The Archaeology of Aduma Middle Stone Age Sites in the Awash Valley, Ethiopia

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ABSTRACT

The Aduma region of the Middle Awash Valley, Ethiopia, contains multiple surface and in situ Middle Stone Age (MSA) occurrences that include lithics and spatially associated faunal and hominid remains. While one Aduma site may, on the basis of lithic comparison, be assigned to an early phase of the MSA, both absolute dates and lithic typology indicate that the remainder represent a significantly later stage of this industrial tradition, likely dating to ca. 80,000 to 100,000 years ago. Assemblages were deposited on an aggrading alluvially dominated landscape which included riverine and floodplain environments. Chronological changes in landform and raw material availability within the geographically limited Aduma region provided a dynamic context that required behavioral flexibility to adapt successfully. Analysis of ten assemblages from eight sites provides the basis for characterizing the Aduma sequence, setting it into broader sub-Saharan context and reconstructing aspects of hominid subsistence strategy and lithic economy.

The Aduma lithic assemblages constitute a regional variant within the MSA characterized by a distinctive range of point, scraper and core types. Most striking are the small "microlithic" size of multiple types all produced by MSA technologies and the increasing emphasis on smaller tools over time, which suggests a process similar to yet independent from that which culminated in the appearance of the Late Stone Age. Faunal remains indicate use of multiple habitats with a strong and consistent reliance on riverine resources including large easily predated fish. Based on cranial remains, the Aduma hominids fall within the range of anatomically modern humans. Intersite comparison reveals a scheduling of subsistence and manufacturing behaviors typical of some ethnographically known hunter and gatherer groups. As raw material availability changed over time, lithic manufacturing and utilization patterns varied in an economically rational manner to maximize efficiently the use of scarce and valuable stone types.

INTRODUCTION

This article reports on a series of Middle Stone Age (MSA) sites excavated in the Aduma region, Middle Awash valley Ethiopia (Fig. 1) between 1993 and 1998 under the aegis of the Middle Awash research project. They derive their significance in part from the fact that they document a portion of the MSA sequence from a region in which little information is available and thus constitute a useful addition of data to the African archaeological record. The sites also serve to define a distinct regional tradition within the MSA and how it developed over time. Within the last decade, with the recognition that both anatomically modern humans and "complex" behaviors first appear in the MSA, increasing attention has been focused on this tradition. Understanding of the MSA, however, has been constrained not only by data limitations themselves but because of the narrow and restricted framework within which this industrial tradition has been viewed. While the debate over modern human origins is clearly of anthropological signifi-

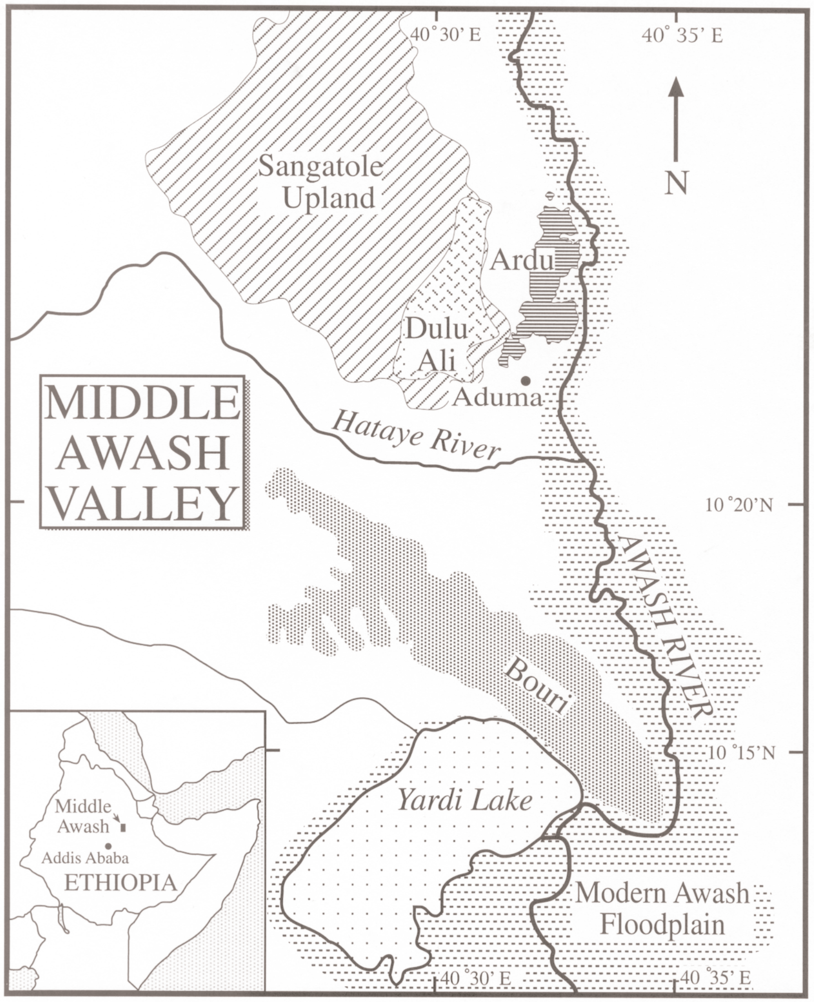

Figure 1. Location of the Middle Awash region, Aduma and the Ardu sediments. The area from Aduma village North to the furthermost Ardu sediment is denoted in this article as "Aduma."

cance and MSA data relevant to its resolution, one negative and unintended side effect is the tendency not to address MSA behaviors in their own right, to ignore potentially unique features and the fact that the MSA constituted a set of changing functioning cultural systems which persisted over a broad expanse of sub Saharan Africa in excess of 200,000 years. Although the paucity of well-dated sites and sequences is partly responsible, also minimized in the "modern origins" debate is the fact that MSA adaptations vary significantly over both time and space; such homogenization not only blurs detail but also makes it difficult to discern adaptations specific to time and place. At Aduma, because of the number of sites excavated and assemblages analyzed, because they are constrained in both time and geography and because they show a range of behavioral variation it is possible to gain some insight into late MSA adaptation within this region.

The Middle Awash Valley Ethiopian Aduma sites reported here are significant within this context. The localities that were given systematic inspection are mapped on Fig. 2. The excavated materials comprise 10 assemblages that include lithics and spatially associated vertebrate faunas from eight sites referred to as A1, A2 (VP1/1 and VP 1/3), A4, A5, A8, A8A, A8B. They represent a distinct localized variant within the Horn of Africa. While a second set of comparable sites (Shea et al., 2002) is possibly present in the Southern Ethiopian Rift Valley in the Omo River Kibish formation, archaeological data are insufficient to delineate clearly the boundaries of what is herein termed the "Aduma

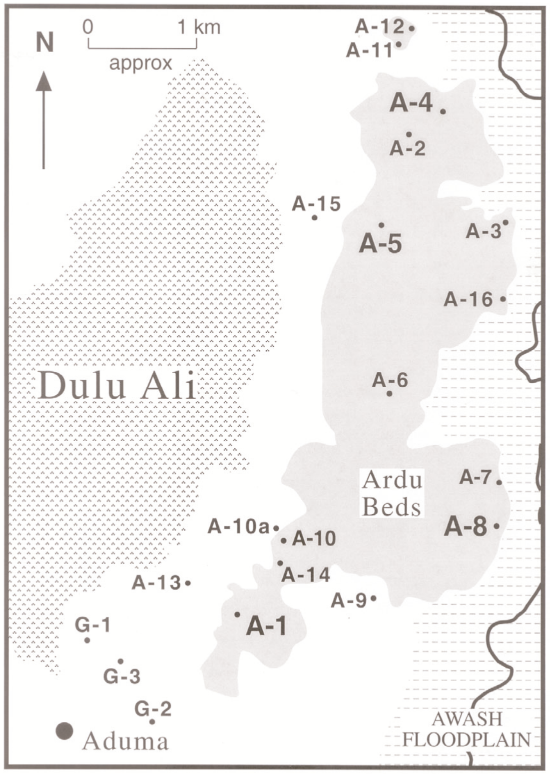

Figure 2. Location of Aduma-related sites. The "A" designation denotes "archaeology", the "G", locations at which geological samples were collected.

Industry." Aduma provides an example of a regional tradition which, while clearly MSA in technology, developed in relative independence following a trajectory towards lithic miniaturization over time; it provides an excellent comparative example to the better known South African sequence. Although at Aduma synchronic paleoenvironmental diversity is limited by a tightly constrained geographical area of only 15 sq. km, rapid geomorphological change characterizes this tectonically active region and the 10 assemblages which constitute the Aduma sample provide insight into how MSA hominids adapted to changing resource availability over time.

GEOLOGY

Aduma, which takes its name from an Afar village at its southern margin, comprises approximately 15 square kilometers of archaeologically rich, dissected Pleistocene sediments located at about 10025'N; 40031'E immediately west of the Awash River floodplain and east and south of a small mostly basaltic massif known as Dulu Ali. In 1976 the area was briefly surveyed by Kalb who noted the presence of "small late Acheulean handaxes." (Kalb, 2001:209). Its larger archaeological potential was realized in 1992 by members of the Middle Awash research project who discovered an extensive pavement of MSA artifacts at "Ardukoba", a co-joined version of the Afar name "Ardu Oba", (denoted as site "A1" in Fig. 2), ca. 2 km northeast of the Aduma village, thus calling attention to the MSA potential of the region. The modern landscape consists of dozens of small eroded conical hills of variably consolidated silts and sands (Ardu Beds), usually less than 13 meters high, which are surrounded by minor bodies of alluvia, both in ephemeral drainage lines and small scale alluvial fans, as well as by eolian veneers. With little vegetation stabilizing them in the modern semiarid climate, these hills are rapidly eroding, revealing numerous MSA horizons on hill slopes, and leaving lags of MSA materials in the intervening flats. Erosion in concert with highly periodic rainfall and intensive modern grazing pressure has divided the Ardu Beds into three "lobes" (numbered 1, 2, and 3 from south to north) bounded by modern valleyways of minor tributary channels (Fig, 3). In addition, the southern section of the Ardu deposits is gently block faulted. This terrain, called the "Ardu Blocks", features vertical throws typically less than 10 m, with fault plane axes broadly transverse to the axis of the modern Awash channel (Fig. 3). Small scattered deposits equivalent to the Ardu Beds may occur on the Bouri Peninsula south of Aduma and equivalent beds may extend east of the Awash floodplain opposite Aduma. Middle Stone Age artifacts have been reported east of the river although similar deposits are not evident on air photographs and security considerations precluded ground survey.

The basal sedimentary deposits near Aduma, informally defined here as the Koba Beds, consist of a series of tilted lacustrine clays and silts which are faulted, contain tephra horizons and occasional carbonate horizons marking relict land surfaces. They record both deep-water and emergent shoreline facies and are associated with rare vertebrate fossils (locality A-13). The age and stratigraphic position of the Koba Beds relative to other Middle Awash sedimentary units is not well understood but the degree of diagenetic and tectonic alteration suggests at least a Pliocene age.

Four litho and morpho-stratigraphic features of limited extent, uncertain age and stratigraphic relation separate the Koba/Dulu Ali from the Ardu Beds (Table 1). First, immediately north of the Afar village of Gaboli is a basaltic ridge which is capped by relict Awash River gravels. These well-rounded to rounded, pebble to medium cobble gravels are the remnants of an ancient channel of a large river. Referred to here as the Gaboli Gravels, these gravels drip down flanks of the ridge. Three localities were informally searched for archaeology (G-1, G-2, and G-3) but none was discovered. Second, the Issiqweeah Beds consist of laterally variable inhomogeneous sandy clay silts and fine silts which are both lacustrine and fluvial in origin and include both dense

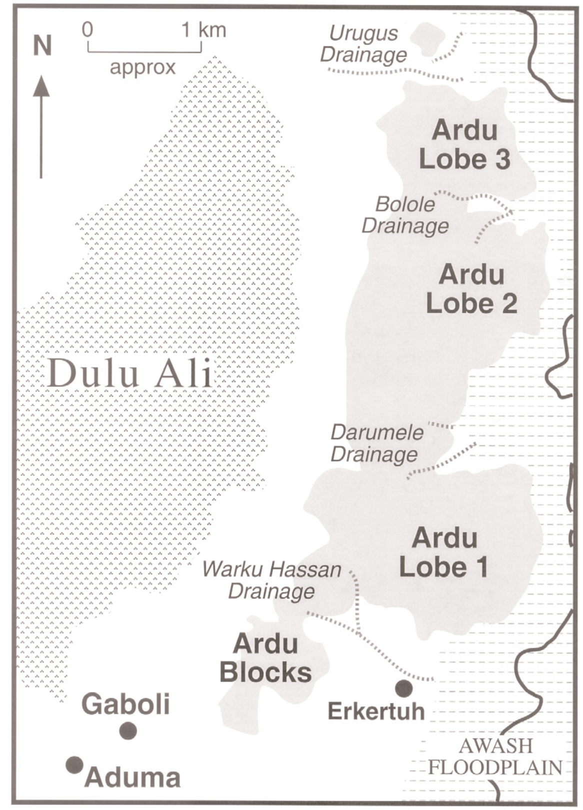

Figure 3. Distribution of Ardu sediments into three "lobes."

TABLE 1: STRATIGRAPHIC SUMMARY: LANDSCAPE NORTH OF ADUMA, MIDDLE AWASH, ETHIOPIA (CA. 10° 26' N, 40° 32' E).

1. RECENT ALLUVIA, COLLUVIA AND EOLIAN VENEERS

2. ARDU BEDS

Ardu C: valley side colluvial of basaltic sands and cobbles merging with Awash alluvia of dark silty clays, capped by carbonate paleosol, including later Middle Stone Age artifacts. Later Stone Age artifacts on surface.

Erosional Unconformity

Ardu B: massive, alluvial, sandy silts and silty clays with high-energy bedforms, carbonate casts of vegetation, mostly derived mollusk shells, later Middle Stone Age artifacts, post-depositional carbonate paleosol. Heterogeneous, uncemented, sole deposits include derived carbonate clasts, mollusc shells, and mixed valley-floor debris.

Erosional Unconformity

Ardu A: diverse, carbonate-cemented relict alluvia, clayey silts, calcretes and sandy silts, tectonically deformed, early (?) Middle Stone Age artifacts.

3. OLDER STRATIGRAPHICALLY DISCONTINUOUS FEATURES

A-10/A-14: Platform valleyside pediment on Koba Beds, lag gravels on surface include Early Stone Age artifacts.

Bodole Tuff: fragmentary, gray, silty volcanic ash

Issiqweeah Beds: diverse, alluvial sands and silts, carbonate cementation, diverse mollusc shells including Cleopatra, casts of tree trunks, no artifacts.

Gaboli Older Gravels: elevated, well-rounded, cobble gravels of an ancient Awash channel. Artifacts not noted.

and dispersed concentrations of the mollusk Cleopatra. These beds rise to about 8 m above the modern Awash floodplain. In one area (locality A-9) these deposits are capped with more than 30 tree stump casts. Overlying portions of the Issiqweeah Beds and present in discontinuous fragmentary outcrops in multiple Aduma areas is an undated tuff, the Bodole Tuff (particularly localities A-2, A-9, and A-15), exposed as both a primary silty airfall ashl and as fluvially redeposited silts. Unfortunately, stratigraphically definitive exposures of the Bodole Tuff have not been discovered and it lacks crystals suitable for K-A and 40Ar/39Ar dating.

Finally, a fault bounded platform ca. 25 hectares in extent, resting on Koba Beds and consisting of sub-rounded to rounded mostly medium and coarse pebbles in coarse sand matrices is present beyond the northern margin of the Ardu Blocks. Cobble and boulder-grade clasts are also included. The gravel lithologies reflect both near and distant sources. While many clasts are from the Dulu Ali volcanic sequence, others reflect a diverse assortment of metamorphic and igneous lithologies including exotic andesites and trachytes, as well as cherts, granites, schists, gneisses and quartzites found along and beyond the distant rift margins. These gravels, mostly currently buried under succeeding Ardu sediments, are of archaeological significance as a potential source of stone tool raw material. Sites A-10 and A-14 both located on the platform incorporate Early Stone Age (ESA) Acheulian artifacts including large highly standardized hand-axes and cleavers as well as non-Levallois flakes. Some tools have weathering rinds, as do the gravels, and rest on the gravel rather than within it. Fragments of mammal teeth are also present. These ESA materials, the earliest recognizable tools at Aduma occur solely in this gravel association. (De Heinzelin et al. 2000).

The Ardu Beds, informally defined here in three depositional units– Ardu A, Ardu B and Ardu C– are younger than the gravel lags that incorporate the ESA artifacts. These beds consist of relict valley-floor alluvia and colluvia best preserved and exposed north of the village of Aduma where, today, they are both fluvially dissected and subtly tectonically deformed.

Sediments correlating to the Ardu Beds elsewhere in the region are not obvious on aerial imagery, but are probably present. Ancient, poorly exposed, calcreted alluvia like the Ardu A appear at several sites along the modern Awash channel south of Aduma. A small area of uncemented silts and sands with MSA tools, much like Ardu B, is present on the eastern end of the Bouri Peninsula (10.21 N, 40.27 E), ca. 15 km to the south. The lateral older valley fill of the Ardu C probably has correlates along much of the lower Awash Valley. Resources and local security considerations limited exploration during this research to the western side of the Awash channel.

Ardu A, the lowest unit, is represented by fragmentary, spatially limited exposures along the eastern edge of all three lobes. The base has not been seen. The erosional unconformity on its surface gently undulates with at least 2 m of local relief over 500 m reflecting a mosaic of erosional-tectonic processes on an ancient Awash Valley floor. Sediments of varied facies and lithologies seem best referred to a poorly preserved relict largely alluvial valley floor with its axis paralleling the modern Awash. The distinctive attribute of Ardu A, compared to capping beds is impressive, post-depositional carbonate sedimentation, both massive and nodular.

Ardu B, the largest and most widely exposed Ardu sedimentary suite consists primarily of monotonous sandy silts and silty sands heavily eroded to form numerous discrete hillocks. Deposits contain extensive but discontinuous carbonate cements of rootdrip, joint fillings and diverse root casts all sometimes coated with iron oxide rinds. Large scale trough cross stratification with dips varying from 0 to 25 degrees in as little as 20 m of outcrop indicates rapid, high-energy sedimentation and together with the lack of true paleosols suggests that Ardu B resulted from a process of rapid aggradation. While the sediment source remains unknown, the consistency of dip directions within the beds indicates that Ardu B aggraded primarily from southwest to north and northeast through a pass in the eastern flanks of Dulu Ali and not precisely down the axis of the modern Awash floodplain. Its genesis as a response to a regional tectonic re-arrangement of drainage on the rift floor (the repeated failure of a former lake[s] upstream?) seems clear. The lower boundary of Ardu B is a complex of poorly exposed, texturally diverse, uncemented, valley-floor debris which in turn rests on the well-defined erosional conformity on top of Ardu A. This basal part of Ardu B is, in most exposures, more sandy sometimes including pebbles and pumice, often with largely derived mollusk shells. Within Ardu B, but particularly in discontinuous lenses near the base, are widespread mollusks such as Unio sp., Corbiculata sp. and Melanoides sp. These lenses most likely indicate areas and intervals of shallow calm water conditions during the major deposition of the upper Ardu B. Thus the processes that led to large-scale trough crossbedding at the macro-scale alternated with intervening intervals of locally ponded water as well as dry and marshy plannar surfaces. Ardu B contains multiple locally dense concentrations of MSA lithics and vertebrate remains most often at the edges of the larger Ardu deposit; these are often associated with dense concentrations of carbonate vegetation casts. The upper boundary of Ardu B is erosional, and an authentic upper depositional boundary does not appear to be preserved: at least two meters apparently have been eroded from the top of Ardu B. A suite of potassium argon dates with an average age of 180 KA derived from pumice in basal Ardu B provides a very maximum constraint for the B unit.

