Arqueologia e paisagem

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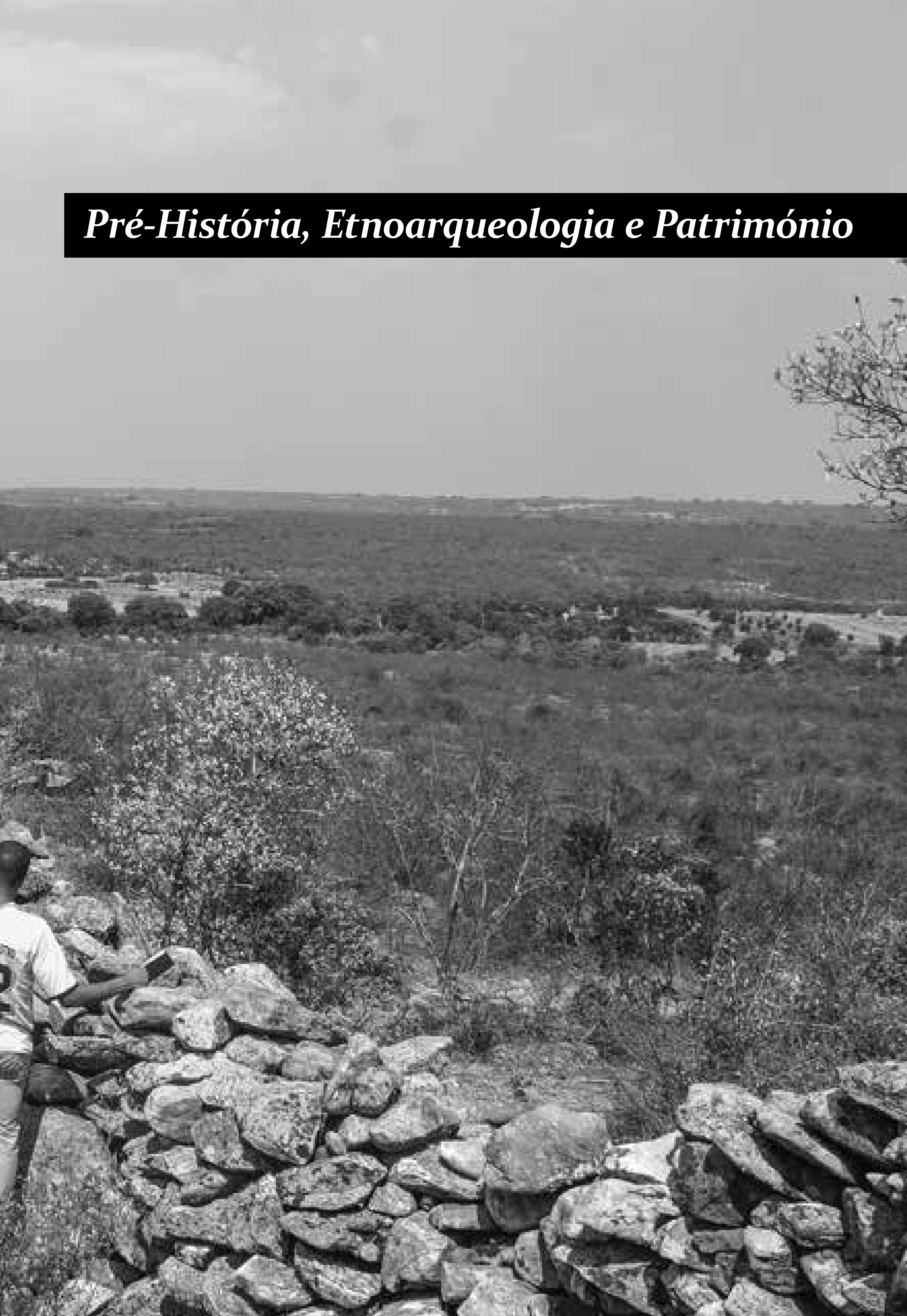
Pré-História, Etnoarqueologia e Património



Middle Pleistocene Lithic Industry and Hominin Behavior at Laetoli

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Introduction and objectives

This study defines the lithic industry and determines hominin technology, behaviours, activities and cognition as reflected by the stone artifacts collected from the upper Ngaloba Beds at Laetoli, northern Tanzania (Figure 001). The lithic assemblage was collected between 1998 and 2003 under the University of Dar es Salaam-Associated Colleges of Midwest (UDSM-ACM) field projects. A large portion of the assemblage (87 %) was collected on the surface but in geologic context of upper Ngaloba Beds at the southern end of Locality 2 (Figure 2). A few of them were found *in situ* and a large portion exhibit sediment matrix of upper Ngaloba Beds. A small percentage (13 %) of the assemblage was excavated from three units dug into the upper Ngaloba Beds at Locality 2 near the finding spot of Early *Homo sapiens* (E *Hs)* cranium (LH18). The lithic assemblage is significant because it documents a portion of the Middle Pleistocene lithic sequence that is poorly understood in Africa and therefore, constitutes a useful addition of information to the African archaeological record and knowledge. The sediments from which the lithic assemblage occurs are reliably dated to 200 kya and have also yielded a cranium of E*Hs*. Accordingly, the lithic assemblage has potential to offer insights about hominin behaviours, activities and cognition during this time span.

A cursory description by Harris and Harris (1981) suggested that the lithic assemblage from the upper Ngaloba Beds is of Middle Stone Age (MSA) antiquity and affinity. Nonetheless, there has been no formal analysis of the materials. Nothing is said about its technology, typology, raw material utilizations, behaviours, activities and cognition of the tool makers (Day *et al.,* 1980; Harris and Harris, 1981; Magori and Day, 1983). Therefore, this study analyzes and classifies the collected lithic assemblage and then compares it with other eastern Africa lithic assemblages of same time period to determine its position within the MSA continuum. The other goal is to interpret the types of hominin behaviours, activities and cognition in accordance to the lithic assemblage and raw material utilizations and thus, contribute to the current debate about hominin behaviours during this period. Sites from this time period are rare, especially ones that have associated hominin species and chronometrically well dated. This study shows that the lithic assemblage of upper Ngaloba Beds is an Early Middle Stone Age (EMSA). This is an MSA lithic industry lying within the Middle Pleistocene after ca. 300 kya and before ca. 130 kya (McBrearty and Tryon, 2005). The associated hominin remain is an Early *Homo sapiens* skull and the behaviours, activities and cognition of tool makers reflect capacities for "modern" behaviours.

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Background to study area

Laetoli is a Plio-Pleistocene site located about 36 km south of Olduvai Gorge in northern Tanzania (Figure 001). The site covers an area about 100 km² and may be viewed as contiguous with Olduvai Side Gorge. Since 1930s, the site has been a focus of much research on early hominin evolution and palaeoecology. More than 24 fossiliferous and artifactual deposit exposures (known as Localities) of volcanic origin spanning from 4 mya to 200 kya occur at the site (Hay, 1987; Drake and Curtis, 1987; Manega, 1993). Research by M. D. Leakey and colleagues has produced over twenty isolated teeth and fragments of cranial and post-cranial remains of fossil hominin including *Australopithecus afarensis*, *Paranthropus aethiopicus,* possibly *Homo erectus* and Early *Homo sapiens* (E*Hs*) or *Homo heidelbergensis*

(Day *et al.*, 1980; Harrison, 2011; Leakey, *et. al.*, 1976; Leakey, 1987; Leakey and Hay, 1979; Leakey and Harris, 1987; Magori and Day, 1983). Other significant discoveries at Laetoli include trails of hominin footprints generally attributed to *Australopithecus afarensis* made by three individuals, animal and avian tracks and rain-drop imprints dated to 3.66 mya, well preserved in volcanic ash within the upper and lower Laetolil Beds (Leakey and Hay, 1979; Leakey and Harris, 1987; Manega, 1993; Deino, 2011).

