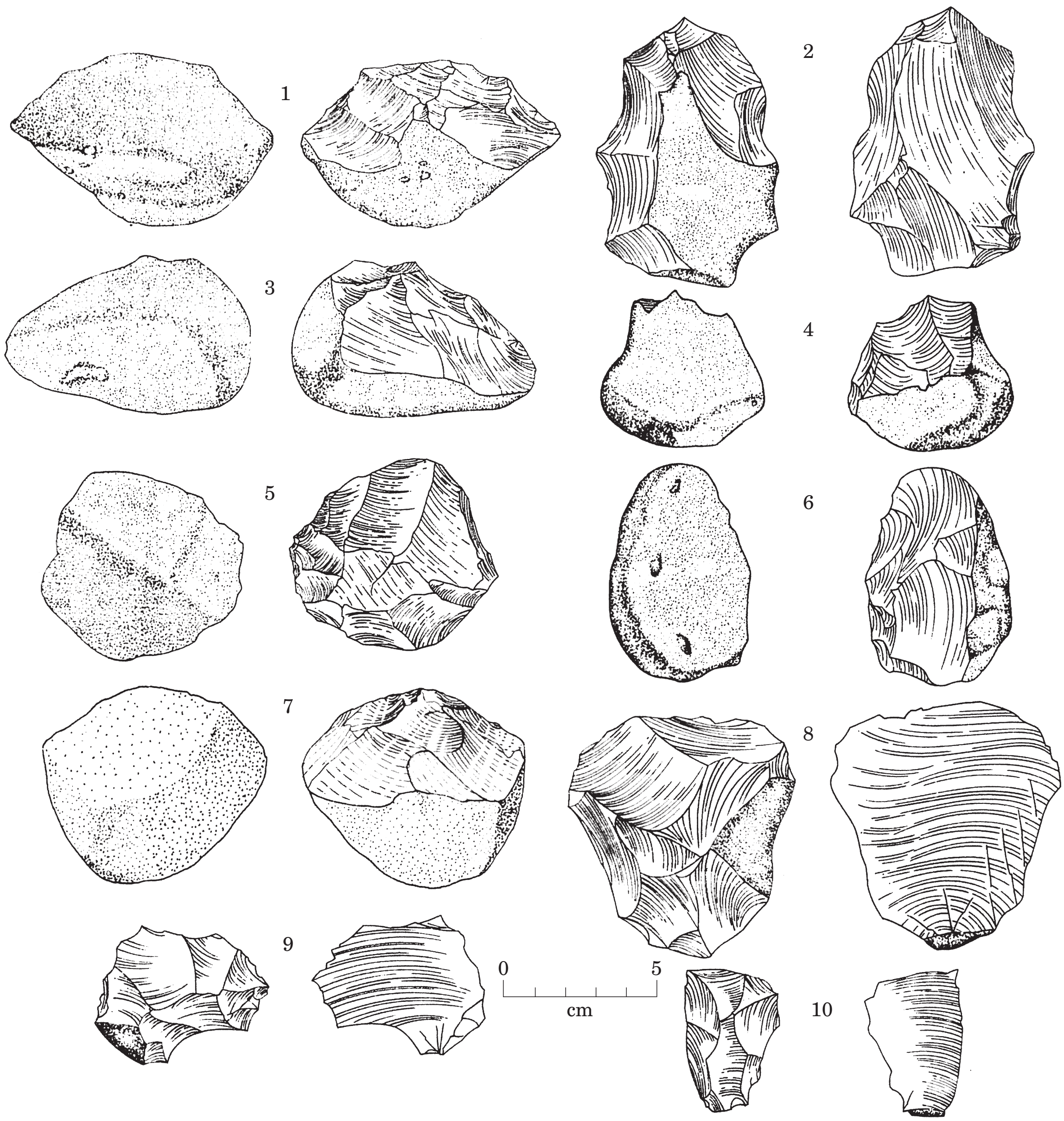


Figure 6. Drawings of artefacts (cores and whole flakes), excavated from EG10 and EG12. (1) unifacial chopper, EG10, (2) discoid, EG10, (3) unifacial side chopper, EG12, (4) unifacial end chopper, EG12, (5) partial (irregular discoid), EG12, (6) unifacial side chopper, EG10, (7) unifacial side chopper, EG12, (8–10) whole flakes, EG10.