Following deposition of Ardu B, the axis of the primary stream on the floor of the Awash rift shifted eastward to about modern channel position. The surface of Ardu B was eroded by minor tributary streams from the west and was subsequently calcreted. On this surface the valley fill of Ardu C was deposited. Textures vary from more alluvial silty clay, that are a characteristically dark gray in color, to decidedly colluvial basalt cobbles, which tumbled in from Dulu Ali. Present at two archaeological sites, A4 and A5, Ardu C sediment consists of a weakly developed andosol with a black color that derives from comminuted, silt-sized basalt fragments. The stabilized Ardu C surface developed a vertic soil with a still preserved substantial carbonate B-horizon. Subsequent erosion of greater than 2 m by minor tributary streams has resulted in only fragmentary preserved isolates which cap a limited number of Ardu B hillocks and vary from ca. 30 cm thick on the eastern edge of the region to more than 3 m in the northwest. Eroded Ardu C surfaces contain scattered MSA as well as rare Late Stone Age lithics.

The youngest sediments in the Ardu region include modern floodplain deposits of the Awash River and basaltic colluvia on Dulu Ali slopes. An array of sediments and smaller-scale landforms within the Ardu hills and ephemeral drainage lines include minor alluvial fills, micro-alluvial fills and slope washes as well as minor eolian deposits. Re-worked MSA artifact scatters, rootdrip and mollusk and vertebrate fossils derived from Ardu B sediment are common.

DATING

Table 2 presents the complete set of chemical and physical analyses conducted to provide relative and absolute chronological information. Five techniques– argon/argon, uranium series, luminescent, shell (Unio sp.) radiocarbon and shell (Unio sp.) amino acid racemization– were applied to materials obtained from the Ardu sequence. Radiocarbon and racemization determinations on ostrich egg shell from a basal pit at A4 were discounted and are not included in this analysis because of uncertainty about stratigraphic integrity. Results are presented in Table 2. While they contain reversals and inconsistencies, they do suggest several patterns and tentative conclusions.

1. Based on six tightly clustered argon/argon dates from feldspar crystals extracted from pumice collected from a horizon below the sand and gravel layer at site A8, the overlying Ardu B sediments are younger than 180 KA. This pumice, in the shapes of small spheroids, was transported into the lower Ardu B from primary beds as yet undiscovered. Thus, with the possible exception of site A1, none of the excavated Aduma materials date to the early stages of the MSA. The pumice is reworked and incorporated into slightly younger sediments.

2. A Woods Hole National Ocean Sciences AMS date of 10,500 radiocarbon years BP on Unio shell collected from lower Ardu C sediments at the culturally sterile site A-11 sets a minimum age for the entire lithic sequence.

3. The Ardu B sand/gravel and overlying silt layer were deposited very rapidly and probably represent a short time interval measured perhaps in hundreds of years rather than tens of millennia. Lack of paleosol development within the Ardu B supports this conclusion. While racemization ratios do not yield absolute ages per se, they do provide relative age information. The Table 2 ratios are based on multiple determinations from different shells within each multi-shell sample.

TABLE 2: DATED ADUMA SAMPLES.

	AR/AR	U SERIES	LUMINESCENT	UNIO SP	RADIOCARBON
Ardu C				D-alloisolucine/ L-isoleucine ratio (mean multiple determinations) 0.562 (+-2.8%)	10,5000 (+-65)
Ardu B-C Contact		100 (+-5)			
Silt Ardu B		84 (1)	41.9 (+-3.3)	1.11 (2.6%)	
		84 (2)	(OSL & TL)	1.076 (2.8%)	
		85 (3)		1.149 (1.5%)	
		88 (3)	91 (5)	1.18 (2.7%)	
		89 (2)	(OSL multi grain)		
		96 (6)			
		102 (2)	93 (16)		
		105 (14)	(OSL single grain)		
Sand/Gravel Ardu B		79 (1)	51 (2.7)	1.045 (2.4%)	
			(OSL & TL)	1.068 (.9%)	
			92 (15)		
			(OSL multi grain)		
			93 (10)		
			(OSL single grain)		
A4 Basal				1.11 (6.2)	
A1 Gravel			39.1 (4.8) ISRL		
			75.9 (10.3) OSL		
			76.0 (10.)		
			OSL single grain		
Pumice	180 (6 samples)				

Within both the Ardu B sand/gravel and the Ardu B silt the variance in ratio is less than the analytic error which suggests rapid deposition for each unit. There is, however, significant difference in mean ratio between the sand/gravel and the silt – a reversal with greater racemization and an implied greater age in the overlying silt specimens. A similar reversal is reflected in the uranium series dates. While a more detailed discussion of the luminescence analysis is presented below, greatest technical reliability may be placed on the 92 K and 93 K ages for the sand/gravel and the 91 K and 93 K ages for the silt. These also imply that the two units were deposited quickly. It is also noteworthy that the Ardu B, as discussed in the site A-5 description below, is capped by two separate generations of carbonate soil formation. This observation suggests that the Ardu B is of earlier Upper Pleistocene age.

4. Unfortunately, the age of the eroded surface of the weakly developed paleosol that caps the Ardu B and contains a dense concentration of MSA lithics and fauna at site A-5, is unknown. Only a single U

series date is available and because it exceeds in age most of the underlying U series counterparts and all luminescent dates, it is highly suspect. Geological evidence– paleosol formation and subsequent partial erosion– indicates a time interval between A-5 and the underlying silt sites which significantly exceeds that between the silt and sand/gravel counterparts units within the Ardu B.

5. If significant reliance is placed on the absolute dates presented in Table 2, the most likely age of the sand/gravel and silt assemblages is between 80 K and 100 K years. Uranium series analyses were made on fossilized mammal and crocodile teeth, fossilized mammal bone and fossilized Clarias ("catfish") bone. Though uranium concentrations were high for all these materials, only the catfish bone samples were low enough in common thorium to permit precise dates to be calculated. To the extent that the U-Th system has remained closed since fossilization, the Ardu B uranium-series dates of 79 to 105 Kyr are lower limits since they reflect not the bone age, but rather the initiation of the fossilization process. It should be noted, however, that bone has a decidedly mixed track record in regard to closure (van der Plicht et al., 1989; Rae and Hedges, 1989; Millard and Hedges, 1966; Pike et al., 2000). The very high common thorium contents of most of the Ardu fossilized bones, however, are extremely unusual and suggest caution in applying lessons learned from uranium-series studies on more geochemically-normal bones.

The widely varying luminescence dates for individual units (Table 2) reflect analyses over a several year period during which developments in method were better able to deal with the problem of signal saturation in these samples. Coarse-grained quartz, which is known to saturate at a relatively early age, was used for dating because coarse-grained feldspar, at least from one of the samples, produced no signal. The initial work for the two samples from Ardu B (from the silts and from the sand/gravel) employed both multi-aliquot thermoluminescence (TL) analysis and early single aliquot optically stimulated luminescence (OSL) procedures (Duller, 1995). Both have difficulties with samples near saturation and the TL analysis has the additional problem of estimating an unbleached residual. Both techniques appeared to underestimate the age of the samples. Later single aliquot methods employed the improved SAR procedure (Murray and Wintle, 2000) and used both multi-grain aliquots and single grains. Of 26 multi-grain single aliquots, only six, three from each sample produced usable results. In most of the others the regeneration points began to saturate at an intensity well below that of the natural signal, a phenomenon often seen in samples close to saturation. Single-grain analysis is recommended in this case because the "bad" saturated grains can be separated out and only good grains accepted for dating (Yoshida et al., 2000). Out of 1000 grains for each sample, only six (four from one sample and two from another) produced datable signals. The data are scant, but the single-grain and the multi-grain single aliquot analyses are in agreement and for both samples produced ages in agreement with the U series dates (80–100K). Coarse-grain material for the A1 sample was scarce and so dating was based on infrared stimulated luminescence (IRSL) of fine-grains and limited OSL of quartz. The IRSL signal suffered from severe anomalous fading and the OSL used the older single-aliquot procedure. Neither result is considered reliable.

DATING

6. Recognizing the potential problems with uranium series dating on fossilized bone and the multiple factors which can affect luminescent dates, it is safest to set interpretation within a less precise, but still highly useful archaeological context. Such an approach is perhaps particularly appropriate since the absolute age determinations on most other MSA sites are also subject to these same factors. It seems reasonable therefore to conclude that the Aduma materials, perhaps with the exception of site A-1: date to the latter rather than earlier part of the MSA; that they probably precede the appearance of the Late Stone Age (LSA) in East Africa, which itself is poorly dated, and that likely they are older than the South African Howiesons Poort which is estimated at 60-70 ka. (McBrearty & Brooks, 2000: 501).

Four archaeologically significant landscapes can be identified in the Aduma sequence consisting from lowest to uppermost: the poorly exposed basal Ardu B; the sand/gravel unit within lower Ardu B; the overlying Ardu B silts; and an eroded soil surface at the Ardu B/Ardu C interface. They contain one, two, four, and one archaeological sites respectively and this four part subdivision provides a useful framework for environmental reconstruction. Relevant data derive from geological (Helgren, Jean de Heinzelin, Garniss Curtis) faunal (Tappen, Stewart), mollusk (Brooks), phytolith (Barboni, 1999) and isotopic (Ambrose, 1997) analyses. Lack of appropriate carbonate material and preserved pollen unfortunately prevented uniform application of all these techniques across all units. For each site, identifiable vertebrate taxa are presented in Table 3. These taxa provide important paleoenvironmental insight, but taxon representation must be interpreted with care because of the multiple factors which can affect representation at an individual site. In particular, post-depositional diagenetic processes have hindered identification of the majority of mammalian bone fragments. Many of these post-depositional taphonomic processes do not necessarily indicate transport, but rather in situ partial destruction of the fauna. In particular, calcrete infiltrating into teeth has split many apart in situ, so that for Bovidae, often the exterior enamel walls have been removed and only the central cavities are found. Likewise calcrete, iron oxide rinds and matrix concentration adhering to surfaces has reduced the number of specimens that can be identified.

From the perspective of a hominid forager several attributes of the paleolandscape and its change over time should be emphasized. First is the primarily aggredational nature of the geological processes involved. Widespread surface gravels which potentially provided a variety of raw materials for lithic production and which were available on the basal B land surface became progressively buried over time. While likely available during the occupation of two sand/gravel sites, they were inaccessible during later periods. Secondly an active river was nearby during all time intervals represented by archaeological assemblages. Third, throughout this period a floodplain broad enough to support an ecologically dependent fauna existed. Finally, for at least the latter part of this interval, a signal from a non-flood plain environment is also present. Each of the individual units is described below.

1. Basal Ardu B: Because this unit is poorly exposed, data derive from a single site. Fauna which include hippopotamus, crocodile and multiple fish species indicate an adjacent river with a broad enough floodplain to sustain reedbuck.

2. Ardu B (sand/gravel): Crocodile, hippopotamus, mollusks, and fish indicate a proximate river presence which strongly imprints the faunal assemblage which was recovered from two sites. Mollusks, including unbroken Melanoides sp. occur and given the presence of this small univalve it is unlikely they were collected by hominids as food. Clarias, a large slow moving catfish constitutes 80–90% of the total fauna. This suggests a floodplain environment with relatively little topographic relief, subject to intermittent flooding due to change either in water level or water course. With the exception of bushbuck which is a mixed feeder, all antelopes are water dependent grazers. Several require cover and thus dense vegetation either within or outside the floodplain was also present.

3. Ardu B (silt): Fauna from four sites incorporated within the silt exhibit a riverine character and the same range of river inhabitants present in the sand/gravel; remains of either an anhingua or comorant, both water birds, are also occur. Reedbuck indicate a floodplain while waterbuck remains suggest the presence of either included or fringing woodland or thickets. With the exception of bushbuck all the antelopes are water dependent grazers and thus mirror the Ardu B sand/gravel pattern. With the exception of raw material availability the Ardu B gravel and silt landscapes are highly similar. A single sediment sample collected by Bonfille (MA94–097) and reported in Barboni (1999) closely match a modern sample collected in a minor, ephemeral streamway on the rift floor plains about 10 km to the northwest. The modern site is grassy and nearly tree- and bush-free. The phytoliths including more abundant C3 phytolith types, suggest a climate significantly cooler than today. Given the dates discussed above, it is tempting to correlate Ardu B sedimentation with a period of meso-glaciation sometime following the last global interglacial.

4. Ardu B/C interface: The majority of data relevant to environmental reconstruction derive from a single site and immediately surrounding area. Although this interface shares a number of characteristics with the Ardu B sites, in several features which indicate a drier environment, it is distinct. In common with the Ardu B counterparts, Clarias dominates the faunal assemblage and the two other riverine species, hippopotamus and crocodile also occur. Reduncine antelopes indi-

TABLE 3: IDENTIFIABLE FAUNA FROM ADUMA SITES.

		SITE							STRATIGRAPHIC CONTEXT			
		A1	A8	A8A	A4	A8B	A2 VP 1/1	A5	A1	Ardu B sand/gravel sites	Ardu B silt sites	Ardu B/C Contact (A5)
Direct riverine association												
MAMMAL												
Hippopotamus amphibius	hippotamus	23 (+7)	5 (+14)	90 (+57)	6 (+19)	x	18 (+6)	62 (+55)	x	x	x	x
REPTILE												
Crocodylus niloticus	crocodile	6	2	14	10		113	9	x	x	x	x
FISH												
Clarias (as % of fish bone)	catfish	65%	100%	100%	100%		90%	100%	x	x	x	x
other catfish	catfish	5%							x			
Barbus		25%					10%		x		x	
Cichlid	minnow	5%							x			
Fish (% total fauna)		3.5–5%	80–90%	90%	85–90%		90%	90%				
BIRD												
Anhinga sp.or Phalacrocorax sp.	anhinga or commorant						1				x	
MOLLUSC												
Achatina sp.	bivalve mollusc		x	x	x		x			x	x	
Melanoides sp.	univalve mollusc		x	?	x		x			x	x	
Unio sp.	bivalve mollusc		x	x	x		x			x	x	
Obligate/Preferential Floodplain												
Redunca cf. redunca	Bohor reedbuck	1	1				2	1	x	x	x	
Redunca sp.	reedbuck			1						x		x
Syncerus caffer	African buffalo				1						x	
Grazer, Water Dependent												
cf. Damaliscus	topi, blesbok							1				x
Cf. Hippotragini	roan, sable	1						4	x			x
Kobus ellipysiprymnus	waterbuck			7			5			x	x	
Neotragini cf. Ourebia	oribi		1							x		

TABLE 3: IDENTIFIABLE FAUNA FROM ADUMA SITES (CONTINUED).

		SITE							STRATIGRAPHIC CONTEXT			
		A1	A8	A8A	A4	A8B	A2 VP 1/1	A5	A1	Ardu B sand/gravel sites	Ardu B silt sites	Ardu B/C Contact (A5)
Grazer, Minimal Water Dependence												
cf. Oryx	oryx							2				x
Savanna to Woodland Not Known to Live in Forest												
Alcelaphini gen et sp.indt.				1			1	2		x	x	x
Crocuta crocuta	spotted hyaena	1							x			
Otomys cf. typus	grooved tooth rat							1				x
Phacochoerus aethiopicus	common warthog		4	5 (+5)	2		4	2		x	x	x
Tatera sp.	gerbil				1						x	
Less Useful Habitat Indicators												
Genetta sp.	genet						1				x	
Homo sapiens	hominid						1				x	
Proboscidea	elephant	1							x			
Rodent indet.	rodent				2		6				x	
Thyromys gregorianus	lesser canerat						1				x	
Tragelaphus scriptus	bushbuck			1			1			x	x	
Bovini		1		1					x	x		
Other												
Bovidae class 2				1			6				x	
Bovidae class 2/3								1				x
Bovidae class 3				2			13	5		x	x	
Bovidae indet.		(1)	(5)	1 (+20)	(4)		(7)	25 (+48)	x			
Bovidae, large				2				1				x

(x = present; numbers = NISP, number of identified specimens, numbers in parentheses are in addition and are small enamel fragments)

cate the presence of an adjacent floodplain. However the absence of mollusks and the undulating interface surface indicates a landscape with higher relief, possibly beyond the range of seasonal flooding. The presence of oryx, a water independent species, suggests a scarcity of standing water beyond the floodplain margin. Organic carbonates from the basal Ardu C immediately overlying the Ardu B/C interface were collected by Ambrose (1997). (Limited time unfortunately precluded extensive carbonate collection throughout the Aduma region and thus samples at a single site only were collected.) The carbonates yielded values which range from -13.6 %o to -12.6%o, reflecting 80-85% C4 plants, and thus an open grassland. Details of the isotopic analysis are presented in Appendix A. Phytoliths recovered from the lower Ardu C at a site ca. 2 km distant (Barboni et al., 1999; sample MA94–098) suggests a landscape more grassy than today with fewer trees and thus supports the isotope data. The phytoliths also suggest a climate significantly cooler than control samples from modern settings and may signal a period of global glaciation. While the faunal material are deposited directly on the eroded Ardu B surface and therefore permit contemporaneous ecological reconstruction, it is less clear how the isotopic and phytolithic data which derive from the immediately overlying Ardu C relate to this horizon.

HOMINID BEHAVIORAL RECONSTRUCTION

Numerous Aduma locales contain dense lithic accumulations in primary context. In most instances these concentrations occur in vertically thin horizons within rapidly aggrading geological contexts, thus implying that the time intervals sampled are tightly constrained. In contrast to associated faunal remains which occur in numbers too small to permit meaningful behavioral reconstructions, lithics provide samples large enough to permit statistical analysis and– at least potentially– yield insight into hominid behaviors and how these changed over time. This goal structured field strategy and in the remainder of this article lithic data is analyzed to elucidate patterns of behavior significant in both the local Aduma and the geographically broader East African context.

Over the course of six field seasons excavations were conducted at six Ardu sites. At an additional two sites, A8B and VP 1/3 surface collections were made. These were chosen to provide a series of in situ assemblages which sampled all strata and provided the greatest potential to examine chronological change. Selection was based on stratigraphic position, low probability of mixing, density of faunal and lithic material, ease of excavation and, in two instances, presence of hominid remains. The sites therefore do not represent a random sample. To preserve the integrity of the Ardu Beds for future research only minimal surface materials were collected. Unless otherwise noted all excavated sediments were dry sieved through 3 mm screen. Table 4 provides site summary information. A more detailed discussion of each site is presented in Appendix B.

Because the hominid signal that Aduma data reveals is mediated, potentially

TABLE 4: ADUMA ARCHAEOLOGICAL SITE SUMMARY.

SITE DESIGNATION	STRATIGRAPHIC ASSOCIATION	LATERAL EXTENT DETERMINANTS	COLLECTION METHOD	SITE TYPE (1)	NOTES
A1	Basal Ardu B	extent unknown; significant sediment overburden	surface collection+ sieving (2)		likely mixed
A4	Ardu B silt	edges defined by erosion	surface collection+ sieving	short term occupation	single arch. Horizon
A5	Ardu B/C contact	edges defined by erosion	sieving	multipurpose	single arch. Horizon
A8	Ardu B sand/gravel	extent unknown; significant sediment overburden	all sediment sieved		single arch. Horizon
A8A	Ardu B sand/gravel	edges defined by erosion	surface collection+ sieving	multipurpose	3 arch. Horizons
A8B	Ardu B silt	edges defined by artifact density/absence	surface collection only	hippo butchery	single arch. Horizon
VP 1/1	Ardu B silt	edges defined by collection area size	sieving	short term occupation	single arch. Horizon
VP 1/3	Ardu B silt	edges defined by collection area size	surface collection only	short term occupation	single arch. Horizon

1. See text for discussion of site types and basis for type determination.
2. This designation indicates that within some areas of site materials were surface collected while in others collection included either excavation sieving or scraping and sieving of surface sediment.

biased and obscured by taphonomic factors as well as excavation and analytic decisions, the constraining effects of these latter must be considered before a behavioral reconstruction is attempted. The most significant are enumerated below:

1. In only one instance– the probable hippo butchery at A8B– could the natural boundaries of a site be established. At A4, A8A and A5 erosion determines the limits of artifact and faunal distribution. At sites A1 and A8 the relevant horizon, of unknown extent, was covered by substantial overburden and only a very limited area was excavated. VP1/1 and VP 1/3 consist of arbitrarily defined units situated within a broader surface lithic scatter. Hominid remains at the center of each resulted in site designations and collection of associated materials.