Laetoli's stratigraphic sequence, particularly the Olpiro Beds has yielded stone artifacts of Oldowan affinity (Harris and Harris, 1981; Ndessokia, 1990). The uppermost stratigraphic unit of Laetoli sequence is the Ngaloba Beds that on the basis of geologic composition is divided into a lower and an upper unit. The lower unit largely consists of conglomerate, sandstone, and claystone and is loosely dated to between 1.2 mya and 200 kya (Manega, 1993). It contains artifacts that have not yet been fully studied, but are considered to belong to the Acheulian industry (Hay, 1987; Harris and Harris, 1981; Leakey, 1987). Acheulian hand axes erode from this unit (personal observations). The upper unit is generally 2 to 3 m thick, and is composed of gray to brownishgray clays and clay-tuffs, and 20 to 50 cm thick very-coarse sandstone consisting of well-rounded pisolitic-looking clasts (Manega, 1993; Hay, 1987). The upper unit is represented by numerous widely scattered erosional remnants on the sides and in the bottoms of valleys. A distinctive brown to reddish-brown calcrete underlies the upper unit and it is overlain by a 1-2 m thickness of black cotton soil (Hay, 1987; Manega, 1993).

The age of the upper Ngaloba Beds is estimated to about 120 ± 3.0 kya, based on stratigraphic correlation with the lower unit of Ndutu Beds at Olduvai (Hay, 1987). A uranium-thorium dating by J. L. Bischoff of a giraffe vertebrae from the LH 18 horizon yielded dates of 129 ± 4.0 kya and 108 ± 30 kya (Hay, 1987). Manega (1993) obtained eight samples of ostrich egg shells from *in situ* in the coarse pisolithic sandstone, about 0.25 to 0.5 m above the LH 18 level. A calibrated amino acid age of >200 kya is obtained for LH 18 using 40Ar/39Ar and AMS C-14 of the recovered five samples of the ostrich eggshells (Manega, 1993). Recent dating by Deino (2011) supports the age of >200 kya for the upper Ngaloba Beds.

Research methods and field results

The upper Ngaloba unit contains lithic materials that are the subject of this study. The 398 stone artifacts analyzed in this study were collected from the southern end of Locality 2 where there are clear exposures of upper Ngaloba Beds (Figure 002, Plate 001). Here, the upper unit is about 3 m thickness of claystone and sandstone and overlain by a 2 m thickness of black cotton soil (Hay, 1987; Manega, 1993; personal observations; Figure 003).

This stratigraphic section is of particular interest because this is where E *H*s (LH 18), stone artifacts and animal fossils were recovered (Day *et al.*, 1980, Figure 003).
Each year from 1998 to 2003 we undertook surface collections from an area of about 2,052 m² (Plate 001). The pedestal for the finding spot of LH 18 served as our surface collection datum point. The position of each found and collected stone artifact was marked by a Germin hand held GPS receiver and its distance measured from the LH 18 datum point (LH 18 DP). Therefore, about 87 % of the studied stone artifacts were collected in this way. The majority of these were found *in situ* and few on the surface of a sandstone horizon near the middle of upper Ngaloba Beds section. This sandstone horizon is also the source of E*Hs* (LH 18) skull, animal and reptilian fossils and the two pieces of ochre pigment we found (Figure 003). Therefore, these lithic materials bear hominin behavioural integrity as they were found *in situ* and some eroding within the upper Ngaloba Beds. The lower Ngaloba unit is not exposed at this area (Hay, 1987) and the youngest deposit overlying the upper Ngaloba Beds is the black cotton soil horizon and it contains neither artifacts nor fossils.
A small percentage (13 %) of the lithic assemblage was recovered from excavation. Three 4 m² excavation units were established in the upper Ngaloba unit where artifacts, hominin and animal remains occur *in situ* or erode from. Since all the exposed deposits at this area belong to upper Ngaloba Beds the excavations proceeded stratigraphically. All the excavated soil was sieved through a 5 mm wire mesh and artifacts and fossil bones were bagged separately. Excavation Unit 1 (EU1) was established about 15 meters southwest of LH 18 (Plate 001). The unit was excavated to about 1.9 meters below unit datum point (BUDP). Ten stone artifacts, 20 fossilized bone fragments and three tortoise carapacea fragments were recovered from 0.4-0.55 m BUDP. Also recovered were seven ostrich egg and 23 landsnail shell fragments. Excavation Unit 2 (EU2) was placed about 40 meters southeast of LH 18 (Plate 001). This was excavated to 80 cm BUDP and no stone artifact was recovered. However, the unit yielded about two animal bone fragments and one ostrich eggshell fragment. Excavation Unit 3 (EU3) was established about 10 meters east of LH 18 and on a higher ground where Ngaloba Beds may not have been eroded away. This unit was excavated to 2 m BUDP. About 43 stone artifacts, 12 animal fossil bone fragments, and two ostrich eggshell fragments were recovered from about 1.5 m BUDP (Figure 004).
Artifacts were carefully cleaned using toothbrushes and water prior to the analysis. All lithic data were analyzed using a step-by-step lithic analysis form designed by the author, which scores specific attributes of the artifacts. In conjunction to this, artifacts were classified according to Mehlman's (1989) typology that categorizes each artifact based on type and further separating them based on dimensions. Mehlman's (1989) typology is used because it is relatively comprehensive and extensively used in eastern Africa in general and northern and central Tanzania in particular (Mabulla, 1996; Bushozi, 2003; Kessy, 2005; Dominguez-Rodrigo *et. al.*, 2007; Diez-Martin *et. al.*, 2009). Data were transcribed onto Fortran coding forms and entered into a computer. Microsoft Excel was then used to tabulate and compare the data, producing charts and descriptive statistics such as frequencies, means, and standard deviations. Neither edge-wear analyses nor scraper angle measurements were performed due to lack of proper instruments.

Lithic analysis results

The upper Ngaloba Beds lithic assemblage consists of 146 retouched pieces, 47 cores, 203 pieces of débitage and two (2) non-flaked stones. The two non-flaked stones are hammerstones. Basic data are presented in Tables 001, 002, 003 and 004. Clearly, analysis of the assemblage permits a general characterization of the stone industry.

Retouched Pieces

There are 146 retouched pieces comprising 36.70 % of the lithic assemblage. These are composed of scrapers, points, burins, becs, bifacially modified pieces, composite tools and heavy-duty tools (Table 001).

Scrapers

Scrapers are defined as possessing one or more sides that have a unifacial retouch angle between 35° and 90° (Mehlman 1989). This tool category comprises 102 pieces forming 70.00 % of retouched pieces and 25.63 % of total lithic assemblage. Scraper fragments are, however, excluded from further analysis. The average dimensions of scrapers are presented in Table 5. About 40 % of scrapers were made on very large blanks, 50.0-97.0 mm in length. Such scrapers can also be considered to belong to the heavy-duty tool category (Mehlman 1989). About 57 % were made on blanks 26.0-49.00 mm. The remaining 3 % were made on blanks less than 26.0 mm in length. Elliptic (40.25 %) forms were the most selected blanks for making scrapers followed by irregular end struck (28.60 %). The majority of scraper`s dorsal surfaces are flaked and no-cortical (85 %) indicating that blanks without cortex were more selected for scraper manufacturing. The dorsal scraper patterns are variable with one direction-convergent and one direction-irregular forming 21.0 % each. These are followed by one direction-parallel (18.5 %), radial (15.0 %), multi-directional (7.4 %), and two directions-opposed (2.5 %). The dorsal scar patterns of the remaining scrapers could not be determined.