Isaac *et al*. (1981) outlined a scheme for classifying early stone assemblages from a simple technological perspective. These were the *Flaked Pieces* (cores/choppers), *Detached Pieces* (flakes and fragments), *Pounded Pieces* (cobbles utilized as hammerstones, etc.) and *Unmodified Pieces* (manuports, stones transported to sites). This is a useful technological approach for describing early stone assemblages, but it may mask certain details important for examining behavioural changes in artefact manufacture and use during the Late Pliocene–Early Pleistocene. The use of Leakey's (1971) typology is still important for comparing early stone assemblages because most artefacts of this period have been described following her conventions (for example, Chavaillon, 1976; Merrick, 1976; Isaac & Harris, 1997). Further technological studies may be essential for devising typological schemes standard for classifying early stone assemblages, and for understanding significant behavioural changes, if any, in Oldowan artefact manufacture through time.

### *The cores*

There were a total of 31 cores (16 *in situ*) from EG10 and a total of 12 cores (9 *in situ*) from EG12 (Table 2). A majority of the Gona cores were worked unifacially from rounded trachyte cobbles (very few on split cobbles). Although most were unifacial, the Gona cores were surprisingly very well-flaked for such an early age. The makers were involved in bold flaking, with excellent eye-hand coordination when seeking acute angles and removing large flakes from cobbles. Despite the unifacial pattern of flaking seen at Gona, some of the cores were exhaustively flaked with negative impression of several generations of scars present. In addition, they were selecting for fine-grained raw materials and a majority of the flakes removed had smooth release surfaces. Using the criteria of Leakey (1971), the majority of the cores (*Flaked Pieces* of Isaac *et al*., 1981) were identified as unifacial side choppers. Nearly 20% of the excavated cores from EG10, and 55% from EG12 were bifacially worked (Table 2). There were pieces identified as discoids, polyhedrons and core scrapers from EG10, but most of the cores from EG12 were side choppers and side and end choppers (except for 1 discoid recovered from the surface).

The *in situ* cores from EG10 range in maximum dimensions between 67–106 mm with a mean of 83 mm (s.d. = 10), and the EG12 cores vary in size between 58–92 mm with a mean of 77 mm (s.d. = 9). Scar counts on *in situ* cores vary between 8–14 scars at EG10 (mean = 11, s.d. = 1) and between 3–23 at EG12 (mean = 11, s.d. = 5). There are no pieces from EG10 and EG12 identified as hammerstones or unmodified pieces.

*Débitage*

The *Detached Pieces* (of Isaac *et al*., 1981) produced during the process of the reduction of the cores were classified as *débitage* following the criteria outlined by Leakey (1971). These include whole and broken flakes (split, snapped, and split and snapped), and angular and core fragments. Close to 99% of the artefacts from both EG10 and EG12 were identified into this category. The most informative in terms of hominid knapping skills and early stone technology are the whole flake category (details are discussed below). The other *débitage* categories are dealt with in greater detail in Semaw (1997) and will not be discussed here.

*The whole flakes*

The complete *Detached Pieces* with diagnostic striking platform, bulbs of percussion and a clear release surface were identified as whole flakes. There were a total of 438 (275 surface and 163 excavated) from EG10 and a total of 241 (94 surface and 147 excavated) whole flakes recovered from EG12. The whole flakes from EG10 account for 18% of the artefacts identified as *débitag*e, where as 30% of the whole flakes from EG12 fall into this category. The most striking feature of the whole flakes from Gona is the presence of clear and prominent bulbs of percussion on a large number of the specimens (Figure 6). As is the case with the cores, trachyte was the dominant raw material.

