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NUMBER 3
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THE CUTTING EDGE:
New Approaches to the Archaeology of Human Origins

Editors

Kathy Schick
Stone Age Institute & Indiana University

Nicholas Toth
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COVER CAPTIONS AND CREDITS

Top: Homo habilis Utilizing Stone Tools. Painting by artist-naturalist Jay H. Matternes. Copyright 1995, Jay H. Matternes. Inspired by a prehistoric scenario by K. Schick and N. Toth in Making Silent Stones Speak: Human Origins and the Dawn of Technology (1993), Simon and Schuster, New York. Pp.147-149.

Lower right: Whole flake of trachyte lava from the 2.6 million-year-old site of Gona EG-10, Ethiopia. Reported by S. Semaw (2006), "The Oldest Stone Artifacts from Gona (2.6-2.5 Ma), Afar, Ethiopia: Implications for Understanding the Earliest Stages of Knapping" in The Oldowan: Case Studies into the Earliest Stone Age, eds. N. Toth and K. Schick. Stone Age Institute Press, Gosport, Indiana. Pp. 43-75. Photo courtesy of Tim White.

Lower left: Prehistoric cut-marks from a stone tool on Sterkfontein hominin partial cranium StW 53. Reported by T. Pickering, T. White, and N. Toth (2000) in "Cutmarks on a Plio-Pleistocene hominid from Sterkfontein, South Africa". American Journal of Physical Anthropology 111, 579-584. Scanning electron micrograph by N. Toth.

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CHAPTER 11

Insights into Late Pliocene Lithic Assemblage Variability: The East Gona and Ounda Gona South Oldowan Archaeology (2.6 Million Years Ago), Afar, Ethiopia

Sileshi Semaw, Michael J. Rogers, and Dietrich Stout

Abstract

The 1992 systematic archaeological excavations of the two East Gona sites (EG-10 and EG-12) resulted in the discovery of the oldest known stone artifacts dated to ~2.6-2.5 million years ago (Ma) (Semaw, 2000, 2005, 2006; Semaw et al., 1997). Trachyte and rhyolite dominate the EG artifact assemblages, followed by basalt and aphanitic volcanics. Artifacts made of fine-grained raw materials such as vitreous volcanics are present, but few in numbers (Stout et al., in prep).

Our continued systematic survey and excavations in the years 1999 and 2000 in the Ounda Gona South (OGS) area produced additional 2.6 Ma stone artifacts at OGS-6 and OGS-7 (Semaw et al., 2003). At the OGS sites, in addition to trachyte and rhyolite, artifacts were made on a greater variety of raw materials including latites and aphanitic volcanics which were well represented in the assemblages. Moreover, vitreous volcanics were more extensively used at OGS-7 than at the EG sites (Stout et al., 2005). The two OGS sites have a minimum age of 2.53±0.15 Ma based on the $^{40}Ar/^{39}Ar$ date of a tuff located stratigraphically directly above OGS-7. Further, the age of the two OGS sites was corroborated with the identification of the Gauss-Matuyama paleomagnetic transition (2.6 Ma) at the level of the OGS-7 excavation. The OGS sites are important for yielding additional stone assemblages that are contemporary with the artifacts excavated from the EG sites, and for providing the opportunity for investigating Late Pliocene hominin toolmaking activities, the variations in the stone assemblages, and patterns of resource exploitations at 2.6 Ma. The most informative artifacts and associated fragmentary fauna were recovered *in situ* from OGS-7, and the materials were excavated within fine-grained sediments. The OGS-6 excavation also yielded *in situ* artifacts, but with no associated fossilized bones. However, at OGS-6, a freshly eroded bone with definite cutmarks was identified from the surface providing direct evidence that the earliest stone artifacts may have been used for accessing animal resources (Semaw et al., 2003; Domínguez-Rodrigo et al, 2005; also see de Heinzelin et al., 1999).

The cobbles from the underlying conglomerates near both the EG and the OGS sites, the probable stone raw material sources used for making the artifacts, were sampled yielding interesting results (Stout et al., 2005, 2008, in prep.). Rhyolite was the most dominant of the raw materials in the cobbles sampled from both the EG and OGS areas. Latites at OGS, and basalt and trachyte near the EG sites, make up the second most prevalent materials in the associated cobble conglomerates in each area. Rhyolite and trachyte dominate the EG assemblages whereas rhyolite, latite (quartz latite) and aphanitics were fairly represented in the OGS assemblages. Most interestingly, vitreous volcanics, which were totally absent from the OGS cobble samples, were frequently used for making the OGS artifacts.

Detailed study of the Gona artifacts shows that a complex scenario of raw material sourcing and selectivity, and different modes of core reduction was already in place at 2.6 Ma. Further extensive sampling and experimental knapping studies will be important to firmly understand the reasons for the differential selectivity of raw materials by the contemporary hominins that lived in the EG and OGS areas. Nonetheless, it has become clear that the earliest toolmakers, even at the threshold of artifact manufacture and use at 2.6 Ma were already selective and preferred raw materials that are fine-grained and

more flakable. The OGS sites are providing new clues on the stone tool behavior of the first toolmakers, and the evidence confirms that by 2.6 Ma they were far more sophisticated in their planning, foresight and modes of artifact manufacture than was previously recognized.

Key Words: Oldowan, East Gona (EG), Ounda Gona South (OGS), earliest stone tools, raw material selectivity, Late Pliocene artifact assemblage variability

INTRODUCTION

The EG sites are located east of the Kada Gona, one of the major rivers from the easternmost part of the Gona study area that feeds into the Awash. The 2.6 Ma EG archaeological sites outcrop about 5 Km upstream from the confluence with the Awash River. The Ounda Gona is a tributary of the Kada Gona from the west, and the 2.6 Ma OGS archaeological sites are located south of the river (Figure 1). The two Late Pliocene sites of OGS-6 and OGS-7 were excavated in 2000 and yielded substantial archaeological materials with major implications for understanding the beginnings of early hominin stone tool behavior, and their ancient habitats. OGS-7 has yielded the most informative artifact assemblage and associated fauna, and more concentrated geological and archaeological investigations were carried out at the site.

Our studies show that the OGS stone artifacts, both in terms of composition of raw materials and modes of core reductions, are somewhat different from the contemporary archaeological materials recovered previously from the EG sites (Semaw et al., 2003; Stout et al., 2005). Our investigations, although preliminary, show that the types of raw materials used, and their differential flaking properties may have played an important role in determining the morphology and characteristics of the lithic assemblages excavated from the two areas. How did the use of different raw materials influence artifact form and size? How variable are the assemblages from the two areas of EG and OGS? Is the evidence sufficient to explain the reasons for the differences seen between the stone assemblages recovered from the EG and OGS areas? This paper explores the role that raw material proximity, accessibility and its flaking-quality may have played in the different modes of core reduction seen at the EG and the OGS sites. Further, we provide preliminary assessment of the assemblage variability seen during the initial stone manufacture and use at 2.6 Ma, and during the Oldowan documented at Late Pliocene-Earliest Pleistocene sites elsewhere in Africa.

Only the *in situ* archaeological materials excavated from EG-10, EG-12 and OGS-7 are analyzed here because these sites have yielded the largest sample of stone artifacts recovered within well-constrained geological/geochronological context. Artifacts greater than 20mm in maximum dimension are treated in more detail. The raw materials used for making the EG stone artifacts were reanalyzed by one of us (DS) following the more elaborate identifications used for the OGS-7 stone assemblages in Stout et al. (2005). The detailed identification of the cobble samples from both the EG and OGS areas indicate differences in the flaking-quality and proportion of the raw material types accessed in the two areas (Stout et al., 2005, in prep). Further systematic and extensive sampling of the cobbles/raw materials, and experimental knapping studies are needed for understanding the raw material selectivity and artifact manufacture practiced by the earliest toolmakers, but our preliminary investigations indicate intriguing and more complex behavior was already in place even during the initial stages of the production of stone artifacts at 2.6 Ma.

Initial research at Gona

The palaeoanthropological importance of the ancient artifact-rich and fossiliferous deposits exposed within the middle reaches of the Afar Rift was first recognized by Maurice Taieb (see Taieb et al., 1976). His initial explorations in the late 1960s laid the groundwork for the systematic investigations undertaken in the Afar during the subsequent four decades. Taieb's preliminary geological reconnaissance survey showed the presence of laterally-extensive artifact and fossil-rich Plio-Pleistocene deposits outcropping along the main course of the Awash River and its major tributaries. Subsequent systematic and extensive field investigations in the Afar led to the discovery of the Hadar, the Middle Awash, the Gona and the Dikika, and recently the Woranso-Mille study areas. Decades of fieldwork at these major sites has produced remarkable fossil hominins and archaeological materials (Kalb et al., 1982a & b; Johanson et al., 1982; Clark et al., 1984, 1994, 2003; White et al., 1994, 2003, 2006; WoldeGabriel et al., 1994, 2001; Renne, et al., 1999; Kimbel et al., 1994, 1996; Semaw, 2000, 2005, 2006; Semaw et al., 1997, 2003, 2005; Quade et al., 2004, 2008; Asfaw et al., 1999, 2002; de Heinzelin et al., 1999; Haile-Selassie, 2001; Haile-Selassie et al., 2004, 2007; Alemseged et al., 2006; Wynn et al., 2006; and references therein).

The archaeological significance of the Gona deposits was first noted in the early 1970s with the discovery of low density surface exposed artifacts from localities named Afaredo-1, and Kada Gona 1, -2, -3 and -4 (Corvinus, 1976; Corvinus & Roche, 1976; Roche & Tiercelin, 1977, 1980). The Afaredo and Kada Gona occurrences were located in the deposits exposed east of the Gona River, just north of the EG sites excavated later by Semaw et al. (1997). The initial fieldwork by Roche et al. (1977, 1980) in the Kada Gona documented artifacts traced between two conglomeratic layers named the Intermediate Cobble Conglomerate (ICC) and the Upper Cobble Conglomerate. The ICC is located just below the EG-10 and EG-12 excavations, and probably it was the source of the raw materials used for making the EG artifacts (Semaw, 2000, 2006; see also Semaw et al., 2003; Stout et al., 2005). Initially, Roche & Tiercelin (1977, 1980) recognized four volcanic tuffs (ashes I-IV) in the stratigraphic sections exposed at East Gona, and three of

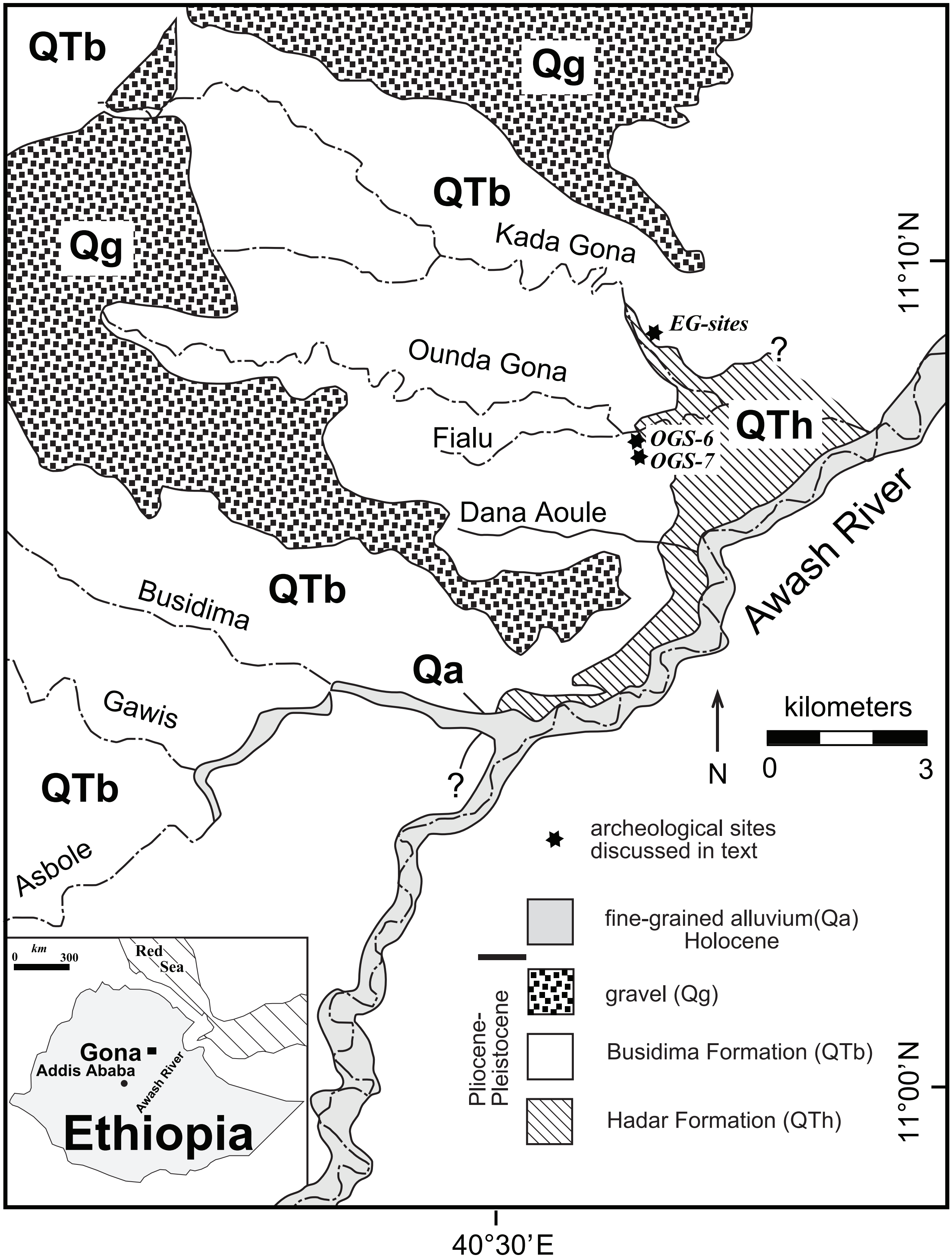

Figure 1. A map of the Gona Palaeoanthropological Research Project Study Area. The East Gona and the Ounda Gona South excavated sites are located in the easternmost part of the Gona study area (after Semaw et al., 2003; map modified by J. Quade).

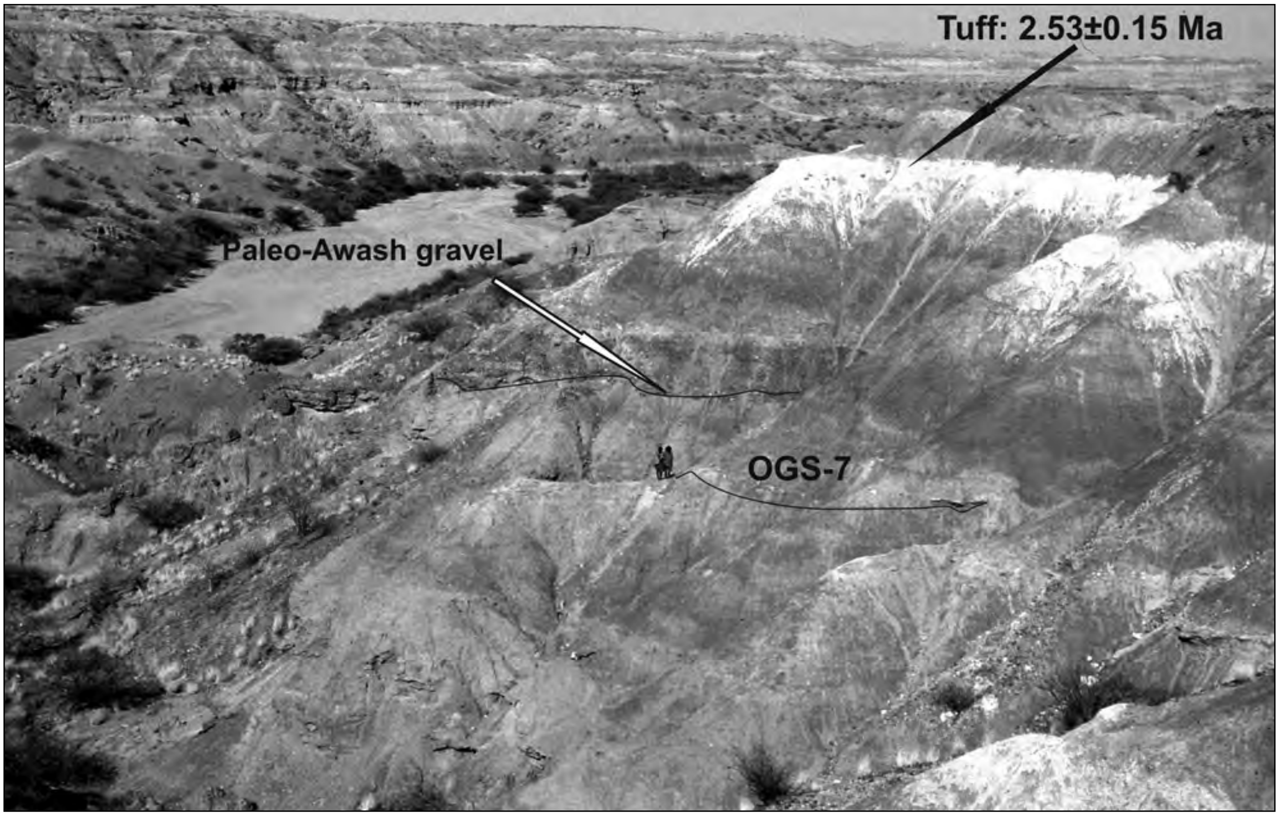

Figure 2. A photo showing the OGS-7 archaeological site with the prominently exposed tuff $^{40}Ar/^{39}Ar$ dated to 2.53±0.15 Ma, the stratigraphic position of the OGS-7 excavation and the cobble conglomerate (paleo-Awash gravel) sampled for this study (after Semaw et al., 2003).

these were later renamed as Artifact Site Tuffs (AST-1, -2 & -3) by Walter (1980). These tuffs were too altered for radioisotopic Ar/Ar dating, but still useful as markers for correlating the archaeological sites in the Kada Gona and associated drainages. The Afaredo and Kada Gona artifacts found in the early 1970s were at the time estimated to 2.5 Ma based on the supposed correlation of the BKT-2 tuff from the Hadar Formation with the AST-2 tuff exposed at East Gona (Walter, 1980; Walter & Aronson, 1982; but see Semaw et al., 1997). The BKT-2 has been re-dated to 2.9 Ma (Kimbel et al., 1994), and the age was later confirmed with the discovery of the Green-marker tuff at East Gona, which was also dated to 2.92 Ma by $^{40}Ar/^{39}Ar$. The Green-marker tuff is a correlative of the BKT-2 from Hadar and stratigraphically located several meters below the EG archaeological sites (Semaw et al., 1997).

In situ stone artifacts from systematic excavations within the Kada Gona drainage were first documented in 1976 from a locality identified at West Gona, later renamed as WG-1 (Harris, 1983; Harris & Semaw, 1989). The WG-1 artifacts were of low density, and like the Afaredo and Kada Gona sites, the 2.5 Ma age for West Gona was again an estimate based on the supposed stratigraphic correlation of the artifact-bearing layer with the BKT-2 tuff from Hadar. Recent geological investigations indicate that the artifact-bearing deposits at WG-1 and the adjacent archaeological localities at West Gona (except probably for WG-5 which may be EG-10 & -12 age) lie stratigraphically above the EG sites, and probably date to ~2.4-2.3 Ma (Quade et al., 2004, 2008).