2. Practical constraints of time and resources limited the amount of excavation at each site. Sample sizes vary and this fact affects both the kinds of analyses that can be conducted and comparability across samples. Mammalian assemblages, for example, are not large enough to permit comparison by body part. At most sites mammal bone surfaces were eroded, and on many specimens adhering matrix made detailed surface examination for cutmarks or carnivore damage difficult to impossible. While lithic samples are larger, cross-site variation often precludes confident ascription of rare type absence to cultural cause.

3. Multiple factors are likely responsible for accumulation of faunal and lithic material within sites. Many sites have complex taphonomic histories, which suggest that both the accumulation and later alteration of material occurred in more than one stage. At several sites mammal bone is rounded and eroded while small delicate unworn fish bones are also present. Likewise bivalves both closed and attached at the hinge co-occur with abraded fauna. The presence of well-defined lithic artifacts at all sites conclusively indicates hominid input. Similarly, cutmarked bone at A8A implicates humans as at least one factor in faunal accumulation. However this is the only site at which cutmarked bone is definitely present. The role of carnivores as accumulating (and altering) agents is less clear. Only three bones in total (from sites A8 and A8A) show carnivore puncture or gnaw marks although adhering matrix and altered bone surface significantly limits observation. The pattern of mammalian longbone fragmentation is typical of carnivores. Evidence for digested mammal bone surface alteration is lacking although Stewart believes a limited number of fish bones may reflect digestive processing. In many instances it is not possible to identify the specific agent of death. Clarias, for example, which constitute the majority of fauna at all sites except A1, are a shallow water fish which are highly vulnerable to human predation (Stewart, 1994). However, they are also susceptible to asphyxiation when trapped in drying floodwater pools.

4. Finally, several post-depositional factors affect assemblage composition. At all sites fauna and lithics were exposed for unknown and likely variable times on the surface before burial, were further affected by both alluvial and colluvial burial processes, and at some sites were possibly further altered by subsequent re-exposure. Cross site comparison, for example, demonstrates a statistically significant correlation between frequency of lithic breakage and estimated degree of taphonomic disturbance. Although many factors affect average lithic maximum length, multiple analyses show that all sand/gravel sites were subjected to strong alluvial current and winnowing almost certainly occurred. Lithics in sand/gravel sites are longer than their silt and A5 counterparts and fish faunal remains display a similar pattern. Varying degrees of carbonate infiltration and expansion contributes to varied faunal preservation and many teeth are shattered into unidentifiable fragments as the result of such action. Finally, it is highly likely that hominids themselves differentially removed lithics from sites. In the three silt sites, for example, obsidian is well represented in the debitage and worked tool components. However, while cores of other raw materials are present, their obsidian counterparts are entirely absent.

In sum, these four factors both constrain and suggest potential avenues for analysis. It is clear that the Aduma sites, together with most of their African open air Paleolithic counterparts, bear a strong taphonomic overprint which significantly obscures behavioral signals and limits the types of analysis which may be usefully employed. On active floodplains, geological processes involved in site burial in particular pose major problems. Examination of spatial distribution of materials within sites, for example, probably makes little sense. On the positive side, major stratigraphic relationships among the sites are clear and each assemblage, again with the likely exception of A1, accumulated over a limited time period. In the four silt sites, and possibly A8 as well, material in each rests on a single clearly defined surface within a rapidly aggrading environment and may in fact sample a time interval more nearly measured in weeks rather than years. The lithics likely reflect activities that occurred at that place.

A major and unfortunately irresolvable question concerns the relationship between lithic and faunal remains and the extent to which human agency is involved in the latter's accumulation. The only unquestionable cut marks occur on crocodile and hippopotamus bone from site A8A. However the highly fragmented and abraded nature of much of the Aduma bone and the extensive concretion on many bone surfaces leaves an insufficient sample for an adequate cutmark evaluation. While numerous lithic points at all Aduma sites attest to hunting and the association of points, and cutmarked bones at numerous MSA sites demonstrate hominid hunting ability during this interval, it is not possible to use Aduma fauna with confidence to reconstruct subsistence patterns. It is striking, however, that a marked similarity in faunal composition with a predominance of Clarias exists across almost all Aduma assemblages (again with the exception of A1) and that this pattern holds regardless of site specific geomorphology. The geological context of A5, for example, is quite distinct from its Ardu B counterparts and it does not occupy a similar river margin position. It is tempting therefore in the search for responsible agency to invoke human behavior and to extend the speculation to other species. However “speculation” it must remain.

On a positive note, it is important to emphasize that there is some taphonomic evidence that the sites do record in situ hominid behavior. For example, at several there are many microflakes of obsidian and basalt, which indicate flint knapping occurred at those places. It is also interesting to note that at A1, VP 1/1, VP 1/3, A4, A8, and A8A, red clasts of hard sediment were recovered. These clasts may represent burnt ground and thus fire. However, chemical and micromorphological confirmation is required.

LITHIC TYPOLOGY

No standard generally accepted lithic typology exists the MSA either across sub-Saharan Africa or within the more limited Horn of Africa region. The multiple typologies employed to categorize the most geographically relevant assemblages (Perles, 1974; Wendorf & Schild, 1974; Clark, et al., 1984) do not provide a consistent, adequate framework for analysis of the Aduma material. While partially referable to idiosyncratic behavior and imperfect sharing of knowledge, this lack of standardization also reflects an underlying reality: the range of assemblages subsumed under the broad label "Middle Stone Age" in fact exhibit a wide range of variation, which is not surprising given the broad time span of over 200,000 years and geographic range involved. Both regional and chronological variation is evident within this broadly defined industry. Given Aduma's location adjacent to both the Sahara and Middle East, an ideal typology would also allow comparison with Middle Paleolithic industries in both regions. Yet Saharan typologies (e.g. Wendorf & Schild, 1992) that are derived from Francois Borde's Middle Paleolithic system do not capture the significant distinctions evident in the Aduma material. In all Aduma sites medium and large size scrapers are ad hoc and can not be divided into the discrete sub groups which constitute an important focus within the Bordian Mousterian typology. The multiple small scraper types which constitute a significant and distinctive part of the Aduma assemblage are undescribed elsewhere in the MSA. Likewise, variation in Aduma point types can not be encompassed within MSA typologies that are based primarily on distinctions between unifacial and bifacial retouch. The Aduma typology employed in this analysis utilizes, to the maximum extent possible, widely accepted types such as "Levallois" or "Nubian" cores; however, it also defines a series of artifact types that are based on the characteristics of the assemblage itself. Obviously any such typology entails a tradeoff that balances sensitive comparison among assemblages under immediate consideration against comparability over a broader geographic and chronological range. The Aduma typology is probably weighted towards the former.

The degree of concordance between artisans' and archaeologists' concepts of typological reality may be judged at least in part by within type attribute variability and covariance. In contrast to more general scraper types such as "end" or "side" scrapers, or to "retouched flakes" or "blades"– all of which show great internal variability and lack of standardization– Aduma types most likely meaningful to the analyst alone - other categories such as individual point types, perforators and a series of small specialized scraper types exhibit highly regularized shapes, vary minimally in size and are made primarily or exclusively on single types of raw materials. For most of these latter types the tight association is maintained across layers– a pattern which argues strongly for congruence between typologists' and artisans' realities. At Aduma, taphonomic analysis can also provide typological guidance. Rating sedimentary context on the basis of depositional energy and length of surface exposure allows creation of a potential damage index based on the assumption that lithics, for example, which were contained within fine particle size Ardu B silts, rapidly buried, and subsequently exposed through excavation were subjected to relatively little post discard damage compared to counterparts which were collected from exposed higher energy gravel surfaces. On this basis a "potential damage index" was constructed for individual assemblages at each site. Correlation analysis, which demonstrates a statistically significant positive relationship between this index and percent of broken lithics within an assemblage, lends credence to such an approach and also provides a framework to determine whether "types" defined on the basis of edge removals result, in fact from purposeful human activity. Not surprisingly when assemblages are compared, no correlation exists between damage index and frequency of points or cores, an expected conclusion since it is extremely unlikely that such forms result from taphonomic action. The strength of the relationship between minimally retouched pieces, originally placed in several different classes of miscellaneous retouched types, and both damage index and percentage of broken pieces led to their elimination as valid typological categories. By this same standard, "retouched flakes and blades as well as denticulate and notched pieces passed muster and were retained.

Based on the assumption that degree of standardization reflects not only tool type reality but also relative significance to the artisan, point, perforator and small specialized scrapers must have played a central role in the Aduma lithic system and provide its strongest defining attributes. Additional data support this conclusion. Obsidian, which in most assemblages is treated as a scarce high quality raw material is preferentially employed in the manufacture of these types, and its within-type frequency varies relatively little across layers. For example, regardless of site and relative scarcity, an artisan almost always (97% of the time) selected obsidian when manufacturing a small specialized scraper. In contrast only a maximum of 52% of generalized scrapers are produced on obsidian and the frequency of obsidian generalized scrapers vs. generalized scrapers of other raw material varies across assemblages from 0% to 52%. General scrapers and retouched flakes and blades that were fashioned from obsidian are relatively more often broken, reflecting either more use generated strain or, more likely, initial manufacture on broken blanks. However possible greater susceptibility to post-discard fragmentation due to trampling or post burial fragmentation due to sediment profile autocompaction or bioturbation cannot be excluded.

The Aduma analytic system distinguishes among cores, retouched pieces, ground stone types and unretouched lithics. Within this latter category additional distinctions are made, but space limitations place them beyond the scope of this present summary article. Likewise discussion of attribute analyses of cores and other retouched types is also deferred to more specialized publications. Maximum length and raw material type was recorded for all pieces. Because of practical constraints lithics were not exported for detailed mineralogical analysis and the ultimate paleoanthropological value of such a study is constrained by the fact that most raw material sources are currently unknown. Of the five analytic categories employed in the Aduma analysis, “chert”, “obsidian” and “quartz” are tightly defined. “Basalt” includes a wider and internally variable range of igneous materials and “Other” is a catch-all category which never exceeds 3% of an individual assemblage. Table 5 and Figs. 4–33 (Appendix C) present the 64 core, retouched and ground stone lithic types. For those which are well defined within Paleolithic archaeology, commonly accepted usages are employed and additional description is unnecessary. The remainder are more fully defined below.

Core, biface: Resemble Acheulean bifaces in the relatively complete peripheral flaking of both the upper and lower surface, a carefully pointed tip and generally convergent sides toward the tip. However differ from late Acheulean bifaces in the following ways: thick relative to length; the edges are not carefully retouched leaving a sinuous edge created by the removal of large flakes in both directions; the cross section is not evenly biconvex but closer to plano-convex or asymmetrical; the butt consists of a relatively abrupt-angle platform which has served as the striking platform for several flake removals. This “striking platform” may be plain or facetted.

Core, chopper: Flaked along two sides of an acute edge of a cobble or nodule, forming a chopping tool-like appearance. Less than half of the periphery is worked.

Core, micro Levallois: Levallois core less than 3 cm in diameter.

Core, Levallois blade: has blade removals from one or two opposed striking platforms across a flat face. Tend to be small and have plain striking platforms. The back surface is often thinned by transverse flake removals. (When removals begin to wrap around the side of the core these are classified as “Blade” or “Bladelet” cores.

Core, micro Levallois blade: Levallois blade cores less than 3 cm in diameter.

Core, Aduma: Levallois core whose lower surface consists of cortical surface and with minimal preparation of the striking platforms. They are very thin for their size. The “ideal” core is made on half of a horizontally split elliptical cobble with no or very few removals from other than on the upper face.

Core, micro-Aduma: Aduma core less than 3 cm in maximum length.

Point, biface: Large and thick; the general size and conformation of a small biface. However retouch is flatter and more invasive than on a normal biface; sides straight or very slightly convex.

Point, Mousterian: Formed by relatively non-invasive retouch on a Levallois or non-Levallois flake. Usually unifacial, the base is usually not thinned.

Point, classic MSA: A symmetrical point, generally shaped by flat invasive retouch; symmetrical both laterally and across dorsal face. Retouch may be bifacial or unifacial and the striking platform may be either thinned or left unretouched; many examples are bifacial with thinned butt; may grade into Mousterian point but in general are more invasively retouched, more symmetrical and more likely to have butt trimming. The sides are generally convex and more rarely straight. Most present an oval or elongated contour rather than the more triangular forms of Southern and Eastern Africa.

Point, short broad: Resemble Classic MSA points in their retouch pattern but are on shorter wider blank. They have either blunt or obtuse angles at the tip rather than the more acute angle of a clas-

TABLE 5: ADUMA ASSEMBLAGE TYPOLOGY.

CORES		
1	core, amorphous	(Fig.13, n. 1)
2	core, biface	(31.1, 32.1, 32.2, 33.1)
3	core, blade	(4.1, 8.1)
4	core, bladelet	(4.2)
5	core, chopper	(23)
6	core, discoidal	(8.2, 13.2, 14.2)
7	core, discoid partial	(8.3)
8	core, flat reversed	(21.1)
9	core, Levallois	(8.4, 14.1, 15.2, 19.1, 19.2)
10	core, micro Levallois	(4.3, 4.4, 4.5)
11	core, Levallois blade	(15.1, 16.1)
12	core, micro Levallois blade	
13	core, Levallois approach	(20)
14	core, Levallois attempt	
15	core, Aduma	(18.1, 18.2, 18.3)
16	core, micro Aduma	(4.6, 4.7, 5.1)
17	core, Nubian	(9.1, 16.2)
18	core, multidirectional	(9.2, 9.3)
19	core, single platform	(22)
20	core, attempt	
21	core, attempt blade	(16.3)
22	core, fragment	
POINTS		
23	point, biface	(28)
24	point, Mousterian	(25.1, 25.2, 26.1)
25	point, classic MSA	(11.1, 11.2, 11.3, 17.1, 26.2)
26	point, short broad	6.1, 6.2, 11.4, 11.5)
27	point, small blunt	(6.3)
28	point, blade	
29	point, acute tip	(6.4, 6.5, 6.6, 11.6)
30	point, misc.	
31	point, broken	
32	point, damaged	
33	point fragment type indeterminate	
OTHER POINTED PIECES		
34	perforator	(7.2, 11.8, 11.9)
35	perforator/borer	(7.3)
36	point/perforator	(7.4, 12.2, 17.3)
37	point/borer	(7.5, 12.3)
38	pointed blade	(27.1)
39	pointed piece	(27.2)
GENERAL SCRAPERS		
40	Scraper	
41	scraper, core	(10.1)
42	scraper, end	(10.2)
43	scraper, end+side	
45	scraper, side	(10.3, 17.4, 21.2)
46	scraper, double side	(21.3, 24.1)
50	scraper, transverse	
51	scraper-point	

TABLE 5: ADUMA ASSEMBLAGE TYPOLOGY (CONTINUED).

SPECIALIZED SCRAPERS		
44	scraper, mini	(5.2)
47	scraper, small convex	(5.3, 5.4, 5.5)
48	scraper, small non convex	
49	scraper, tabular quartz	(5.6)
RETOUCHED PIECES		
52	blade, retouched	(12.4, 12.5, 12.6)
53	bladelet, retouched	(7.6)
54	flake, retouched	(12.7, 24.10)
55	flake/blade, Levallois retouched	
NOTCHED AND DENTICULATE PIECES		
56	denticulate	
57	blade, denticulate	(17.5)
58	flake, denticulate	
59	notched flake	(10.4, 10.5)
OTHER RETOUCHED TYPES		
60	Ovate	(10.6, 17.6)
UNRETOUCHED TYPES		
61	pounding stone	(29)
62	Grindstone	(30)
63	grindstone?	
64	hammerstone	

sic MSA point.

Point, small blunt: Fashioned on small but not particularly thin flakes. They have a blunt tip and tend to be unifacial.

Point, blade: A blade with sides retouched to form a point at the distal end.

Point, acute tip: Made on flakes, most have a very acute angle at the tip; sides are straight. Although variable in size, they tend to be small.

Scraper, small convex: Characterized by small size, shape generally oval, size range 18–36 mm in maximum diameter. The retouched edge is moderately convex, symmetrical with dorsal (obverse) scalar even retouch to give a smooth continuous well defined edge, often terminating in an acute angle on one or both corners. The scraping edge is usually located parallel to or actually constitutes the maximum dimension of the piece.

Scraper, small non-convex: Conforms in general pattern to a small convex scraper but scraping edge is either straight or concave. Made to the same small convex scraper pattern with well delineated edge.

Scraper, mini: Similar to a small convex scraper but significantly smaller in size.

Scraper, tabular quartz: Manufactured on small squarish thick crystal quartz chunk. Exhibits a small convex edge shaped by fine even retouch. The retouch is limited to the lower part of the edge and does not extend far onto the dorsal face.

Scraper-point: Small scraper with a point as termination of one working edge.

Ovate: Oval in shape and fabricated on thin flakes; ovates may have either dorsal, ventral or bifacial retouch. Although striking platform may be present, they are normally retouched around entire circumference. In size and retouch pattern are similar to classic MSA points and share most of their attributes. Are clearly distinguished however by their very rounded proximal end.

LITHIC ANALYSIS

The Aduma lithic material consists of approximately 736 cores and retouched pieces and 15,479 pieces of debitage. Basic data are presented in Tables 6, 7, and 8. Analysis permits a general characterization of the industry, its definition as a distinctive regional variant within the MSA and recognition of time dependent trends. It both allows reconstruction of multiple situation-specific approaches to processing and discard that are conditioned by varying access to scarce valued raw materials, and also provides the basis for defining multiple site types. Two of the assemblages, A1 and the basal pit at A4, are given minimal consideration because of possible admixture and uncertain stratigraphic affinity. This yields a remainder of nine with secure stratigraphic association: four from the sand/gravel which initiates the Ardu B sequence (A8, A8A gravel, A8A sand gravel contact, A8A surface); four from the main overlying Ardu B silts (A8B, A4, VP 1/1, VP 1/3); and one from the surface of the eroded paleosol which caps the Ardu B sediments (A5). While a summary article precludes such detailed data presentation, multiple analyses of debitage were in fact conducted to examine relationships among piece size and raw material frequency across time. The same interactions were considered within typed material; frequencies and associations among types both individually and grouped by functional category were also analyzed. Detailed attribute information for points, cores, scrapers, and a representative debitage sample were collected.

Seven factors, all controllable to varying, degrees complicate inter-assemblage comparison and these are enumerated briefly:

Collection technique: In contrast to all other sites, VP 1/3 and A8B were surface collected and not screened. While controlled excavation was conducted at A5, unscreened surface materials were collected as well. While this difference precludes the inclusion of these three samples in cross assemblage comparisons of size attributes and typed piece/debitage ratios (since debitage has a smaller average maximum length) comparisons of typed pieces, likely because of their larger size and higher visibility, seem unaffected and thus are not excluded from cross assemblage analyses. Lack of significant difference between the A5 screened and unscreened typed samples supports this approach. At all screened sites, recovered piece minimum length was controlled by a screen mesh size of 3 mm.

Winnowing: Particle size of covering sediments correlates significantly with lithic assemblage maximum length characteristics, and winnowing can not be eliminated as a potential causative factor. The four assemblages contained within a larger particle matrix– A8, A8A-S (sur-

TABLE 6. ADUMA TYPED PIECES.