The flake type system developed by Toth (1982) was used in order to examine the stages of flaking represented at these localities. Toth (1982, 1987) recognized six flake-types based on presence/absence of cortex on the striking platform and dorsal surface of whole flakes. These include Type I (cortex platform/cortex dorsal), Type II (cortex platform/part cortex dorsal), Type III (cortex platform/no cortex dorsal), Type IV (no cortex platform/cortex dorsal), Type V (no cortex platform/part cortex dorsal), and Type VI (no cortex platform/no cortex dorsal). Cortical flakes (Toth types I, II and IV) are rare, and the whole flakes are dominated by Toth types III, V and VI. Observations from experimental replicative work suggest that the preponderance of Toth Type III in the whole flakes seem to be consistent with the abundance of extensively flaked unifacial cores at Gona (Toth, pers. comm.). Dorsal scar counts on the whole flakes attest that the hominids were actively working on reducing the cores. The number of dorsal scars on the *in situ* whole flakes from EG10 vary between 1–12 (mean = 3, s.d. = 2), and those from EG12 range between 0-7 counts (mean = 2, s.d. = 1). In terms of sizes, the maximum dimensions of the *in situ* whole flakes from EG10 range between 10–85 mm (mean = 38, s.d. = 16), and those from EG12 between 10–128 mm (mean = 34, s.d. = 16).

*Raw materials*

Trachyte was the main raw material utilized for making the EG10 and EG12 excavated artefacts, accounting for more than 70% of the assemblages. The trachyte from Gona tends to be fine-grained, light-brown or grey in colour often with phenocrysts and dark brown cortex. The main raw material sources for the Gona tool-making hominids were stones from nearby ancient streams accessible in the form of water-worn, rounded, fist-sized cobbles. For example, the presence of a channel cut-and-fill geologically documented between EG12 and EG13 indicated that the clasts from the underlying Intermediate Cobble Conglomerate were readily available from nearby ancient streams for tool-making hominids *c*. 2·5–2·6 Ma. This same conglomerate is exposed laterally for more than 1 km, and a total of 103 cobbles suitable for making artefacts were randomly picked from the conglomerate exposed below EG10 for a preliminary assessment of the dominant raw material types accessible for making the Gona artefacts. The size of the clasts picked vary between 170–60 mm (mean = 105, s.d. = 28). About 48% of the raw material types were identified as trachyte (or trachytic ignimbrite). Raw materials identified as rhyolite accounted for 27%, lava for 23% and chalcedony and breccia for the remaining 2%. Artefacts made of rare and exotic raw materials such as chert are known from WG2 and EG13. The preponderance of trachyte (>70% of the EG10 and EG12 assemblage) at Gona implies that the hominids had a preference for this particular raw material, and they selected it over others because of its good flaking quality.

## Late Pliocene Artefact Assemblages from Other East African Sites

There are only a handful of archaeological sites in Africa which are older than 2·0 Ma. These include the Omo, Hadar and Bouri localities from Ethiopia (Chavaillon, 1976; Merrick, 1976; Howell *et al*., 1987; Kimbel *et al*., 1996; de Heinzelin *et al*., 1999), and the Lokalalei sites from Kenya (Roche, 1989, 1996; Kibunjia *et al*., 1992; Kibunjia, 1994; Roche *et al*., 1999). With the exception of Gona and Bouri, the age of these sites cluster between 2·3–2·4 Ma. There are two sites, Senga 5a from Eastern Zaire and Mwimbi from the Chiwondo Beds in Malawi, with claims for the presence of archaeological sites with estimated ages of *c*. 2·2–2·3 Ma. However, there are no absolute dates to corroborate these claims (Harris *et al*., 1987, 1990; Kaufulu & Stern, 1987).

It will be important to provide a brief review on the context and assemblage characteristics of the artefacts from the well-dated Late Pliocene Lokalalei sites for a better understanding of the issues raised by various researchers on the beginning of stone working technology and on the knapping skills of the earliest tool makers, and thereby for assessing the industrial affinity of the earliest artefact assemblages.