A wide variety of scraper types are present in the upper Ngaloba assemblage (Table 001, Figures 005a and b). The dominant scraper type is the concave scraper. However, concavity, sundry side, denticulate, and convex side scrapers are also well represented. Analysis of scraper edge type indicates no preference for a particular edge type as both combination, concave, convex and sundry (rectilinear or irregular) edges are well represented (Figure 006). Important attributes recorded for scrapers are the type, position, distribution, morphology and extent (invasiveness) of retouches. The retouch was done utilizing unifacial (87 %) and part-bifacial (13 %) techniques. About 77.14 % of the retouched edges were continuous, covering the entire intended scraper edge while 22.86 % were continuous but partially covering the intended scraper edge. The retouches were positioned on the distal (30.00 %), mesial-distal (25.71 %), proximal (24.29 %) and mesial-proximal (20.00 %) sections of scraper blanks. About 97.14 % of the retouch is scaled and 2.86 % is stepped. The extent (invasiveness) of retouch was categorized based on measurements into marginal (0-5 mm), semi-invasive (5-10mm), invasive (10-15mm), and covering (entire face). Of these, semi-invasive makes up 46.43 %, marginal retouch 37.50 %, invasive 16.07 %, and covering is absent from the assemblage.

Other important aspects of the scraper are the type and size of striking platforms and blank terminations. Platform size was categorized based on measurements into broad (>10mm breadth) and thin (<5mm thick), broad and thick (>5mm thick), restricted (<10mm breadth) and thin, restricted and thick, and indeterminate. Analysis shows that 81 % of scrapers were made on blanks with broad and thick striking platforms. There are no signs of thinning either the bulbs or striking platforms, suggesting that scrapers were possibly not intended for hafting. The majority of the scrapers have plain (52.00 %) and facetted (40.51 %) striking platforms. Although blanks with feather terminations (80.00 %) were mostly selected for making scrapers, hinge (7.8 %), step (7.8 %) and overshoot (6.4 %) terminations are also represented.

Points

A total of 17 points are present in the assemblage forming 11.64 % of retouched pieces and 4.27 % of total lithic assemblage (Table 001, Figure 007). Unifacial, alternate edge and bifacial points are all present (Figure 008). Many of them were made from triangular flakes, a few from *Levallois* flakes and one from side struck flake (side struck point, Figure 007). The average dimensions of points are presented in Table 005 indicating that they are relatively small and thin. About 94 % of points' dorsal surfaces are flaked and non-cortical suggesting selection of blanks without cortex for making points. One-direction convergent (47.00 %) and radial (27.00 %) dorsal scar patterns dominate the point assemblage indicating preference of peripheral core reduction strategy for producing flake blanks for points. Triangular (47.00 %) and elliptic (33.00 %) were the most selected blank forms for making points. Facetted and plain platforms are equally represented (Figure 009). There are no signs of standardization in points' butt or base shape as straight (38.46 %), rounded (30.77 %) and pointed (23.10 %) butts are well represented. About 35.30 % of points have thinned butts/bases or bulbs. This was accomplished through either thinning the point's platiform thicknesses, narrowing the platform length or thinning the bulbs. Such technological innovations suggest knowledge of hafting technology or behavior. Butts or bulbs may have been thinned and/or narrowed to facilitate hafting of points into wooden shafts. In terms of bit (tip or distal end) shapes, pointed bits/tips predominate, forming 70.60 % of all points (Figure 010). The point's mean length and breadth are 39.75 and 28.45 respectively. The points mean length is 39.75 and is smaller than the mean length of 46.2 for experimental throwing spear tips (Shea, 2006). The mean breath is 28.45 and is significantly larger than the mean breath of 22.9 for experimental throwing spear tips (Shea, 2006). The point's sizes and the occurrences of points with pointed bits/ tips and thinned and/or narrowed butts, indicate that points were produced to be used as inserts for thrusting spears About 80.00 % of points have feather termination indicating controlled force and knowledge for the production of points' flake blanks. About 6.70 % of points have overshoot termination and the rest could not be determined.

Heavy duty tools

Of the nine (9) heavy-duty tools found, six (6) are core/large scrapers, one (1) is a biface, one (1) pick and one (1) is a core-axe (Table 001, Figure 011). Basically, core/large scrapers are either chunks or large flakes (≥50 mm) with steep unifacial retouches (Mehlman, 1989). The core-axes are bifacially flaked to create one good chopping side and a rather thick butt end. The retouches on these heavy-duty tools are continuous, covering the entire intended edges. This suggests initial intensions on the toolmakers to produce such tools. Overall, the tools in this category are heavy, but the core-axe is heavier, weighing about a kilogram. Core-scrapers and core-axes are important to recognize because of their common association with larger and older toolkits. Nonetheless, they are rare within the analyzed lithic assemblage.

Other tools

Also present in the toolkit are 13 becs, two (2) burins, one (1) bifacially modified piece and two (2) composite tools (Table 001, Figure 005a). Becs are robust points formed by steep retouch and are common throughout the MSA. Unlike scrapers and points, the majority of becs (92 %) were made from blanks with cortex dorsal surfaces suggesting that primary

and secondary blanks were selected for making becs. The average dimensions of becs are presented in Table 005. Facetted (54 %) and plain (38 %) striking platforms are well represented with the majority (92 %) being broad and thick platforms. There is no sign for thinning of either platforms or bulbs to suggest hafting of becs.
The average dimensions of burins are presented in Table 005. Each of the burins has one burin spall removed perpendicular to the ventral surfaces. The bifacially modified piece is elliptic in form with bifacial retouches, lenticular in cross-section and lack cortex. The two composite tools have average length of 42.10mm (std. 4.16), average breadth 31.0mm (std. 3.40) and average thickness of 14.0mm (st.d. 1.65). They exhibit no cortex.

Cores

Cores are the templates on which flakes and debitage are detached. Depending on the nature of raw material, cores may reveal the lithic reduction strategies that were employed. The analyzed lithic assemblage comprises of 47 cores forming 11.87 % of total assemblage (Table 2). Core support is essentially a nodule, although one case is observed where the support could have been a large flake. Core classification is carried out by the interaction of four types of attributes: core shape, number of platforms, scar directionality or polarity and faciality (Mehlman, 1989; Dominguez-Rodrigo, *et. al.*, 2007). Through combination of these criteria, three major core categories are observable: peripheral, platform, and amorphous. The peripheral group consists of flakes removed on both faces from a well-defined periphery or "equator" (Mehlman, 1989). This group is composed of radial, disc, *Levallois* and part-peripheral core types forming 68.18 % of the core assemblage (Table 002, Figure 012). Levallois and disc cores exhibit signs that define the production of predetermined flakes. The platform group consists of chunky, sub-rectangular, sub-cuboid and tabular cores with striking platform angles approaching 90° (Mehlman, 1989). This group comprises pyramidal/prismatic single platform, divers single platform, opposed double platform, adjacent double platform, multiple platform and platform/peripheral cores, forming 29.79 % of the typed cores (Table 002, Figure 012). A core on flake forming 2.13% of the cores represents the amorphous group.
The cores vary greatly in size and weight. The smallest core weighs 4.8 gm and the heaviest weighs 746.75 gm. The average weight is 104.93 grams (std. 133.54); the high standard deviation maybe due to the wide variance in the cores of this assemblage. The average dimensions of cores are presented in Table 005. By examining core circumference utilization, percentage of cortext present, number of core negative scars, and the degree of core abandonment, one can estimate the intensity of lithic raw material utilization. About 52.3 % of cores show no signs of cortical areas on both surfaces while the remaining retains small amounts of cortex. The majority of cores (80 %) display a high level of continuous spalling around their circumferences. The level of core abandonment was classified into three stages: stage I (cores minimally flaked), stage II (cores considerably flaked and hominins could have chipped off a few more flakes) and stage III (cores could not be flaked any further, Mabulla 1996). About 11 % of cores were abandoned in stage I (too early), 50 % were abandoned in stage II (prematurely), and 39 % were abandoned in stage III (exhausted). Flake negative scars on cores (93.5 %) predominate over blade negative scars (6.5 %). The average length of negative scars on cores is 35.70 mm (std. 12.56) and average breadth is 23.52 (std. 7.30). These values are clearly lower than the mean measurements observed in whole flakes, suggesting that the core sample retrieved represents later stages of the reduction sequence.