The East Gona Archaeological Localities of EG-10 and EG-12 and the Stone Artifacts: Brief Summary

EG-10 and EG-12 were discovered in 1992, and the surface and *in situ* artifacts from both sites combined number more than 3,000. The two sites were excavated within fine-grained deposits securely dated between 2.6-2.5 Ma (for details see Semaw et al., 1997). Within the upward-fining stratigraphic sequence exposed at East Gona, the Intermediate Cobble Conglomerate (ICC) is located just below EG-10 and EG-12, and prominently exposed near the two sites. The ICC also extends laterally within the Kada Gona and associated drainages and it may have been the closest source of the cobbles used for making the EG stone artifacts. The AST-2.75 tuff (discovered in 1993), located ~5-7 meters above the EG sites, was dated to 2.52± 0.075 by $^{40}Ar/^{39}Ar$, and assisted in resolving the age of the oldest Gona artifacts (Semaw et al., 1997). Paleomagnetic analyses of the sediments sampled along the stratigraphic sections exposed near EG-10 and EG-12 placed the Gauss-Matuyama transition dated to 2.58 Ma (McDougall et al., 1992) within the ICC, also corroborating the age of the overlying tuff. Hence, the EG-10 and EG-12 artifacts are securely dated between 2.52 -2.6 Ma, with the excavated layers closer to the maximum age.

The EG-10 and EG-12 stone assemblages consist of cores/choppers and *débitage* (whole and broken flakes and angular fragments), representing the main artifacts known in the Oldowan or Mode 1 core/flake Industry (M. Leakey, 1971; Clarke, 1969). A majority of the EG cores were unifacially-worked using the hand-held percussion technique as the main mode of core reduction. A large number of the cores were made on trachyte and rhyolite cobbles and most were identified as unifacial side choppers (*sensu* M. Leakey, 1971). Although unifacial-flaking was dominant, a large number of specimens were also bifacially-worked and some were identified as core scrapers, including one partial discoid from EG-10 and a heavily reduced small polyhedral core recovered from EG-12.

Artifacts identified as *débitage* comprise about 97% of the stone assemblages of EG-10 and EG-12. The whole flakes from both sites were well-struck and show clear platforms, prominent and pronounced bulbs of percussion and smooth release surfaces. Like the cores, a majority of the whole flakes were made of trachyte and rhyolite, and mainly side-struck. EG-10 and EG-12 contain a large number of split flakes and angular fragments, and again the pieces were dominated by trachyte and rhyolite. Although unifacial working was the main mode of flaking, bifacial/polyfacial working was also practiced, confirming that the makers were skilled knappers with clear understanding of the mechanics of conchoidal fractures on stones, and that the hominins were capable of manipulating the cores for acute flaking angles. Retouched pieces (though whether deliberate or accidental is unclear), are present, but rare.

The OGS-7 Archaeological Locality, Ounda Gona South

The Late Pliocene deposits exposed in the Ounda Gona South (OGS) area, located ~ 3-5 km south-southwest of the EG sites were systematically surveyed in 1999, and the presence of archaeological sites lower in the stratigraphy at OGS was first noted with the discovery of a high density of Oldowan artifacts and fauna on the surface at the locality named OGS-6 (Figure 1). Intensive survey of the immediate area in 2000 produced OGS-7, the most informative of the OGS sites (Semaw et al., 2003). OGS-7 was found in the Fialu (40° 31' 42.758'N, 11° 6' 3. 479'E), one of the major streams feeding into the Ounda Gona. Both sites were excavated in 2000, and OGS-7 yielded the highest and densest concentration of artifacts and associated fauna *in situ*. OGS-6 also yielded a limited number of excavated artifacts and a surface eroded bone with evidence of definite cutmarks (Semaw et al., 2003; Domínguez-Rodrigo et al., 2005). Although the bones were poorly preserved, the OGS-7 excavated materials provide the oldest documented associations of artifacts and fragmentary fauna dated close to 2.6 Ma, and the most informative artifact assemblage for investigating and understanding the raw material selectivity of the first toolmakers.

Stratigraphy and dating

During the 2000 survey, surface exposed artifacts at OGS-7 were found eroding out of a steep-walled section, which also showed the relationships of the artifact-bearing horizon to the overlying dated tuff, and the entire stratigraphic sequence at the site (Figure 2). The archaeological site is situated within the newly designated Busidima Formation and stratigraphically lies immediately above the geological disconformity widely documented at Gona (Quade et al., 2004, 2008). The disconformity is stratigraphically located below the fluvial sediments associated with the paleo-Awash, and above the lacustrine and deltaic sediments preserved in the post-Hadar-age deposits (<2.9 Ma). Penecontemporaneous lacustrine and deltaic sediments are also exposed at East Gona just below the ICC and above the Green-Marker tuff dated to 2.92 Ma. The disconformity is laterally-extensive and well-exposed in both the OGS and EG areas, and it is estimated between 2.9-2.7 Ma (see Semaw et al., 1977, 2003; Quade et al., 2004, 2008). At OGS-7, above the disconformity are a series of ~5-8 m thick upward fining sections with conglomerates at the base, followed by rhyzolith-rich sands and bedded silts capped by paleo-vertisols (Semaw et al., 2003; Quade et al., 2004). Figure 3a shows the stratigraphic sequence at OGS-7. Stratigraphically OGS-7 is placed within the middle of the second upward fining cycle. The excavated artifacts and fragmentary fossilized fauna are confined to a <10cm-thick fine vertisol, and the materials were uncovered resting flatly on a local contact between coarse sand below and bedded silt above.

The volcanic tuff prominently exposed ~7 meters directly above the OGS-7 excavation was dated by $^{40}Ar/^{39}Ar$ to 2.53±0.15 Ma, and the Gauss-Matuyama chron geomagnetic polarity transition (GPTS) dated to c. 2.58 Ma (McDougall et al., 1992; Cande & Kent, 1995) was traced at the level of the site (Figures 2 and 3b). Thus, the age of the OGS-7 archaeological materials is well-constrained between 2.6-2.53 Ma. The artifact-bearing horizons at both OGS-6 and OGS-7 are extensive and can be traced laterally between the two sites, which are separated by only about 300 meters; hence, both sites are dated to the exact same age (Semaw et al., 2003). Further, the stratigraphic position of the EG and OGS sites appear to be similar suggesting that the toolmakers in both the EG and OGS areas may have shared a contemporary landscape, but probably with diverse habitats and varied access to raw material sources.

The OGS-7 Excavation and Archaeology

The OGS-7 archaeological site was found on a steep-walled section with the dated tuff prominently exposed directly above it (Figure 2). About 200 artifacts (including surface scrapes) were collected from the surface, and more than 700 excavated artifacts (with a large number

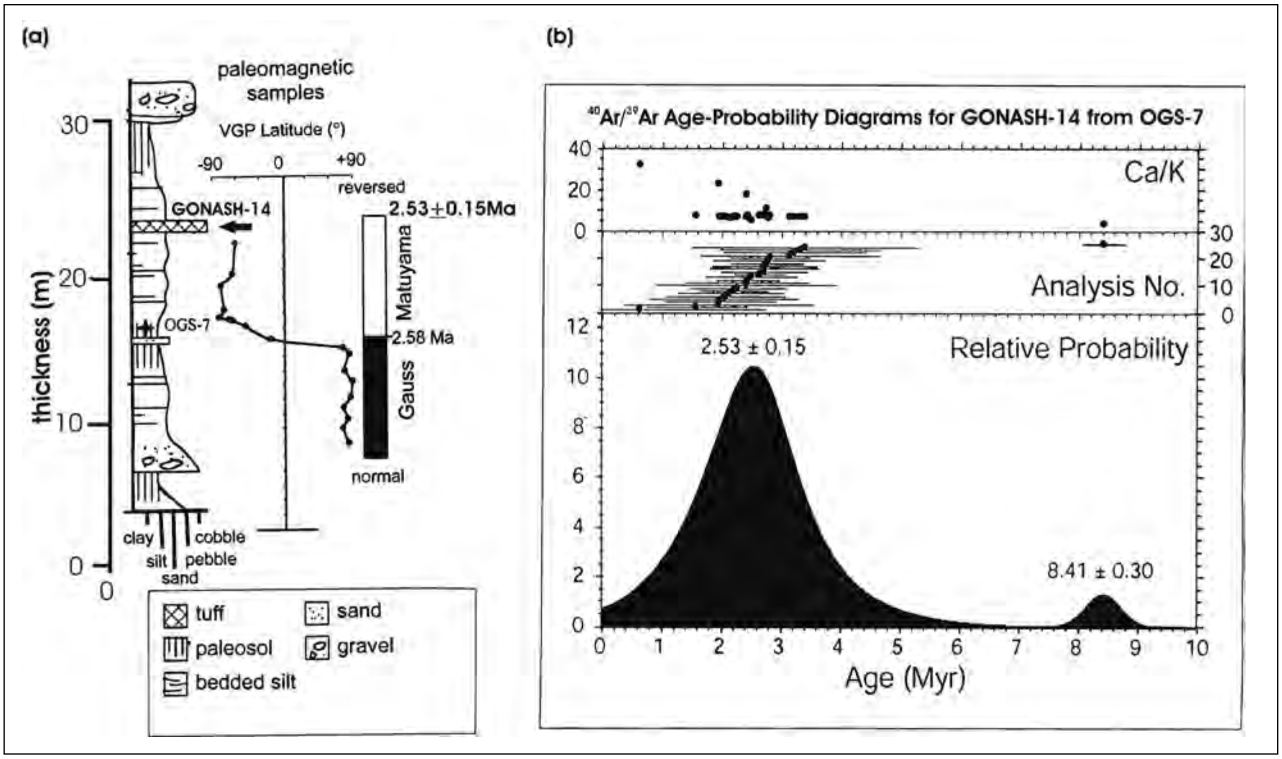

Figure 3. The stratigraphy and paleomagnetic analysis of OGS-7. a) Site-mean virtual geomagnetic polarity (VGP) latitude is plotted against stratigraphic level; negative VGP latitude indicates reversed polarity, b) $^{40}Ar/^{39}Ar$ spectra on GONASH-14 (after Semaw et al., 2003).

measuring <20 mm) and fossilized bone fragments were recovered *in situ* within fine-grained sediments. Figure 4 shows some of the *in situ* artifacts excavated within fine-grained sediments. Over 25 meters of overburden lie in the steep exposures above OGS-7 and only a portion (4m × 0.65m) of the site was excavated. Because of the steep exposures, excavations were undertaken on steps cut for standing, and the archaeology team dug into the wall slowly succeeding to uncover only a portion of the site. Despite the difficulty of removing the overburden, and the small size of the area excavated, the materials recovered at OGS-7 were of very high density (at least 162 artifacts/m^2 and 13 bone fragments/m^2 piece-plotted only). Figure 5 shows the horizontal and vertical distribution of the excavated artifacts. The artifacts were very fresh and vertically restricted within <10cm-thick layer with no preferred orientation, implying an undisturbed archaeological association. The artifacts consist of typical Oldowan choppers/cores and *débitage* (whole flakes, broken flakes and angular fragments) made of a variety of raw materials including trachyte, rhyolite, latite, aphanitic and vitreous volcanics. More than ~97% of the artifacts fall into the *débitage* category. Although the artifacts were very fresh, the fauna were very fragmentary probably due to hominin-induced breakage and damage, and possibly as a result of pre-fossilization weathering.

A variety of raw materials were used for making the artifacts, but unique for OGS-7 is the presence of a large number of *débitage* made of vitreous volcanic (12%), a fine-grained raw material type rare for any of the Gona assemblages dated to 2.6-2.5 Ma. Vitreous volcanics were totally absent from the cobble samples randomly collected within the associated conglomerate (the most likely source of the clasts used for making the artifacts), and none of the OGS-7 cores were identified to this raw material. In contrast, all of the remaining raw material types utilized for making the OGS-7 artifacts were identified within the cobbles sampled from the conglomerate associated with OGS-7.

All of the cores from OGS-7 were bifacially/polyfacially-worked, heavily-reduced and smaller in size, except for 1 unifacial (centripetal), but intensively worked specimen, attesting to the sophisticated understanding of conchoidal fracture on stone and superb knapping skills of the makers. Most striking at OGS-7 is also the presence of a considerable number of well-struck, knife-like whole flakes and some deliberately retouched pieces made of fine raw materials. The fossilized bones excavated from OGS-7 were fragmentary and poorly-preserved for documenting stone tool-induced modifications, and *in situ* bones with evidence of cut marks have yet to be excavated from the oldest 2.5-2.6 Ma sites at Gona. However, a bovid calcaneus with definite cut marks was found on the surface at OGS-6 (Domínguez-Rodrigo et al., 2005). The OGS-6 cut-marked bone was recovered along with a large number of freshly exposed artifacts. The fossilized bones excavated from OGS-7 were tightly clustered (horizontally and vertically) with the artifacts. A bone flake with a clear striking platform and diagnostic bulb of percussion was also recovered

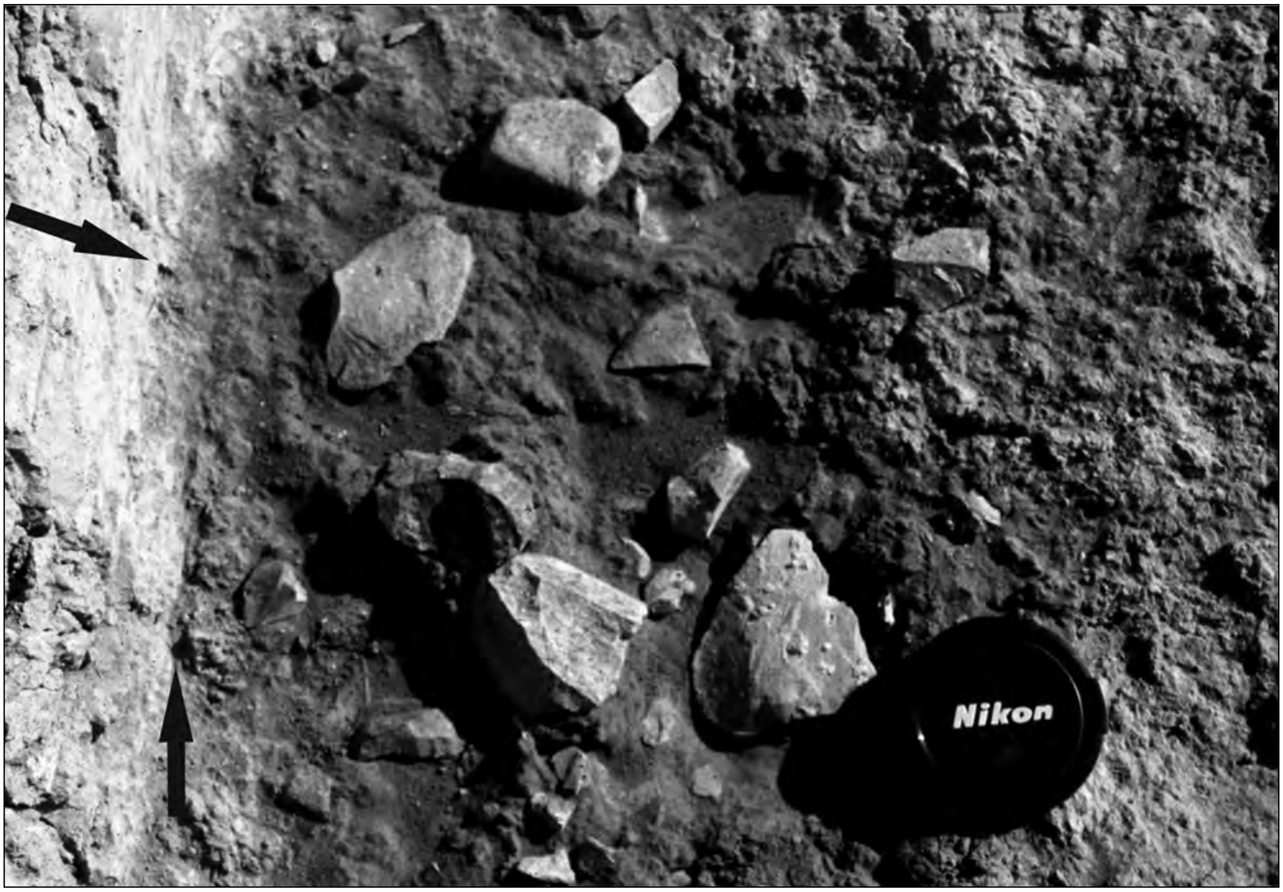

Figure 4. The OGS-7 "excavation floor" showing the in situ artifacts and fragmentary bones recovered in fine-grained sediments. (the excavation wall is shown by the arrows)

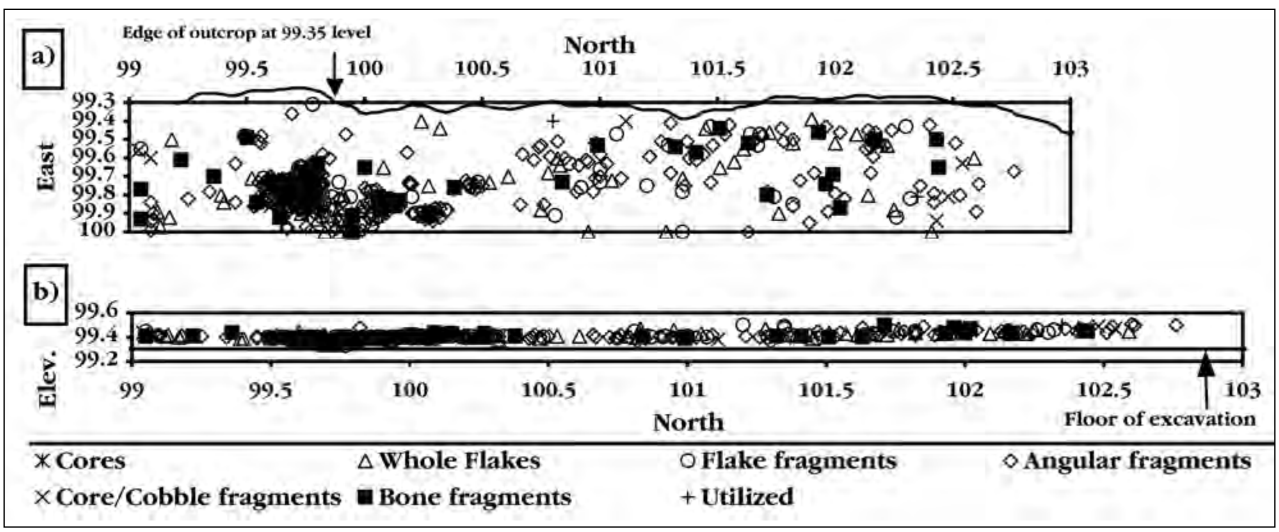

Figure 5. Artifacts and bone piece plot showing, a) the horizontal and b) the vertical distribution of the excavated materials at OGS-7.

in situ in association with the OGS-7 excavated stone artifacts pointing to hominin activities related to carcass processing. Stone tool cut-marked bones are also known from contemporary deposits at Bouri, in the Middle Awash (de Heinzelin et al., 1999). The Bouri excavated bones lack associated stone artifacts, but the cut mark evidence clearly shows that ancestral hominins by ~2.6-2.5 Ma used sharp-edged flaked stones for processing animal carcasses for meat. Despite the fragmentary nature of the excavated bones, and lack of *in situ* cut-marked bones at Gona, the association between artifacts and broken fossilized remains of ancient animal bones with clear evidence of damage induced by hominin activities at 2.6-2.5 Ma has been unequivocally established for the first time with the evidence from OGS-6 and -7.

The Stone Raw Materials Used at the Earliest Sites at Gona

Most of the Plio-Pleistocene archaeological sites at Gona, including OGS-7, are located near conglomerates, the probable cobble sources exploited for the raw materials used for making the stone artifacts. The cobbles were deposited along the main course of the ancestral Awash and would have been accessible on cobble bars in the main channel, especially during the dry season (Quade et al., 2004). Clasts may also have been exposed in tributary channel cuts on the nearby floodplains. One of us (DS) undertook systematic and random sampling of the cobbles from the conglomerates exposed just below and laterally to the OGS-7 excavation to assess the availability of cobbles suitable for knapping and to determine the selectivity of the toolmakers (for details see Stout et al., 2005, in prep). Figure 6 shows the raw material types identified from the cobble samples from EG13 (~100-200 meters from EG-10 and EG-12) and OGS-7 and the composition of the raw materials used for making the artifacts.