There are two Late Pliocene archaeological localities at West Turkana including Lokalalei 1 (GaJh5) excavated in 1987 and 1991 (Kibunjia *et al*., 1992; Kibunjia, 1994), and Lokalalei 2C (LA2C) excavated in 1997 (Roche *et al*., 1999). The artefacts at both localities were found within the same horizon traced stratigraphically above the Kalochoro tuff. This tuff was chemically correlated to tuff F of the Shungura Formation and the Lokalalei artefacts were dated to 2·3–2·4 Ma (Feibel *et al*., 1989). *Australopithecus boisei*/*aethiopicus* is the only hominid known thus far at West Turkana from deposits that are near contemporary with these artefacts (Walker *et al*., 1986). The Lokalalei assemblages are important for understanding Late Pliocene hominid stone working technology, and their behavioural implications require a closer examination.

### *Lokalalei 1 (GaJh5)*

A total of 466 stone artefacts (417 excavated) including cores whole and broken flakes, angular fragments and pounded pieces were recovered at Lokalalei 1 (Kibunjia, 1994). The artefacts were in silty claystones, and they were fresh. Two bones with possible cutmarks were identified from the excavations. More than 50 cores were identified which average close to 100 mm in size. The main raw material used was lava. According to Kibunjia (1994: p. 165), despite the presence of "opportune striking platforms on the cobbles", the cores were not intensively flaked, with only 1–12 flake scar counts. "About 80% of the flaking scars on these cores are characterized by step fractures and only a few instances of complete flake removals were observed . . . Cores appear to have been abandoned after several attempts of flaking if most of the products obtained were the step/hinge flakes" (Kibunjia, 1994: p. 165). There were also some well-flaked cores at Lokalalei 1. The presence of two types of cores (several with lots of steps/hinges, and some well-flaked) was recognized, but the reasons for these differences were not adequately explained. Nonetheless, Kibunjia (1994: p. 165) concluded that "factors other than raw material account for the poor technology" and he named a new "Nachukui Industry" (also referred to as the "Nachukui facies") to differentiate Lokalalei 1 from assemblages that postdate 2·0 Ma. The "Shungura facies" earlier named by Chavaillon (1976) for the Omo was accepted as a distinct industry (facies), and both were assigned into a new Omo Industrial Complex. With no details yet available, the Gona artefacts were also included in this Industrial Complex (Kibunjia, 1994).

### *Lokalalei 2C (LA2C)*

The artefact occurrences at LA2C are *c*. 1 km distance from Lokalalei 1 (Roche *et al*., 1999). LA2C yielded over 2500 stone artefacts which consisted of cores and *débitage* and some retouched pieces. Unique to the assemblages is the presence of a large number of refitting pieces, accounting for 20% of the excavated artefacts. There were no cut-marked bones at LA2C. Ten different raw materials were identified as potential sources, but basalt and phonolite were selected and used. The cobbles ranged from coarse to fine-grained basalt, with minimal flaking observed on the coarse-grained cobbles (Roche *et al*., 1999).

Remarkable differences in technology and motor skills are reported for the Lokalalei 1 and LA2C assemblages (Roche, 1989; Kibunjia, 1994; Roche *et al*., 1999). Despite the fact that both localities were traced within the same stratigraphic horizon separated by only *c*. 1 km, the Lokalalei 1 hominids were suggested to be less competent in striking flakes from cobbles (Roche, 1989, 1996; Kibunjia, 1994), and the LA2C artefacts were described as "sophisticated", and the hominids more advanced in cognitive and motor skills capable of striking flakes from prepared platforms (Roche *et al*., 1999). Furthermore, the two types of cores, i.e. the "less elaborate", apparently flaked from the coarse-grained basalt and the more elaborate struck from the fine-grained cobbles, were found in both the Lokalalei 1 and LA2C assemblages.