Debitage

This category is composed of core fragments, angular fragments, flakes, blades (only one blade) and other points forming 51.13 % of the lithic assemblage (Table 003; Figure 013). Nonetheless, core fragments, angular fragments and flake fragments are excluded from further analysis and discussion.

Whole flakes (n=98), trimmed/utilized flakes (n=52) and *Levallois* flakes (n=2) comprise 75.0 % of total debitage and 38.30 % of lithic assemblage. The average dimensions of flakes are presented in Table 005. Sixty-two percent of flakes are considered small blanks (<50mm long). About 75 % of whole flakes have dorsal surfaces that lack cortex, 24 % retain small amounts while 1 % is totally covered by cortex. This indicates that the majority of initial core reduction processes were taking place away from the site. The dorsal scar patterns are variable with one direction-convergent (20.62 %), one direction-parallel (18.6 %), one direction-irregular (16.5 %), multi-directional (16.5 %) and radial (8.2 %) patterns forming the majority. This variability suggests that there is a lack of standardization in the flake reduction strategy. The majority of flakes have plain (53.6 %) and facetted (34 %) platforms. The occurrence of flakes with convergent and radial scar patterns and facetted platforms suggest the use of core preparation techniques, including radial, disc and *Levallois* technology. Broad and thick platforms dominate, forming 82.5 % of whole flakes. The bulbs are well represented by normal (38.5 %), prominent (28.1 %), absent (16.7 %), scarred (11.5 %) and crushed (4.2 %). These characteristics exhibit the use of hard-hammer reduction techniques.

The average dimensions of trimmed/utilized flakes are presented in Table 005. About 75 % of utilized flakes are on small blanks (<50mm long). About 74 % have dorsal surfaces that lack cortex and dorsal scar patterns are variable with one direction-irregular (26 %) and multi-directional (18 %) scars forming the majority. Plain (55 %) and facetted (35 %) platforms dominate as well as large and thick platform (82 %) size. Feather termination (82 %) dominates although hinge (6 %), step (4 %) and overshoot (8 %) terminations are also present. This shows that upper Ngaloba hominins had excellent manipulation skills; they knew the exact amount of force needed to chip off a flake from a core and did not make mistakes very often (Andrefsky, 2005; Odell, 2003).

Table 005 presents the average dimensions of *Levallois* flakes and utilized *Levallois* points. The majority (82 %) lack cortex and have convergent dorsal scar patterns (82 %). Facetted (68 %) and plain (32 %) platforms are the only represented striking platforms most of which are broad and thick (89 %). Prominent (50 %) and scarred (21 %) bulbs form the majority suggesting hard hammer percussion. About 75 % exhibit a feather termination suggesting good skills and control of lithic reduction techniques by prehistoric knappers.

Lithic raw materials

The raw materials selected by hominins for use can yield behavioral and cognitive information regarding hominin's choices, transport and ranging patterns as well as technological and typological aspects (Blumenberg, 1983; Kuhn, 1995). The hominins of upper Ngaloba Beds utilized a wide range of lithic raw materials. These were grouped into: non-vesicular basalt, vesicular basalt, quartz, quartzite, chert, phonolite, calcrete and silicified mudstone lithic raw materials. As shown in Figure 014, vesicular basalt predominate (33.00 %) followed by non-vesicular basalt (28.00 %), quartzite (17.00 %), quartz (14.00 %), chert (4.00 %), phonolite (2.00 %), calcrete (1.00 %) and silicified mudstone (1.00 %). Vesicular basalt is a dense and hard coarse-grained material characterized by olivine and pyroxene rich red to black lavas and is less optimal for tool production compared to other materials used (Adelsberger *et. al.,* 2011). The source for this lithic raw material is the Ogol lavas that outcrop within the Laetoli site. Non-vesicular basalt is a coarse to fine grained material characterized by large, platy crystals of plagioclase feldspar with rare to absent pyroxene (Adelsberger *et. al*., 2011). The source for this lithic raw material is Mt. Makarut about 20 km east of Laetoli. Nonetheless, non-vesicular basalt cobbles may have been washed downstream to Laetoli during the upper Ngaloba Beds and therefore, may have been obtained locally (Adelsberger *et. al*., 2011). Also locally available is calcrete that occur as nodules in the upper Laetolil Beds. Not locally available are quartz, quartzite, chert and phonolite lithic raw materials. The upper Ngaloba quartzes are white and massive similar to those found in the Eyasi Basin about 20 km southeast. In the Eyasi Basin, quartz exists as veins throughout the Precambrian gneiss (Mabulla, 1996). Quartzite is characterized by coarse to fine-grained texture and breaks more smoothly. Coarse-grained quartzite may have been obtained from metamorphic hills around the Olduvai Gorge basin and about 35 km north of Laetoli. The fine-grained quartzites are dark red in color (jasper) similar to those recovered from the Loiyangalani River Late Middle Stone Age (LMSA) site in the Moru Kopjes area, Serengeti National Park (personal observations). This is about 120 km northwest of Laetoli. Phonolites are typically dark green in color and fine-grained in texture. These may have been obtained from Mt. Engelosin located about 48 km north of Laetoli area (Hay, 1976).

Analysis of lithic raw materials vs. artifact types shows interesting patterns about raw material choices and utilization. About 41 % of scrapers were made from non-vesicular basalt, 29 % from quartzite, 16 % from vesicular basalt, 6.25 % from quartz and chert respectively and 1.25 % from phonolite. The preferred raw materials for making points were quartzite (47 %) followed by quartz and non-vesicular basalt (20 % each) and vesicular basalt (13 %). The two burins were respectively made from quartz and quartzite raw materials while becs were made from non-vesicular basalt (92 %) and vesicular basalt (8 %). The heavy-duty tools are almost equally made from quartz (33.33 %), non-vesicular basalt (22.22 %), vesicular basalt (22.22 %), and quartzite (22.22 %). The cores are on non-vesicular basalt (28.3 %), vesicular basalt (30.4 %), quartz (19.6 %), quartzite (15.2 %), chert (4.3 %) and phonolite (2.2 %). The two hammerstones are on quartz and quartzite respectively.

Lithic raw material analysis shows that lithic qualities and durability may have played important roles in selecting a particular material for making a particular tool. This is especially supported by the analysis of scraper's lithic raw materials. Also, analysis shows that the intended functions of the tool may have played an important role in selecting a particular raw material for making a particular tool. This observation is supported by the analysis of points whereby hard quartz and quartzite raw materials were more selected for making points.