The cobbles in the samples (random and systematic from the conglomerate exposed near OGS-7) included trachyte, rhyolite, latite and aphanitic volcanic materials, and only one-fifth of those systematically sampled were > 5cm in maximum dimension, i.e. of a size suitable for knapping. Artifacts made of vitreous volcanics are abundant at OGS-7, but such materials were absent from the cobble samples. Of the 116 cobble samples systematically excavated from the conglomerate associated with OGS-7, "31% were identified as trachyte, 26% as rhyolite, 26% as latite, 11% as aphanitic lava and the remaining as indeterminate (6%). The random outcrop sample was dominated by latite (41%) and rhyolite (34%), with a smaller percentage of basalt (18%) and trachyte (7%), but no chert clasts [vitreous volcanic] were recognized" (Semaw et al., 2003, p. 175).

The OGS-7 site is undisturbed post-depositionally and preserves a high percentage of *débitage* (~97%) for contrasting the types of raw materials sampled in the conglomerate, and to determine the selectivity of the hominins. "The raw material composition of the OGS-7 excavated *débitage* (29% latite, 20% trachyte, 14% rhyolite, 12% chert [vitreous volcanic] and 25% others including aphanitic) contrasts strongly with the availability of raw materials in the conglomerate" (Semaw et al., 2003, p. 175).

In fact, no significant correlations were detected between the frequency of the raw material types identified in the cobble samples and in the OGS-7 *débitage* (see Semaw et al., 2003; Stout et al., 2005 for details).

The heavy utilization of vitreous volcanics (12% of the *débitage*) is striking with almost every vitreous volcanic flake produced from a different original nodule. However, no vitreous volcanic cores were recovered from the excavation, and such materials were completely absent from the associated cobble samples. It remains most likely that the toolmakers obtained these materials locally (although precise transport distances remain unclear), however, the failure to recover a single vitreous volcanic clast from a combined sample of 216 cobbles indicates an extremely low rate of occurrence. Thus, the presence of abundant artifacts made of vitreous volcanics and other raw materials that were not identified in the cobbles sampled near OGS-7 implies that the homi-

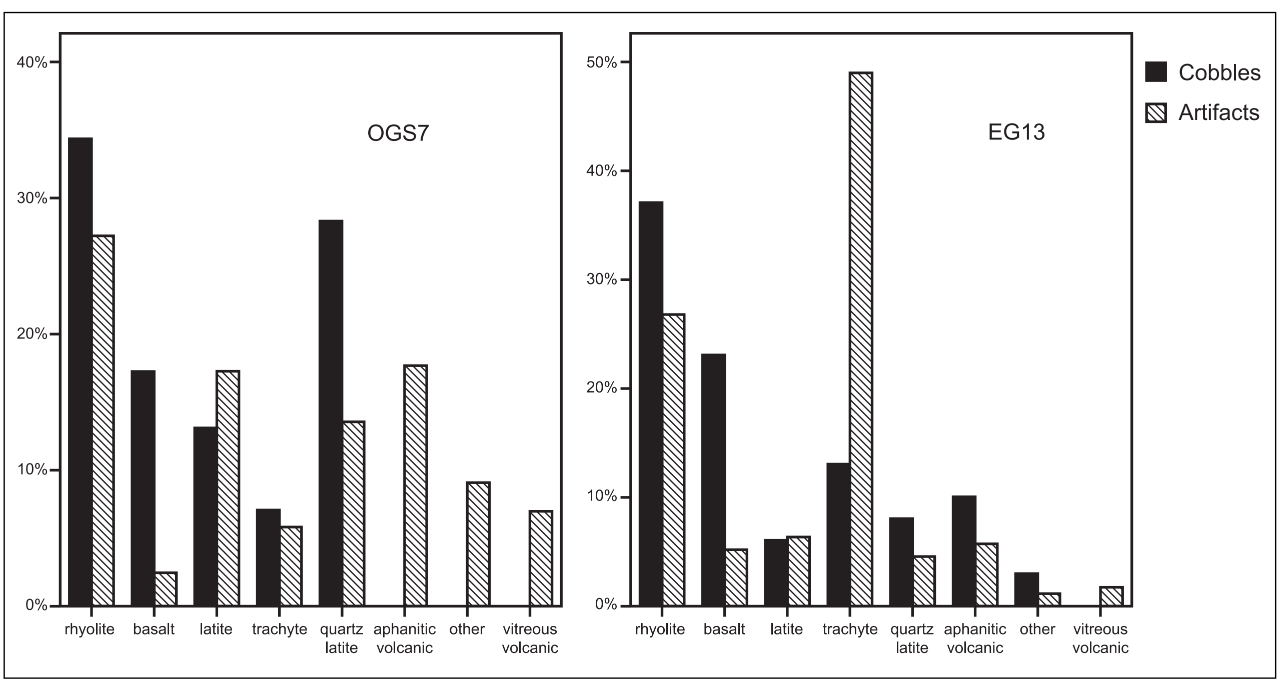

Figure 6. The distribution of raw material types in the conglomerate samples and actual artifacts from OGS-7 and EG13 (after Stout et al., 2005).

nins practiced a high level of selectivity for good-size (fist-size) and better-flaking quality cobbles accessed from nearby sources.

In contrast, the EG-10 and EG-12 artifacts were predominantly made of trachyte and rhyolite cobbles selected from the nearby gravels associated with the ICC. The ICC was the closest source of raw materials and fist-sized cobbles suitable for making artifacts were accessible from ancient channels located near EG-10 and EG-12. The toolmakers had to travel only a short distance to acquire these cobbles. Stout et al. (2005) carried out random sampling of the cobbles found eroding from the ICC near EG13. The preliminary study of Stout et al. (2005) shows that a majority of the cobbles sampled from the ICC were rhyolite and basalt (~60% of the samples) with trachyte cobbles making up just over 10%, and other raw materials such as latite and vitreous volcanics making up the remainder. Interestingly, a majority of the EG13 (nearly 50%) stone artifacts were made of trachyte, and close to 30% on rhyolite, and the remainder on basalt and other raw materials, a pattern of selectivity similar to EG-10 and EG-12 (Stout et al., 2005). Figures 7-9 show the artifact breakdown by raw material types. The EG-10 and EG-12 raw materials were recently reanalyzed by one of us (DS) following the criteria outlined in Stout et al. (2005). Trachyte and rhyolite dominate the EG assemblages, followed by latite, aphanatic and vitreous volcanics. The distribution of detached pieces raw material types at EG-10 and EG-12 is statistically indistinguishable (n=445, Pearson's Chi Square =7.65, df=8, p=0.469), but differs significantly from that seen at OGS-7 (n=620, Pearson's Chi Square=179.7, df=8, p<0.001). The detached pieces make up ~97% of the total assemblages from each of the EG and OGS sites, and the results clearly show the differing patterns of raw material selectivity between the two areas.

Further systematic and exhaustive sampling and experimental work on the cobbles exposed near the EG and OGS sites is needed to conclusively determine the composition of the raw material types accessible in the conglomerates. The initial analyses of Stout et al. (2005, in press) indicate that the toolmakers in both areas show selectivity for particular raw materials for making the Oldowan stone artifacts. However, why the major em-

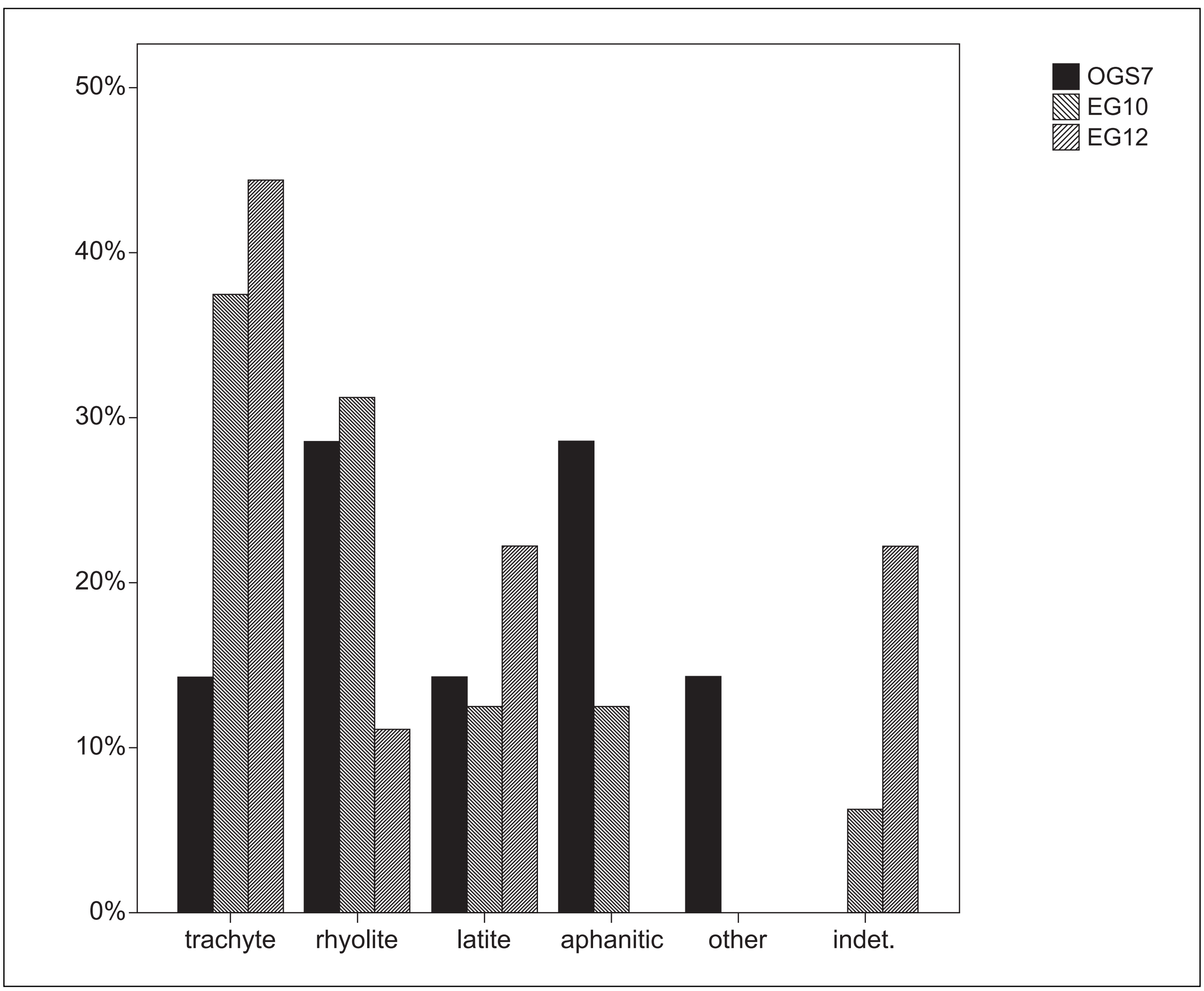

Figure 7. Percentage frequency of the raw material types used for making the EG-10, EG-12 and OGS-7 excavated cores.

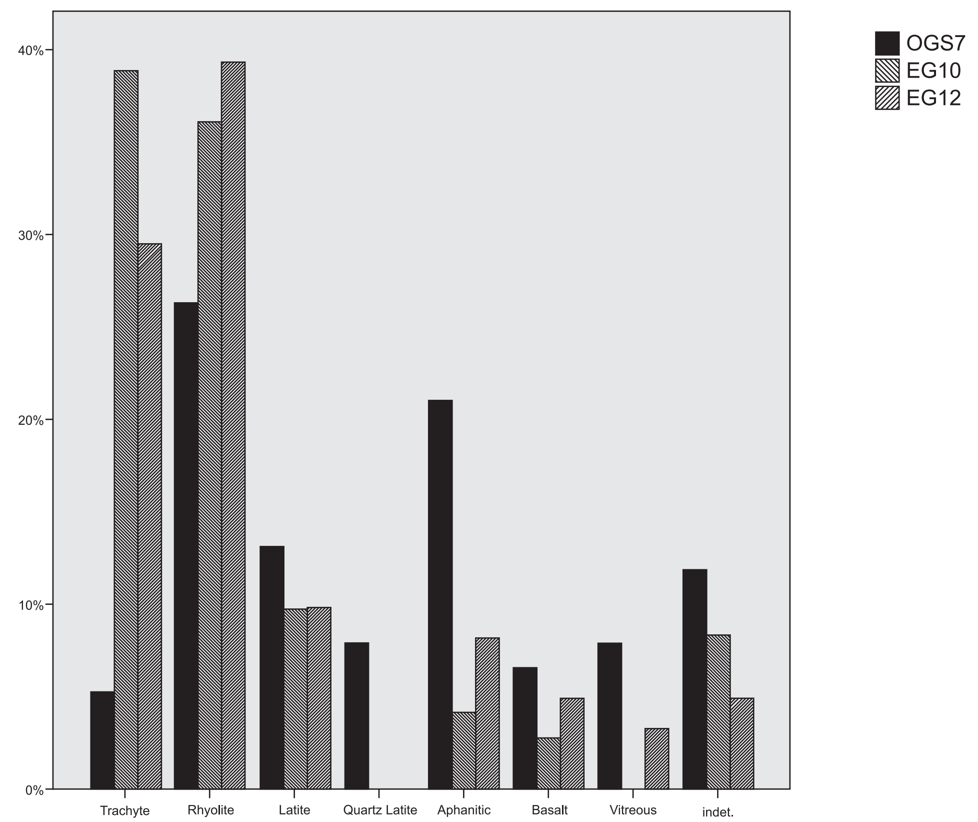

Figure 8. Percentage frequency of the raw material types used for making the EG-10, EG-12 and OGS-7 excavated whole flakes (after Stout et al., in prep).

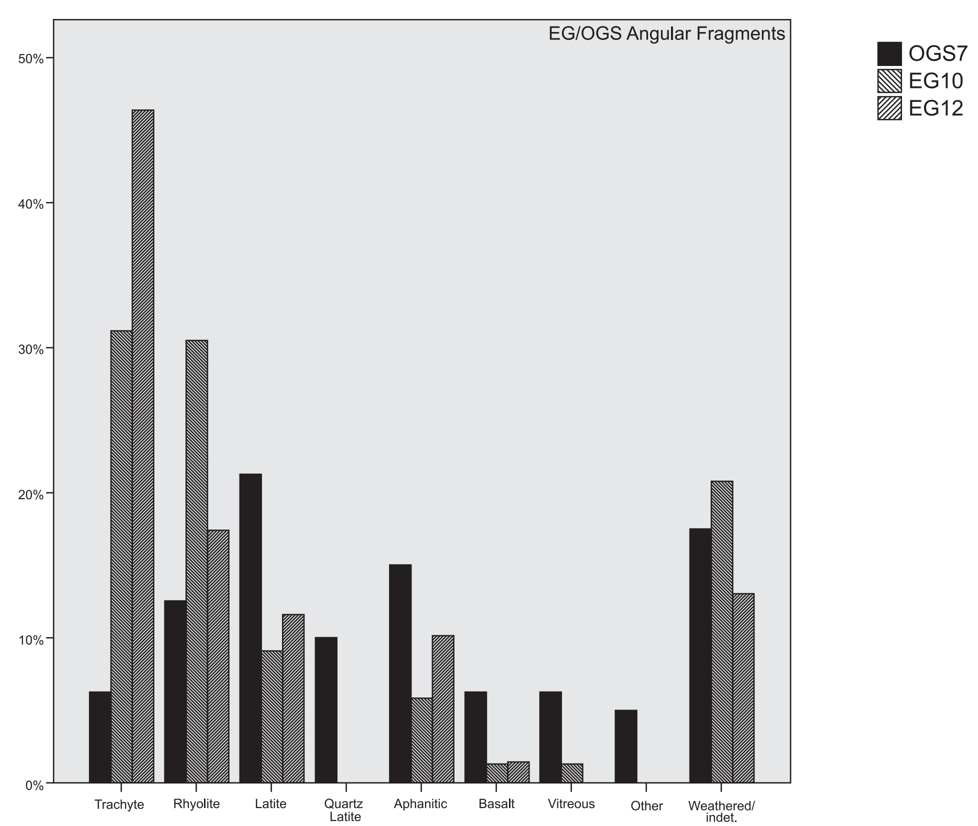

Figure 9. Percentage frequency of the raw material types used for making the EG-10, EG-12 and OGS-7 excavated angular fragments (after Stout et al., in prep).

Table 1. Percentage composition of all surface and excavated artifacts from OGS-7, EG-10 & EG-12. Data modified after Semaw, 2006. (n) = number of artifacts. The description of the artifacts follows M. Leakey's (1971) terminologies. Isaac et al's (1981) artifact categories are shown in parantheses. Note: The OGS7 artifact count includes only the specimens >20mm.

	OGS7		EG10		EG12	
	Surface	**Excavated**	**Surface**	**Excavated**	**Surface**	**Excavated**
All Lithics (n)	53	269	1549	687	309	444
All Artifacts (n)	53	269	1549	685	308	445
Manuports (Unmodified Stones)	0	0	0	0	0	0
Split Cobbles	0	0	0	1	1	0
Cores/Choppers or Tools (Flaked Pieces)	1.90	2.60	1.1	2.19	1.3	2.03
Débitage (Detached Pieces)	98.11	97.40	98.9	97.81	98.7	97.97
Utilised Materials (Battered & Pounded Pieces)	0.00	0.00	0.00	0.00	0.00	0.00
% Artifacts	100	100	100	100	100	100
Cores/Choppers or Tools (Flaked Pieces) (n)	1	7	17	16	4	7
Cores/Choppers	100.00	100.00	88.24	73.33	100.00	88.89
Discoids	0.00	0.00	5.88	20.00	0.00	0.00
Core Scrapers	0.00	0.00	5.88	6.67	0.00	11.11
% Total	100.00	100.00	100.00	100.00	100.00	100.00
Débitage (Detached Pieces)	52	262	1532	670	304	436
Whole Flakes	19.23	29.01	18.01	24.48	30.92	33.94
Angular Fragments	65.38	55.34	74.28	60.45	54.93	51.83
Split Flakes	5.77	10.69	5.42	8.36	12.17	9.86
Snapped Flakes	9.62	4.97	0.72	3.43	0.66	2.06
Split & Snapped Flakes	0.00	0.00	0.07	2.69	0.00	0.00
Core/Cobble Fragments	0.00	0.00	1.50	0.59	1.32	2.31
% Total	100.00	100.00	100.00	100.00	100.00	100.00
Utilised Materials (Battered & Pounded Pieces)	0	0	0	0	0	0

phasis was placed on trachyte at the EG sites and why other more fine-grained raw materials were selected/preferred (or used) at OGS-7 is an issue that needs further investigation.

The evidence from OGS-7 strongly corroborates earlier observations made regarding the sophisticated artifact manufacture, the raw material selectivity, and the effective knapping strategies of the hominins responsible for producing sharp-edged cutting flakes recovered from the EG sites (Semaw et al., 1997). The overall archaeological evidence from OGS-7 further reinforces the fact that the first toolmakers were more advanced in their decision-making and stone crafting behavior than previously recognized.