## The Stone Working Technology/Artefact Tradition Between 2·6–1·5 Ma

The industrial affinity of the stone assemblages known from archaeological sites that are dated between 2·6–2·0 Ma remained controversial until the discovery of a high density of well-flaked artefacts from EG10 and EG12 (Semaw, 1997; Semaw *et al.*, 1997). Late Pliocene hominid understanding of the mechanics of conchoidal fracture, and their ability to strike workable flakes from cores prior to 2·0 Ma has been questioned by a number of archaeologists (Chavaillon, 1976; Piperno, 1989; Roche, 1989; Kibunjia, 1994). These researchers argued that the hominids who lived prior to 2·0 Ma had poor coordination and less knapping skills compared to the more competent stone knappers who made the Oldowan known later in the Early Pleistocene (for example at Olduvai and Koobi Fora). A "pre-Oldowan" phase was suggested by the main proponents of the idea (Roche, 1989, 1996; Piperno, 1989) to differentiate the pre-2·0 Ma assemblages from the "elaborate" Oldowan artefacts known later between 2·0–1·5 Ma. However, the validity of this assessment was put in to question following the discovery of the oldest well-flaked artefacts at Gona which were assigned to the Oldowan Industry (Semaw *et al.*, 1997). The recent discovery from LA2C corroborates Semaw *et al.*'s (1997) earlier observation on the sophisticated understanding of stone flaking techniques by ancestral hominids prior to 2·0 Ma.

The two opposing views of Roche, (1) that all the artefact assemblages that are older than 2·0 Ma are technologically less elaborate and group into the "pre-Oldowan" (1989, 1996), and (2) that the 2·3–2·4 Ma artefacts from LA2C are "sophisticated" (Roche *et al.*, 1999), were arguments forwarded based on ideas mainly derived from the study of the artefacts from the two spatio-temporally associated Lokalalei sites. Semaw *et al.* (1997) have shown that the hominids responsible for making the 2·5–2·6 Ma Gona artefacts understood the flaking properties of the raw materials available, that they selected for appropriate cobbles for making artefacts and that they were as competent as Early Pleistocene hominids in their knapping skills (Figure 6). Roche *et al.*'s (1999) discovery indicated that the hominids at LA2C had access to basalt (coarse-grained and fine-grained), and the majority of the refitted artefacts were made of the fine-grained type. This evidence clearly shows that the earliest tool makers selected for finer and better-flaking raw materials. In addition, albeit small quantity, the artefacts from Hadar are typical of the Oldowan tradition (Kimbel *et al.*, 1996). Contemporary hominids at Omo had access to small sized quartz pebbles, and the small size of the artefacts at Omo was dictated by the size and flaking quality of the quartz raw materials (Merrick, 1976).

The main thrust of Semaw *et al.*'s (1997) argument was to show that the "pre-Oldowan" designation suggested earlier by Roche (1989, 1996; and Piperno, 1989), and the Omo Industrial Complex subsequently proposed by Kibunjia (1994) for assemblages older than 2·0 Ma are not warranted because of the presence of well-flaked artefacts from the Gona deposits and LA2C. Because of the similarities among the cores and the high level of flaking skills observed, the stone artefacts dated between 2·6–1·5 Ma group into the Oldowan Industry (*sensu* Leakey, 1971), and there is no compelling evidence for a "pre-Oldowan" phase. Differences in raw material types, quality of flaking and distances to sources may account for the relatively greater degree of core reductions shown for the Olduvai and Koobi Fora artefacts compared to Gona and other Late Pliocene assemblages (Semaw *et al.*, 1997). Because of a lack of remarkable differences in the techniques and styles of artefact manufacture for over 1 million years (2·6–1·5 Ma), a technological stasis was suggested for the Oldowan Industry (Semaw *et al.*, 1997). A recent study of the artefact assemblages from this time period by Ludwig & Harris (1998) is in agreement with the technological stasis proposed here.