Lithic assemblage assessment and classification

Classification and interpretation of this lithic assemblage is based on tool types, lithic production techniques, and lithic raw material utilization and procurement strategies. The analyzed upper Ngaloba artifact assemblage consists predominantly of stone artifacts, most of which the edges are basically unabraded or sharp (62 %), but some have moderate (36 %) to heavily abraded/rolled (2 %) edges and surfaces. All classes of lithic artifacts are represented – shaped tools, cores, non-flaked stones, and débitage that range from large flakes and angular fragments to *Levallois* points and flakes. Among the shaped tools, scrapers dominate and are represented by various types. Also present are points, burins, and becs. Composite tools, heavy-duty tools and bifacially modified pieces are also present but rare. Various core types are represented including both peripherally and platform struck cores. Some of the shaped tools, cores and débitage exhibit clear evidence of prepared core technology (radial, *Levallois,* etc.). There is an overall lack of standardization within the various tool types, seen by wide size distribution and various flaking patterns (dorsal scars). Tools were predominantly created on non-cortical end-struck blanks and retouched mainly utilizing unifacial techniques. However, bifacial retouch is present in some of the points and heavier tool types. The extent (invasiveness) of retouch is limited suggesting that hominins minimally reworked their tools.

Since some lithic raw materials are locally available and others within short distances, minimal reworking of tools suggests that hominins would rather create a new tool than continue manipulating a pre-existing one. This indicates an efficient strategy of lithic raw material economies, suggesting cognitive competence as a possible reason for the observed results. Fresh tools are more desirable or useful than extensively utilized tools that may present some functional disadvantages (Kuhn, 1995). Broad and thick plain, and facetted platforms with normal and prominent bulbs dominate, indicating the use of hard hammer. Intense utilization of cores suggests that hominins learned how to manipulate cores to their fullest potential and exhaustively use them. These results suggest that hominins continued to manipulate a pre-existing core, rather than creating a new one, representing a curative tool making technology.

Typologically, the lithic assemblage contains a mix of both light and heavy-duty toolkits. The light-duty tools predominate and include scrapers, points, becs, and burins. These implements are common in Late MSA (LMSA, ca. 130 kya, see Mabulla, 1996; Mehlman, 1989; McBreaty and Tryon, 2005; Tryon and McBreaty, 2002) tool assemblages. The heavy-duty tools include core/large scrapers, bifaces and core-axes. These implements are characteristic of late Acheulian/MSA transitional industries that in eastern Africa are variously known as the "Sangoan" or "Njarasan" industries (Mehlman, 1989; Foley and Lahr, 1997; Klein, 1999; McBrearty and Brooks, 2000). Nonetheless, these heavy-duty tools are rare within the upper Ngaloba lithic assemblage and toolkit.

Both peripheral and platform core reduction techniques using hard hammers were employed to produce both small (≤50mm long; 62 %) and large flake blanks (≥50mm long; 38 %). Peripheral core reduction technique dominates, forming 63.8 %. Cores resulting from this reduction technique include radial (44.68 %), *Levallois* (44.26 %) and disc (14.90 %) cores. Such cores are considered as byproducts of core preparation reduction technique (Andrefsky, 2005; Kuhn, 1995; Odell, 2003). Also, the occurrence of *Levallois* flakes and points and blanks with radial and convergent dorsal scar patterns and facetted platforms indicate knowledge of core preparation technique.

Therefore, technological, typological and metrical analysis and observations indicate that the upper Ngaloba Beds lithic assemblage is neither "typical" MSA nor Acheulian assemblage . Overall, it is a light-duty toolkit (93.84 %) mixed with a very small percentage of heavy-duty tools (6.16 %). The light-duty tools include scrapers, points, becs and burins. Scrapers dominate forming about 70.82 % of the retouched pieces. These include circular, combination, concave, convergent, convex, denticulate, nosed and sundry scrapers (Figure 006). Points, which are the hallmark of African LMSA assemblages (McBrearty, 2007) are well represented forming 11.04 % of retouched pieces (Table 001; Figures 007). These points are unifacially, bifacially and alternate edge retouched (Figure 008). Also present are *Levallois* and trimmed/utilized *Levallois* points, forming 13.30 % of débitage. Becs form 8.97 % of retouched pieces. Though present, burins are rare. The heavy-duty tools include core/large scrapers, biface/picks and core-axes. These are rare, forming only 6.16 % of retouched pieces. Cores resulting from peripheral or core preparation technique dominates. In terms of flake blank size, the assemblage is dominated by small blanks (62 %) mixed with large flake blanks (38 %). Most of them are end-struck blanks.

Chronologically, (about 200 kya), the upper Ngaloba Beds lithic assemblage is situated between the end of late Acheulian (ca. 400 kya) and the beginning of "typical" or Late MSA (LMSA, ca. 130 kya). In eastern Africa, the lithic assemblages belonging to this time period are variously classified as the "Sangoan" or "Njarasan" industry (Cole, 1967; Clark, 2001; Mehlman, 1989; McBrearty, 1988, 1991). Such industries are considered to be "intermediate" or "transitional" between the Acheulian and LMSA. These industries are loosely defined to encompass lithic assemblages that combine heavy-duty and light-duty implements dated between 400 and 150 kya (Clark, 1988). The main threads that hold this loosely defined industry together are the higher proportions of heavy-duty tools (e.g., core-axes, core/large scrapers, picks, and bifaces) to light-duty tools (Cole, 1967; Clark, 2001; McBrearty, 1988, 1991; Mehlman, 1989). Contrary, the upper Ngaloba Beds lithic assemblage has higher representation of light-duty tools and a very low representation of heavy-duty tools.

In consideration of all data and interpretations of tool assemblages spanning the late Acheulian to LMSA, I place the upper Ngaloba Beds lithic assemblage to an Early Middle Stone Age (EMSA) Ngaloban industry. This EMSA Ngaloban industry contains few heavy--duty tools (6.16 %) such as core/large scrapers, biface/picks and core-axes but largely is dominated by light-duty tools (93.84 %) such as different types of scrapers, retouched and *Levallois* points, becs, and burins. Also the EMSA Ngaloban industry is dominated by small flake blanks and only one blade was observed. The closest approximation to the EMSA Ngaloban industry is the EMSA Kapthurin Formation industry, Kenya, dated to about 285 kya (Deino and McBrearty, 2002; McBrearty and Tryon, 2005).

Hominin Behavioural Implications

Fauna remains that reveal evidence for subsistence and predation behaviours were not analyzed due to their fragmentary nature. Two pieces of red ochre covered by matrix of upper Ngaloba deposits were recovered from the surface, but *in situ* and in direct association with EMSA Ngaloban artifacts (Figure 015). Ochre does not occur naturally in the Laetoli area. The closest ochre source that is exploited by Maasai is the Ndorosi quarry site in Makhoromba area near Mt. Oldean (Saimon Kateyo, Godfrey Ole Moita and Magreth Kaisoi, pers. comm., July 2012). This modern quarry site is located about 60 km east of Laetoli. Another source ochre that was exploited by the Maasai while leaving in the now Serengeti National Park is in the Moru Kopjes area, about 120 km (Pers. Observations, 2010). Although the ochre pieces lack any evidence of hominin utilization or modification, their presence indicates that they were transported to the Laetoli area during the upper Ngaloba Beds. Clearly, this suggests use of red pigments by E *Hs* during EMSA Ngaloban industry and therefore, evidence for symbolic behaviour. Such ochre pigments have also been found within the EMSA Kapthurin Formation industry predating 285 kya (Deino and McBrearty, 2002; McBrearty and Brooks, 2000; McBrearty and Tryon, 2005) and at Twin River, Zambia (Barham, 1998).