Characteristics of the EG and OGS Stone Assemblages

The Cores: Flaking modes, and the extent of core reductions

A large number of cores have been excavated from the East Gona archaeological sites, including 16 from EG-10, and 7 from EG-12. Table 1 shows the artifact composition of the EG and OGS-7 artifacts. A majority of the EG cores are unifacially-flaked (EG-10 ~70%, and EG-12 ~50%). Following M. Leakey (1971), most of the EG cores could be classified as unifacial side choppers. A large number of the EG cores/choppers are not as heavily-worked (compared to OGS-7). However, a number

Table 2. Basic measurements of the excavated cores

		OGS7	EG10	EG12
No. of Cores/Choppers		7	16	7
Maximum Dimensions				
	Mean	62.57	82.75	74.11
	Std	7.61	10.16	9.5
	Range	(45-70)	(68-106)	(58-87)
Length				
	Mean	44.14	83.33	74.45
	Std	13.68	10.34	8.72
	Range	(28-67)	(69-105)	(58-93)
Breadth				
	Mean	59	60.90	59.73
	Std	8.54	9.18	8.06
	Range	(45-70	(44-80)	(49-77)
Thickness				
	Mean	37	45.27	43.73
	Std	8.2	12.36	7.74
	Range	(22-49)	(30-69)	(25-53)
Total Scars				
	Mean	6	10.27	8.91
	Std	1.6	3.74	3.45
	Range	(3-8)	(6-21)	(3-15)
Largest Scars/ Dimensions				
	Mean	50.71	48.07	45.45
	Std	7	11.79	8.40
	Range	(41-60)	(30-65)	(33-60)
B/L				
	Mean	0.77	0.73	0.77
	Std	0.3	0.08	0.09
T/B				
	Mean	0.8	0.74	0.71
	Std	0.4	0.16	0.14

Table 3. Basic attributes of the excavated whole flakes

		OGS7	EG10	EG12
No. of Artifacts		73	114	62
Maximum Dimensions				
	Mean	44	42.18	40.94
	Std	15.5	15.56	13.85
	Range	(20-82)	(20-85)	(20-71)
Length				
	Mean	39.1	37.38	34.50
	Std	14.3	15.34	12.84
	Range	(13-80)	(14-78)	(15-66)
Breadth				
	Mean	37.1	34.63	35.55
	Std	14.1	13.74	13.23
	Range	(13-74)	(14-77)	(19-66)
Thickness				
	Mean	12.7	13.18	12.13
	Std	5.07	6.26	5.76
	Range	(3-26)	(3-33)	(4-30)
Dorsal Scars				
	Mean	2.2	3.07	3.00
	Std	1.5	1.72	1.54
	Range	(0-5)	(0-10)	(0-8)
Platform Breadth				
	Mean	23.23	22.86	24.56
	Std	10.67	11.37	13.27
	Range	(8-64)	(4-60)	(5-58)
Platform Thickness				
	Mean	9.1	10.21	10.10
	Std	4.2	6.04	5.65
	Range	(1-19)	(2-34)	(2-29)
Breadth/Length				
	Mean	0.99	0.96	1.08
	Std	0.34	0.26	0.30
Thickness/Breadth				
	Mean	0.36	0.39	0.34
	Std	0.14	0.11	0.11

Table 4. Maximum dimension, in situ angular fragments, and split flakes

	OGS7	EG10	EG12
Angular Fragments			
Count > 20mm	84	181	91
MD Avg.	30.48	27.02	26.81
STD	9.48	7.6	8.56
Range	(64-20)	(77-20)	(62-20)
Split Flakes			
Count > 20mm	26	46	38
MD Avg.	31.58	37.93	38
STD	8.4	11.99	12.4
Range	(26-20)	(73-22)	(77-21)

of the specimens were multifacially/polyfacially-flaked, heavily-reduced, and include polyhedral and discoidal cores (Figures 10-12). In addition, one 'Karari-like' core scraper was recovered from the EG-10 excavation (Figure 13). In contrast, six of the seven excavated cores recovered from OGS-7 were multifacially/polyfacially-worked, heavily-reduced (retaining only <25% cortex), and most can be identified as bifacial side choppers (with some polyhedral cores), and one as end chopper. Figures 14 and 15 show heavily-worked cores from EG-10 and OGS-7. Examples of two of the heavily-reduced cores excavated from OGS-7 are shown in Figure 16. Only one of the excavated cores from OGS-7 can be identified as a unifacial centripetal core. The maximum dimensions on the cores show the heavy-reduction of the OGS-7 cores (Table 2, Figure 17). Actually, the maximum dimension recorded for a flake from OGS-7 is greater than the maximum dimension of the largest core (82mm for the flake vs. 70mm for the core), which is not the case for the EG sites, where the maximum dimension of the cores is definitely larger than the flakes, as expected (see Tables 2 & 3).

A majority of the EG cores were made on trachyte (~55%) and the remaining on rhyolite and aphanitics. In contrast, most of the OGS-7 cores were made on rhyolite (~30%) and aphanitic volcanics (~30%), and the remaining on trachyte, latite and other (~14% each). Interestingly, none of the cores from OGS-7 (excavated or surface) were identified as vitreous volcanics, but 12% of the *in situ débitage* were of this raw material type. Based on observations of the color and texture of the *débitage*, at least four or five vitreous volcanic nodules may have been used at OGS-7, however, none of these flaked pieces were recovered at the site. Interestingly, EG-12 has yielded one core made on a glassy latite, but the number of *débitage* on this raw material from the EG sites is very low. The cores from the EG sites were predominantly unifacial and the evidence seems to be persuasive that this mode of core reduction may have been the dominant stone working technique in the EG area.

In terms of flake scars, the EG-10 cores have ~10 scars on average, whereas the OGS-7 cores retain an average of ~6 flake scars (Table 2). The relatively low number of flake scars recorded for OGS-7 may be due to the exhaustively-worked nature of the cores resulting in the removal of previous flaking scars in the course of the heavy-reduction process. The absence of vitreous volcanic cores at OGS-7 raises important questions. Based on our preliminary work at OGS-7, it can be argued that this raw material was sought after for its fine-grained property and better-flaking quality, and the cores were exhaustively-reduced for generating the most flakes. Fur-

Figure 10. Photo showing the EG-10 and EG-12 cores. The top row shows bifacially-flaked cores, and the bottom row examples of unifacially-flaked cores. The two cores on the top row are made on trachyte, and the third one on rhyolite. The two cores in the bottom row are made on trachyte, and the third on aphanitic volcanics. All the specimens (except for the larger piece in the bottom row) are excavated.

Figure 11. Photo showing the opposite faces of the cores in Figure 10.

ther, the cores that were already flaked at the site were probably conserved and transported by the hominins for further reductions at other yet undiscovered 'activity areas' across the ancient landscape. However, we need to expand the OGS-7 excavation to verify the validity of this suggestion. The less-exhaustively worked nature of the EG cores corresponds with the great abundance of suitable-size trachyte and rhyolite cobbles that were easily accessible and readily available in the ICC.

The nature of the cores from the EG and the OGS sites provides important clues on ancestral human behavior regarding conservation and transport of raw materials. The evidence from the EG and OGS sites strongly indicates that the heavy/moderate reduction and the size of the cores appear to correspond with the proximity and easy access to good-flaking raw materials. The heavy-reduction of the cores seen at OGS-7 is a good example of early hominin selectivity of raw materials with excellent flaking-quality, and exploitation of fine-grained raw materials to the maximum, possibly due to the relative scarcity of the most-favored raw material types. These finer-grained materials tend to be sharper, harder, and more durable than the coarser-grained lavas (N. Toth, pers. comm.).

Rounded-cobbles usually identified as hammerstones at other Early Pleistocene assemblages in East Africa are not known from either the EG or the OGS sites. However, a few of the cores from the EG sites show pitting/pounding marks on their cortical butt probably a result of use as hammerstones or possible use for pounding activities related to processing of animal carcasses such as for breaking bones for marrows. There are a few cores from OGS-7 that also have cortical butts that could have been used for the same purpose. Toth et al. (2006) point out that heavy-reduction of cores is an indicator of good flaking skills, and the overall archaeological evidence attests that the OGS-7 toolmakers were proficient knappers. The preponderance of side choppers is also listed by Toth et al. (2006) as an indicator of good knapping skills, and all the Gona sites contain a large number of specimens identified into this category (with a few number of end choppers), again confirming the superb knapping skills of the 2.6 Ma toolmakers at Gona.

The débitage

Whole flakes

A majority of the whole flakes both from the EG and the OGS sites show clear platforms, bulbs of percussion and smooth release surfaces. The flakes were well-struck showing that the makers were skilled knappers and understood the flaking property of the raw materials used (Figures 18-20). Like the cores, the EG-10 and EG-12 whole flakes are dominated by trachyte and rhyolite, with the remaining on aphanitics and latite (Figure 8). Just a few (<5%) were made of vitreous volcanic, basalt and other raw materials. In contrast, the OGS-7 whole flakes were predominantly made of rhyolite, trachyte, latites,

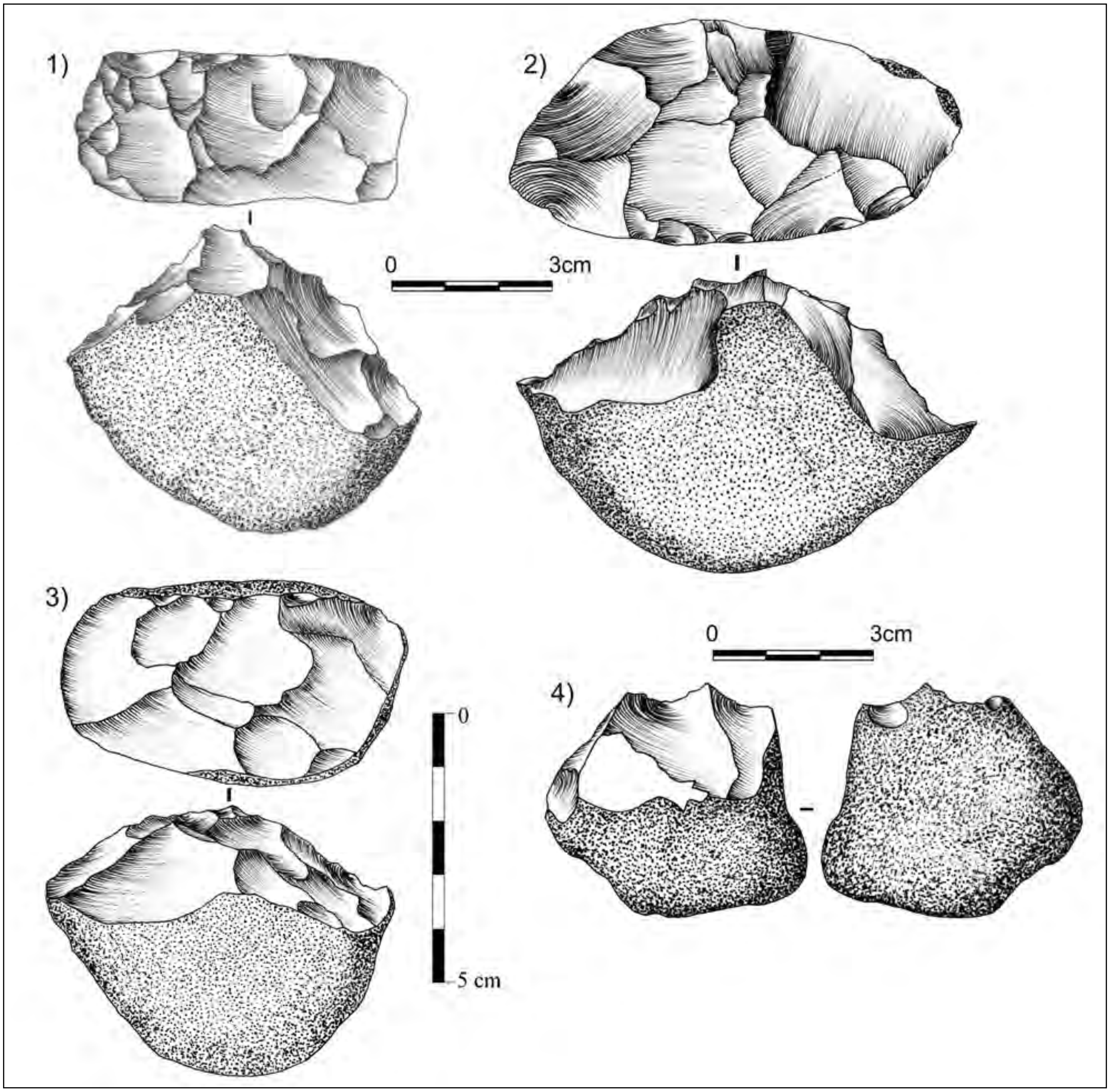

Figure 12. Drawings of excavated cores. 1 & 2, from EG-10, and 3 & 4, from EG-12. Note: these represent the typical cores excavated from the EG sites. Artifact drawings by D. Cauche.

aphanitic and vitreous volcanics, all represented in fair proportions. As shown in Figure 8 trachyte and rhyolite clearly dominate the raw materials on the whole flakes excavated from the EG sites, but the predominance of rhyolite at OGS-7 is not as marked. The flakes recovered from both the EG and OGS-7 assemblages average ~ 40mm (Table 3). Figure 21 shows the size frequency of the EG and OGS-7 whole flakes, and Figures 22 and 23 show some of the Gona flakes (including the cut-marked bone recovered from OGS-6) attesting the superb skill of the makers.

Flake types

Flake types are good indicators of the prevalent mode of core reduction represented in an assemblage, i.e. they provide the means for determining whether or not an assemblage is dominated by unifacial or bifacial-flaking (Toth, 1985, 1987). As shown in Figure 22, the most dominant flake types at EG-10 and EG-12 are flake type 3 (~45%) followed by type 2. In contrast, type 6 dominates at OGS-7 (>40%) followed by type 5. Interestingly, flake type 1 is missing from both the EG-10 and EG-12 whole flakes, but at OGS-7 flake type 1 comprises over 5% of the whole flakes. OGS-7 also has better representation of flake type 4 (~5%) compared to EG-10 (0%) and EG-12 (~1%). Generally, the flake types represented at EG-10 and EG-12 show that unifacial flaking of the cores was the dominant mode of reduction at both sites. In contrast, the higher percentage of type 6 and type 5 flakes at OGS-7 suggests predominantly bifacial

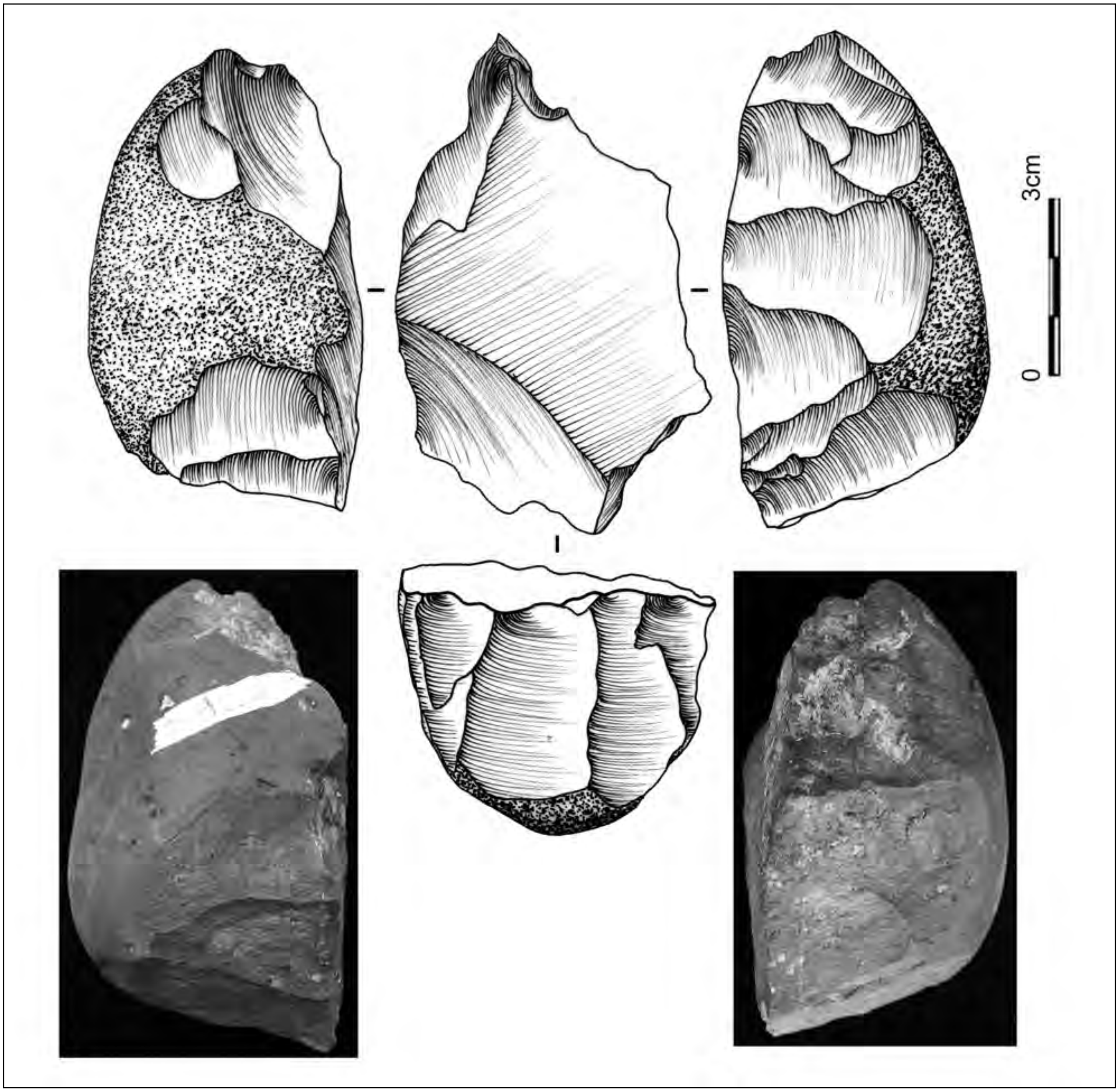

Figure 13. Drawing and photo of a "Karari-type" single-platform core (on trachyte) excavated from EG-10. Artifact drawings by D. Cauche.

reduction of the cores. The high incidence of flakes type 3 and type 2 at the EG sites clearly shows that a majority of the cores were unifacially-reduced through consecutive flake removal carried out by targeting the cortical surface of the cores. At OGS-7, flake type 6 and 5 dominate the whole flakes which is consistent with intensive bifacial and polyfacial reduction of cores.

Angular fragments and broken flakes

EG-10 has produced the highest number of artifacts, and as expected a large number of angular fragments as well (Table 4). Like the cores and the whole flakes trachyte and rhyolite dominate the angular fragments at EG-10 and EG-12 followed by latite and aphanitic volcanics (Figure 9). As shown in Figure 9, various raw materials are again more evenly represented in the OGS-7 angular fragments, with a fair proportion of latites and aphanitics as well as some rhyolite and vitreous volcanics.

Overall, a relatively large number of split flakes are documented at both the EG and the OGS sites, and until recently the implication of this pattern at Gona was unclear. However, recent experimental work by Toth et al. (2006) showed that higher percussive force results in the production of a large number of split flakes, and that the Gona hominins were applying appropriate force in striking large flakes from the cores (for details see Toth et al., 2006).