Contrary to earlier views for Lokalalei 1, the LA2C excavated artefacts were argued to be "sophisticated" (Roche *et al.*, 1999). How sophisticated were the LA2C artefacts compared to older, contemporary or younger Oldowan assemblages? This point is not clear from the refitting analysis. In addition, according to Roche *et al.* (1999: p. 59), "the stasis hypothesis cannot hold out against the detailed technological analysis of the LA2C". How the discovery of these abundant refitting pieces imply more "sophistication" and how their analysis refutes the "technological stasis" hypothesis need further explanations. The presence of a high percentage of refitting pieces at LA2C at 2·3–2·4 Ma strongly suggests that the fine-grained basalt cobbles accessible for the Lokalalei hominids were of good flaking quality, the site was well-preserved and it was not disturbed by fluvial processes (for example, see Schick, 1986, 1987). There were two grades of basalt cobbles (coarse and fine-grained) used at Lokalalei 1 and LA2C. It is possible that the fine-grained cobbles flaked well yielding a large number of the refitting pieces, and the coarse-grained cobbles did not flake well and they were discarded after several attempts failed to produce flakes sustainable for use (see Kibunjia, 1994). It seems that experimental replicative work is required to determine the influence of the raw materials (for example, Toth, 1982; Jones, 1994), and to explain why there are "technologically sophisticated" and "less elaborate" cores within the assemblages of the spatio-temporally well-constrained Lokalalei sites which are within walking distance from each other. The flaking quality of the cobbles and the distances hominids had to travel to acquire raw materials had bearing on the nature and degree of core reductions seen in the assemblages documented during the Late Pliocene. The Omo artefacts were technologically simple and smaller in size because they were made of small size quartz brought from further distances (Merrick, 1976). The well-flaked nature of the Gona artefacts, and the presence of a high concentration at EG10 and EG12 can be explained by the fact that the hominids at Gona had easy access to well-flaking raw materials available from nearby ancient streams.

Simple unifacially and bifacially flaked cores, and a very high percentage of *débitag*e are the main artefacts known in almost all of the Late Pliocene–Early Pleistocene Oldowan assemblages. Further investigations will be carried out to determine whether or not the preponderance of unifacial flaking was typical of the oldest Gona artefacts or a result of sampling bias. More bifacially/multifacially flaked cores including spheroids/subspheroids and retouched pieces appear later *c*. 1·6–1·5 Ma with the "Developed Oldowan". It is strongly argued here that there is no compelling evidence to warrant different facies or industries for the stone assemblages known between 2·6–1·5 Ma other than the Oldowan as originally defined by Leakey (1971).

## The Makers and the Function of the Earliest Stone Tools

There are no modified stones or bones with evidence of definite stone tool-cut marks known from deposits that are older than 2·6 Ma. Therefore, it is likely that *Australopithecus afarensis* was not involved in activities that required the use of modified stones. There are two hominids known *c*. 2·5 Ma in East Africa including *Australopithecus aethiopicus* originally identified in the Omo (Howell *et al*., 1987), and later at West Turkana (Walker *et al*., 1986); and *Australopithecus garhi* recently discovered from the Hata beds of the Bouri Formation in the Middle Awash (Asfaw *et al*., 1999). According to Suwa *et al*. (1996), both the non-robust and the robust lineages are represented *c*. 2·7 Ma in the Shungura Formation. The robust lineage was identified as *Australopithecus aethiopicus* and it was sampled from Members C through F (2·7–2·3 Ma). The non-robust hominids from Members E-G are assigned to aff. *Homo* sp. indet. Those known *c.* 2·0–2·4. Ma are early representatives of the genus *Homo* and have similarities to species labelled as *Homo rudolfensis* (Suwa *et al*., 1996). Fossil remains of early *Homo* estimated to this time interval are also known from other parts of Africa (Hill *et al*., 1992; Schrenk *et al*., 1993). Thus far, the known range of *Australopithecus aethiopicus* is restricted to the Omo/Turkana basin, and *Australopithecus garhi* is identified only from the Afar region of Ethiopia. *Australopithecus garhi* is argued to be a strong candidate responsible for making and using the oldest known artefacts in the Afar, but some argue that there are no grounds for excluding *Australopithecus boisei* as maker and user of stone tools (Wood, 1997). Both hominid species are contemporary with the earliest stone tools dated between 2·5–2·6 Ma. Actually, the stone artefacts from Gona are close to 2·6 Ma, and a bit older than *Australopithecus garhi*. Therefore, there is a possibility for further discovery of the same species from older deposits, or the likelihood of finding a different species in the Afar region that may have lived between *Australopithecus afarensis* and *Australopithecus garhi* in the time interval between 2·9–2·5 Ma. The fossil remains of early *Homo* identified from the Omo (2·4–2·0 Ma) and Hadar (2·4–2·3 Ma) are contemporary with the Hadar, Omo and Lokalalei artefacts. Therefore, early *Homo* may be uncontested as the maker and user of stone artefacts, but the case for *Australopithecus garhi* as the first tool maker is also compelling.