The makers of EMSA Ngaloban industry utilized a range of lithic raw materials, including vesicular basalt (34 %), non-vesicular basalt (28 %), quartzite (17.5 %), quartz (14 %), chert (3.5 %), phonolite (1.8 %), calcrete (1.8 %) and gneiss (0.3 %). Vesicular basalt and calcrete are locally available within the Laetoli area, forming a total of 35.8 % of utilized lithic raw material types. Non-vesicular basalt, quartzite, quartz, green phonolite, chert and gneiss are non-local and form 64.2 % of the assemblage. These materials occur about 20 to 120 km away from Laetoli area indicating that hominins had ranging patterns of up to about 120 km (eg; the dark red fine-grained quartzite or jasper from Moru Kopjes, Serengeti), though most of the time may have stayed within a 20-60 km radius and had a thorough cognition of their landscape and its resources including lithic raw materials (see also McBrearty and Brooks, 2000).

The choice for lithic raw material size, shape and quality reflect the intelligence of the maker because it influences the final product, that is, the specific tool type (Blumenberg, 1983). Therefore, the makers of EMSA Ngaloba industry had high cognitive abilities as indicated by the use of high quality lithic materials such as non-vesicular basalt, quartzite, chert and green phonolite that form about 51 % of the assemblage. Moreover, hominin cognitive abilities and skills are indicated by the preferences of particular lithic raw materials for manufacturing particular tools as discussed earlier.

Quartz's crystalline structure contains internal fractures making it more faulty and difficult material to work with. Therefore, its occurrences within EMSA Ngaloban industry suggest hominin skills to manipulate such a hard material that is also largely characterized by internal flaws. When combined together, quartz and quartzite form 31.5 % of the utilized lithic raw materials. The use of these materials by EMSA Ngaloban hominins highlights a trend towards an almost exclusive use of such materials during LMSA as evidenced at the nearby site of Mumba rock shelter in the Eyasi Basin (LMSA "Sanzako" and "Kisele" industries, see Mehlman, 1989).

The occurrences of retouched and *Levallois* points suggests that hafting technology was already in place at Laetoli during EMSA Ngaloban industry, about 200 kya. Some of the points' butts were deliberately thinned, signalling the presence of complex projectile weaponry system during EMSA (Brooks *et al.*, 2005). Therefore, the EMSA Ngaloban industry indicates that its makers were behaviourally "modern". The only hominin remains within the upper Ngaloba Beds is an adult cranium of E *Hs* (LH 18). This was found in direct association with stone artifacts and fossilized animal bones (Day *et al.*, 1980). The artifacts presented in this study were collected from the same locality and stratigraphic horizon with the E *Hs* (LH 18) cranium.

Conclusion

Middle Pleistocene hominin technology, behaviours, activities and cognition are poorly understood in Africa because sites from this time period are rare, especially ones that have associated artifacts and hominin species and chronometrically well dated. This study presents the lithic assemblage from middle Pleistocene upper Ngaloba Beds at Laetoli, northern Tanzania. The upper Ngaloba Beds, dated to about 200 kya have also yielded a cranium of E *Hs* (LH18), in direct association with stone artifacts. The study reveals that the stone artifacts of the upper Ngaloba Beds represent a predominantly light-duty toolkit (93.84 %, scrapers, becs, burins and points) mixed with a lower percentage (6.16 %) of heavy-duty toolkit (core/large scrapers and core axes). This combination of light-duty and heavy-duty toolkits is best described as Early Middle Stone Age (EMSA) Ngaloban industry. The associated hominin behaviours, activities and cognition reflect that E *Hs* at Laetoli had "modern" behaviours including range expansion, use of pigments, efficient strategy of lithic raw material economies and knowledge of projectile weaponry system and hafting technology.

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Table 001 – Upper Ngaloba Typed Retouched Pieces

Type #	Artefact Type *SCRAPERS*	*fx*	% Retou- -ched Pieces	% Total assemblage
2	scraper, convex end	6	4.11	
4	scraper, convex end and side	2	1.37	
5	scraper, circular	2	1.37	
6	scraper, nosed end	4	2.74	
7	scraper, convex side	7	4.80	
8	scraper, convex double side	3	2.05	
9	scraper, nosed side	1	0.68	
10	scraper, sundry end	5	3.42	
12	scraper, sundry end and side	2	1.37	
13	scraper, sundry side	8	5.48	
14	scraper, sundry double side	1	0.68	
15	scraper, concave	11	7.53	
16	scraper, concavity	8	5.48	
18	scraper, sundry combination	2	1.37	
19	scraper, convex end + concave combination	1	0.68	
20	scraper, convex side + concave combination	2	1.37	
22	scraper, convergent	1	0.68	
23	scraper, fragment	17	11.64	
106	scraper, denticulate	7	4.80	
108	scraper, concave side and sundry end	2	1.37	
110	scraper, concave side and sundry side	5	3.42	
111	scraper, nosed end + bec	2	1.37	
112	Scraper, convex end + sundry side + concavity	2	1.37	
113	Scraper, concave double side and sundry end	1	0.68	
	Total scrapers	**102**	**70.00**	**25.63**
	POINTS			
35	Point, unifacial	13	8.90	
36	Point, alternate edge	2	1.37	
37	Point, bifacial	2	1.37	

	Total points	**17**	**11.64**	**4.27**
	BURINS			
39	Burin, angle	2	1.37	
	Total burins	**2**	**1.37**	**0.50**
	BIFACIALLY MODIFIED PIECES			
43	Bifacially modified piece	1	0.68	
	Total bifacially modified pieces	**1**	**0.68**	**0.25**
	BECS			
44	Bec	13	8.90	
	Total becs	**13**	**8.90**	**3.27**
	COMPOSITE TOOLS			
48	Scraper + other composite tool	2	1.37	
	Total composite tools	**2**	**1.37**	**0.50**
	HEAVY-DUTY TOOLS			
50	Core/large scraper	6	4.12	
51	Biface/pick	2	1.37	
116	Core-axe	1	0.68	
	Total heavy-duty tools	**9**	**6.16**	**2.26**
	Total retouched pieces	**146**	**100.00**	**36.68**

Table 002 – Upper Ngaloba Typed Cores

Type #	Artefact Type CORES	*fx*	% Cores	% Total assemblage
57	core, part-peripheral	2	4.26	
58	core, radial/biconic	21	44.68	
59	core, disc	7	14.90	
60	core, levallois	2	4.26	
61	core, pyramidal/prismatic single platform	1	2.13	
62	core, divers single platform	3	6.38	
64	core, opposed double platform	3	6.38	
66	core, adjacent double platform	2	4.26	
68	core, multiple platform	2	4.26	
69	core, platform/peripheral	3	6.38	
114	core, on flake	1	2.13	
	Total Cores	**47**	**100.00**	**11.81**

Table 003 – Upper Ngaloba Typed débitage

Type #	Artefact Type *CORE FRAGMENTS*	*fx*	% Débitage	% Total assemblage
77	core, fragment	2	0.99	
	Total core fragments	**2**	**0.99**	**0.50**
	ANGULAR FRAGMENTS			
78	angular fragment	10	4.93	
79	angular fragment, trimmed/utilized	1	0.49	
	Total angular fragments	**11**	**5.42**	**2.76**
	FLAKES			
84	flake, whole	98	48.30	
85	flake, trimmed/utilized	52	25.62	
86	flake, talon fragment	9	4.43	
92	flake, levallois	2	0.99	
115	flake, longitudinally split	1	0.49	
	Total flakes	**162**	**79.80**	**40.70**
	BLADES			
88	Blade, whole	1	0.49	
	Total blades	**1**	**0.49**	**0.25**
	OTHER POINTS			
107	point, levallois	24	11.82	
109	point, trimmed/utilized levallois	3	1.48	
	Total other points	**27**	**13.30**	**6.80**
	Total débitage	**203**	**100.00**	**51.00**