TYPE NUMBER	TYPE	SITE/ASSEMBLAGE										
		A1 in situ	A4 contact	A5 Excavated	A5 Excavated Surface	A8	A8A Surface	A8A Contact	A8A Gravel	A8B	VP 1/1	VP 1/3
Cores												
1	core, amorphous	0	0	0	7	0	0	0	0	0	0	0
2	core, biface	0	0	0	0	0	0	0	0	0	0	0
3	core, blade	1	0	0	6	0	0	0	0	0	0	0
4	core, bladelet	0	0	0	2	0	0	3	1	0	0	0
5	core, chopper	1	0	3	8	0	0	0	1	0	0	0
6	core, discoidal	2	0	1	4	0	0	0	0	0	1	1
7	core, discoid partial	2	0	0	5	0	1	0	0	0	0	1
8	core, flat reversed	1	0	0	2	0	1	1	0	1	0	0
9	core, Levallois	3	0	3	34	0	0	0	3	5	1	7
10	core, micro Levallois	0	0	3	11	1	0	0	2	0	0	0
11	core, Levallois blade	0	0	2	10	0	0	0	0	0	0	0
12	core, micro Levallois blade	0	0	0	2	0	0	0	0	0	0	0
13	core, Levallois approach	0	1	3	14	0	0	0	0	0	1	2
14	core, Levallois attempt	0	0	0	0	0	0	2	1	0	0	0
15	core, Aduma	0	0	0	9	0	0	1	1	0	0	0
16	core, micro Aduma	1	0	1	7	0	0	0	0	0	0	0
17	core, Nubian	0	0	0	3	0	0	0	0	0	1	0
18	core, multidirectional	0	0	4	9	1	1	1	1	1	1	2
19	core, single platform	0	0	1	2	0	0	0	0	0	0	1
20	core, attempt	4	0	1	11	0	0	0	1	0	2	3
21	core, attempt blade	2	0	0	0	0	0	0	0	0	0	0
22	core, fragment	1	0	2	8	0	0	0	5	0	0	4
Points												
23	point, biface	0	0	0	0	0	0	0	0	0	0	0
24	point, Mousterian	0	0	0	0	0	0	0	0	0	0	0

TABLE 6. ADUMA TYPED PIECES.

TYPE NUMBER	TYPE	SITE/ASSEMBLAGE										
		A1 in situ	A4 contact	A5 Excavated	A5 Excavated Surface	A8	A8A Surface	A8A Contact	A8A Gravel	A8B	VP 1/1	VP 1/3
25	point, classic MSA	3	3	0	4	0	2	4	4	0	1	2
26	point, short broad	0	6	0	3	1	7	4	4	1	0	0
27	point, small blunt	0	0	0	4	0	0	0	0	0	0	0
28	point, blade	0	0	0	1	0	1	0	0	0	0	1
29	point, acute tip	0	0	1	12	1	0	3	7	0	2	2
30	point, misc.	2	0	0	4	0	1	4	5	0	0	2
31	point, broken	1	0	0	0	1	0	0	0	0	0	0
32	point, damaged	0	0	0	0	0	0	1	0	0	0	0
33	point fragment type indeterminate	0	0	0	1	0	0	0	0	0	0	0
Other Pointed Pieces												
34	perforator	1	0	5	16	0	3	11	6	0	1	0
35	perforator/borer	0	0	0	0	1	1	0	3	0	0	0
36	point/perforator	1	0	0	9	0	5	4	4	0	0	0
37	point/borer	0	0	0	0	0	0	0	0	0	0	0
38	pointed blade	0	0	0	0	0	0	0	0	0	0	0
39	pointed piece	0	0	1	4	0	0	0	0	0	0	0
Scrapers												
40	scraper	0	0	1	5	0	3	5	1	0	2	0
41	scraper, core	0	0	0	0	0	1	1	0	0	0	0
42	scraper, end	0	0	0	2	0	1	2	2	0	0	0
43	scraper, end+side	0	0	0	1	0	0	0	1	0	1	0
44	scraper, mini	0	0	1	11	0	0	0	0	0	0	0
45	scraper, side	0	1	1	9	1	3	2	9	1	0	4
46	scraper, double side	1	0	0	2	0	2	1	2	1	0	0
47	scraper, small convex	0	0	0	0	1	6	8	10	0	0	2

TABLE 6. ADUMA TYPED PIECES.

TYPE NUMBER	TYPE	SITE/ASSEMBLAGE										
		A1 in situ	A4 contact	A5 Excavated	A5 Excavated Surface	A8	A8A Surface	A8A Contact	A8A Gravel	A8B	VP 1/1	VP 1/3
48	scraper, small non convex	0	0	0	0	0	1	1	2	0	0	0
49	scraper, tabular quartz	0	0	0	0	0	2	2	0	0	0	0
50	scraper, transverse	0	0	0	0	0	0	1	0	0	0	0
51	scraper-point	0	0	0	3	0	0	0	0	0	0	0
Retouched Pieces												
52	blade, retouched	1	0	5	12	0	5	9	15	0	2	7
53	bladelet, retouched	0	0	0	7	0	0	0	0	0	1	0
54	flake, retouched	1	1	0	7	0	3	6	18	1	2	8
55	flake/blade, Levallois retouched	0	0	0	0	0	0	3	1	0	0	0
Notched and Denticulate Pieces												
56	denticulate	0	1	0	0	1	2	0	0	0	0	0
57	blade, denticulate	0	0	0	0	0	2	1	0	0	0	0
58	flake, denticulate	0	0	0	0	0	2	3	2	0	2	0
59	notched flake	1	1	1	7	0	3	2	6	0	3	4
Other Retouched Types												
60	ovate	1	0	0	4	0	1	1	0	0	0	1
Unretouched Types												
61	pounding stone	0	0	0	1	0	0	0	0	0	0	0
62	grindstone	0	1	0	2	0	0	0	0	0	0	0
63	grindstone?	0	0	0	0	0	0	0	0	0	1	0
64	hammerstone	0	0	0	0	0	0	0	1	0	0	0

TABLE 7. ADUMA DEBITAGE

ASSEMBLAGE	# PIECES DEBITAGE
A1 (in situ)	681
A4 (contact)	784
A5 (excavated only)	1515
A8	569
A8A Surface	1855
A8A Contact	3092
A8A Gravel	5238
A8B	112
VP 1/1	380
VP 1/3	1253

face), A8A-C (sand-gravel contact) and A8A-G (gravel)– exhibit larger modal piece size, a higher percentage of pieces 3+ cm in maximum length and a very low percent of lithics in the 0–1cm category. The likely occurrence of winnowing and its variable affect across layers complicates examination of factors which influence size. This can be partially controlled either through comparisons of assemblages from similar sedimentary contexts or through within-assemblage comparisons between, for example, different raw materials from a single site.

Lack of raw material control: Accurate mineralogical identification of many raw materials necessitates chemical analysis and/or a fresh facet for visual examination, both rendered unpractical by local constraints. While three of five analytic categories– chert, quartz and obsidian– could be definitively discerned, "basalt" includes a variety of visually distinct igneous materials of different flaking quality and a final "other" category includes a wide range of materials. With the exception of some local basalts, raw material sources are unknown.

Differential retouch visibility: Retouch necessary for inclusion in an all but ground stone “typed” category is more readily discernable on fine grained obsidian and chert than on coarser grained basalts. This difference almost certainly resulted in error which is consistent across assemblages and, thus, does not preclude comparison among them.

Sample size effects: In sieved samples, assemblage sizes including both typed pieces and debitage vary by a factor of 13, from 404 pieces in VP1/1 to 5354 in the gravel level of A8A; this fact significantly affects typological composition because in small samples rarer types are less likely to be represented. Although not normally a concern in lithic analysis, sample size effects have received considerable attention by faunal analysts (Grayson, 1984). Plotting the relationship between the total number of pieces in an assemblage and the number of types present reveals a statistically significant relationship in which the number of types first increases rapidly with sample size, and then reaches a plateau when the sample is sufficiently large. Log-log regression yields an r2 of .831. This same relationship also holds when the number of types is plotted against the number of typed pieces. Assemblages that contain 2,000 total pieces (typed + debitage) or 60 typed pieces lie on the plateau and thus are not affected by sample size constraints. Only four of the Aduma assemblages, A8A sur-

TABLE 8: ADUMA LITHICS: RAW MATERIAL AND MAXIMUM LENGTH DATA.

SITE	LOCATION/ STRATIGRAPHY	RAW MATERIAL	MAXIMUM LENGTH												
			0–1 cm	*1–2 cm*	*2–3 cm*	*3–4 cm*	*4–5 cm*	*5–6 cm*	*6–7 cm*	*7–8 cm*	*8–9 cm*	*9-10 cm*	*10–11 cm*	*11–12 cm*	*12–13 cm*
A1	Area D	basalt	18	112	152	88	53	16	12	9	0	1	0	2	
	(= all excavated pieces)	chert	1	26	49	14	4	0	0	0	0	0	0	0	
		obsidian	4	23	19	16	7	3	5	2	0	0	0	0	
		other	0	23	22	10	10	4	1	2	0	0	0	0	
		quartz	0	1	1	0	0	0	0	0	0	0			
A4	Contact surface	basalt	42	168	68	23	13	7	6	3	4	2	1	1	
		chert	0	24	8	11	2	0	5	1	0	0	0	0	
		obsidian	105	244	35	9	0	2	0	0	0	0	0	0	
		other	0	3	4	3	4	1	0	0	0	0	0	0	
		quartz	0	0	0	0	0	0	0	0	0	0	0	0	
A5	All excavated pieces	basalt	385	493	174	82	66	36	15	6	3	4	3		
		chert	8	17	7	5	2	0	0	0	0	0	0		
		obsidian	89	88	32	9	0	1	0	1	0	0	0		
		other	4	16	11	1	2	1	0	0	0	0	0		
		quartz	0	0	0	1	0	0	0	0	0	0	0		
A8	All excavated pieces	basalt	7	101	108	25	9	7	4	1					
		chert	2	67	67	44	13	3	3	0					
		obsidian	0	5	18	8	4	4	1	0					
		other	0	4	10	4	2	0	0	0					
		quartz	0	6	35	12	3	1	0	0					
A8A	All surface material	basalt	1	199	888	414	120	28	4	4	1				
		chert	0	6	24	24	13	6	0	1	0				
		obsidian	0	18	42	55	14	3	0	0	0				
		other	0	0	3	9	7	0	0	0	0				
		quartz	0	2	15	9	4	1	0	0	0				

TABLE 8: ADUMA LITHICS: RAW MATERIAL AND MAXIMUM LENGTH DATA. (CONTINUED)

SITE	LOCATION/ STRATIGRAPHY	RAW MATERIAL	MAXIMUM LENGTH														
			0–1 cm	1–2 cm	2–3 cm	3–4 cm	4–5 cm	5–6 cm	6–7 cm	7–8 cm	8–9 cm	9-10 cm	10–11 cm	11–12 cm	12–13 cm	13–14 cm	14–15 cm
A8A	Contact	basalt	2	560	1367	586	158	43	6	2	0						
	(all excavated pieces)	chert	0	17	53	35	26	3	1	2	1						
		obsidian	1	39	88	71	26	3	4	1	0						
		other	0	2	7	12	7	0	0	0	0						
		quartz	0	5	28	17	1	1	0	0	0						
A8A	Gravel	basalt	1	1152	2316	814	244	46	13	4	0						
	(all excavated pieces)	chert	0	48	111	84	27	6	1	0	0						
		obsidian	3	79	141	97	37	12	4	2	0						
		other	0	18	28	17	8	3	2	0	1	1					
		quartz	0	8	17	6	2	1	0	0	0						
A8B	surface; hippo associated	basalt	0	1	11	18	21	17	21	12	11	6		0	3	0	2
VP 1/1	All pieces	basalt	4	71	36	14	16	9	3	4	4	1	1				
		chert	0	17	10	9	1	0	0	0	0	0	0				
		obsidian	19	77	78	22	4	0	0	1	0	0	0				
		other	0	0	1	0	0	0	0	0	0	0	0				
		quartz	0	2	0	0	0	0	0	0	0	0	0				

Numbers include both debitage and typed pieces.

See Appendix B for site-specific information.

face (A8A-S), A8A sand gravel contact (A8A-C), A8A gravel (A8A-G) and the combined A5 surface + excavated (A5-total) meet these criteria. The situation becomes more complicated when raw material type is taken into account. Because of their relative scarcity in all assemblages, at no site are "chert" or "other" typed pieces abundant enough to escape sample size constraints and this precludes a cross assemblage comparison of types made on these raw materials. For both "basalt" and obsidian, five assemblages contain sufficiently large samples to permit meaningful study.

Analysis of residuals provides a partial way around this problem. Considering only typed pieces, one may pool all Aduma assemblages, calculate the percent of each type and use these results to define a predicted value for each type within each assemblage. If, for example within the pooled assemblage Levallois cores totaled 10% and in reality no behavioral factors differentially influenced the composition of individual assemblages, then in an assemblage of 150 pieces, one would expect ca. 15 Levallois cores. If one then plots predicted against actual numbers– a graph in which each point represents one type from a single site– one can determine which cases lie sufficiently far from the regression line to reflect something other than the influence of sample size. Thus, if within a large assemblage a generally common type is almost completely lacking or within a small assemblage a relatively rare type is abundant, these outliers most likely convey behaviorally significant information. The linear regression between predicted and actual numbers is quite high, r2 = 62.5%; thus more than half the inter-assemblage difference in type presence/absence and frequency can be explained through recourse to sample size. A normal probability plot of residuals allows the tails to be isolated and emphasis is placed on these outliers in the following lithic conclusions.

Multi-behavioral causation: Inter-assemblage lithic variability at Aduma may be explained through reference to multiple aspects of hominid behavior, the effects of which can be difficult to disentangle. Because individual assemblages can be grouped by stratigraphic unit and placed in chronological sequence typological differences that correlate with stratigraphic order (especially if directional over time) are assumed to be caused by time dependent processes. Lithic assemblages also reflect site function. Thus, for example, the assemblage from A8B, a short term, probable, butchery site, contains fewer lithic types than it's A8A counterpart which, based on the density of remains and diversity in both fauna and lithic raw materials, was occupied for a longer period. Finally striking differences in raw material utilization are reflected across layers. Analyses of core frequency, debitage to typed piece ratios and debitage size indicate that availability of different raw materials varied across layers, that relative value also changed and that hominids adapted their manufacturing and utilization habits accordingly. This is reflected, for example, in degrees of reworking and changes in what was carried into and away from individual sites. Thus chronology, site function and raw material utilization are treated separately in sections below.

The Aduma lithic assemblages demonstrate that:

1. The entire Aduma sequence may be typologically encompassed within the Middle Stone Age. The Aduma assemblages are primarily flake-based and lack hand axes and cleavers as well as crescents or other backed microlithic types indicative of Early Stone Age or Late Stone Age affinity respectively. Levallois cores, while also present in the later Early Stone Age constitute a hallmark of the East African MSA and 22% of the 237 Aduma cores fall within this category. An additional 30% such as Levallois blade and micro-Levallois cores utilize a Levallois flake removal approach and taken together Levellois and Levallois-like pieces constitute a majority of the core assemblage. Nubian cores, a Levallois variant present in other Ethiopian MSA assemblages and most common in southern Egypt and the northern Sudan represent 1.6% (N = 4) of the core assemblage. Likewise discoidal and partial discoid cores, another marker of the MSA, are present although uncommon, constituting less than 1% of the core assemblage. Points, which serve as the most distinctive typological hallmark of the MSA, are well represented at Aduma. They include a number of distinct types, exhibit both unifacial and bifacial retouch and are present in all assemblages. They constitute 23% of the entire retouched sample and vary in frequency between 17% and 64% within individual assemblages. While not diagnostic, other types such as retouched flakes and blades, generalized scrapers, notched and denticulate pieces as well as infrequent grindstones and hammer stones fit comfortably within a MSA context.

2. The Aduma assemblages constitute a distinct localized regional tradition. MSA sites within the Horn of Africa provide the most appropriate comparative context for the Aduma assemblages and relevant locations include Porc Epic (Clark et al 1984, Perles 1974), K'one (Kurashina, n.d.), Gademota (Wendorf & Schild, 1974), the Omo Kibish Formation (Shea et al., 2002), Melka Kunture (Chavaillon et al., 1979), Gorgora (Leakey, 1943, Moysey, 1943) as well as a series of excavated and surface sites examined by Clark (1954) and Brandt (1986). While this sample is relatively large, comparison is hampered by several factors. Members of the Aduma research group have had the opportunity to directly examine only K'one in detail and to view limited portions of relevant Porc Epic, Omo and Melka Kunture material. Of the remainder only Gademota is well published. The MSA in the Horn spans an interval of at least 175,000 years and the chronological control necessary to tease apart time and geographic variation is, unfortunately, lacking. Within the comparative group only Gademota, which significantly predates Aduma, is well dated. In most instances lithic descriptions are limited and relatively few illustrations are provided, which also makes detailed comparison difficult. Gresham and Brandt (1996) describe "Little MSA" surface assemblages from the Jubba River Valley in Somalia and state that the Levallois cores from these sites average just under 3 cm in diameter. Although careful comparison between these and small cores from Aduma would be worthwhile, the Jubba Little MSA assemblages appear to lack other types that characterize the Aduma material. Ongoing excavations by John Shea and colleagues in the Omo Kibish formation have recovered material that appears typologically very similar to Aduma counterparts. Thus, quite possibly, the “Aduma tradition” extends within the Rift from Central to extreme Southern Ethiopia.

While some time-related typological change can be discerned across the Ardu B – Ardu C assemblages, and these are described in the following section, all share a basic set of distinguishing characteristics. From a typological perspective, blades, defined on the basis of a length to width ratio of greater than 2:1, form a significant part of the overall assemblage. Yet, true blade cores are rare. The six blade and six bladelet cores present constitute only 6.8 % of the entire core sample. In contrast, scrapers, which are generally uncommon in MSA contexts are abundant at Aduma. They vary in frequency and constitute between 7% and 33% of retouched pieces in individual assemblages. Likewise the Ardu B sand/gravel sites as well as A-5 are unusual in the high frequency of perforator and bec types and the general elaboration of this "pointed piece" category. In these two layers, frequency within retouched tools varies between 13% and 22%. Although cross site comparison is complicated by different typologies, point variation and elaboration at Aduma appears extremely high; five distinct types are defined for the Ardu B and Ardu C assemblages and an additional two occur at site A-1.

A series of types distinguish the Aduma assemblages and justify their designation as representative of a unique geographic variant within the MSA. With the exception of a single piece from the Omo Kibish formation, ovates appear uniquely characteristic of the Aduma sites. Aduma cores evidently are solely limited to these assemblages and constitute a distinctive Levallois-related type. Within the universe of MSA scrapers, which are generally large and do not conform to tightly defined specifications, the Aduma materials are distinct. Three types– mini, small convex, small non-convex– all manufactured almost exclusively of obsidian, and a fourth type on tabular quartz are all of a small size more characteristic of the LSA. For each, within type variation in overall length, width and thickness, as well as in scraper edge size and conformation is minimal. Their distribution within the Aduma assemblages is also time dependent. Small blunt points, limited to site A-5, also appear unique in a MSA context and share the small scrapers tightly constrained form and diminutive size.

The Aduma assemblage contains three core types which, although technologically within the MSA Levallois tradition, in terms of overall size are in fact "microlithic" and appear out of place within the MSA. Micro Aduma, micro Levallois, and micro Levallois blade cores average 19.5 mm, 25.1 mm and 21.5 mm in MxL respectively and size distribution analysis indicates that they should be considered distinct types and not placed within the tail end distribution curves of their larger counterparts. Taken together, the micro-cores, small scraper and small point types indicate an industry that while MSA in technology has moved in a microlithic direction and in several characteristics mirrors the LSA.

3. The Aduma sequence exhibits directional change over time. While absolute dates, unfortunately, are inconsistent and do not provide an adequate chronological framework for examination of rate of lithic change, geological data offer a relevant proxy. The Ardu B unit which lacks paleosols accumulated rapidly possibly in hundreds or thousands rather than tens of thousands years. Site A-5 rests on top of a partially eroded paleosol which caps the Ardu B thus indicating a time separation greater than that among the assemblages incorporated within this unit. Although a detailed understanding of the land surfaces which underlie Ardu B is lacking, the paleo-land surface which contains site A-1 predates the Ardu depositional sequence and likely, in relative terms, is significantly earlier. Lithic and geological analyses yield complementary conclusions.