The Gona assemblages also consist of core fragments and snapped flakes, but these are relatively small in number. However, it is possible that some of the core fragments actually may be exhausted cores, and further experimental work may provide clues on the extent of

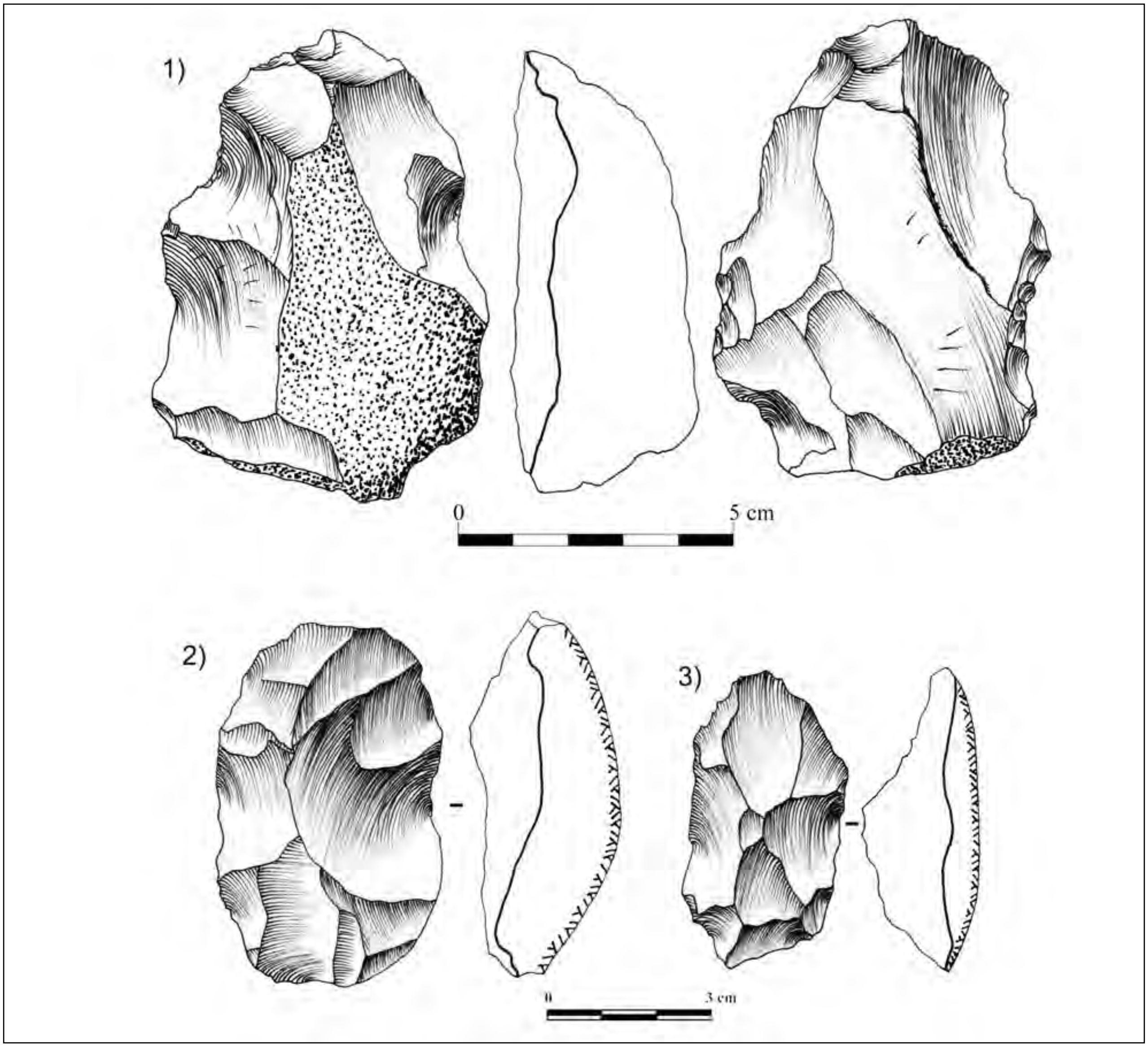

Figure 14. Drawings of cores from EG10 and OGS7. 1) Bifacially flaked "irregular discoid" on rhyolite from EG-10, 2 & 3) exhaustively-flaked unifacial cores on rhyolite from OGS-7 surface and excavation. Artifact drawings by D. Cauche.

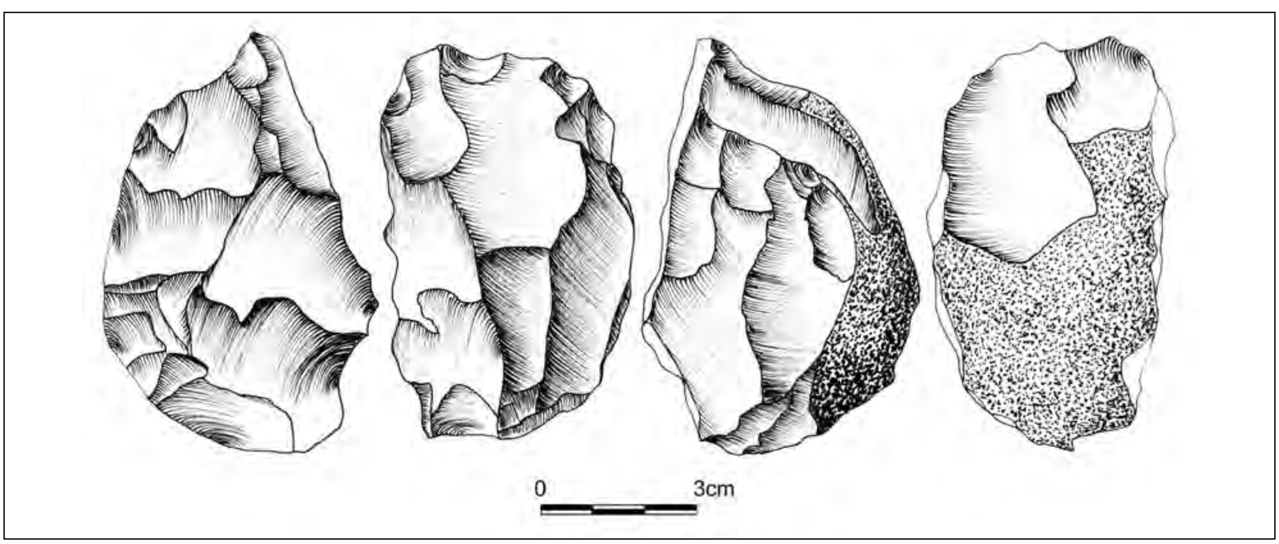

Figure 15. Drawings of a polyfacially and heavily-flaked excavated core on trachyte from EG-10. Artifact drawings by D. Cauche.

core reduction possible on the different raw materials accessible at Gona, on the characteristics of heavily-worked cores, and how to recognize those in an assemblage.

Late Pliocene-Early Pleistocene Hominin Artifact Transport?

As shown in Figure 22, OGS-7 has better representation of all of the flake types (Toth, 1985, 1987) compared to the EG sites where type 1 and type 4 flakes are missing. Despite the limited excavation at OGS-7, a much higher density of stone artifacts were recovered from the small area opened at the site. Further, the OGS-7 "excavation floor" appears to be littered with flaking debris, and it is likely that the assemblage represents much of the flaking that was conducted on site. Analysis of the EG-10 and EG-12 whole flakes by Toth et al. (2006) suggests active transportation of flakes from the EG sites probably for use elsewhere on the landscape. At OGS-7 all the flake types are fairly represented and this may not be apparent, but other lines of evidence indicate possible transport of artifacts may have been practiced at OGS-7 as well. In the case of OGS-7, it is likely that the cores made of fine-grained vitreous volcanics were transported by the hominins for further reduction over other parts of the ancient landscape. Again, further excavation at OGS-7 will be important for investigating the artifact transport behavior of the toolmakers.

The fact that hominins may have been transporting artifacts away from the densest concentrations, i.e. large sites (or traditionally referred to as 'workshops') is indicated by the composition of the artifacts from the EG and OGS sites. Isaac et al. (1981) have suggested that small sites ('mini sites') may provide clues regarding hominin activities away from larger sites ('maxi sites'), the focus of most research by Palaeolithic archaeologists. It is possible that the absence of a single core made of vitreous volcanics at OGS-7, in part, may have been due to the transport of these valuable cores into other yet to be discovered 'activity areas'. In addition, the manufacture of such a large number of artifacts that are still in fresh condition is intriguing. One would expect to find a large number of 'retouched pieces' or specimens damaged as a result of utilization, but only a few such possible pieces are found at most Late Pliocene sites (e.g., Gona, Lokalalei, Omo, etc.; see Delagnes & Roche, 2005; Chavaillon, 1976; Merrick, 1976; Merrick & Merrick, 1976). As suggested by Toth et al. (2006) there is a strong likelihood that 'favored specimens' may have been transported away from the larger sites and utilized elsewhere over different parts of the ancient landscape. Most likely such utilized specimens (retouched pieces or specimens with evidence of edge-damage) may be discovered at low-density archaeological sites or 'mini-sites' of Isaac et al. (1981). This is a possible scenario and will be the focus of further field investigations at Gona.

Discussion

Continued investigation of the Gona archaeological sites, study of the stone artifacts from EG-10 and EG-12 and comparison with the stone assemblages excavated from OGS-7 is providing important clues on yet unrecognized complex behavior of the first toolmakers. Previous study of the EG-10 and EG-12 archaeological materials has clearly shown that the earliest toolmakers had excellent mastery and control of fractures on stones and that the hominins produced thousands of artifacts during the initial stages of stone manufacture and use ~2.6 Ma (Semaw, 2000, 2006; Semaw et al., 1997). The OGS sites, located ~3-5 Km to the west/southwest of the EG sites, have yielded additional important information revealing more complex hominin raw material selectivity and transport behavior ~2.6 Ma.

Our investigation of the technological aspects of the earliest stone assemblages at the EG and OGS sites clearly indicate that no marked trends exist at Gona or elsewhere in East Africa for Late Pliocene-Early Pleistocene core reduction strategies to have gradually evolved from unifacial to bifacial/polyfacial stone working. Our recent studies also show that the behavior of the earliest toolmakers was much more complex than previously recognized. The evidence from Gona confirms that the first toolmakers practiced both unifacial and multifacial/polyfacial core reduction techniques just at the beginning of stone tool manufacture and use ~2.6 Ma, and selected for high quality raw materials. The degree of core reduction (minimal or exhaustive) seems to be related to the fine-grained nature and flaking-quality of the raw materials, and transport of artifacts over different parts of the ancient landscape may have been part of the overall technological repertoire. Although the final shape of the artifacts appear to be highly influenced by the size, flaking-quality, abundance and distances traveled to sources of raw materials, unifacial reduction of cores may have been the norm at the EG sites while bifacial/polyfacial working of cores was heavily practiced by the contemporary toolmakers at the OGS sites. It is unclear as of yet what influence, if any, cobble shape may have played in the difference.

Detailed study of the EG and OGS stone assemblages shows that the makers of the Gona artifacts at 2.6 Ma were proficient knappers, had clear understanding of stone fracture mechanics, and sophisticated skill and coordination for creating sharp-edged cutting stone flakes used for processing animal carcasses. In particular, the archaeological evidence from OGS-7 indicates that the hominins were economical where raw materials such as vitreous volcanics (with good-flaking quality) were scarce. Compared to the cobble source associated with the EG sites where fist-sized trachyte clasts were abundant and easily accessible, the situation at OGS-7 is unclear regarding how far the hominins had to travel to procure vitreous volcanics. The absence of any vitreous volcanic clasts from both the random and systematic

Figure 16. Photo of exhaustively-flaked cores from OGS-7 on trachyte and rhyolite respectively, both excavated.

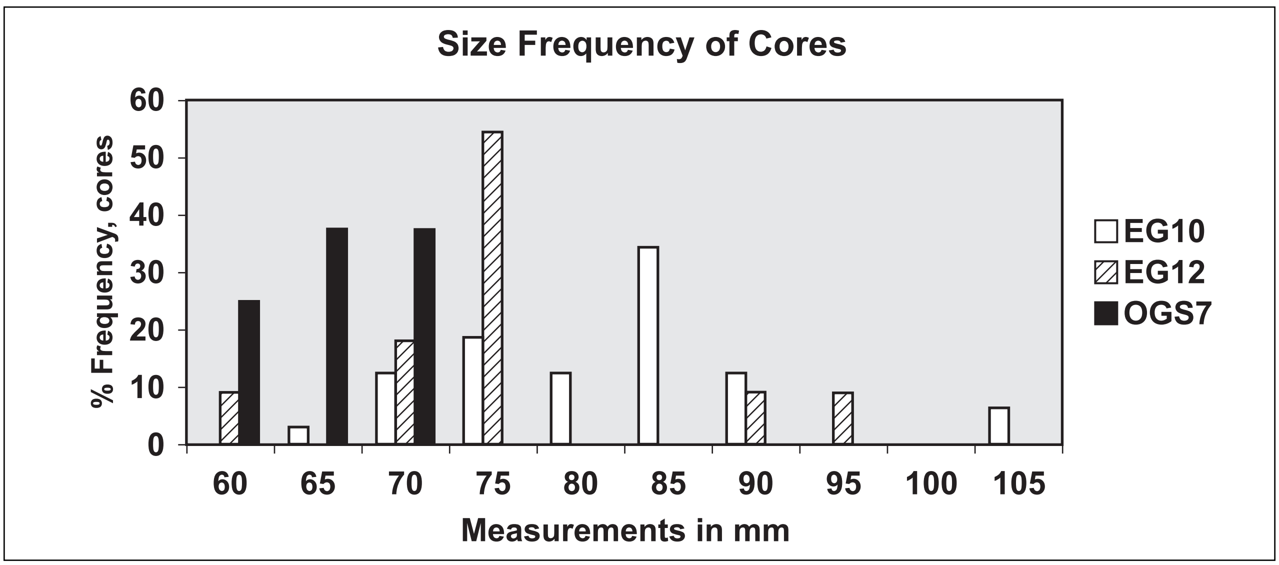

Figure 17. Size distribution of the excavated cores.

samples in the conglomerate associated with OGS-7, and the absence of even a single core made on this raw material from the OGS-7 excavation (or the surface) strongly suggests that the hominins were exhaustively reducing the vitreous volcanic cores and/or conserving and transporting them across the ancient landscape for further flaking at activity areas located away from the densest concentrations (sites) where initial flaking took place. At OGS-7, despite the small area excavated and the relatively small number of artifact recovery (i.e. compared to the EG sites), all of the six flake types were recovered implying some presence of all of the reduction stages on site (Toth, 1985, 1987). In contrast, flake types 1 and 4 are missing from the EG assemblages implying possible transport of artifacts away to other activity areas.

Based on the comparison of the excavated EG stone assemblages with the artifacts generated through experimental knapping of the cobbles sampled from the ICC, Toth et al. (2006) pointed out that early hominins at the EG sites were probably transporting selected large flakes away from the sites for further use over different areas of the ancient landscape. The evidence from OGS-7 reinforces Toth et al.'s (2006) observations with the difference that here the hominins appear to have transported cores rather than flakes. Toth et al. (2006) sampled unmodified cobbles selected from the ICC (on the basis of external appearance, like smooth cortex, size and shape), and imported the samples (through permission granted by the Ethiopian Antiquities and the Ministry of Mines) intact to the US for experimental knapping. Subsequent

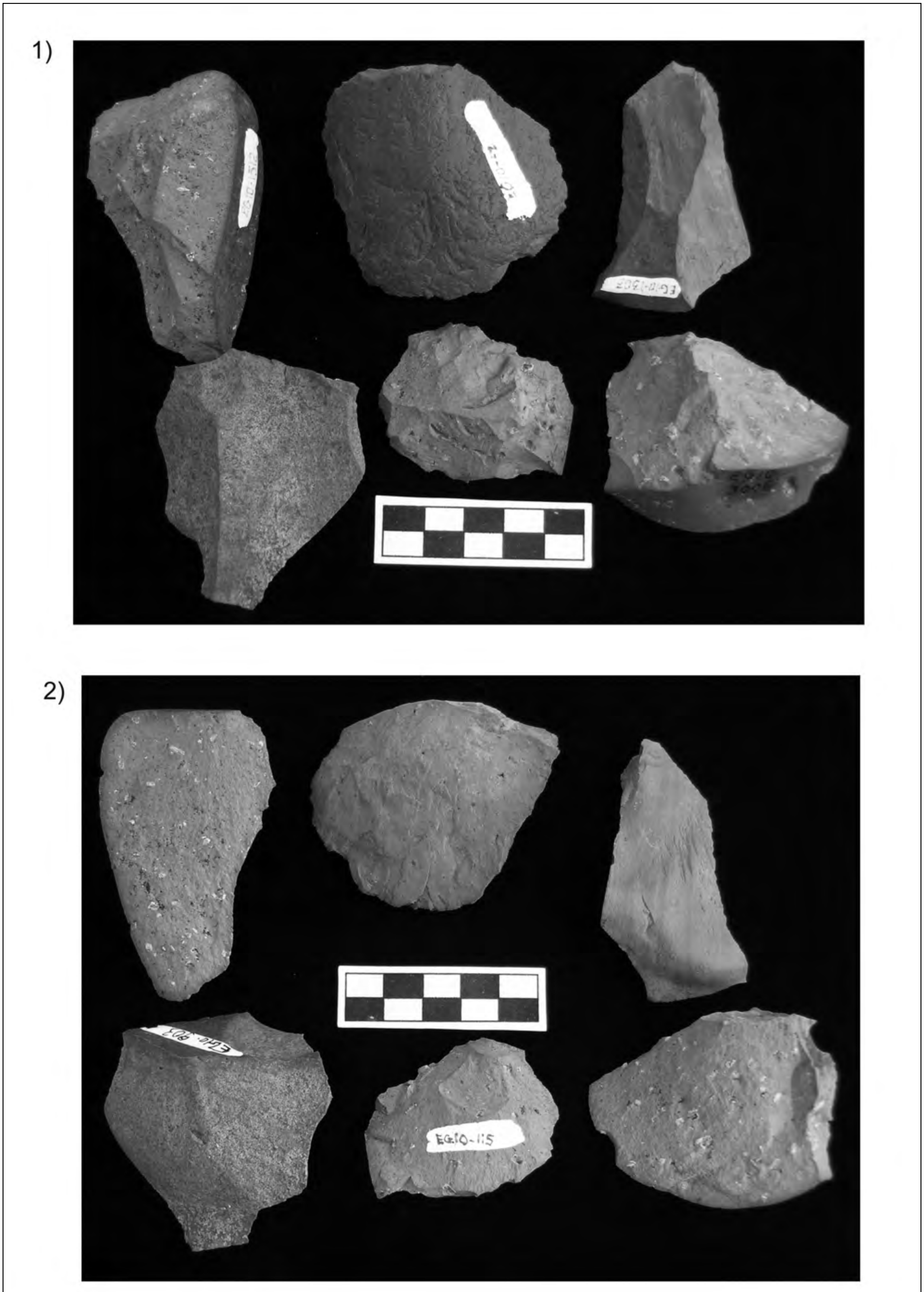

Figure 18. Photo of whole flakes from EG-10 & EG-12, made mainly on trachyte, rhyolite, aphanitic and vitreous volcanics.

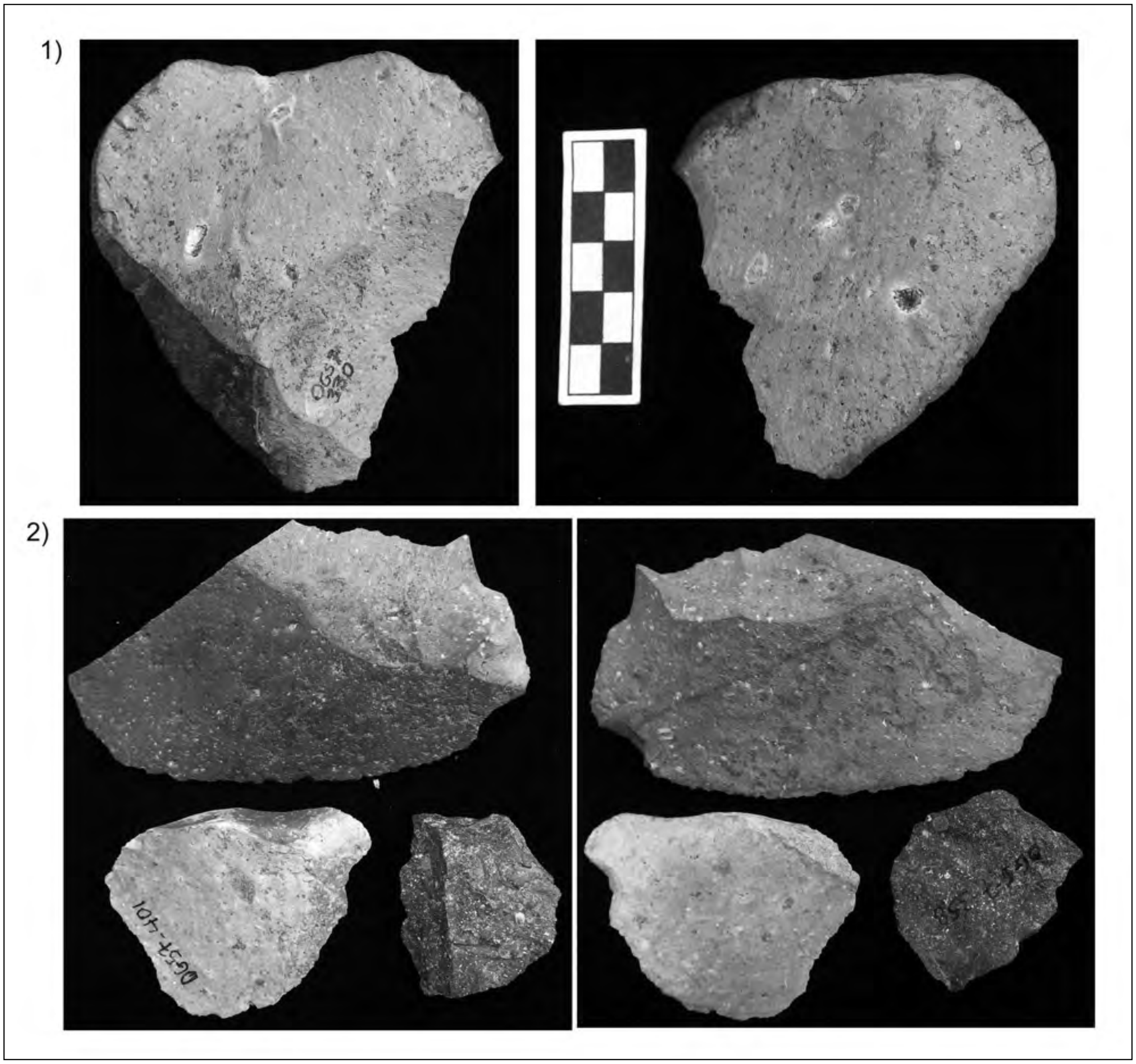

Figure 19. Photo of excavated whole flakes from OGS-7. 1) A large whole flake on trachyte from OGS-7 (actually larger in maximum dimension than any of the OGS-7 excavated cores), 2) examples of the whole flakes excavated from OGS-7. OGS-7-401 is made on vitreous volcanics, the larger piece on trachyte and the smallest piece on latite.

experimental knapping showed that about 75% of the cobbles selected from the ICC were of good-to-excellent flaking-quality, strongly suggesting that the Gona hominins were 'test-flaking' the cobbles at the gravel sources, and selecting for raw materials with "excellent" flaking-quality before transporting the cores for extensive knapping over the floodplains where the sites were formed. The Gona hominins at 2.6 Ma were highly selective and clearly utilized better-flaking-quality raw materials, and the evidence from OGS-7 supports earlier observations made regarding the sophisticated behavior and planning shown by the first toolmakers at the EG sites (Semaw et al., 1997).