Table 004 – Upper Ngaloba Typed Non-flaked Stones

Type #	Artefact Type *NON-FLAKED STONE*	*fx*	%	% Total assemblage
94	hammerstone	2	100.00	
	Total non-flaked stone	**2**	**100.00**	**0.50**
	Total lithic assemblage	**398**	**100.00**	**100.00**

Table 005 – Average dimensions of retouched pieces, cores and *debitage*

Artifact Type	Length (mm)	Std.	Breadth (mm)	Std.	Thickness (mm)	Std.
Scrapers	48.00	15.00	42.00	14.00	14.00	7.00
Points	39.75	15.45	28.45	8.21	13.40	3.70
Becs	42.56	12.30	35.00	14.00	12.50	3.00
Burins	35.50	3.50	23.70	8.00	9.20	0.30
Cores	50.57	14.66	43.33	14.64	25.74	11.49
Flakes	47.00	11.45	39.34	12.68	13.03	4.1
Trimmed/utilized flakes	42.50	11.00	38.2	10.00	14.7	10.65
Levallois and utilized levallois points	57.50	9.80	44.17	8.33	14.12	2.10

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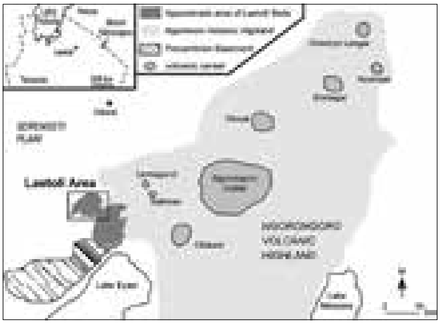

Figure 001 – Regional map showing study area of Laetoli (Adopted from Adelsberger *et al.*, 2011).

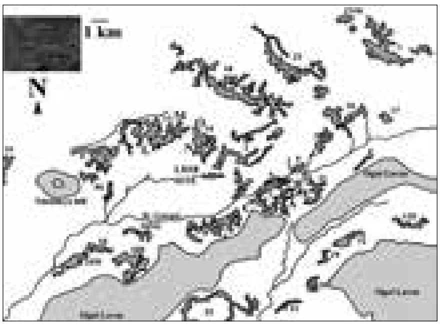

Figure 002 – Map of Laetoli's sediment exposures or localities showing study site at LH 18, southern end of Locality 2
(Adapted from Musiba *et al.*, 2008).

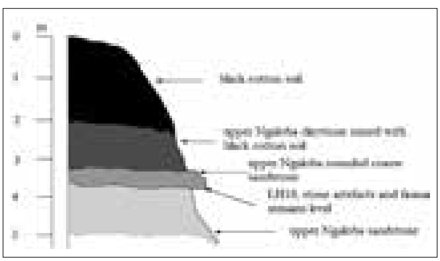

Figure 003 – A generalized stratigraphic section of upper Ngaloba Beds at LH18, southern end of Locality 2.

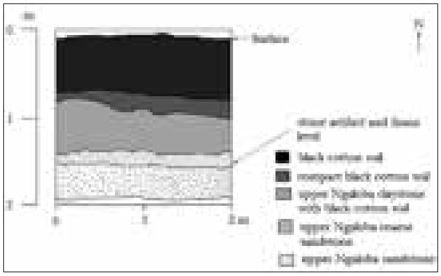

Figure 004 – Excavation Unit 3 northern wall profile.

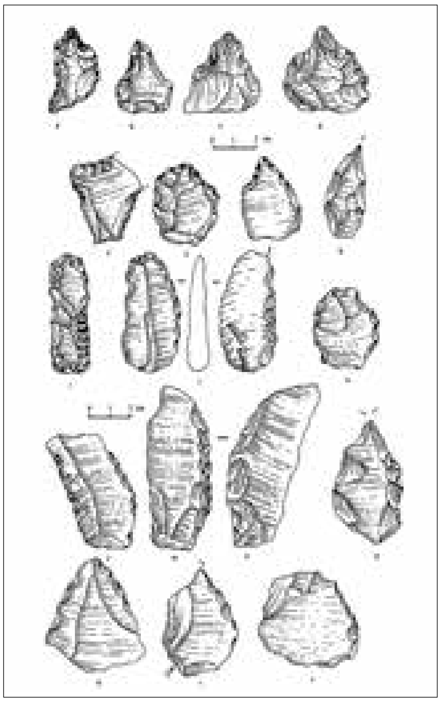

Figure 005a – Shaped tools: a, j=convex side +concave combination scrapers; b, c, d, g, p=becs; e=sundry end +side scraper; f, k, s=convex end +side scrapers; h, r=angle burins; i=denticulate scraper; l=convex side and sundry scraper; m, n=convex side scrapers; p=dihedral burin. Raw materials: a, f=quartz; b, c, d, i, k, m, p, r=quartzite; e, h, j, s=chert; g, l, n, q=non-vesicular basalt.

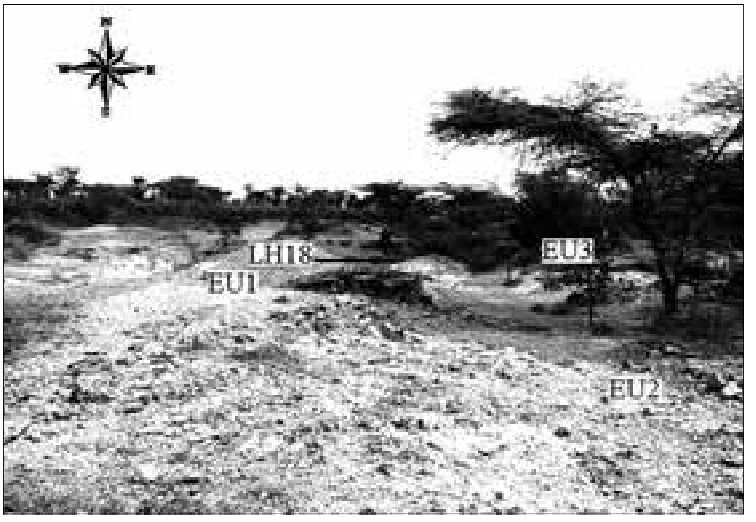

Plate 001 Upper Ngaloba sediments at southern end of Locality 2 showing LH18 pedestal (man standing on it) and Excavation Units 1 to 3 (EU1-EU3).

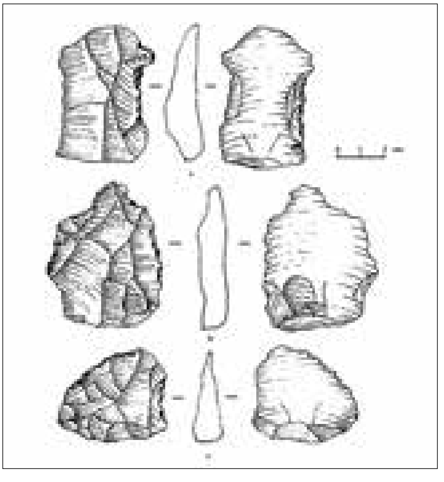

Figure 005b – Shaped tools: a=concave double side scraper + bec; b=nosed end scraper; c=convex side + concave side scraper. Raw Material: a=quartzite, b=non-vesicular basalt; c=chert.