Without associated fossilized animal bones bearing evidence of cut marks, the function of the oldest stone artefacts from Gona remained speculative for a long time. The recent cut-mark data from Bouri indicates that early hominids *c*. 2·5 Ma began incorporating some amount of high nutrient meat in their diet. Further detailed research is needed to determine why meat became an important food item by this time and how it was acquired. It is not clear whether or not the first stone artefacts were used for processing plant foods. There are certain indications from microwear studies on artefacts from Koobi Fora (Keeley & Toth, 1981) and from Gona (Beyries, 1993), but strong cases have yet to be made based on the archaeological record to demonstrate the use of flaked stones for processing plant food items.

## Summary

Late Pliocene hominids began manufacturing and utilizing flaked stones *c*. 2·6 Ma, and the Gona localities provide the earliest evidence of a high density of stone artefacts from laterally-extensive deposits exposed east and west of the Kada Gona river. The beginning of the use of modified stones was a major technological breakthrough which opened windows of opportunities for effective exploitation of available food resources including high nutrient meat and bone marrow from animals. The cut-mark and bone fracture evidence from Bouri provides strong evidence for the incorporation of meat in the diet of Late Pliocene hominids as early as 2·5 Ma. The sudden appearance of thousands of well-flaked artefacts documented from several localities in this time interval is intriguing. It may mean that the beginning of the manufacture and use of flaked-stones was a novel adaptive strategy which appeared abruptly *c*. 2·6 Ma and spread through populations quickly. On the other hand, there is a possibility of finding modified stones/and or bones from older deposits if the manufacture and use of flaked stones evolved gradually. Thus far, the evidence is strongly in favour of an abrupt appearance of modified stones in the archaeological record between 2·5–2·6 Ma or probably a bit earlier.

Research is still under way to address the question of what triggered early hominid beginning of the use of modified stones *c*. 2·6 Ma. Some link the appearance of stone tools and early *Homo* with the onset of the build up of ice sheets in the northern hemisphere which resulted in major global cooling documented beginning *c*. 2·7–2·8 Ma (Vrba 1985, 1988, 1990, 1995; de Menocal, 1995; de Menocal & Bloemendal, 1995; Shackleton, 1995). Exactly how global cooling affected Africa and the causal links which led to the physical and behavioural changes seen in early hominids *c*. 2·6–2·5 Ma are not yet well understood. Others argue for regional uplifts and tectonic activities having a major impact on Late Pliocene hominids and the faunal community in Africa at this time (Denys *et al*., 1986; Pickford, 1990; Partridge *et al*., 1995). Future investigations at Gona of the palaeoenvironment from this critical time period based on faunal evidence, geological and isotope studies, can provide further crucial evidence for understanding the settings for the appearance of stone artefacts and to identify the makers (Cerling & Quade, 1993; Brown, 1995; Wesselman, 1995; White, 1995; Cerling *et al*., 1997).