Some researchers have suggested that high incidence of steps/hinges indicate low level of knapping skills (e.g., Kibunjia, 1994). The experimental knapping of the Gona cobbles by Toth et al. (2006) casts doubt if any relationships exist between steps/hinges and the level of hominin knapping skills. More instances of steps/hinges were recorded from the results of the knapping experiment conducted on the Gona cobbles by modern humans, i.e. compared to the number of steps/hinges counted on the Gona artifacts.

The use of different raw materials and proximity to sources may explain why different modes of flaking were practiced contemporaneously at EG and OGS, but it is also possible that factors related to group norms, microhabitats and tool function may have impacted the extent of core reductions seen in the two areas. Thus, investigations of aspects of the ancient environment ~2.6 Ma will be the goal of our future research. Experimental replication study of artifacts is a great tool for unravel-

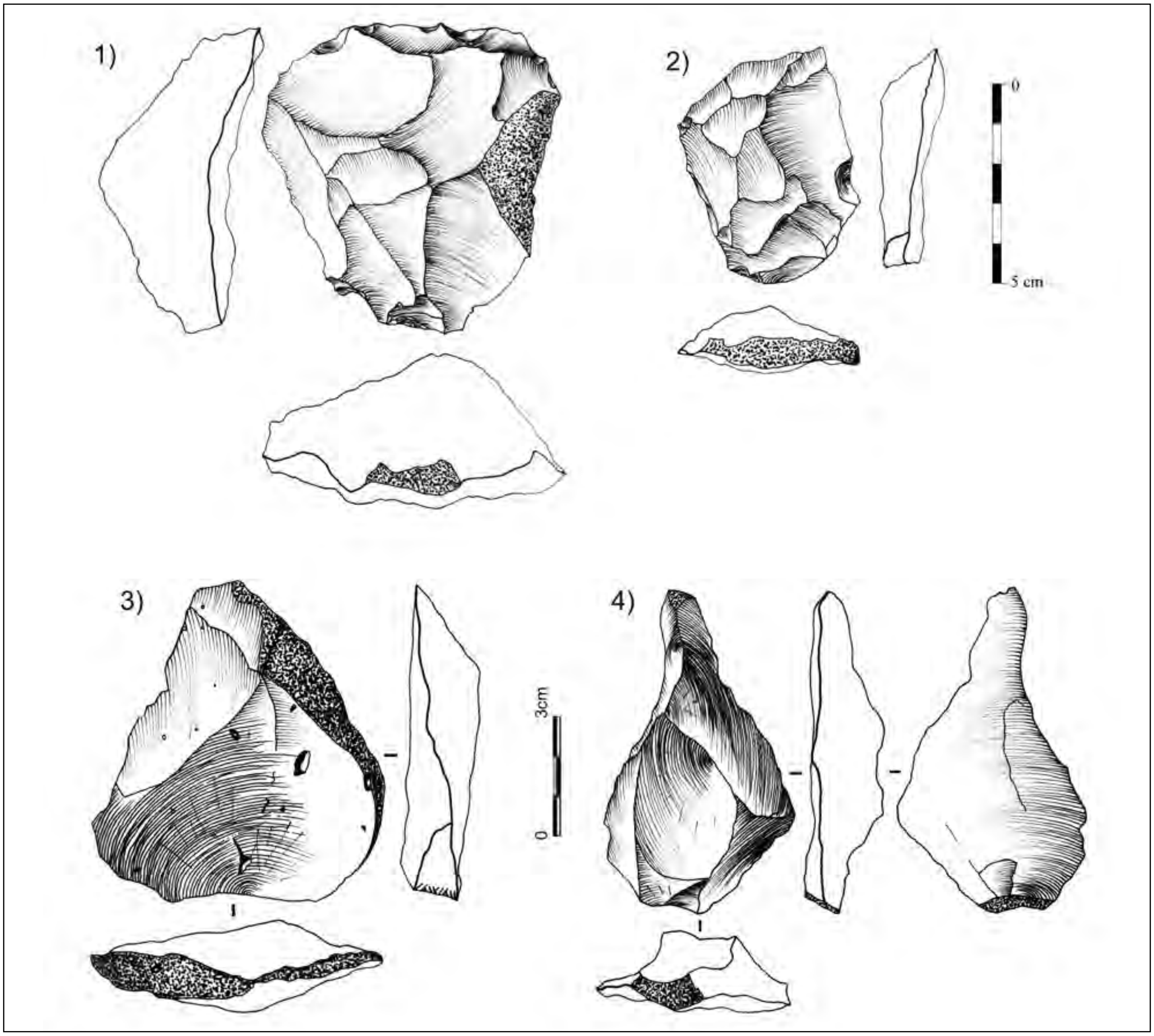

Figure 20. Drawings of excavated whole flakes. 1 & 2) from EG-10, both on trachyte, and 3 & 4 from OGS-7, both on trachyte. Note: whole flake #1 is the largest flake excavated from EG-10, and the maximum dimension of whole flake #3 from OGS-7 is larger than any of the cores recovered (excavated/surface) at the site. Artifact drawings by D. Cauche.

ing some of the intricacies in the toolmaking behavior of the Gona hominins, and further such investigations will be critical to firmly understand the meaning of the variations seen in Oldowan assemblages between 2.6-1.7/1.6 Ma (e.g., Toth, 1985, 1987; Toth et al., 2006; Schick & Toth, 1994; Sahnouni et al., 1997; Jones, 1994).

The Earliest Stone Technology

Currently, a large number of Oldowan archaeological localities with dense concentrations of artifacts dated to 2.6-2.5 Ma are documented at Gona through the field investigations carried out between 1999 and 2007. These earliest archaeological occurrences are distributed across a much wider area (~10-15 Km) west/southwest of the EG sites. Relatively younger Oldowan sites dating ~2.3-2.0 Ma are also known in the deposits prominently exposed in the eastern part of the study area. Further, the deposits that are older than 2.6 Ma have been targeted during the past several years, and the very rare pockets of sediments surveyed in the 2.9-2.6 Ma time interval in the Kada Gona, Ounda Gona and Dana Aoule drainages have not produced any traces of archaeological materials, i.e. flaked stones (modified stones) or bones damaged by a hominin agent. The geological disconformity and the scarcity of fossil-bearing sediments between 2.9-2.7 Ma at Gona or elsewhere in Africa unfortunately hinders the resolution of the issue of whether or not hominins made and used stone artifacts earlier than 2.6 Ma.

However, the sophisticated understanding of stone fractures and advanced knapping skills shown by the Gona toolmakers strongly suggests that ancestral hominins probably began experimenting on the use of stones as tools prior to 2.6 Ma. The appearance of thousands of flaked stones in the deposits dated to 2.6 Ma may not be an indication of ancestral hominin behavioral threshold

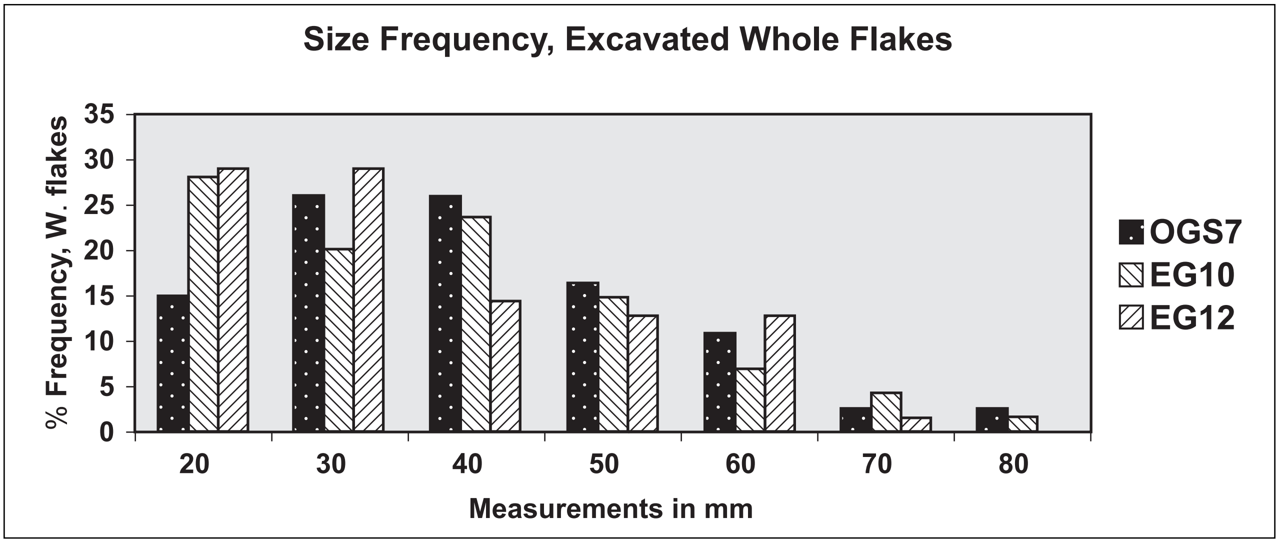

Figure 21. Size frequency of excavated whole flakes.

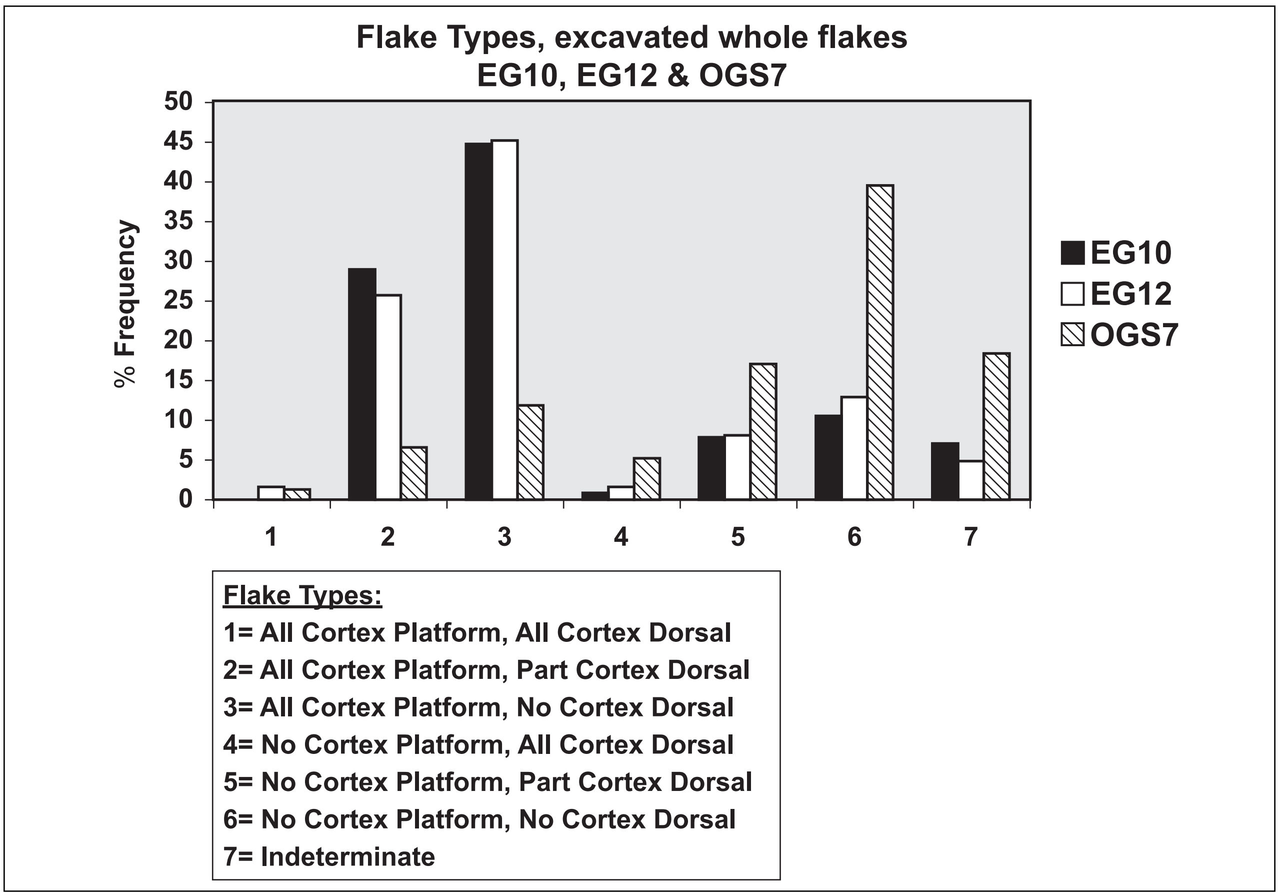

Figure 22. Flake Types, excavated whole flakes from EG-10, EG-12 and OGS-7.

at this particular time, but the earliest preservation and documentation of such evidence in the geological record at Gona. The evidence from Gona, both from the EG and OGS sites indicates that the advent of thousands of flaked stones by 2.6 Ma into the geological record seems abrupt and the manufacture and use of stone artifacts widespread across much of the ancient Gona landscape. Early hominins by 2.6-2.5 Ma were adept in manipulating stones, and the practice appears to have been widespread based on the large number of archaeological sites documented at Gona and the stone tool cutmarked bones recovered at Bouri, located c. 90 Km south in the Middle Awash (Semaw et al., 1997, 2003; Semaw, 2000, 2006; de Heinzelin et al., 1999; Asfaw et al., 1999).

Did hominins use modified stones prior to 2.6 Ma? What would these artifacts look like? Further investigations and empirical data are needed from the older deposits (2.9-2.6 Ma) to answer these questions con-

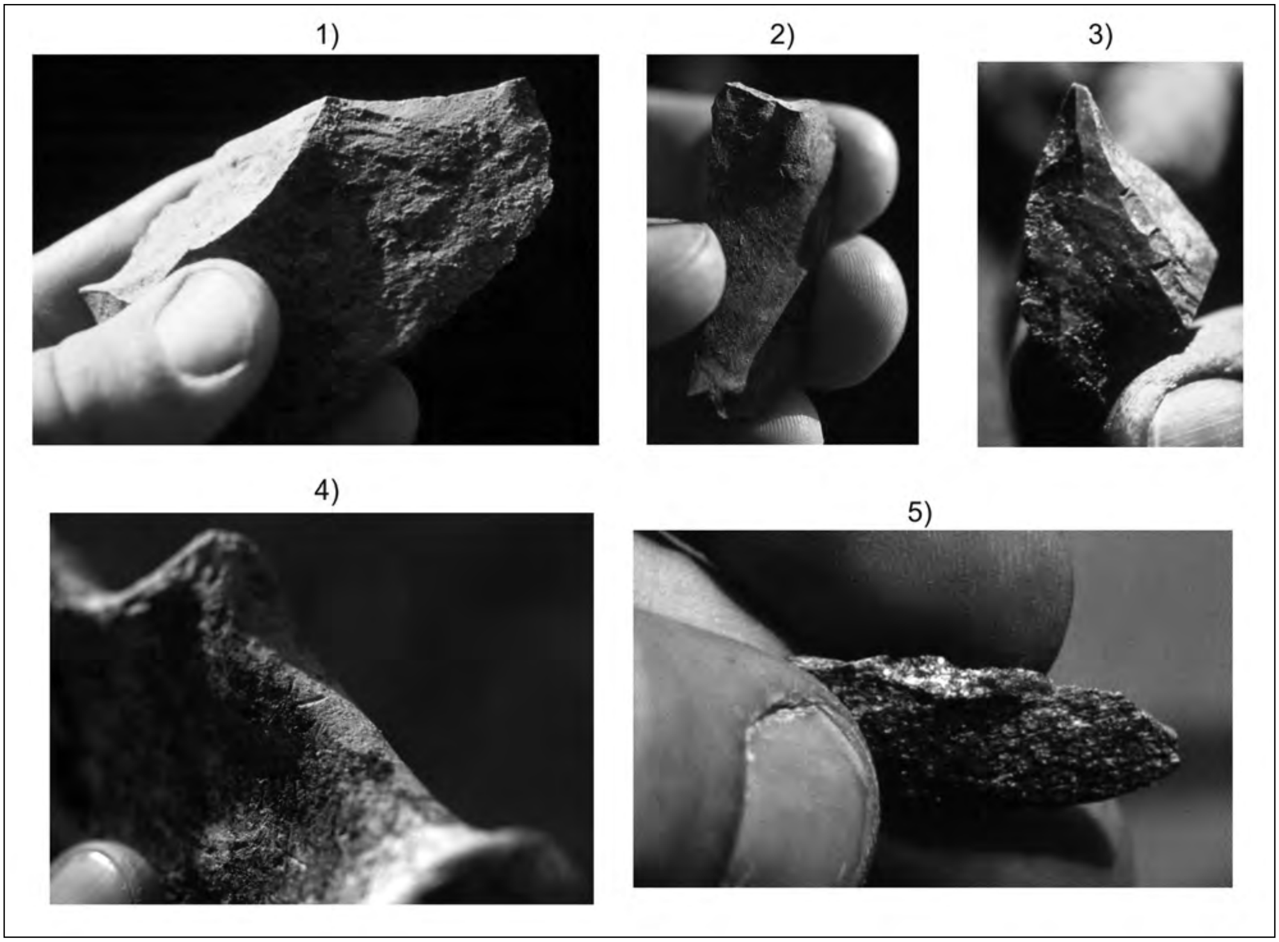

Figure 23. Photos showing, 1) knife-like flake- OGS-7, 2) blade-like flake- OGS-6, 3) pointed-piece- OGS-7, 4) cut-marked bone- OGS-6, & 5) bone-flake- OGS-7. All of the specimens were excavated, except for the cut-marked bone.

clusively. However, based on our investigations of the Gona deposits, currently the earliest evidence for ancestral hominin use of stone artifacts dates back just to ~2.6 Ma. It can be argued based on the sophisticated nature of the earliest artifacts from Gona, the large number of archaeological sites already documented across a wide area, and the high density concentrations of artifacts at these sites that ancestral hominins may have began using modified stones as early as 2.9 Ma, but not prior to 3.0 Ma. To date, there are no archaeological indications for the use of any modified stones by *Australopithecus afarensis*.