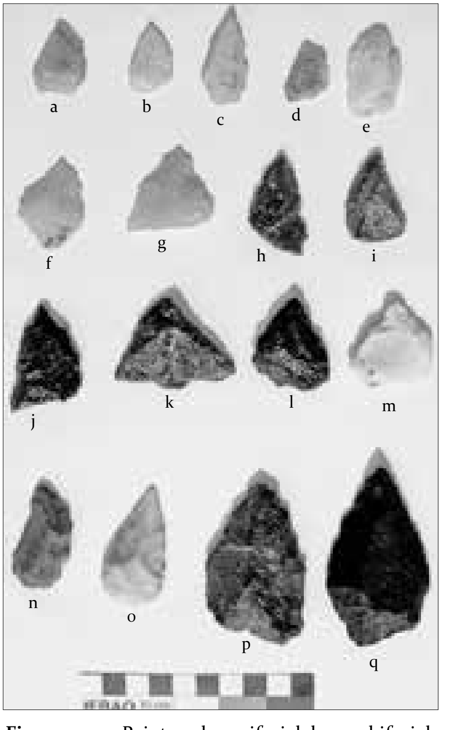

Figure 007 – Points: a-k= unifacial; l, n, o=bifacial; m= side struck; p-q=alternate edge. Raw Material: a-g =quartz; h-l=quartzite; m-o= chert; p=silicified mudstone; q=non-vesicular basalt.

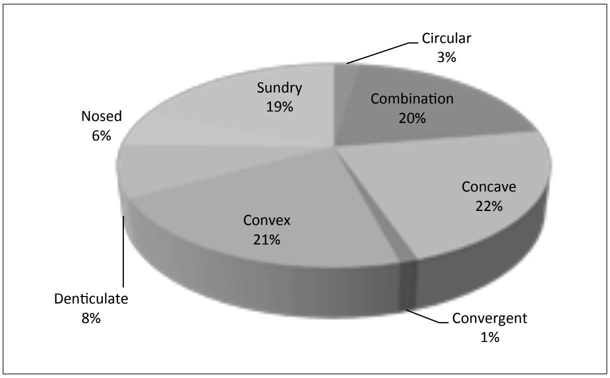

Figure 006
Frequency of scraper edge type.

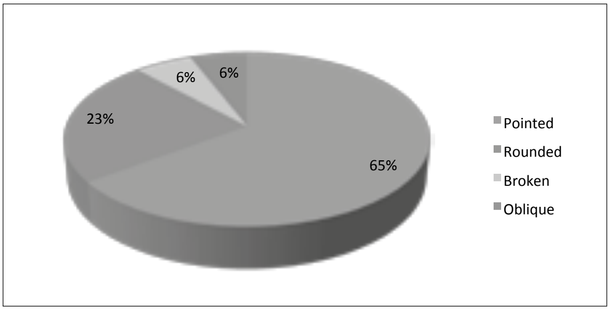

Figure 010
Point bit shapes.

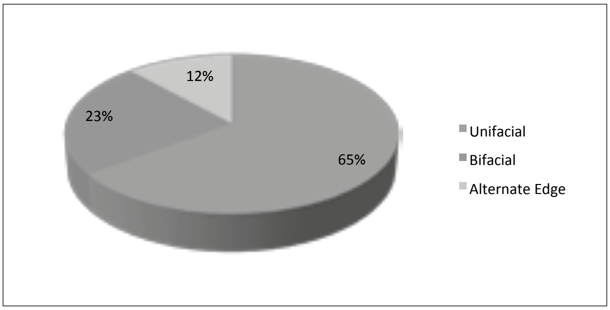

Figure 008
Point retouch types.

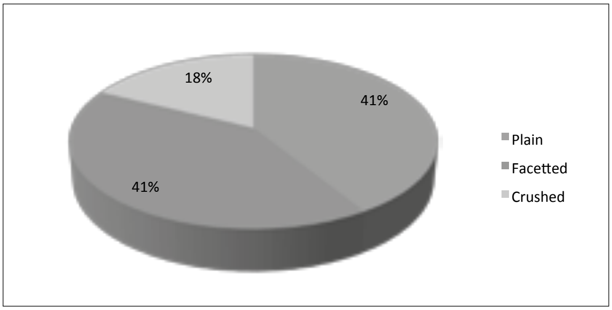

Figure 009
Point platform types.

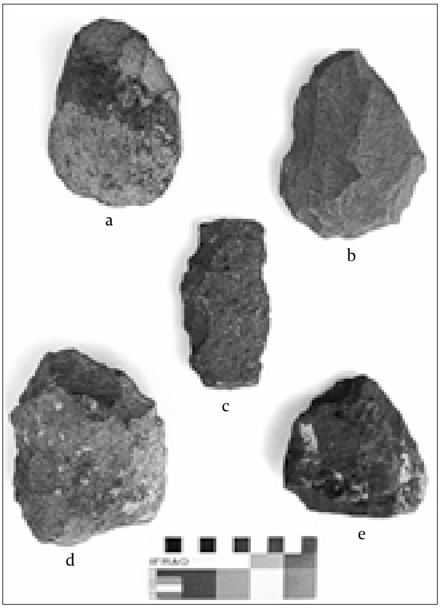

Figure 011 – Heavy-duty tools: a=core-axe, b= biface, c=large scraper/knife, d=core-scraper, e=pick. Raw material: a, c, d, and e=vesicular basalt; b=andasite.

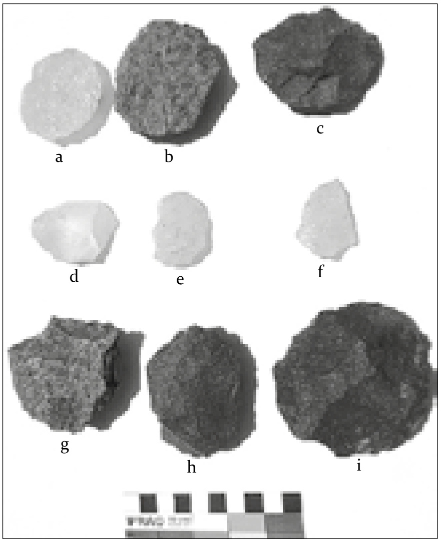

Figure 012 – Cores: a-c: discoid; d=levallois; e=opposed double platform; f=divers single platform; g-i=radial. Raw material: a, e, f=quartz; b, g, h=vesicular basalt; c=non-vesicular basalt; d=chert.

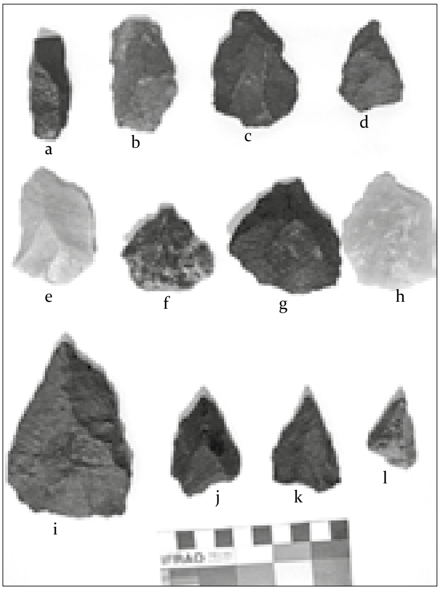

Figure 013 – Debitage: a=blade; b-h= *Levallois* flakes; i-l= *Levallois* points.

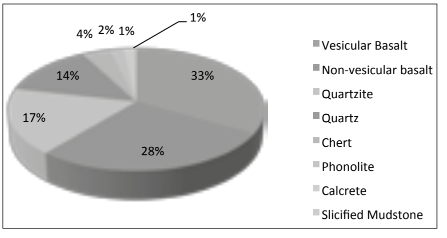

Figure 014 – Assemblage lithic raw materials.

Figure 015 – Pieces of red ochre pigment.