The archaeological evidence from Gona at 2·6–2·5 Ma and the other Late Pliocene sites dated to 2·4–2·3 Ma and their implications for understanding early hominid behaviour can be summarized as follows.

(1) The makers of the earliest Gona artefacts had a clear mastery of the mechanics of conchoidal fracture by *c*. 2·6 Ma and well-flaked artefacts are known from several archaeological sites dated to 2·3–2·4 Ma in East Africa.
(2) Ancestral tool makers (beginning *c*. 2·6–2·5 Ma) chose appropriate size cobbles when making artefacts, selected for raw materials with good flaking quality, sought for acute angles when striking cobbles and produced sharp-edged implements used for cutting.
(3) It seems that the main intent of Oldowan tool makers was the production of cores and flakes with sharp-edges which were probably used for cutting up carcasses to access high nutrient meat from animals (not yet clear whether hunted or scavenged). The absence of well-preserved high density of bones with stone tool-cut marks from the sites dated between 2·5–2·0 Ma may be a taphonomic bias, but some of the artefact occurrences of this period are found in association with numerous broken bones.
(4) The makers of the earliest stone artefacts travelled long distances to acquire raw materials (for example at Omo and Bouri), implying greater mobility, long-term planning and foresight not recognized earlier. They probably habitually carried artefacts (as suggested by the evidence from Bouri) and unmodified stones over the landscape.
(5) The oldest archaeological traces known in Africa are thus far restricted to the Afar region and the Omo/Turkana basin. Although these occurrences are geographically restricted, the artefacts are of a high density character probably implying habitual tool use as early as 2·6 Ma.
(6) Plio-Pleistocene hominids lived close to water and raw material sources, mainly along courses of ancient streams, where there were trees used as shelters and as refugee from predators.
(7) The same stone working techniques and styles of tool manufacture persisted for over 1 million years (2·6–1·5 Ma) implying a technological stasis in the Oldowan.

Further palaeoanthropological multidisciplinary field and laboratory studies can help elucidate the environmental settings for the appearance of stone artefacts, for understanding of their adaptive significance, and for assessing the reasons for the behavioural and physical changes seen in Late Pliocene–Early Pleistocene hominids. The two contemporary Afar sites of Gona and Middle Awash have great potential for providing archaeological data for further detailed understanding of these questions. Furthermore, the identity of the makers may be clarified through further discoveries at Gona. A new round of multidisciplinary systematic research at Gona organized in 1999 has made a promising start in addressing these questions, and the results will be published in the near future.

## Acknowledgements

A field permit for the Gona research was issued by the Center for Research and Conservation of Cultural Heritage (CRCCH) of the Ministry of Information and Culture of Ethiopia. I would like to thank the L. S. B. Leakey Foundation, the National Science Foundation, the Boise Fund and Ann and Gordon Getty for their generous support for the 1992–1994 field seasons. EG10 and EG12 were excavated with Professor J. W. K. Harris (Rutgers University). He deserves special mention for his advice and time in the field. Dr Craig Feibel (Rutgers University) assisted in the field and laboratory with the details on the geology of Gona. Dr Paul Renne of the Berkeley Geochronology Center (BGC) is responsible for the paleomagnetic and $^{40}Ar/^{39}Ar$ dating, and I am grateful for his assistance in resolving the age of the Gona artefacts. I am grateful to Dr Nicholas Toth and Dr Kathy Schick (CRAFT, Indiana University) for offering me a Postdoctoral fellowship, and for their invaluable comments on an earlier draft of this manuscript. I would like to thank Yonas Beyene, Berhane Asfaw, Tim White, Clark Howell, Desmond Clark, Manuel Dominguez-Rodrigo, Robert Blumenschine and John Cavallo for their support. I also thank Michael Rogers for his comments and kind assistance. My gratitude goes to the Afar people for their hospitality and support in the field. Part of the fellowship for my Graduate Studies was provided by the Institute of Human Origins and Rutgers University.

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