With the possible exception of A-1, strong typological continuity is evident across the Aduma sequence, and 27 of 46 "real" types (which exclude "broken points", "attempted cores" and the like) are present in both early Ardu B sand/gravel and capping A-5 assemblages. All functional categories occur throughout and five point types span this entire interval as well. Again excluding A-1, all assemblages can most easily be included within a single Aduma sub-tradition. Individual layers however do have distinguishing characteristics that are not explainable by either sample size or other variables such as site function or raw material economy. Because the majority of the A-1 sample was collected from a long exposed erosional surface (and the excavated sample is too small to draw reliable conclusions), the possibility of admixture with material from overlying eroded Ardu units cannot be excluded and therefore shared types assume little analytic significance. A-1, however, contains several unique highly distinctive types– large biface cores and bifacial and Mousterian points which suggest an early MSA affiliation. Although too small and thin to fall within the Acheulean range, the A-1 bifacial points may represent an endpoint in handaxe diminution.

The differential distribution of multiple types serves to distinguish among layers. Two of the specialized scraper types, tabular quartz scrapers and small non-convex scrapers occur only in the basal Ardu B assemblages. A third specialized type, small convex scrapers, is present in both basal and mid Ardu B, but absent in A-5. Perforator-borers, represented by only three specimens, are unique to the basal sites, which also lack bladelets and both single platform and Nubian cores. Characterization of the four Ardu B silt sites is complicated by small sample size but with no uniquely associated types as a group they appear transitional, sharing three types exclusively with the underlying sand/gravel unit and another three with A-5. Mini scrapers, scraper-points and small blunt points as well as micro-

Aduma, micro-Levallois blade and Levallois blade cores occur only in A-5.

Changes in frequency as well as the appearance and disappearance of specific types reveal three broad chronological trends across the Aduma sequence. First, several shifts may be discerned. Within the point category, short broad as well as classic bifacially worked MSA points significantly decrease in frequency in A-5 and the small blunt point, possibly replacing the other two first appears. In A-5 mini scrapers entirely replace their similar but larger small convex and small non-convex counterparts. Secondly, a clear shift from a flake towards a blade based industries evident. Levallois blade and micro-blade cores as well as regular blade cores first appear in A-5. The frequencies of retouched blades and bladelets increase while the frequency of retouched flakes decrease significantly. Notched flakes also decrease in frequency and denticulate flakes disappear entirely. Finally, in A-5 the emphasis on miniaturization increases. Mini scrapers and small blunt points are not only absolutely small within an MSA context but are relatively smaller than the scraper and point types that they replace. Two miniature core types– the micro-Aduma and micro-Levallois blade cores– occur only in A5 and the frequency of micro-Levallois cores increases. This size decrease is noted for both obsidian and basalt artifacts. Given ready access to adjacent basalt outcrops it is highly unlikely that increasing raw material scarcity is a causal factor. While additional assemblages of A5 age would strengthen this conclusion, it does appear that across the time span which separates the Ardu B sand/gravel and silt assemblages from their A5 counterparts, stylistic change as well as pronounced shifts towards size diminution and a blade based industry occur. If the ca. 90K age estimate for Ardu B is correct, this entire process takes place within the latter part of the MSA.

4. Relative raw material abundance affects processing decisions. The two most geographically separated Aduma sites, with the exception of A-1, are slightly under 4 km apart and, therefore, daily foraging ranges from each would probably have significantly overlapped. Therefore, in principle, a similar suite of lithic raw material sources should be available over time. However the picture is complicated by geomorphological changes associated with an active rift system. For example, the basal cobble pavements exposed on the surface during the pre-Ardu were initially minimally buried with the deposition of the first Ardu B gravels and sands and then completely and deeply covered by Ardu B silts. Other tectonically related changes in raw material availability, while undetermined, are not implausible. Thus although site location is tightly constrained over time, raw material availability varies. Since the Aduma assemblages fall within a single regional tradition of limited duration, it may be conceived as a single system reflecting a single cultural mindset. The assemblages, therefore, offer the opportunity to examine how this system responds to changes in lithic source availability and distribution. Analysis demonstrates strong coherence within and equally great difference between stratigraphic units and the existence of this pattern lends credence to the above assumptions.

While Dulu Ali, the basaltic massif which defines the western edge of Aduma, provided an abundant supply of this material throughout the sequence, sources of other raw materials are not known and geological mapping, in its current stage, provides no insight into relatively scarcity. Three categories of raw material, quartz, "chert" and "other" constitute minimal components in all Aduma assemblages and small sample sizes preclude meaningful statistical analysis. The same constraint however does not apply to either basalt, a virtually unlimited low grade raw material, or obsidian, and comparison between the two provides insight into raw material economy. The "value" of a raw material is determined by both scarcity and utility and a priori it is reasonable to assume that on both scales obsidian ranks more highly than basalt for the production of flaked stone tools. While quite possibly closer locations exist, the nearest known obsidian source is ca. 30 km distant. Typological analysis demonstrates that the more tightly defined types – points and small scrapers– are made primarily or exclusively of obsidian. It should be noted however that within "basalt" itself, significant texture gradation exists and more complicated core types such as Levallois and discoidal which require a series of carefully placed sequential removals preferentially occur on finer grained variants. Amorphous core and chopper counterparts more frequently are associated with coarser raw material.

Analysis of assemblages by several measures and attributes provides insight into raw material economy. These measures include variation in raw material usage across assemblages within the total combined number of pieces (typed + debitage), numbers of debitage and typed pieces (sometimes including and at others not including cores) and typed pieces by functional category. While large attribute sets were recorded for cores, points, scrapers and debitage, in this study only two– raw material and maximum length (MxL) are employed. These measures and attributes allow multiple types of analyses to compare not only utilization patterns of different raw material within a single site, but also among assemblages both within and across stratigraphic units. While space limitations preclude inclusion of the large set of analyses that provide the basis for conclusions below, three illustrative examples are provided. All sites in all stratigraphic units contain discarded basalt cores. While obsidian cores are relatively abundant in the four sand/gravel Ardu assemblages they are rare in comparison to their basalt counterparts in A-5, and entirely absent in all sites within the Ardu B silt. In three of the latter, both obsidian typed pieces and debitage are present. This pattern implies that within the silt obsidian cores are carried away when the site is abandoned and that obsidian was regarded as a scarce and highly conserved resource. When obsidian is examined across sites on the basis of three variables, percentage of total lithic frequency by raw material, the ratio of typed pieces to debitage and finally MxL the following pattern emerges: (1) in comparison to their gravel/sand Ardu B counterparts, in all silt sites as well as A-5 the ratio of typed pieces to debitage is significantly lower. Fewer tools in relation to debitage implies greater reworking; (2) within each assemblage this ratio of debitage to typed pieces is directly related to the absolute frequency of obsidian within the assemblage. This also is an expected result of reworking since reworking would not only increase the amount of debitage relative to typed pieces but also the total amount of obsidian relative to other raw materials within the assemblage. This relationship both holds true across all sites and thus supports the hypothesis that reworking in fact provides the cause; (3) finally in the Ardu B silt and A-5 sites where hypothesized reworking of obsidian occurred, the average maximum length of obsidian debitage is relatively shorter than in the sand/gravel Ardu B assemblage. This would be expected in a reworking scenario since the debitage from successive reworkings would decrease in size. In this analysis size differences due to winnowing can be controlled through use of ratios in which within each assemblage obsidian MxL is compared to its basalt counterpart. Thus, cross assemblage comparisons are based not on absolute distribution of maximum length, but rather individual obsidian: basalt ratios. A similar overall pattern does not hold for basalt indicating that, obsidian may be considered a rarer, more highly conserved material and that its scarcity and value are greater in the Ardu silt sites and A-5 than in the Ardu B sand/gravel assemblages.

The treatment of basalt and obsidian varies across different stratigraphic units. In the Ardu B silt sites and at A-5 obsidian was highly conserved. It was brought into Ardu B silt sites primarily as flakes and finished tools. At A-5 a small number of cores were carried in as well. Within these sites intensive reworking occurred and useful byproducts, cores and large flakes as well as relatively more tools were carried away. In contrast, obsidian was not highly curated in sand/gravel Ardu B assemblages. Relatively little reworking took place and relatively more tools and large unworked flakes and cores were discarded. Within the silt sites and A-5 basalt was treated as a common, easily obtained and highly expendable raw material. It was introduced as trimmed nodules. Reduction occurred on site, the degree of utilization is low and large flakes and cores were discarded. Core reduction strategies such as Levallois which are relatively wasteful of raw material were employed more frequently. In comparison to its obsidian counterpart, basalt within the sand/gravel Ardu B sites was treated as a less common raw material. Flakes and finished tools rather than large numbers of nodules were brought into the site, the degree of reworking was relatively high, and large flakes, cores and finished tools were taken from the sites. Categorization of tool type by raw material demonstrates that in all layers obsidian was preferentially used in manufacture of points and small scrapers. In the sand/gravel Ardu B sites, chert preferentially filled in behind obsidian for types of secondary importance while in the silt sites as well as A-5 basalt served this function. While insufficient chert is present to draw firm conclusions, it appears to mirror obsidian and have been treated in similar fashion.

Thus analysis indicates the existence of a well defined system to utilize raw material efficiently. Because of intrinsic value and relative scarcity, obsidian provided the primary driver and as availability decreased the system compensated accordingly. Although multiple causes may be responsible, possibly pre-Ardu surface pavements provided the source for obsidian and chert and their burial by massive Ardu B silts accounts for their rarity in silt and A-5 assemblages.

5. Functional analysis provides insight into Aduma hominid settlement and foraging strategies. Standard lithic typologies, because they combine form and function, do not necessarily provide maximum insight into tool use. In the Aduma case, the category “scraper” combines small types which are made on obsidian and conform to tightly specified shapes with larger types, which are less typologically distinct and which share few small scraper characteristics. The retouched edges of these generalized large scrapers are similar to and grade almost imperceptibly into the retouched edges on retouched flakes and blades. Thus, in a functional analysis it is reasonable to group all small scraper types together into one category and general scrapers, retouched flakes and retouched blades into another. Because cores are not “tools” per se and are sensitive to lithic economy decisions, in this functional analysis they are removed from consideration. Comparison of the Aduma assemblages by shared presence and by frequency of functional categories yields two important results. First, although many of the levels of association are not statistically significant, all functional types correlate positively with each other. This argues strongly against a specialized or complementary foraging and manufacturing strategy and for an additive pattern of site use. If, for example, Aduma foragers specialized in catching fish and shaping reeds at one site and hunting and scraping skins at another– a complementary pattern– one would expect negative correlations among tool types primarily associated with each cluster of activities. Analysis indicates that, in fact, the opposite occurs. Secondly, correlation data shows a strong relationship between the number of assemblages in which a functional type occurs and its overall frequency in the sites in which it is present. Thus for example both "points" and "general scrapers + retouched flakes and blades" are present in all 11 assemblages; they constitute between 29% and 38% of each assemblage. "Special scrapers" and "pointed pieces" occur in only 6 and 7 assemblages respectively and they constitute on the average 11% and 15% of the assemblages in which they occur. This pattern also supports an additive model. Points and retouched edges according to this scenario are used to meet needs essential to maintenance of life on a daily ongoing basis. Less important functions take place on an intermittent basis. Such a model in fact conforms to an observed northern Kalahari Kung Bushman pattern. (Yellen, 1974). Ethnographic observation indicated that individual activities had different daily occurrence probabilities and that subsistence related tasks in general tended to be more frequent and manufacturing tasks less so. Thus subsistence activities occurred in all sites regardless of length of occupation while the probability that a specific manufacturing task would occur was a time related function.

Aduma site A8B provides a basis for speculation on the relationship between tool type and function. Because A8B consists of the disarticulated remains of a single hippopotamus in close spatial association with a thin scatter of lithics all of a single local basalt type, it is most reasonable to assume that a single butchering episode constituted the main and probably the sole activity. Basalt nodules were obtained and trimmed away from the site, roughouts were carried in and further reduction then took place. In addition to cores and debitage, over 70% of the retouched pieces are either general scrapers or retouched flakes or blades. Thus, these types are almost certainly associated with butchering activities. Notched and denticulate pieces, pointed pieces and special scrapers were completely lacking. The general scraper-retouched piece and the point categories are well represented at all sites and, thus, it is reasonable to conclude that butchering and hunting constituted important activities at each. The ubiquitous presence of mammal and fish remains supports such an interpretation. Pointed pieces and small specialized scrapers are primarily associated with the sand/gravel Ardu B sites and with A-5 which imply that they were longer term occupations at which a variety of manufacturing/maintenance activities also took place. Although lack of volumetric data precludes quantification, the density of material in all A8A assemblages and at A5 in contrast to thin scatters at VP 1/1, VP 1/3 and A-4 suggests more intensive occupation at the former. Thus during both the Ardu B sand/gravel and the Ardu B-C contact interval, Aduma archaeological sites reflect longer term occupation while during the Ardu B silt period occupations were brief and subsistence focused. Perhaps a seasonally flooded rapidly aggrading landscape was less hospitable and lacked easy access to important, now buried lithic source materials. Hominids may have followed a “hit and run” strategy.

CONCLUSIONS

While the first systematic archaeological excavations were conducted in Ethiopia in 1929 (Teilhard de Chardin 1930 in Brandt 1986)– over 70 years ago– the number of well described and excavated sites which contain MSA is highly limited. To argue convincingly that the Aduma MSA represents a distinctive regional lithic tradition would require a dense sample of assemblages dated to an age range of ca. 100 - 70 K and such data, unfortunately, are unavailable to argue this position convincingly. Yet, comparison with available Ethiopian MSA material strongly suggests that such is the case. A recently excavated assemblage in the Omo Kibish formation (Shea, personal communication) contains distinctive small Aduma cores and it is reasonable to postulate that the two sites form part of a spatially limited, perhaps Rift associated, regional MSA variant. In the Central Kenyan Rift which contains a greater density of MSA occurrences, such types are unknown (Clark 1988). Given multiple known MSA regional variants, such an interpretation is neither unreasonable nor surprising. It is noteworthy, however, that the small highly formalized specialized scrapers in the Ardu B sand/gravel likely predate the Howiesons Poort and thus are the earliest examples within the MSA. In form, although not in manufacture technique, they presage the LSA and thus likely reflect new and functionally adaptive patterns of behavior. Within this context, their constrained spatial distribution is surprising and may suggest extremely low population densities during this interval with groups separated by large uninhabited areas.

A second noteworthy observation about the Aduma assemblages is that they exhibit directional change within this limited tradition over time. While the Ardu B sand/gravel and silt sites are, from an archaeological perspective simultaneous, based on geological data A-5 is not. Typologically A-5 is distinct from its predecessors and this difference can not be explained through recourse to sample size, taphonomy, raw material availability or site function. Most of the differences reflect an increasing emphasis on the production of smaller flakes and blades and specialized microlithic sized tools. While quantum changes– such as the abrupt appearance and subsequent demise of the Southern African Howiesons Poort are noted within the MSA, the directional change exhibited by the Aduma lithics is distinctive and is more characteristic of change that typifies European Upper Paleolithic traditions. While the Aduma microlith-zation based on a MSA Levallois technology proved a typological dead end, less efficient than the blade based LSA, it seems in fact to represent an independent process moving in a directed fashion towards the same goal. Unfortunately, lack of secure chronology does not provide insight into rate of change. However, dates do suggest that Aduma provides another example of MSA innovation such as true microliths, engraved ochre plaques, and barbed bone points which characterize the later MSA at sites such as Mumba Cave (Mehlman 1979, 1989), multiple South African sites which contain the Howiesons Poort, Blombos (Henshilwood & Sealy, 1997) and Katanda (Yellen et al., 1995).

Finally, the Aduma sites provide some insight into adaptive behavior. While the faunal evidence is open to multiple interpretations, it suggests that while Aduma groups utilized varied microhabitats, they depended heavily on riverine resources, including hippopotamus and crocodile and very likely incorporated large slow moving fish into their diet. While a distinct butchery site likely can be recognized, specialization is not evident among presumed habitation sites and variation within this category can most simply be explained by length of occupation. Finally, the Aduma people employed a system of lithic economy that recognized situational variability and emphasized behavioral flexibility. The rationality underlying the system is readily understandable to lithic analysts today.

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APPENDIX A

PALEOSOL STABLE ISOTOPE ANALYSIS

(This appendix written and analyses conducted by Stanley Ambrose).

Stable carbon isotope ratios of tropical paleosol (fossil soil) carbonate nodule carbonate, and disseminated organic carbon in the sedimentary matrix and within carbonate nodules, can be used to reconstruct the proportions of tropical grasses versus trees in plant biomass (Cerling 1984). Plants with the C3 photosynthetic pathway, which comprise trees, shrubs and most leafy (dicotyledous) plants, as well as grasses from cool and/or shaded habitats, have mean ¥13C values of -26.5‰. C4 plants, which are mainly tropical grasses in open habitats, have mean ¥13C values of -12.5‰. Leaf litter decomposition causes a shift of about +1-2‰ in soil organic matter ¥13C values (Nadelhoffer and Fry 1988). Soil organic carbon ¥13C value end-members for 100% C3 and 100% C4 are thus assumed to be -25‰ and -11‰, respectively. The isotopic composition of soil organic carbon integrates that of the flora in the immediate vicinity of the sample site. The vertical resolution is about ±10 cm in modern aggrading soils in the Kenya Rift Valley, and horizontal resolution is less than 10 meters (Ambrose & Sikes 1991).

Soil carbonate carbon is derived from CO_2 from plant root respiration and soil organic matter decomposition (Cerling 1984). The ¥13C value of pedogenic carbonate is typically enriched over that of the soil organic matter by +14‰ at 25°C to + 17‰ at 0°C (Cerling et al. 1989). Average tropical carbonate ¥13C value end-members for 100% C3 and 100% C4 are estimated to be -10.5‰ and +3.5‰, respectively. Carbonate nodules can form at varying depths beneath the land surface whose vegetation supplies most of its stable isotopic signature. Carbonates form at greater depths with higher rainfall. Because pedogenic carbonates form slowly, and grow for unknown lengths of time, they may record a muted average of varying environmental conditions at varying times after that of the soil matrix at the level in which they are found. This may be a major source of variation in Δ13Ccarb-org values.

Oxygen isotope ratios of pedogenic carbonates reflect those of soil water. The isotopic composition of meteoric waters is controlled by polar ice volume, altitude, temperature, humidity and evapotranspiration (Dansgaard 1964; Gat 1980). ¥18O values are highest in hot, arid habitats and low latitudes and altitudes (Craig 1961). Oxygen isotopes of pedogenic carbonate nodules can thus provide evidence for humidity, temperature and microclimate (Cerling 1984).

The Aduma A5 paleosol samples were taken from a fresh cutting in the main archaeological excavation. (See Table 9 and Fig. 34) Methods of sample preparation for isotopic analysis are described in detail elsewhere (Cerling et al. 1991; Ambrose and Sikes 1991). The soil profile has five readily discernible horizons, which are described in Fig. 34. Analytical data are presented in Table 9. Descriptions loosely follow the terminology used

TABLE 9: ADUMA 5 PALEOSOL ORGANIC MATTER AND PEDOGENIC CARBONATE STABLE CARBON AND OXYGEN ISOTOPIC COMPOSITION.