This hominin species lasted in the geological record up to 2.9 Ma at Hadar, and a major gap still exists in the hominin fossil record up to 2.6 Ma in East Africa (Kimbel et al., 1994). *Au. aethiopicus and Au. garhi*, and probably early *Homo* are the three penecontemporaneous hominin species overlapping with early stone tools in East Africa (Walker et al., 1986; Hill et al., 1992; Schrenk et al., 1993; Suwa et al., 1996; Kimbel et al., 1994, 1996; Asfaw et al., 1999; Prat et al., 2005), and further hominin discoveries along with possible flaked stones within the deposits dated between 2.9 Ma and 2.6 Ma will be critical to determine if stone toolmaking hominins existed from this least known time interval. Up to now, no artifacts or modified bones have been reported from any of the early hominin study areas that are older than 3.0 Ma like Hadar, Middle Awash, Gona, Woranso-Mille, and Dikika in Ethiopia; or from any of the early hominin sites known elsewhere in East Africa such as Alia Bay in Kenya and Laetoli in Tanzania. Thus far, the lack of any traces of stones or bones modified by a hominin agent (e.g., Blumenschine & Selvaggio, 1988; Bunn et al., 1980; see also Goren-Inbar et al., 2002) from any of these sites renders the possibility of early hominin use of flaked stones prior to 3.0 Ma unlikely.

A number of researchers have argued for ancestral hominin use of tools prior to 2.6 Ma (e.g., McGrew, 1993, Mercader et al., 2002; Panger et al., 2002). The close genetic relationships between the African great apes (particularly chimpanzees) and humans, and the capacity of modern chimpanzees in manipulating tools, both in the wild and in controlled environments, are used as strong indications for ancestral hominin use of tools prior to 2.6 Ma. It is likely that ancestral hominins may have been capable of using/throwing unmodified stones, and manipulating such perishable items as wooden clubs, tree branches, etc. for defense against predators, etc. prior to 2.6 Ma, but these materials do not fossilize as well as flaked stones and the use of such simple tools remains difficult to prove archaeologically, and probably remains speculative.

The recent study by Toth et al. (2006) of the results from the experimental stone knapping of the Gona cobbles by chimps (bonobos) and by modern humans, and comparison of the experimentally-generated materials with the artifact assemblages excavated from Gona dated to 2.6 Ma showed that chimps are capable of knocking flakes off similar cobbles used by the first toolmakers, but the chimp-generated assemblages exhibit important differences from the Oldowan stone technology. Toth et al. (2006) concluded that- "If such a bonobo assemblage were discovered in a prehistoric context, with so many distinct differences from early Oldowan artifact assemblages in so many attributes, particularly ones associated with skill, it might be assigned to a "Pre-Oldowan" stage of technology." Toth et al.'s (2006) chimp-generated assemblages provide a useful guide for archaeologists who pursue further field investigations for traces of possible artifactual remains that may have been left by ancestral hominins prior to 2.6 Ma.

The results from Toth et al.'s (2006) analysis cast much doubt on the validity of earlier conclusions reached by Mercader et al. (2002) on the purported similarity between the chimp-generated "artifacts" from West Africa and the Omo and Koobi Fora archaeological assemblages. In fact, Mercader et al. (2007) have more recently come around to the view that the accidental thrusting percussion by-products of chimpanzee nutcracking are indeed distinct (and distinguishable) from the controlled flaking products of hominins (p. 3046). The prevalence of bashing technologies at some Oldowan sites may be underappreciated (Mora & de la Torre, 2005), however, the earliest assemblages from Gona display clear evidence of highly controlled and systematic flaking aimed at the production of sharp edges.

The earliest Gona stone assemblages consist of artifacts typical of the Oldowan tradition with cores and *débitage* (whole and broken flakes, and angular fragments), and the toolmakers utilized stone working techniques (mainly hand-held-percussion) similar to Early Pleistocene Oldowan assemblages documented from elsewhere in Africa (Semaw, 2000, 2005, 2006; Semaw et al., 1997, 2003). Our investigations of the EG and OGS stone assemblages show that the earliest toolmakers were more complex in their raw material selectivity, and stone manufacture and use behavior with the production of unifacially as well as bifacially/polyfacially-reduced cores that are typical of most Oldowan assemblages known from the Early Pleistocene. The Gona stone assemblages are classified into the Oldowan Industry because of the similarity in the techniques of artifact manufacture and comparability in the composition of the stone assemblages with other Early Pleistocene sites known in Africa. The Oldowan stone technology persisted for almost a million years with little or no change until the advent of the more standardized Acheulian artifact tradition dated to ~1.6/1.7 Ma (Beyene, 2003, 2004, 2008; Beyene et al., 1997; Roche, 2005; Suwa et al., 2007; Semaw et al., in prep). The long duration of the same manufacture techniques of the core/flake dominated stone assemblages between ~2.6-1.7 still reinforces earlier suggestion of "technological stasis" for the Oldowan Industry (Semaw et al., 1997).

The Oldowan, the earliest artifact tradition

A number of researchers have proposed a "Pre-Oldowan" stage of stone technology, along with several presumed 'facies,' for characterizing the evolutionary stages of the stone assemblages recovered in Africa within the deposits that are older than 2.0 Ma (e.g. Roche, 1989, 1996, 2000; Piperno, 1989; Kibunjia, 1994; see Semaw, 2006 for earlier treatment of this issue). Among the major proponents of the "Pre-Oldowan," some still uphold this supposed stage of stone technology, and the idea seems to linger in the archaeological literature with newer perspectives added to it (e.g., Roche, 2000, 2005; de Lumley et al., 2004, 2005; Barsky et al., 2006). The "Pre-Oldowan/Oldowan" dichotomy and the presence/absence of different stages of stone technology during the Late Pliocene-Earliest Pleistocene is becoming an issue, and currently the idea has extended even beyond Africa to include the stone assemblages recovered from the earliest archaeological sites known in Eurasia (de Lumley et al., 2005). Therefore, it is timely to address the issue of the "Pre-Oldowan" again, and to evaluate some of the shortcomings of its use for classifying Late Pliocene-Early Pleistocene archaeology.

Despite Roche et al.'s (1999) discovery of a large number of refitting pieces (with evidence of 'sophistication') at Lokalalei 2C (LA2C) in West Turkana, and dated to 2.34 Ma, Roche (2000, 2005) continues to argue for the presence of different stages of stone technology during the Late Pliocene-Earliest Pleistocene. Roche and colleagues argue that these earliest stone assemblages evolved from a "Pre-Oldowan" to an "Oldowan" stage some time ~ 1.9/1.8 Ma. Although the LA2C artifacts were argued to be more 'sophisticated,' i.e. based on the large number of refitting pieces recovered from the site, there is still lack of sufficient explanations regarding why some of the LA2C artifacts at 2.34 Ma look more sophisticated compared to the artifacts recovered even within the same site, and to the pene-contemporaneous artifact assemblages excavated earlier from Lokalalei 1 (LA1), located just one Km distance north of LA2C (Kibunjia, 1994; Kibunjia et al., 1992; Roche et al., 1999, 2003; Delagnes & Roche, 2005). Both sites are dated to ~2.34 Ma, but LA2C may be slightly younger (~2.3 Ma, see Brown & Gathogo, 2002; McDougall & Brown, 2008), though, still not significantly younger than LA1.

The Lokalalei researchers, justifiably, had a great appreciation of the data generated from the LA2C refitting pieces, and the information these specimens provided regarding the sequence of core reductions carried out at the site. They recognize the diversity/variation within the Late Pliocene stone assemblages based on the differences attested in the success/failure of the flake productions at the two sites of LA2C and LA1. Further, they recognize the differential accessibility/availability of the raw materials, and they also note the differential flaking quality of the raw materials available for the toolmakers in the two areas. However, they attribute the variations/differences mainly to hominin skills, or lack thereof, when comparing the LA2C and LA1 assemblages. Explaining why some cores did not have "organized *débitage*," i.e. why some were less intensively exploited at LA2C, Delagnes & Roche (2005) note that

> "most of these cobbles are angular specimens, their shape being quite similar to that of the cores on which an organized *débitage* was carried out. On the other hand, most of them are medium grained trachyte, a less homogeneous raw material than the phonolite that represents the dominant raw materials used at Lokalalei 2C…The reason for the premature abandonment of these specimens very likely lies in the poor flaking quality of the raw material" (Delagnes & Roche, 2005, pp. 444-445).

The differences in the flaking-quality of the medium-grained trachyte and basalt (poor-flaking-quality) vs. phonolite (good-flaking-quality) has been recognized, and interestingly out of the six major refitting pieces recovered from LA2C, five were made on phonolite and only one of the major refitting pieces on basalt. They recognize that some of the LA2C cores did not have "organized *débitage*" (i.e. the cores were less intensively exploited) because of the low flaking quality of the raw materials (e.g., medium-grained trachyte and basalt). However, in comparison to LA1, they argue that raw materials do not account for this difference. It is puzzling why the role of the raw materials is not considered as a major possible contributing factor for explaining the differences in the LA2C and LA1 stone assemblages, and why total emphasis was placed only on the "differential knapping skills" of the toolmakers. From our point of view, it is simply evidence of stone reduction (behavioral) flexibility, similar to what we see at the EG vs. OGS sites at Gona. Obviously, from their published information the flaking-quality of the different raw materials accessed by the toolmakers has greatly impacted the extent of core reductions and the success/failure of flake productions.

The researchers attribute the entire success/failure to the stone manipulating ability of the toolmakers despite the obvious effect of the variations due to the flaking-quality of the raw materials used. Comparing the two sites of LA2C and LA1, it is argued that the technology of the LA1 artifacts showed "clumsiness and poor manual dexterity" (Roche, 2005, p. 37) whereas the sophisticated LA2C artifacts exhibit "high level of manual dexterity" (Roche, 2005, p. 39). Who made the LA2C stone assemblages? Does this imply two different hominin species were responsible for the LA2C stone assemblages? Delagnes & Roche's (2005) section on the raw materials makes reference to the shape and size of the original cobbles accessed by the toolmakers, the transport of unmodified or flaked cobbles to the site and close proximity of the basalt sources, though, they provide little discussion regarding the differential flaking property of the raw materials playing a major role impacting the variations seen in the assemblages recovered at LA2C (Delagnes & Roche, 2005, pp. 464-465).

According to Roche (2005) the "Pre-Oldowan" lasted between 2.6-1.9 Ma, and it was characterized by "simple expedient flaking, more organized *débitage*, and occasional retouching" (p. 37), and what differentiates it from the succeeding "Oldowan" (1.9-1.7/1.6 Ma?) is the appearance of "polyhedral and spheroidal shaping" in the latter. A number of studies (e.g., Sahnouni et al., 1997, Schick and Toth, 1994) have shown the effect of the differential flaking-quality of the various types of raw materials accessed by Early Pleistocene hominins in influencing the final shape of the stone assemblages. Schick and Toth (1994) have experimentally demonstrated how quartz chunks, after several hours of use as percussors, tend to transform into artifacts traditionally labeled as battered spheroids, and Sahnouni et al. (1997) have shown how extensively flaked limestone cobbles tend to transform into cores traditionally labeled as facetted spheroids. Preliminary investigations by Stout et al. (2005) have clearly illustrated the raw material selectivity of the earliest toolmakers at Gona, and Semaw et al. (2003, also this chapter) have shown how the quality of raw materials influenced the flaking modes of the 2.6 Ma artifact assemblages excavated at the two penecontemporaneous East Gona and Ounda Gona South sites.

We believe that Oldowan hominins (2.6-1.7/1.6 Ma) produced cores and stone flakes with sharp cutting edges used for processing animal carcasses. Why would the hominins deliberately design "polyhedral and spheroidal" artifacts at 1.9/1.8 Ma? Roche (2005) argues that during the so called "Pre-Oldowan" stage the flakes were the main artifacts that the hominins sought after (the cores being the waste), and during the Oldowan stage (1.9/1.8 Ma) the emphasis shifted more on the cores (at this time the flakes becoming the waste). What were the function of the "Pre-Oldowan" flakes and the adaptive role of the "polyhedral and spheroidal" shaped artifacts during the "Oldowan?" To date, no substantial and clear explanations have been provided by Roche and colleagues as to why hominins were making these stone artifacts, and no discussions are available on their functions and the adaptive role tool use may have played for the Late Pliocene toolmakers.

As discussed above, the Gona hominins at 2.6 Ma produced unifacially and bifacially/polyfacially-worked cores. Therefore, "the polyhedral and spheroidal" criteria for distinguishing the so called "Pre-Oldowan" from the Oldowan, and the arbitrary boundary of 1.9/1.8 Ma for separating the two "artifact traditions" does not seem to be meaningful, and is not supported by the existing archaeological data. Clearly, spherical specimens do appear in the archaeological record by 1.9/1.8 Ma, mainly at Olduvai Gorge, at Ain Hanech, and slightly later at Melka Kunture (M. Leakey, 1971; Sahnouni et al., 1997; Piperno et al., 2004), but these occurrences are exceptions to the rule and not universal. Experimental evidence indicates that the existence of these spherical specimens both at Olduvai and at Ain Hanech at 1.9/1.8 Ma, and other Early Pleistocene sites is probably a result of the use of limestone and quartzite. If such a behavioral succession from the so called "Pre-Oldowan" to the Oldowan stage existed in the archaeological record (as proposed by Roche, 2005), spherical specimens should have been found at several other sites dated to 1.9/1.8 Ma in East Africa, and should have been documented irrespective of the flaking-quality of the raw materials used for making them. For example, the archaeological sites at Koobi Fora (East Turkana, Kenya) dated to 1.9/1.8 Ma do not document any such specimens because hard basalt was the primary raw material used (Isaac & Harris, 1997). Further, at the contemporary site of Fejej from Ethiopia, also dated to 1.9/1.8 Ma, quartz and basalt were the primary raw materials used, and no spherical specimens are reported there (de Lumley et al., 2004; Barsky et al., 2006). Although Roche (1989, 2000, 2005) advocated a "Pre-Oldowan" stage, later publications (Delagnes & Roche, 2005) seem to deemphasize its significance, though arguing that the variations still reflect different stages of hominin skills and competence in manipulating cores during the Late Pliocene.

Currently, de Lumley et al. (2004, 2005; see also Barsky et al., 2006) also have joined in support of the "Pre-Oldowan" argument claiming the presence of such a technological phase in Africa and Eurasia. de Lumley and colleagues base their argument on the presence/absence of "retouched pieces" in Plio-Pleistocene stone assemblages, and use this as a criterion for differentiating the supposed technological stages, i.e. by classifying sites where retouched pieces are absent as "Pre-Oldowan" and sites with retouched pieces as "Oldowan," and implying the latter to be technologically more advanced. Interestingly, retouched pieces (not clear if systematic or edge-damaged), although few in number, are present in the 2.6 Ma excavated Gona assemblages (EG-10 and OGS-7), and even Roche (2005; see also Delagnes & Roche, 2005) recognizes the presence of occasional retouched pieces (e.g., ~21 pieces at LA2C) in Late Pliocene assemblages. Most of the Late Pliocene/Earliest Pleistocene Oldowan stone assemblages in Africa document only a small number of retouched pieces (e.g., Olduvai) except for Ain Hanech where a relatively large number of retouched pieces are documented at 1.8 Ma (Sahnouni & de Heinzelin, 1998; Sahnouni et al., 2002). Of the relatively large number of retouched pieces recovered at Ain Hanech, most were made on flint (Sahnouni & de Heinzelin, 1998). Even at Olduvai, a majority of the retouched pieces appear only after the hominins began exploiting chert (M. Leakey, 1971, but see de la Torre & Mora, 2005). However, some of the pieces from Olduvai were probably not intentionally retouched.

> "Indeed, most of the chert pieces from FLK North SC [Sandy Conglomerate] are excellently preserved. Nonetheless, the edges of the chert pieces, sharper than most of the quartzes and lavas, are also more sensitive to damage (pseudo-retouching in this case) produced by the sediment itself. Most of the so-called retouched pieces Leakey (1971) describes present a very marginal modification on the edges, which is irregular, not systematic. Therefore, and although several are subject to equifinality, we believe the majority are not clear enough to be considered retouched pieces" (de la Torre & Mora, 2005, p. 85).

A majority of the stone artifacts from the Late Pliocene-Early Pleistocene sites in East Africa have not been subjected to microwear analyses, and it is still not clearly determined whether or not hominins used un-retouched flakes and/or just the retouched pieces for processing animal carcasses or for other activities related to subsistence, etc. However, some of the Koobi Fora and Ain Hanech excavated artifacts were analyzed for microwear polishes, and it was discovered that both un-retouched flakes and retouched pieces bear evidence of meat-polish (Keeley & Toth, 1981; Sahnouni & de Heinzelin, 1998). Therefore, there is no need for *a priori* assumption that Late Pliocene/Earliest Pleistocene hominins used only the retouched pieces. At Ain Hanech, further reanalysis of the retouched pieces is planned to determine whether or not most of the specimens identified as retouched pieces were intentional and systematic (Sahnouni, *pers. com.*).

What does the presence of "retouched pieces" in an Oldowan assemblage signify? Are these pieces formal tools like those known at later times? The number of retouched pieces particularly during the Late Pliocene and the Earliest Pleistocene was insignificant, and begs the question of whether or not the "retouched pieces" occasionally found at Oldowan sites are clearly identified to be a result of intentional hominin action or if edge-damaged specimens resulting from use or others from bioturbation and trampling could have been mistakenly identified as retouched pieces (see de la Torre & Mora, 2005). Further, how much of the retouching was influenced by hominin selectivity of certain raw materials for this purpose? Nonetheless, the fact remains that, 1) the Late Pliocene sites including Gona and LA2C contain occasional retouched pieces, and 2) the number of "retouched pieces" found at several of the Earliest Pleistocene sites in Africa including Olduvai Gorge is insignificant (e.g., de la Torre & Mora, 2005).

To date, the only Early Pleistocene archaeological site in Africa with relatively large number of retouched pieces is Ain Hanech, and a majority of the retouched pieces are on flint, a fine-grained raw material compared to the limestone available for the toolmakers (Sahnouni et al., 2002). In most cases, archaeological investigations show that non-local raw materials procured from further distances tend to be heavily-reduced and more retouched pieces were made on them compared to raw materials available from nearby sources (see recent review by Blumenschine et al., 2008). In conclusion, 1) there is lack of rigorous study and strength in de Lumley et al.'s (2004, 2005) argument, and 2) classifying younger Oldowan archaeological sites in Europe lacking retouched pieces as "Pre-Oldowan" (e.g., Elefante and Fuente Nueva 3, dated to ~1.4-0.9 Ma) and older sites in Africa with a small number of retouched pieces as "Oldowan" (e.g., Olduvai dated to 1.9/1.8 Ma) appears to us to be anachronistic, and de Lumley et al.'s criteria of presence/absence of retouched pieces for differentiating the supposed "Pre-Oldowan" from the Oldowan (*sensu stricto*) unnecessarily compounds the issue.

As was suggested by Toth et al. (2006), the term "Pre-Oldowan" may suit possible modified stones yet to be found in the deposits that are older than 2.6 Ma, i.e. if and when the existence of such hominin-modified materials (stones/bones) is proven archaeologically through future field investigations; and if these yet to be found modified materials are actually different from the Oldowan (*sensu stricto*). Palaeolithic archaeologists are gaining a better understanding of the earliest phase of ancestral human stone technology and behavior through field and laboratory investigations undertaken over the past two decades, and in particular our study at Gona has clearly shown that, to date, there is no such "Pre-Oldowan" stage of stone technology.