STRATUM (HORIZON)	SAMPLE MATERIAL	SIMA#	LAB #	WT.% C ORGANIC	$\delta^{13}C$‰ 1	$\%C_4$ ORGANIC	LAB #	WT. % ROASTED 2	WT.% $CACO_3$ 3	$\delta^{13}C$‰	$\delta^{18}O$‰	$\Delta^{13}C$‰ 4 CARB-ORG	$\%C^4$ CARBONATE
2 (A/Bt)	Matrix	96-1	2	0.142	-12.6	85.5							
3 (Bk)	Nodule	96-2	4	0.104	-13.1	84.6	3	76.9	66.64	-0.2	4.2	13.0	73.6
3 (Bk)	Matrix	96-3	6	0.091	-13.4	83.1							
4 (B/C)	Nodule	96-4	8	0.080	-13.6	81.4	7	78.8	70.55	-4.2	-0.5	9.4	45.3
4 (B/C)	Nodule	96-4					82[5]	78.8	69.64	-4.2	-0.7	9.4	45.1

Notes:

1. *Stable isotope ratios are expressed as delta (δ) values in parts per thousand (‰) difference from the PDB carbonate international reference standard, calculated as:* $\delta X(‰) = [(R_{sample}/R_{PDB}) - 1] \times 1000$*, where X is* ^{13}C *or* ^{18}O *and R is* $^{13}C/^{12}C$ *or* $^{18}O/^{16}O$.
2. *This is the sample weight remaining after roasting under vacuum at 400°C for four hours. It is a measure of the loss of volatiles, water and clay hydroxyls from the pedogenic carbonate matrix rather than the actual weight of* $CaCO_3$*. Carbonate concretions with low carbonate contents lose more weight on roasting. Removal of these fractions increases the accuracy and precision of oxygen isotope analysis.*
3. *Weight % carbonate in the roasted sample was determined from amount of* CO_2 *generated by reaction with 100% phosphoric acid. This is the true carbonate content of the sample. The high weight loss on roasting (~23%), and low wt%* $CaCO_3$ *show that these carbonates contain substantial amounts of clayey sedimentary matrix.*
4. *Difference between carbonate and organic* $\delta^{13}C$ *values.*
5. *Replicate analysis of #7. The small difference in %* C_4 *reflects a difference in* $\delta^{13}C$ *at the second place beyond the decimal point.*

by Birkeland (1984), Mack et al. (1993) and Retallack (1990).

This section appears to preserve the nearly complete soil profile of a typical vertic soil, the equivalent of modern cracking clay vertic soils that are found in seasonally saturated, poorly-drained, level, open tropical grasslands. Vertic soils are typically very dark brown, and develop prominent deep vertical cracks between large polygonal columnar peds (vertic structure) resulting from substantial swelling and shrinking during wet and dry seasons. The section spans the Ardu B/C boundary, and the paleosol formed on

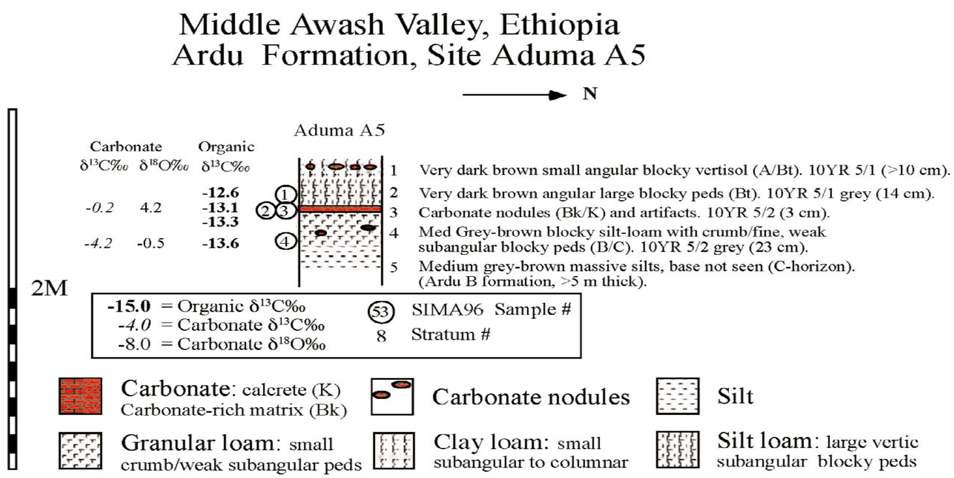

Figure 34. Stratigraphic section of site Aduma A5 stable isotope sampling section, showing positions of samples and carbonate and organic matter stable isotopic compositions. The stratigraphic section is described from the top of the excavated section, in a cutting 10 cm into the west wall of square 89S 100E.

Stratum 1. > 10 cm. thick. Very dark brown small angular blocky friable vertic soil, with small carbonate nodules (1-2 cm) scattered throughout (A/Bt horizon). Lower boundary abrupt; top of stratum is eroded present surface.

Stratum 2. 14 cm. Very dark brown angular blocky, with deep vertical cracks (Bt horizon). Lower boundary abrupt marked by carbonate cementation.

Stratum 3. 3 cm. Very dark brown angular small blocky soil with a continuous horizon of small brick-like blocky carbonate nodules. MSA artifacts and bones are cemented into this unit. This is effectively a Bk or incipient K (carbonate) horizon. Lower boundary abrupt.

Stratum 4. 20 cm. Medium gray-brown silty loam with large crumb to fine subangular blocky structure, with small carbonate nodules and a few large vertic cracks extending down from overlying levels (B/C horizon). Lower boundary gradational.

Stratum 5. > 10 cm thick. Medium gray-brown massive silt (C horizon, unaltered by soil formation). Base not seen.

massive gray-brown silts of the Ardu B formation.

The top of the original soil profile is probably absent from this section. It is likely to have been a mollic epipedon, which is a dark, organic-rich surface soil characteristic of the uppermost parts of grassland soil profiles. Stratum 1 carbonate nodules and soil matrix were not sampled for isotopic analysis because they may have been exposed to surface contamination. Stratum 1 is an A/Bt horizon; Stratum 2 is a clay-rich vertic Bt horizon; Stratum 3 is a clayey, vertic, jointed, carbonate-cemented Bk horizon with MSA artifacts. Stratum 4 has weak blocky soil structure and a low illuvial clay content. Because it is only slightly altered by pedogenesis, it is classified as a B/C horizon. Unit 5 is the massive silty unaltered parent material on which the soil developed, and is thus a C horizon. Stratum 5 belong to the Ardu B formation, and overlying strata belong to the Ardu C formation.

Stable carbon isotope ratios were analyzed for soil matrix organic carbon and disseminated organic carbon within carbonate nodules, and carbon and oxygen isotope ratios were determined on the carbonate fraction. Organic ¥13C values of strata 2, 3 and 4 range from -13.6‰ to -12.6‰, reflecting 80-85% C4 plants, and thus an open C4 grassland habitat. The carbonate sample from Stratum 3 suggests a floral biomass with 74% C4 grass. The carbonate oxygen isotope ratio Stratum 3 is relatively high, which indicates relatively high soil temperatures and/or intense evaporation close to the time of occupation. Therefore the carbonate of Stratum 3 probably formed relatively high in its soil profile. Carbonate ¥13C values in Stratum 4 suggest significantly lower percentages of C4 plants (45%) than those of the associated disseminated organics. The carbonate-organic difference (Δ13C‰) value of 9.4‰ for Stratum 4 is significantly smaller than expected for synchronic carbonate and organic matter formation, which may indicate formation of carbonate under grassy woodland to wooded grassland conditions. The low carbonate ¥18O value for this sample indicates formation in a cooler and/or wetter habitat, which is consistent with the carbonate carbon isotope data for a more closed habitat. Because carbonates form at greater depths at higher rainfall levels, the carbonates of Stratum 4 may reflect a more wooded environment above (post-dating) Stratum 1.

In conclusion, the soil isotopic and pedologic evidence, combined with the presence of a well-developed soil profile, and the absence of fluvial features, suggest the site was located in open grassland in a distal floodplain depositional environment during the MSA occupation.

APPENDIX B

EXCAVATED/COLLECTED ADUMA SITES

This appendix, together with associated figures provides detailed information about each of the excavated and surface collected Aduma sites. A. Brooks and J. Yellen curate the original excavation notes and maintain the excel files which contain the primary lithic data. As of time of publication, they may be contacted at jyellen@nsf.gov or abrooks@gwu.edu. Fauna and artifacts are housed in the National Museum in Addis Ababa, Ethiopia and copies of field notes and other relevant data are currently (and hopefully will remain) stored in cabinets which contain the artifacts.

A1

In 1992 Middle Awash Project members noted a dense concentration of MSA materials in a lag adjacent to the base of the 12 m high steep-sided small horst known locally as Ardu Koba (10.23.21 N; 40.30.51 E) and located in the Ardu Blocks at the southern-most edge of the Ardu deposits. (Fig. 35) One should also refer to Fig. 2 for site locations. The following year Brooks and De Heinzelin conducted one season of excavation at the site. Three step trenches were cut into the hillside and a 3 meter x 4 meter pit was excavated into intact Ardu B sediments which were adjacent to the lag deposit. This pit reached a maximum depth of 1.45 meters. Approximately 840 lithics and a similar number of faunal remains were recorded either by three dimensional provenience or by 10 cm vertical interval

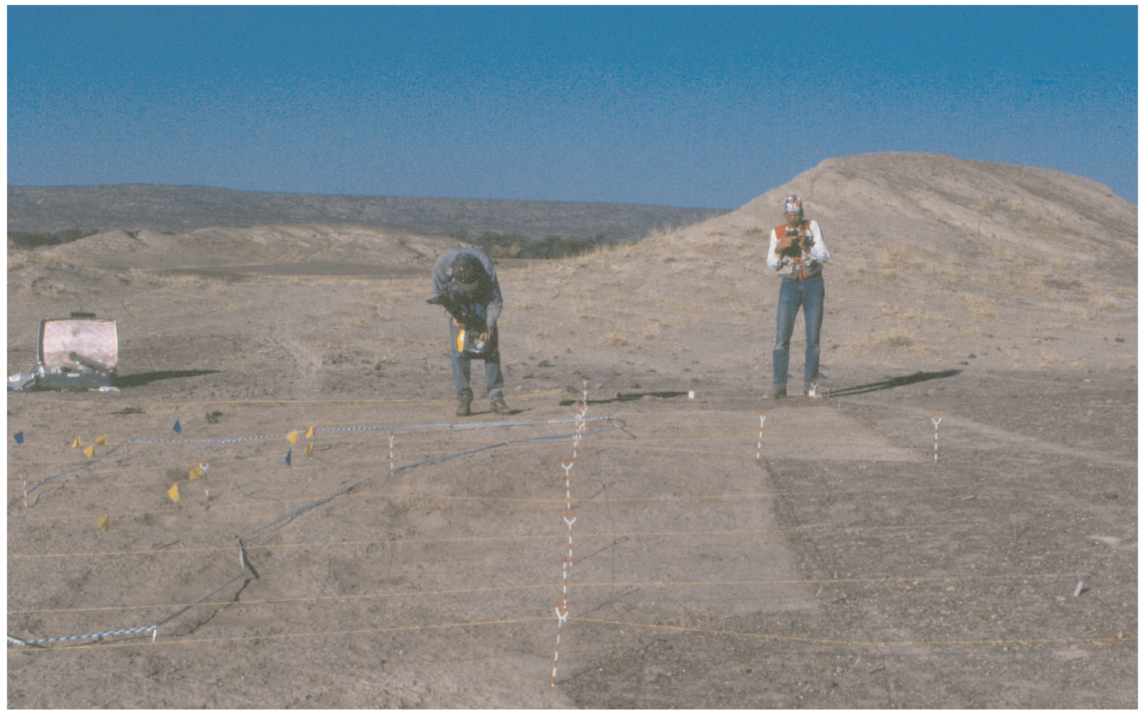

Figure 35. Aduma site A1. Gravel layer with surface MSA artifacts in foreground. Ardu B sediments left background.

within 1 meter squares. Additional surface materials were collected from the lag surface to include lithic types not represented in the excavation. A1 contains three geological units: basal Koba deposits, an overlying gravel deposit which varies in thickness from 5 cm to 25 cm and finally capping Ardu B sediments. The gravels, which are distinct from their finer counterparts at sites A8 and A8A incorporate gypsum horizons, carbonate nodules and other indicators of multiple episodes of deposition, concretion and erosion. They were not noted anywhere else in the Aduma region and are best viewed as a combined, thin fluvial and lag deposits present on the valley floor before the main Ardu B sedimentation. The bottom ca.10 cm of the Ardu B silts are also distinctive as they include many different kinds of concretions suggestive of a long and complicated diagenetic history. MSA lithics and associated faunal remains are clearly associated with the lag surface and the lowermost 10 cm of the Ardu B sediments. The underlying Koba sediments are sterile and while a hippo skeleton was observed eroding from the hill face within the main Ardu B, no lithic artifacts were observed or recovered in the test trenches from the upper part of this unit.

The A1 surface assemblage is likely mixed and represents more than one time period within the MSA. The geological evidence cited above indicates that the sediments which incorporate the archaeological material reflect a complex history. The physical state of the lithics themselves also suggests multiple origins. For example, one large flake collected from the exposed lag surface contains an adhering root cast of Ardu B silt and thus is clearly derived from the overlying deposit. Also recovered from this surface was a large obsidian bifacial core which was extremely brittle with a thick hydration rind. No obsidian artifacts from other Ardu B deposits exhibit any surface hydration. The artifacts present a mixed typological picture as well. If credence, however, is given to the suggested dates of ca. 80,000 to 100,00 years for the overlying Ardu B, at least a portion of the A1 lithics exceed this in age. The assemblage includes large bifacially worked elongated unstruck cores, a Mousterian point and diminutive handaxe which appear out of place in the East African late MSA and they are not present in any of the other Aduma sites. However, the A1 assemblage shares many types with the other clearly in situ Ardu B assemblages described below including a distinctive derived type of Levallois core which appears unique to the region and thus is unlikely to have an extended time depth. Given the problem of admixture it is likely unwise to interpret the associated fauna as a single unit. A1 contains clasts of hardened red sediment, possibly indicating burnt ground and the presence of fire. Other interesting finds include three fragments of fossil wood, two lithified casts of snails, and a lithified impression of the penultimate and ultimate caudal vertebrae and spines of a fish. A total of 1250 bone fragments, including specimens under 2 cm in maximum dimension, were recovered from the excavations. Of these 42 NISPs were identified to taxon , including 24 identifiable teeth. An additional 27 fragments of enamel

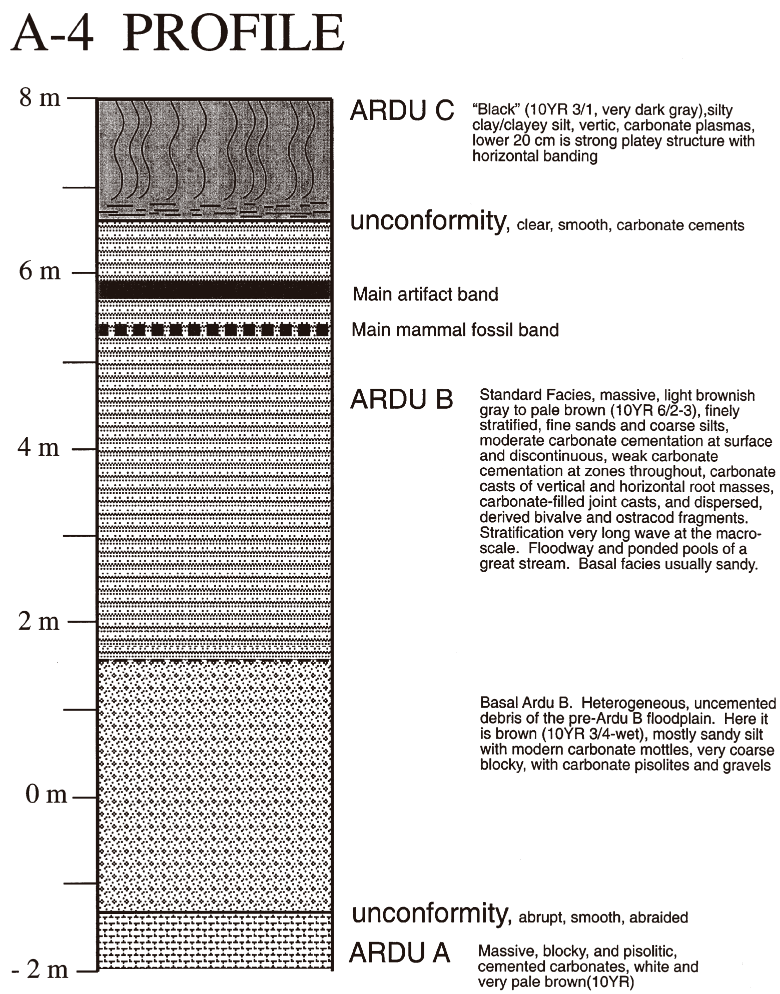

Figure 36. Stratigraphic profile of A-4 archaeological site.

from mammalian teeth were uncovered that were not identifiable. The remaining non-tooth NISP includes a bovini horncore fragment, an unfused ischium of a proboscidian, and several post-cranial bone fragments from hippopotamus, crocodile and one from a spotted hyaena. It is worth noting A1 is the only site in which fish do not dominate the fauna - they constitute ca. 5% and in which Clarias constitute less than 90% of the fish remains. For A1 and all following sites, specific species presence absence data are presented in Table 3. Tables 6, 7, and 8 provide summaries of lithic material.

A4

First examined in 1994 and more extensively excavated in 1996 the remnant hill designated A-4 (10.26.19 N; 40.32.01 E) is located on the northernmost Ardu lobe and rises 8.2 meters above the modern Awash floodplain. Erosion has resulted in a steep sided hill of Ardu B sediments with a shouldered summit capped with a small 2 meter high remnant of Ardu C deposit (Figs. 36, 37). A resistant thin calcreted layer within Ardu B constitutes the capping unit over the shoulder of the hill. A-4 drew archaeological attention because of numerous lithics and well-preserved fauna, including hippopotamus and Clarias remains both on the shoulder and the surrounding base of the hill. During a 1994 reconnaissance a narrow step trench was rapidly excavated on the western face and a pit dug into the ground level surface in front of the hill. A complete, unsieved, surface collection of lithics was made from a 3 m x 2 m area on the shoulder and a small selective sample of diagnostic lithics collected

Figure 37. Aduma site A4. Note black Ardu C cap on central raised hill. All other sediments are Ardu B. 1994 trench to right and 1996 trench to left. The lateral extension to the left of 1996 trench marks artifact horizon. Figures in foreground are standing at 1996 test pit.

from both shoulder and base of the hill. In 1996 a 2 meter wide step trench through Ardu C and B sediments was excavated adjacent to its 1994 counterpart. It encountered a shell horizon with abundant Unio sp. and smaller numbers of Corbicula sp. and Melanoides sp. 209–223 cm below the summit and a single thin sloping cultural horizon of calcreted MSA lithics and faunal remains at 245–255 cm Red clasts are associated with this horizon. Four scattered non diagnostic flakes were recovered in the Ardu C deposit. A continuation of this step trench below ground level to a depth of 698 cm below the summit yielded neither lithic nor faunal remains. An additional 3 m square test pit was excavated into the floodplain surface in line with and 46 meters east of the step trench terminating at water level 155 cm below the surface. It encountered a sequence of presumably Ardu B alternating sands, gravels and silts unobserved elsewhere in the Aduma region. It is not possible to correlate stratigraphically this test pit with the basal levels of the step trench. At ca. 132 cm below the surface of the current Awash floodplain, an artifact horizon yielded 22 lithics with scattered fauna. Primarily flake fragments, all of coarse basalt, the assemblage included a Levallois Point, an end scraper on a flake, one blade fragment and a possible handaxe butt. Most specimens were broken and none exhibited fresh edges. While most easily attributed to the MSA the sample is too small to permit definite conclusions. Shell samples for amino acid racemization dating were collected from both the 209–223 cm layer within the step trench and the basal artifact containing layer within the test pit.

Excavation of the Ardu B MSA horizon was extended laterally in one meter squares to encompass 15 square meters. A thin vertically restricted scatter of lithics and fauna was encountered over the

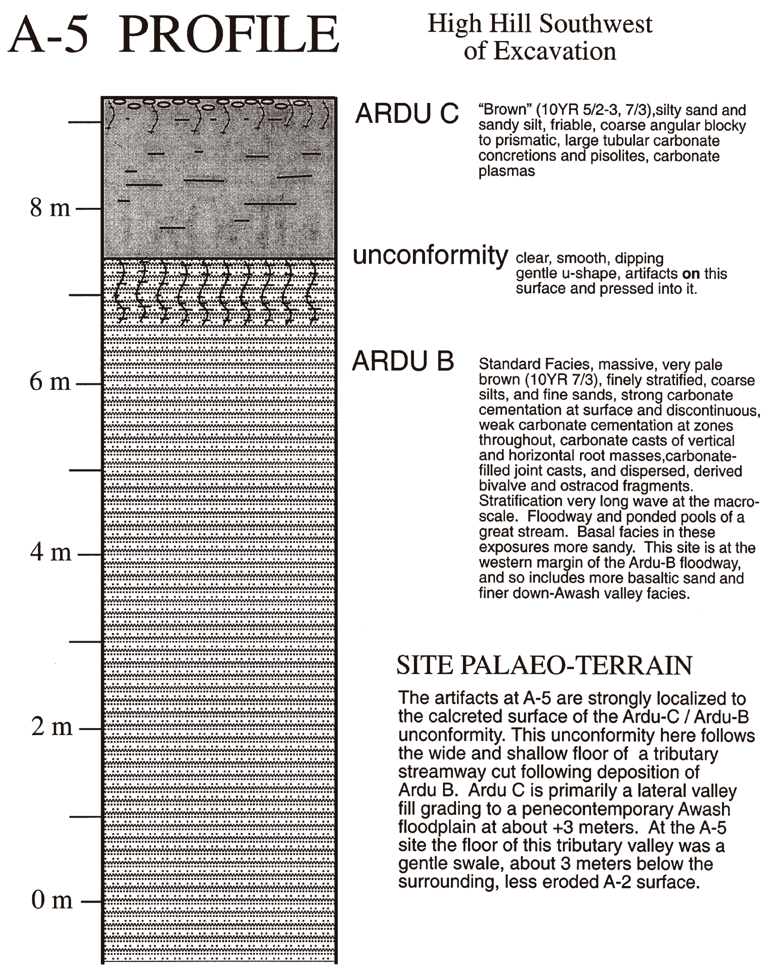

Figure 38. Stratigraphic profile of A-5 archaeological site.

entire surface, encased in a calcrete crust. The underlying silt is of slightly finer texture than its overlying counterpart and the materials were deposited on an ephemeral land surface which after burial experienced carbonate development. Varied lithic planar orientations indicate trampling or other post depositional disturbance on a soft, possibly wet surface. Although direct contact between excavated surface and hill shoulder was not established, exposed material on the latter are most likely synchronous, incorporated into a lateral extension of the same surface. Likewise abundant surface lithics which surround the base of the hill likely derive from the same source and were displaced through lateral hillside erosion.

At A4 2,900 bone fragments were recovered in total, about 85% of which are from fish. For the remaining tetrapods, most were small fragments under 2 cm with a few larger pieces (e.g. 8 cm). These include a NISP of 45 specimens identifiable to taxon, including 10 crocodile teeth, 7 teeth from mammals and 23 identifiable enamel fragments (Table 3). Only nine post-cranial elements were identifiable to skeletal element: 4 of hippopotamus, 4 of medium mammal and 1 rodent femur. Several more fragments are also likely from hippopotamus based on their size, but were broken and covered in calcrete.

A5

Discovered by Brooks and Yellen in 1994 and excavated the following year, A5 is located in the western margin of lobe 2 (10.25.39 N; 40.31.43 E) and contains the youngest in situ materials in the Aduma archaeological sequence (Figs. 38, 39). The steep sided hill rises 4.5 m above the floor of the adjacent valley, is oriented in a southwest–northwest direction and measures 28 m x 14 m across its gently rounded top. Composed primarily of Ardu B deposit, it is capped by an archaeologically sterile deposit of Ardu C sediment approximately 20 m by 2 m in extent. Two taller, less eroded adjacent hills share the same stratigraphy, but lack A5's rich archaeological horizon. A dense scatter of faunal and lithic remains rests exclusively on the contact between Ardu B and C on the eroded surface of an ancient weakly developed paleosol formed on top of Ardu B silts. These materials significantly postdate the deposition of the Ardu B complex. Although recovered in primary context, many of the lithics display "on edge" orientation suggesting trampling into a soft substrate. The edges of most pieces, however, are sharp implying primary context deposition. Carbonate concretions underlie and also encase some lithics, thus showing that formation of a calcrete horizon at this level postdates artifact deposition. Comparison of elevations of the Ardu B-C boundary across hillsides indicates that the archeological materials at A5 were deposited on the floor of a minor depression or tributary valleyway likely containing a shallow seasonal marsh or pond. Carbon isotope (Ambrose 1997) and phytolith (Barboni et al. 1999) indicate an open grassland environment.

Because erosion proceeded more rapidly around the edges of the hillside, the central Ardu C "cap" was surrounded by 329 square meters of Ardu B surface with abundant lithic and faunal remains. The entire hilltop was gridded in one meter squares and surface materials were collected within these designated units. The

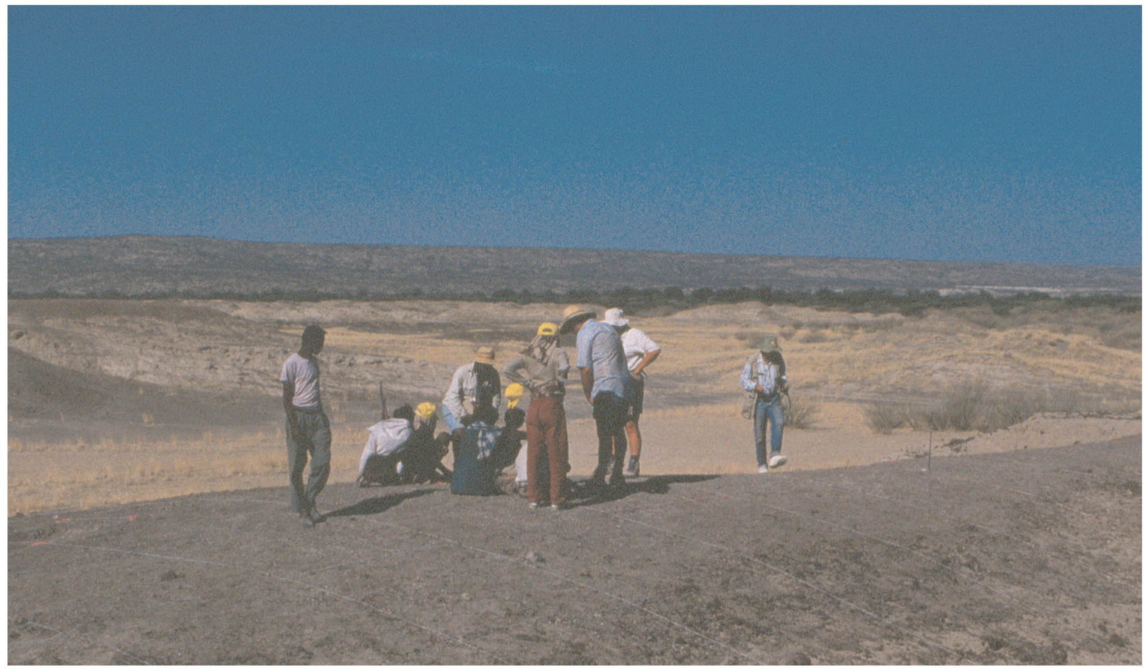

Figure 39. Aduma site A5. Photograph from top of A5 hill. The darker area on which individuals stand is Ardu C remnant overlying Ardu B in foreground. Treeline in background is Awash River fringing forest. The sediments between river and A5 are all Ardu B.

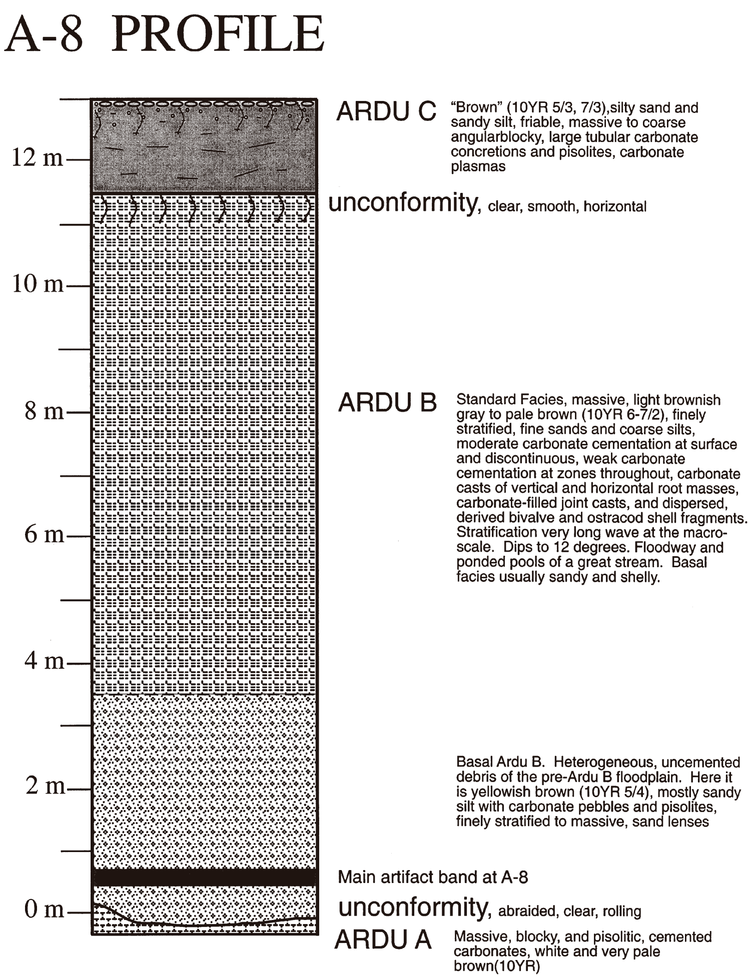

Figure 40. Stratigraphic profile of A-8 archaeological site.

surface sediments were not collected and sieved. Nine one meter squares, four of these contiguous, were excavated through the Ardu C and underlying cultural horizon into the uppermost part of the Ardu B. In all squares, artifacts and fauna were concentrated at the Ardu B-C contact. The sediment was sieved.

A5 has the largest bone assemblage with some 4,000 bone pieces, including all size ranges. The bone from A5 has been severely fragmented by calcrete growing in cracks and breaking the fossils apart in situ. Typically specimens are very small fragments (< 2 cm) although there are also some large fragments, most of hippopotamus based on associated teeth, but they are broken and eroded (post-fossilization), and coated with calcrete. These latter specimens are most often from the surface.

There are 285 teeth and fragments of teeth from the site, of which two-thirds (N=177) are merely enamel fragments (55 hippopotamus, 48 bovidae indet. (mostly central cavities of cheek teeth), 76 mammal indet). These teeth make up the majority of the identified specimens (NIS). Also notable is an alcelaphine, cf. Damaliscus horncore. Post-cranial remains that were identified to element and size class totaled 26, the majority from medium-sized bovids but also some fragments of hippotamus. The post-cranial elements represent the range of the entire skeleton, vertebrae, ribs, long bones, tarsals, etc. and so do not sort out into a single hydraulic transport class. One set of possible tool marks was observed on a hippopotamus rib fragment, but usually bone surfaces were not visible due to the calcrete and post-fossilization surface erosion. "Small numbers of marks always should be viewed with caution due to equifinality.

A8

"A-8" designates an elongated flat topped hill approximately 100 meters in length and about 13 m in height located near the eastern margin of the middle Ardu lobe (10.23.58 N; 40.32.22 E) (Figs. 40, 41). Figure 40 provides a composite sequence for the entire A8 region including the sites of A8, A8A, and A8B. During a 1995 survey Helgren noted an extensive ring of lithics around the nose of the hill, no doubt, exposed through lateral erosion. Excavation was conducted at the site that same year. The hill extends in a northwest –southeast direction and a geological trench was excavated at the southernmost end of the northeast facing side. It exposed 2 meters of Ardu B sediments with an undifferentiated silt zone underlain by a zone of typical alternating silt and sand with a thin gravel layer at the base. This lower zone is designated "sand/gravel" in contrast to the overlying Ardu B "silt." A single archaeological horizon occurs in association with this sand/gravel. This "sand/gravel" directly overlies undifferentiated lower Ardu B sediments which contain a concentration of small pumice nodules within its upper 50 cm Six K-A determinations of this pumice yielded an average age of 180 K. Samples of overlying lower Ardu B sand were collected for luminescence dating.

Figure 41. Aduma site A8. Excavation is into Ardu B hillside.

A trench 8 m x 2 m was excavated in and parallel to the northeast face of the hill with its southeast end immediately adjacent to the geological section. While the entire floor of all of the "innermost" row of squares intersected the archaeological horizon, because of the irregular shape of the hillside in parts of the "outermost" row, erosion had removed portions of this horizon. The well-defined tightly vertically constrained surface contained a thin scatter of MSA lithics, fauna and

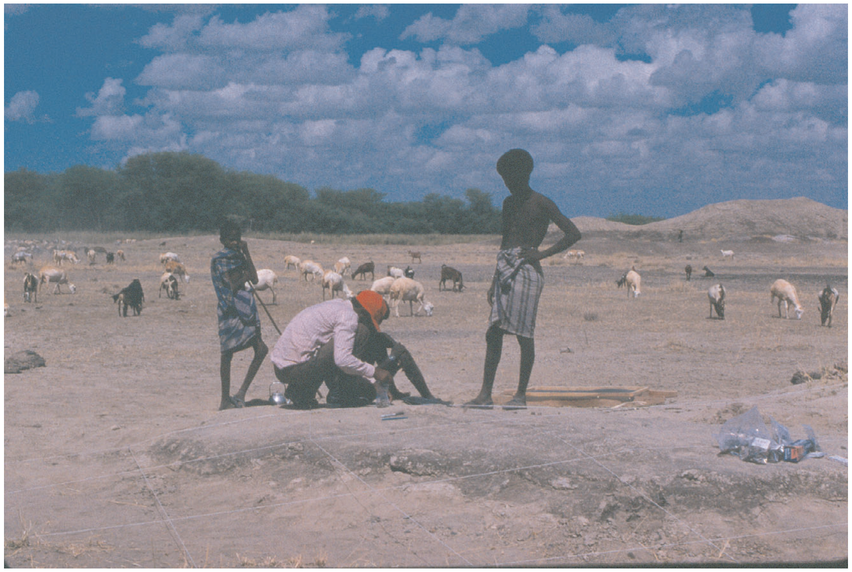

Figure 42. Aduma site A8A. The site consists of a low raised area of Ardu B sediment. The sediment in near and far background is also Ardu B. Trees mark the edge of the Awash River fringing forest.

Figure 43. Aduma site VP 1/1. Foreground and right background consist of Ardu B sediment. Flags mark positions of hominid cranium fragments.

Unio sp., Corbicula sp., many with shells attached at the hinge, and the univalve Melanoides sp. Five hundred bone specimens were recovered from the excavations at A8, 80–90% were fish. Identifiable tetrapods included twelve identifiable teeth and enamel fragments and 12 unidentifiable enamel fragments (Table 3). Post-cranial elements include a vertebral body, rib and 7 long bone shaft fragments of medium mammal (the latter broken while fresh) and a fragment from a crocodile pelvis. Carnivore tooth marks are found on one specimen. Red clasts also occurred. Materials were collected in 25 cm x 25 cm units.

A8A

In 1995 Brooks discovered a small roughly elliptically shaped area 17 m by 5 m which was raised ca. 25 cm above ground surface with portions of its surface covered with a dense concentration of well-preserved fauna and lithics (Fig. 40). The western margin of this low pediment was likewise marked by band of exposed materials which had eroded from the deposit and come to rest on the valley floor. The site, designated A8A (10.23.55 N; 40.32.24 E), is located 106 m. south of A8 and east of

A8B. The research team covered exposed surfaces with sand and flat stones to reduce further erosion and conducted excavation in 1996 and 1998. The site was gridded into one meter squares and surface material collected from the tops and eroded edges of 14 of them. An additional 14 squares were subdivided into 20 cm sq. units and excavated by stratigraphic unit to expose the Ardu A surface. Small .5 m X .5 m test pits in both northern and southern portions of the side indicate that this underlying layer is devoid of lithic material. A complete hippopotamus vertebra with intact fragile dorsal and lateral spinal margins indicates that this now compact sediment was once sufficiently soft and waterlogged to permit burial of the bone (through trampling?) into it. The uneven Ardu A surface reflects trampling by hippopotamus and/or other large mammals. Over most of its surface A8A is capped with a thin ca. 8 cm layer of Ardu B silt. In the southern-most portion this is replaced by a hard consolidated “mudstone” deposit. The base of this silt-mudstone is separated from the top of Ardu A by a laterally variable layer of sand, silt and gravel ca. 5 cm in thickness. This corresponds stratigraphically to the lithic bearing layer at A8 and also contains Unio sp. and Corbicula sp.) with some of the bivalves in occluded position. Two, and possibly three cultural horizons are present. In an upper horizon at the contact between Ardu B/mudstone/silt and underlying sand/gravel, abundant lithics with fresh unrolled edges are oriented with planar surface horizontal. The underlying gravel layer contains both fauna and lithics in varying concentrations. These lithics in contrast have rounded edges and varying orientations. Red clasts were situated within the site. Although likely mixed, surface materials were collected separately and analyzed as a discrete unit.

At A8A 3,100 bone fragments were recovered, and again the majority of these were fish. Thirty-nine teeth were recovered, including a hemimandible of Kobus ellipsiprymnus with all cheek teeth in place, 75 identifiable enamel fragments and 72 enamel fragments of mammalian indet. Definite stone tool cut marks (v-shaped, internal striations) were found on an unbroken adult hippopotamus humerus and several ribs, as well as on infant hippopotamus bones. Rare specimens have carnivore gnaw marks, including a crocodile vertebra with punctures of the size range made by very large predators.

A8B

A peninsula of Ardu B sediment standing more than 10 m above the level of the adjacent modern Awash floodplain extends from a larger massif of Ardu B and capping Ardu C deposits to a point ca. 50 m. west of site A-8A. Partial remains of two hippopotamus skeletons, each with a tightly associated cluster of MSA lithics, are exposed on the surface. Additional skeletal remains lower in the Ardu B deposit are exposed in the eroding northern side of the peninsula. The site was discovered in 1995 and the following year a surface collection was made of the lithics associated with one of the fully exposed skeletons. Because of the difficulty of transporting large fragile faunal remains

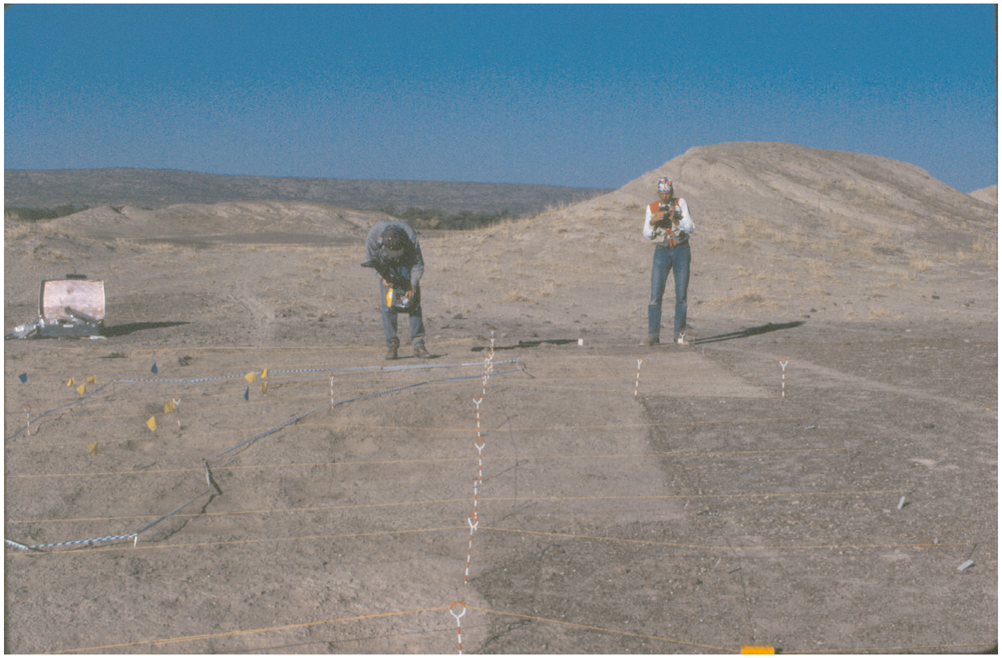

Figure 44. Aduma Site VP 1/3 Both foreground and immediate background sediments are Ardu B. Flags mark positions of hominid cranium fragments.

the skeletal material was left in situ. Although the surface was not scraped and screened, very few small flakes were observed and likely little was missed. No remains attributable to species other than hippopotamus were observed. The lithics are large and derive from a single basalt type. A8B is the sole site which can reasonably be attributed to a single known activity. Hominids most likely butchered a hippo, dead from unknown causes, by obtaining basalt from outcrops perhaps several kilometers distant, likely trimming the raw material at the collection point and then carrying out final reduction at the butchering site.