Like Roche and colleagues, we recognize the presence of assemblage variability in the Oldowan Industry during the Late Pliocene-Earliest Pleistocene (2.6-1.7/1.6 Ma.). However, we attribute these variations mainly to differences in raw material proximity, availability, and flaking quality and the interaction of these variables with predominant modes of core reductions. For the simple Oldowan (Mode I) Industry, the discovery by some group of hominins of conchoidal fractures on stones and the invention of sharp-edged cutting flakes was the major behavioral breakthrough (Isaac, 1976). Once this discovery was made, i.e. in the case of the Oldowan (2.6-1.7/1.6 Ma), there is no reason to assume that any one group of hominins were capable of removing only one or two flakes during the earliest phase of artifact manufacture, and such other superior group (species) of penecontemporaneous hominin species to have been more knowledgeable and skilled to remove tens of flakes from a core. The current evidence clearly shows that once hominins understood that striking one cobble (the core) with another one (used as a hammerstone) results in the creation of sharp-edged cutting knives, following acute angles, unifacial/polyfacial-working of cores and the success/failure of flake productions appear to have been largely dependent on the flaking-quality of the raw materials accessible to hominins. Quoting Isaac's (1976) statement on a similar issue will be appropriate here:

> "Distinctive features of stone artifact assemblages can be attributed to differences in the traditions or cultures of the hominids that made them. Clearly before this is done it is desirable to distinguish features which may have been induced largely by *differences in raw materials*, and differences which may reflect *varied activities* by the same people at different times and places. The distinctiveness of the Shungura industries *vis-à-vis* Olduvai and Koobi Fora may be an example of differences induced by contrasting raw materials, which therefore cannot be interpreted as necessarily indicative of other cultural or developmental stage differences." (Isaac, 1976, p. 496, original emphasis).

The variability seen between the EG and OGS assemblages appears to be somehow similar to the above observations made by Isaac (1976, p. 496) on the lithic variability earlier witnessed at Omo, Olduvai and Koobi Fora, which he explained to have been a result of the use of different raw materials. Roche and colleagues attribute the success/failure of flake productions at the Lokalalei sites solely to differential manual dexterity and hominin skills. In the EG and OGS assemblages we see no such evidence of differential success/failure, despite substantial differences in the raw materials selected and reduction methods employed. There seems to be no reason to assume that this variability reflects the different abilities of different toolmaking species. Even if the possibility of differential skills existed among Late Pliocene hominins, as assumed by Roche and colleagues (see Harmand, 2007), it would still be difficult, if not impossible to attribute particular Oldowan stone assemblages between 2.6-1.7/1/6 Ma to any one particular hominin species and to prove this archaeologically.

Currently, there is no evidence for associating early *Homo* with the earliest Oldowan artifacts (2.6 Ma) at Gona. Hominin species known from East Africa at this time include *Au. aethiopicus* and *Au. garhi*, actually with *Au. garhi* being a somewhat more compelling candidate as an early toolmaker on the basis of its cranial anatomy, proposed ancestry to early *Homo* and proximity to the earliest archaeological traces (Asfaw et al., 1999). As always, such attributions represent only our current best knowledge and remain subject to further fossil discoveries. Somewhat later, early *Homo* does emerge as a likely toolmaker, and there are currently two Late Pliocene archaeological sites (LA1α at West Turkana and A.L. 666 at Hadar), dated to ~2.3 Ma, that represent stratigraphic associations of early *Homo* with Oldowan artifacts (Prat et al., 2005; Kimbel et al., 1996). However, these assemblages are no more skilled or "sophisticated" than those known from 2.6 Ma, and there is no evidence that phylogenetic change was associated with technological change ~ 2.3 Ma.

Interestingly, the LA1α early *Homo* molar was found ~100 meters south of LA1, a site argued to contain artifacts produced with "poor manual dexterity," and the artifact assemblage is close in age to the LA1α hominin (Roche et al., 2003; Prat et al., 2005). Following the discovery of this molar, Roche and colleagues (see Prat et al., 2005) conclude that early *Homo* is the best candidate for making the LA1 artifacts. If this is accurate, and if different hominin species are responsible for the variability between the two Lokalalei assemblages (LA1 and LA2C), the question is then who made the "more sophisticated" but slightly younger artifacts excavated from LA2C?

Isaac's (1976, p. 496) cautionary note seems relevant to Roche and colleagues' interpretation of the lithic assemblages from the two Lokalalei sites. Again, we believe that the variability witnessed in the two Lokalalei stone assemblages to a large extent appears to have been a result of the diverse quality of the raw materials, and probably not related to differential knapping skills of Late Pliocene hominins. Further, our argument is supported by the fact that the makers of the Gona stone tools, which are at least 250,000 years older than those of Lokalalei, were already accomplished knappers at 2.6 Ma, and based on current data, the most likely candidate responsible for the stone assemblages would be *Au. garhi* (Asfaw et al., 1999; de Heinzelin et al., 1999).

The main goal of the Late Pliocene-Earliest Pleistocene toolmakers was the production of sharp-cutting flakes (resulting in core/flake assemblages) which were mainly made with the hand-held percussion. Core/flake assemblages with occasional retouched pieces (some associated with cutmarked bones) are the hallmark of the Oldowan (Mode I) Industry (M. Leakey, 1971; Clarke, 1969), and this is why we still argue for "technological stasis" in the Oldowan (Semaw et al., 1997; Stout et al., in prep). We believe the major distinction in terms of manual dexterity, mental template, and imposition of form and symmetry on stone artifacts did emerge with the larger-brained hominin (probably early *Homo erectus/Homo ergaster*), contemporaneous with the Early Acheulian Industry. The Acheulian was obviously qualitatively as well as quantitatively different from the Oldowan stone technology and the transition was probably rapid (Isaac, 1969; Semaw et al., in press). During the Early Pleistocene, archaeological sites become more abundant and widely documented across Africa, and some are associated with a large number of cutmarked bones (e.g., Bunn, 1983, Bunn et al., 1980; Potts, 1988; Potts & Shipman, 1981; but see Domínguez-Rodrigo et al., 2007).

The fact that the first toolmakers were "sophisticated" in their artifact manufacture and raw material selectivity was originally proposed by Semaw et al. (1997). Besides the clear archaeological evidence for the sophisticated knapping skills of the Gona hominins, Semaw et al. (1997, 2003) have shown the presence of variations in Late Pliocene stone assemblages, and that this appears to be primarily a result of the differential flaking quality of the raw materials available to the toolmakers. However, more experimental work is needed on the various stone raw materials used during the Plio-Pleistocene to firmly determine what role the flaking quality of the various raw materials accessed by early hominins played in influencing the variations we see in Oldowan stone assemblages. Again, experimental investigations with the raw materials used by the Lokalalei hominins appears to be a necessary step towards a better understanding of the reasons for the variations seen in the Lokalalei stone assemblages.

Based on current understanding, the use of the term "Oldowan" is appropriate for classifying the Plio-Pleistocene core/flake (Mode I) dominated stone assemblages (*sensu* M. Leakey, 1971). To date, evidence for a "Pre-Oldowan" phase is non-existent and the use of this term is unwarranted.

The archaeological evidence from Gona has clearly shown that the stone raw material selectivity, artifact transport and use behavior of Late Pliocene toolmakers was much more complex than generally understood. Further research is needed for understanding the paleohabitats of the earliest toolmakers, and for gaining a better grasp of their land use and patterns of resource exploitations over different parts of the ancient landscape. Nonetheless, the Oldowan still remains the earliest known phase of ancestral hominin manufacture and use of flaked-stones until the presence of hominin modified stones/bones is proven/shown in the deposits that are older than 2.6 Ma.

Summary

Based on our recent study of the EG and OGS archaeological materials, current understanding of the earliest stone artifacts ~2.6 Ma, and Late Pliocene stone assemblages can be summarized as follows:

a) The first toolmakers had extraordinary mastery of conchoidal fractures on stones, and they preferentially selected fine-grained raw materials for making the earliest documented stone artifacts at 2.6 Ma,

b) The materials from OGS-7 show strong evidence for hominin selectivity of raw materials with excellent flaking-quality such as vitreous volcanics. In addition, artifacts may have been selectively transported across the ancient landscape for further use at activity areas away from the densest concentrations (sites) where initial flaking activity took place (see also Toth, et al., 2006).

c) The makers of the Late Pliocene-Earliest Pliocene stone artifacts were primarily after sharp-edged cutting implements; and to a large extent, the final shape of the artifacts appear to have been influenced by the proximity and the flaking quality of the various raw materials accessed by the toolmakers (Toth, 1985, 1987; Toth et al., 2006). However, the factors that may have influenced the modes of flaking (unifacial-dominated at EG vs. bifacial/polyfacial-dominated at OGS) and differing reduction intensity at the two Gona areas may need further research.

d) The variability seen in artifact assemblages at EG/OGS and at Lokalalei indicates that Oldowan hominins were capable of some behavioral flexibility with respect to lithic reduction.

e) The earliest stone tools at Gona were used mainly for processing animal carcasses for meat (Domínguez-Rodrigo et al., 2005; Semaw et al., 2003; see also de Heinzelin et al., 1999).

f) The EG and OGS artifacts consist of unifacial, bifacial and polyfacial cores, and *débitage*, as is typical of the Oldowan tradition. The toolmakers utilized similar stone working techniques (mainly hand-held-percussion), the same stone knapping techniques also used for making most other Early Pleistocene Oldowan assemblages known from elsewhere in Africa (Semaw, 2000, 2006; Semaw et al., 1997, 2003). Thus, the archaeological evidence points to almost a million years of "technological stasis" for the Oldowan Industry. Evidence for a "Pre-Oldowan" phase is so far non-existent, and the use of the term is unwarranted.

g) Site frequency and artifact densities and the occurrence of retouched pieces all probably increased through time and became much higher during the Earliest Pleistocene, but the Oldowan artifacts made between 2.6-1.7 Ma were still technologically within a continuum and with no significant departures seen in the stone working techniques and composition of the artifacts from the earliest stone artifacts recovered at Gona. Artifacts made of substantially larger cobbles and flakes, and with controlled design, predetermined shape and symmetry were unknown within the Oldowan; and bifaces and cleavers emerged by ~1.7/1.6 Ma with the advent of the Acheulian tradition in Africa (Asfaw et al., 1992; Beyene, 2003, 2004, 2008; Beyene et al., 1997; Roche, 2005; Suwa et al., 2007; Semaw et al., in press).

The overall archaeological evidence from Gona shows a more complex behavior was already in place even during the initial stages of stone artifact manufacture at 2.6 Ma, including greater foresight and planning involving selectivity of fine-grained raw materials with good-flaking quality, and probably transport of selected artifacts out of the high density sites into other activity areas over different parts of the ancient landscape. Although the extent of core reductions was highly influenced by the flaking-quality of the raw materials and proximity to sources, the differences seen at the EG and OGS-7 sites in the choice of raw materials and the prevalent core reductions, unifacial at EG vs. bifacial/polyfacial at OGS indicate the possibility of local norms, although other factors related to raw material size, shape and type cannot be ruled out. The earliest toolmakers already had skills and foresight as complex as Early Pleistocene hominins and it seems appropriate to classify the Gona and all the simple core/flake assemblages dated between c.2.6-1.7/1.6 Ma into the Oldowan (*sensu* M. Leakey, 1971).

The Bouri archaeological site dated to 2.5 Ma from the Middle Awash, 90 Km to the south of Gona, has yielded excavated fossilized bones with evidence of stone tool cutmarks, but without associated artifacts (de Heinzelin et al., 1999). Therefore, the Gona sites with the oldest documented associations between artifacts and broken fauna, and the materials from Bouri provide complementary and direct evidence attesting that the earliest stone tools were definitely used for processing animal carcasses for meat.

Concluding Remarks

The Gona sites preserve the earliest known archaeological evidence for the advent of flaked stones in the geological record, but the sophisticated techniques of artifact manufacture and the presence of a high density of archaeological materials distributed over a wider area may be suggestive of possible earlier beginnings of stone tools probably as early as 2.9 Ma. The archaeological and faunal record between 3.0-2.6 Ma is incomplete at Gona and elsewhere hindering our understanding of the initial beginnings and the ecological settings for the behavioral changes seen in Late Pliocene hominins. The question of what triggered the beginnings of the use of flaked stones, and why early hominins resorted to a novel means of adaptation by incorporating meat in their diet can be answered only with detailed investigations and understanding of the environmental settings of sites within deposits dated between 2.9-2.6 Ma.

Global climate changes roughly between 2.8-2.5 Ma associated with astronomical forcing have been linked to faunal evolutionary changes and the origin of diverse hominin lineages, and have also been cited as among the driving forces triggering changes in hominin behavior that led to the beginnings of the use of stone artifacts (e.g., Vrba, 1995; deMenocal, 1995; Kingston et al., 2007). Much of the evidence for climatic fluctuations and its relations with global climatic change are well-documented in marine cores (deMenocal, 1995). Current data from Pliocene localities dated between 2.7-2.55 Ma in the Baringo Basin (Kenyan Rift) is providing evidence for orbitally mediated environmental changes impacting terrestrial fauna (Kingston et al., 2007). Because of the disconformity the time interval between 2.9-2.7 Ma is not well-represented at Gona, and lacking any archaeological or faunal evidence for detecting effects of global climate (Quade et al., 2004, 2008). Although establishing causal links are difficult due to limiting factors related to sedimentation and the influence of volcano-tectonics, the time interval between 2.9-2.7 appears to have been a critical time period in human evolution with the disappearance of *Au. Afarensis* from the geological record, and the emergence of a diversified hominin lineage and the beginnings of the use of stone artifacts in East Africa (e.g., Walker et al., 1986; Hill et al., 1992; Schrenk et al., 1993; Suwa et al., 1996; Kimbel et al., 1994, 1996; Semaw et al., 1997, 2003; Asfaw et al., 1999; de Heinzelin et al., 1999). Recent studies at Hadar within sediments dated between 3.15-2.9 Ma show significant increase in arid-adapted fauna likely related to climatic oscillations associated with climatic variability, but still difficult to establish cause-effect relationships between global climate changes and human evolution (Campisano & Feibel, 2007).

Future discoveries are needed of possible archaeological materials from deposits dated between 2.9-2.7 Ma, which also coincides with the climatic shifts known to occur globally and the local changes documented regionally; faunal, geological and isotope studies may also help resolve some of the major questions regarding the beginnings of the manufacture and use of flaked-stones (e.g., Vrba, 1995, 1999; Wesselman, 1995; de Menocal, 1995; Shackleton, 1995; Behrensmeyer et al., 1997; Levin et al., 2004; Bobe & Behrensmeyer, 2004; Campisano & Feibel, 2007; Kingston et al., 2007; Potts, 2007). Therefore, further research combining geology, fauna and archaeology will be critical for determining the driving force(s) that pushed ancestral hominins to invent cutting tools by flaking stones, for assessing why ancestral hominids resorted to a novel means of adaptation by utilizing animal resources in their diet and for testing various environmental hypotheses of this consequential event in human evolution (cf. Potts, 2007). The best clues, most likely, may still lie in the few pockets of deposits dated between 2.9-2.7 Ma at Gona or elsewhere in Africa (Rogers & Semaw, in press).

The current archaeological evidence from Gona shows that stone artifacts made an abrupt appearance in the geological record by c. 2.6 Ma, and so far any traces of modified stones or bones confirmed to be a result of hominin involvement, and from well-controlled geological context are unknown in the deposits that are older than 2.6 Ma (but see de Heinzelin, 1983). The archaeological evidence from our recent investigations at Gona reinforces earlier suggestions made on the sophisticated techniques and skills seen in the stone tool manufacture practiced ~2.6 Ma (Semaw et al., 1997). Our preliminary observations also indicate that the intended function, proximity/distance to raw materials sources, availability, size and the flaking quality of accessible raw materials may have played a prominent role in hominin selectivity of raw materials and its effect on the final forms of the artifacts. Although no hominids were discovered from the Late Pliocene deposits at Gona, it is likely that *Au. garhi* discovered with the Bouri archaeological materials could have been the first toolmaker (Asfaw et al., 1999). Further investigations are needed to shed light on the reasons behind the differences seen in the assemblages of the two areas, but environmental differences and idiosyncratic norms and behaviors in the selection of raw materials and the extent of reduction of the cores may have dictated the final forms of the artifacts found at different parts of the ancient landscape.

The presence of fossilized fauna modified by ancestral hominins at the OGS-6 and OGS-7 archaeological sites, albeit fragmentary and very small in number, and the absence of such evidence at the EG sites is intriguing. It is still unclear if the absence of bones at the EG sites was a taphonomic bias related to the lack of preservation or a direct reflection of the differences in the tool use behavior of the hominins that lived in the two areas. On the outset it may seem that the OGS hominins exploited resources more effectively for activities related to animal butchery compared to the lack of evidence for fossilized bones and related activities at the EG sites. However, it will be difficult at this stage to attribute such differences between the two areas to a more effective use of stone material sources as well as better exploitation of animal carcasses at OGS vs. at EG. Only ~ 3m^2 has been excavated at OGS-7 because of the large amount of overburden above the site, and if major differences exist between the EG and OGS areas, the full picture can be understood only with further expansion of the EG and OGS excavations and recovery of additional archaeological materials *in situ*, and continued investigations of the raw material sources and the ancient environments in the two areas.

The discovery of sharp cutting tools made on stones ~2.6 Ma (or probably even earlier) was a major technological breakthrough which greatly facilitated access to new food sources like meat. The behavioral threshold crossed with the invention of flaked stones some time in the Pliocene has changed the course of human evolution forever, eventually leading to the expansion/enlargement of ancestral hominin brain through a complex mechanism of feedback interplay of continued tool use ultimately resulting in human dependency on technology.

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Appendix 1

The Gona palaeoanthropological study area

The Gona Project was organized and the international research team began large-scale palaeoanthropological investigations in 1999. The Gona Palaeoanthropological Research Project study area is located in the west-central Afar Rift and covers an area of >500 Km^2 badlands with fluvio-lacustrine fossiliferous and artifact-rich deposits. The major rivers and their tributaries drain regions of the study area and seasonally flow into the Awash, also cutting through ancient sediments and exposing Plio-Pleistocene artifacts and fossilized fauna. Cobble conglomerates and interbedded tuffaceous markers are prominent through out much of the stratigraphic sequence providing local markers for correlating sites and the materials critical for dating the fossil and artifact-rich deposits.

To the east of Gona is the contiguous Hadar study area well-known for yielding a wealth of fossil hominins attributed to *Australopithecus afarensis* (including the famous fossil skeleton known as 'Lucy'). The foothills of the Gona Western Escarpment mark the boundary of the Gona study area to the west. The fossiliferous deposits in the Gona Western Escarpment are patchy, but contain important Late Miocene fauna and hominins dated to $\geq$ 5.6 Ma. The Early Pliocene deposits exposed in the adjacent Gona Western Margin have also yielded abundant hominins dated between 4,5-4.3 Ma and attributed to *Ardipithecus ramidus* (Semaw et al., 2005). The Bati-Mile road limits the northern extent of the Gona study area.

The eastern and southeastern portion of the study area in the Kada Gona, Ounda Gona and Dana Aoule drainages contain >80m thick sediments with Plio-Pleistocene fossil fauna, and artifact-rich deposits with multiple Oldowan levels within the 2.6-c. 1.5 Ma time interval. Successive layers of several Acheulian occurrences estimated between 1.7-0.5 Ma are documented in the Dana Aoule, Busidima and Gawis drainages. Further to the east the deposits at Gawis and Ya'alu are rich with Late Acheulian, surface scattered Middle Stone Age, and Late Stone Age sites. The deposits that contain Early and Late Acheulian stone artifacts have also yielded several hominin fossils (Semaw et al., in prep; Simpson et al., 2008). The Asbole and further upstream the Dera Dora Rivers mark the southern limit of the study area. The deposits exposed towards the southwestern part of Gona contain Mid-Late Pleistocene archaeology and fauna. The fossil and artifact-rich deposits outcropping in the Gona study area are now providing windows of opportunities for systematic archaeological, palaeontological, and geological field investigations, and the research team has carried out successive fieldwork between 1999 and 2007.