Sites VP1/1 and VP 1/3

The Aduma deposits were surveyed by Haile-Selassie et al. (2004) who collected hominid remains from two areas. Both were in a terrain where Ardu hills had apparently been nearly eroded away. Thus the apparent original context of these remains was near the base of the main Ardu B silts and sands. There are no Ardu C deposits preserved near these collecting areas. Both are in a broad region encompassed by archaeological locality A-2.

VP1/1 ("VP", "Vertebrate Paleontology" denotes a separate specimen recording system maintained by the Middle Awash paleontology group.) In December 1994 Yohannes Haile-Selassie discovered fragmentary hominid cranial remains exposed on the erosional ground level surface (10.26.05N; 40.31.55 E) on the northern Aduma lobe (Fig. 43). A thin scatter of lithics and faunal remains and red clasts co-occurred with the cranial fragments and extended outwards over a larger area. There was no clear edge to the scatter. Hominid remains were plotted and collected and a surrounding area was swept and screened. In 1996 Brooks excavated a step trench in the immediately adjacent hillside and opened a series of 1 meter squares beneath the hominid remains.

This and the second hominid-bearing site described below, are situated between two small hills of Ardu B sediment. The step trench in the VP 1/1 associated hill revealed a sequence of silt underlain by alternating bands of sand and silt which included multiple shell horizons. No artifacts were recovered in the sediments overlying the exposed archaeological surface which itself immediately overlay a dense horizon of shells contained within a Ardu B silt matrix. No in situ cranial remains were found, and some of the cranial fragments exhibit post fossilization weathering and some are unweathered. This strongly suggests that both hominid remains, as well as associated lithics and fauna, originate within the Ardu B and were in the process of exposure when discovered. There are over 3000 bone fragments from VP1/1. Thousands of these are fish, and many others completely unidentifiable because of severe fragmentation, post fossilization erosion or calcrete covering morphology. The most striking aspect of the fauna is the large percentage of fish bone and crocodile teeth (113). The mammal bones are often better preserved than at other sites. Like the other sites, weathering stages are not reliably observed on most of the bones, but when identifiable they are stage 0 or 1. NISPS presented in Table 3 include 45 identifiable mammalian teeth. There are also six horncores (3 of Kobus, 1 Reduncia, 1 Tragelaphus). A variety of post-cranial elements were also identifiable, including bovidae size class 2: NISP = 6; bovidae size class 3 = NISP = 6, large (cf. hippopotamus) NISP = 4 (vertebrae); medium mammal NISP = 4.

At VP 1/3 further fragmentary hominid cranial remains were discovered by Tim White in 1996. Located ca. 300 meters south of VP 1/1 and in the same stratigraphic context, fragments were plotted and collected (Fig. 44). The thin surface scatter of lithics and fauna within a 20 meter radius was collected by intensive surface crawl and comparison of lithic size distributions between sieved VP 1/1 and unsieved VP 1/3 suggests that few if any pieces were missed at the latter. Red clasts were also noted. The variable post-fossilization weathering exhibited by the cranial fragments also suggests nearly in situ material in early stage of erosional exposure. One occipital fragment exhibits a partial, weathered, circular perforation, wider on the ectocranial than endocranial surface. The shape and placement of this hole is consistent with carnivore activity, but the postfossilization erosion of the bone surface precludes a definitive conclusion. In total the Middle Awash team recovered fragments of four hominid crania from Ardu B sediments of which VP3 is the most complete. Haile-Selassie et al. conclude all fall within the range of anatomically modern humans.

ACKNOWLEDGMENTS

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APPENDIX C

FIGURES 4–33

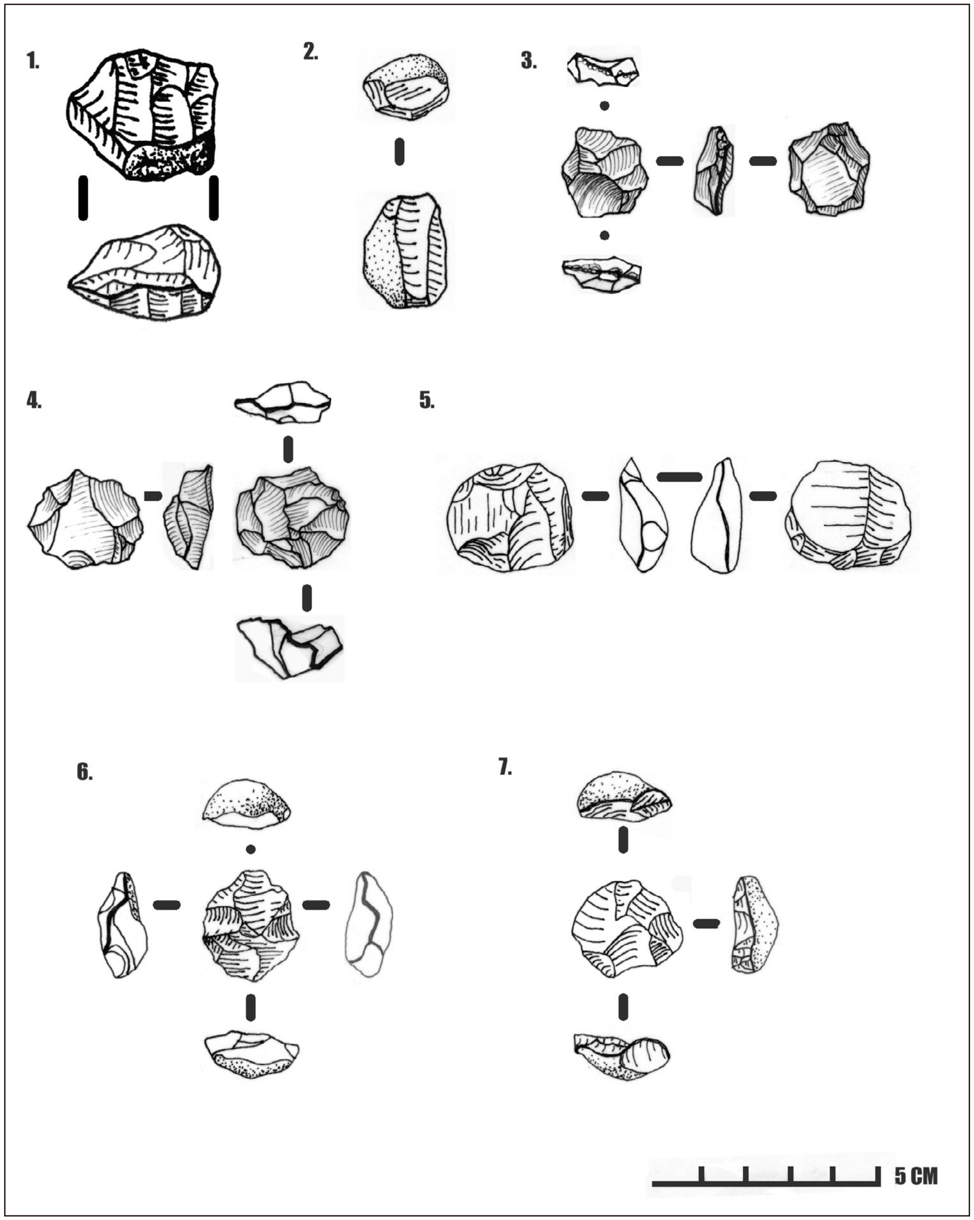

Figure 4. Aduma lithics. 1. (site A5) core, blade, 2. (A5) core, bladelet, 3, 4, 5. (all A5) core, micro Levallois, 6, 7, (both A5) core, micro Aduma.

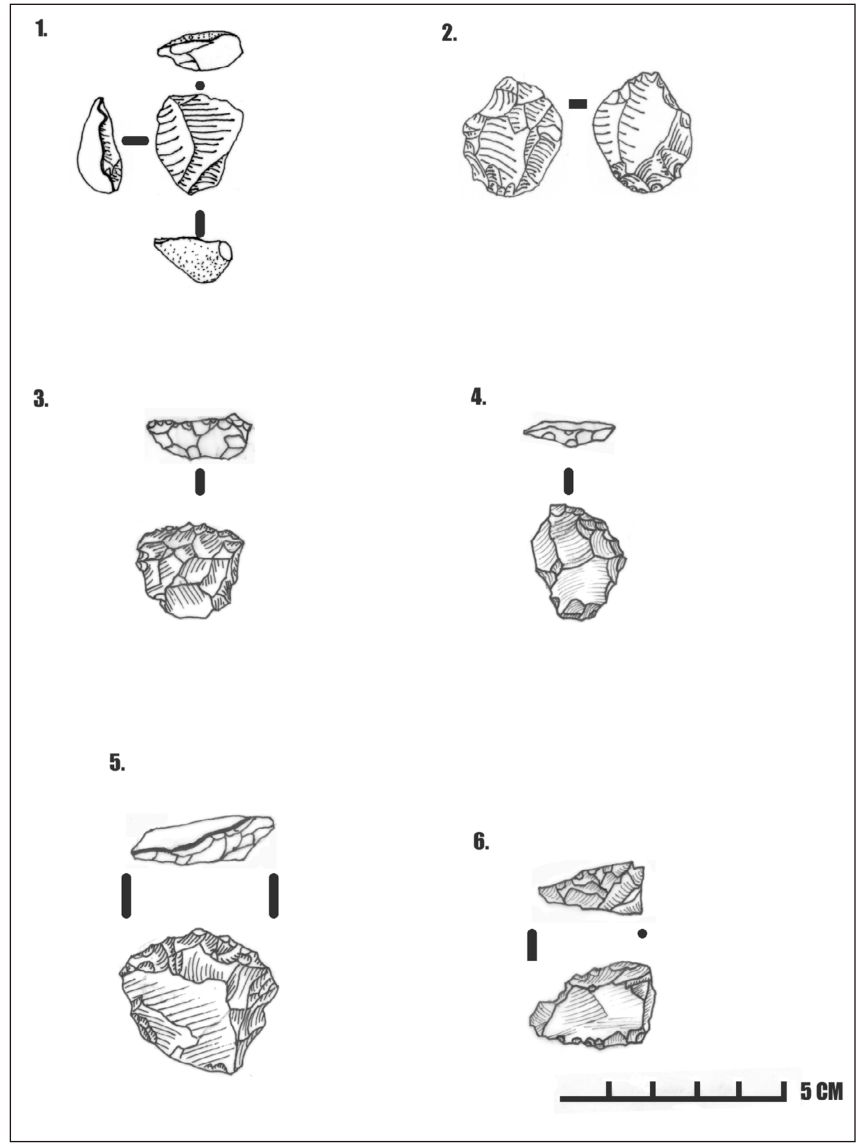

Figure 5. Aduma lithics. 1. (A5) core, micro Aduma, 2. (A5) scraper, mini, 3, 4, 5. (all A8A) scraper, small convex, 6. (A8A) scraper, tabular quartz.

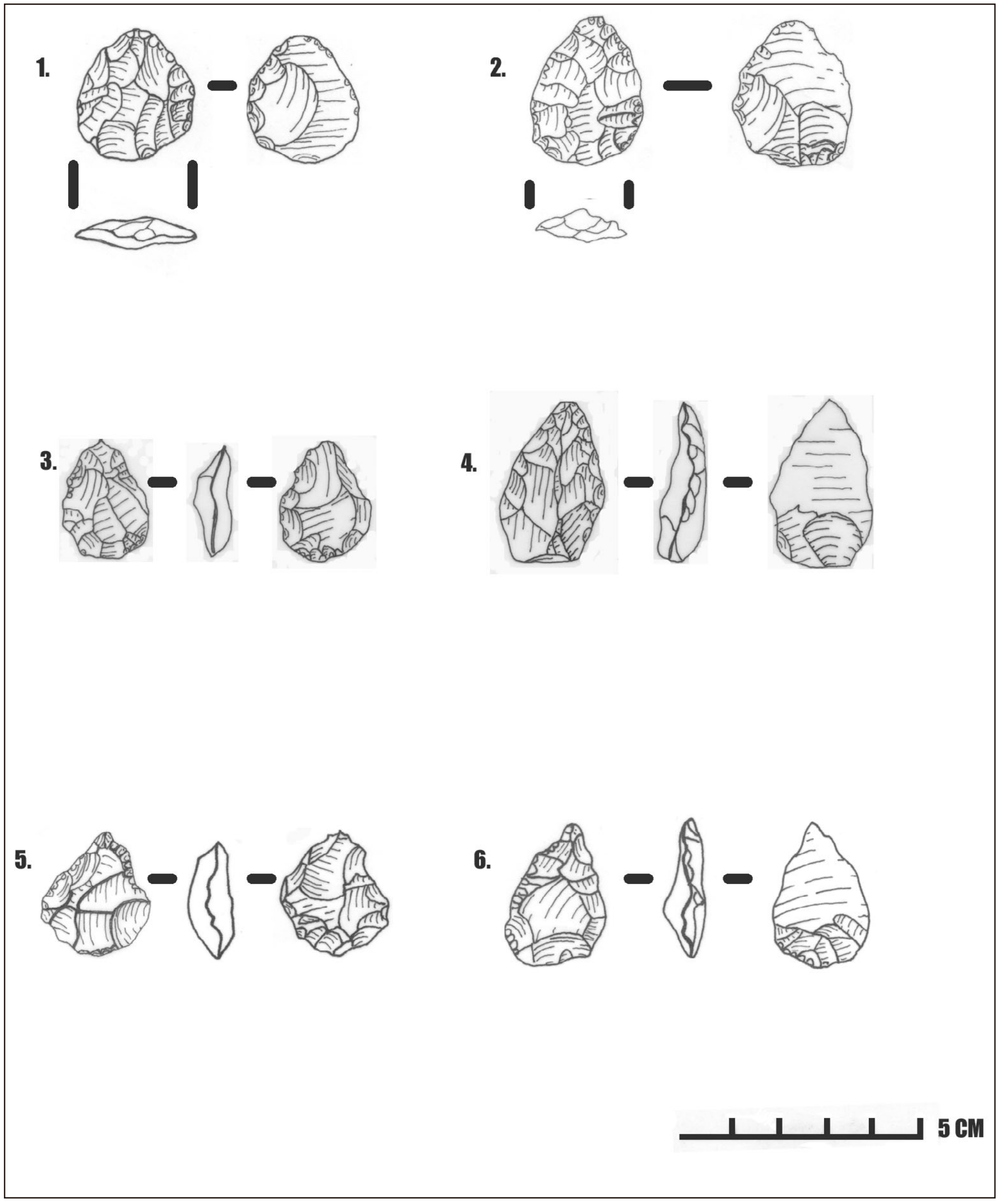

Figure 6. Aduma lithics. 1, 2. (both site A8A) point, short broad, 3. (A5) point, small blunt, 4, 5, 6. (all A5) point, acute tip.

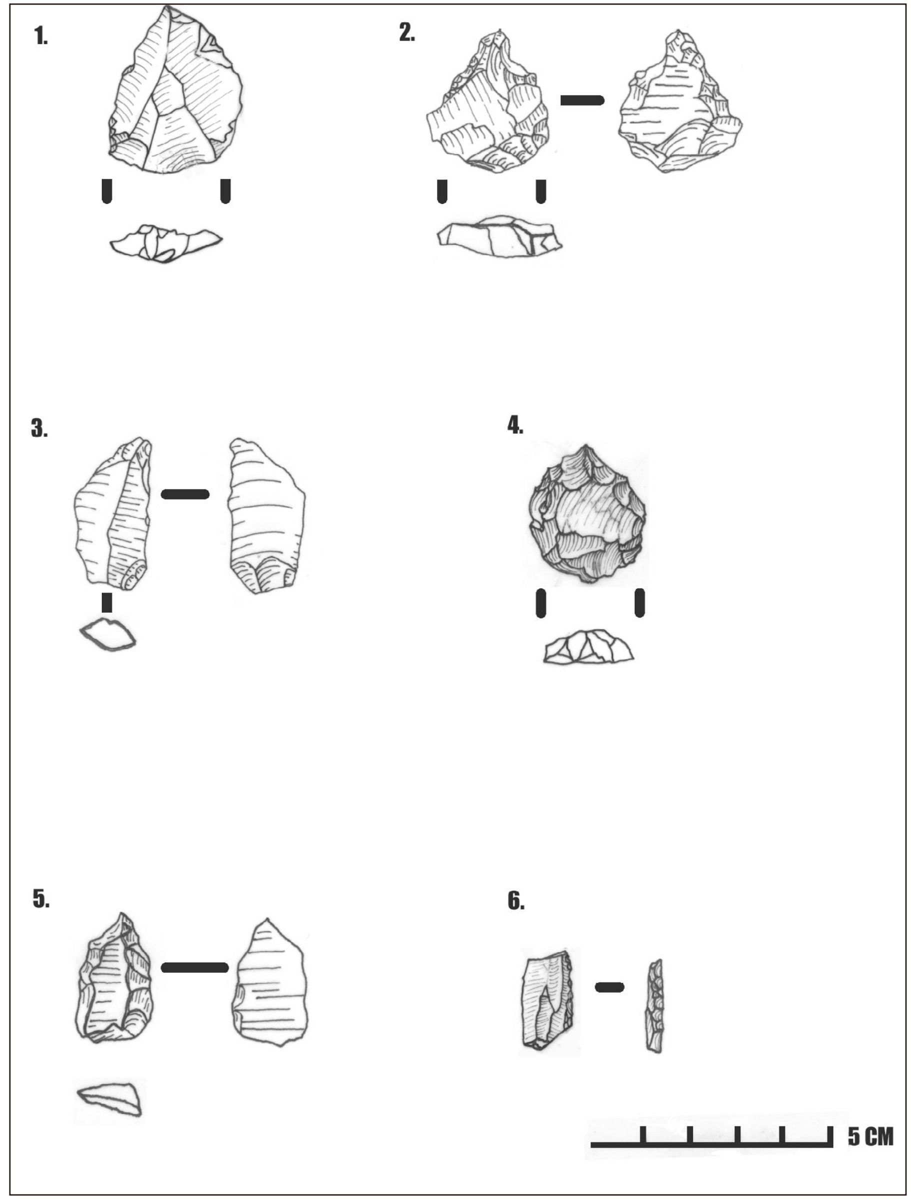

Figure 7. Aduma lithics. 1. (A5) point, Levallois, 2. (A8A) perforator, 3. (A8) perforator/borer, 4. (A8A) point/perforator, 5. (VP1/1) point/borer, 6. (VP1/1) bladelet, retouched.

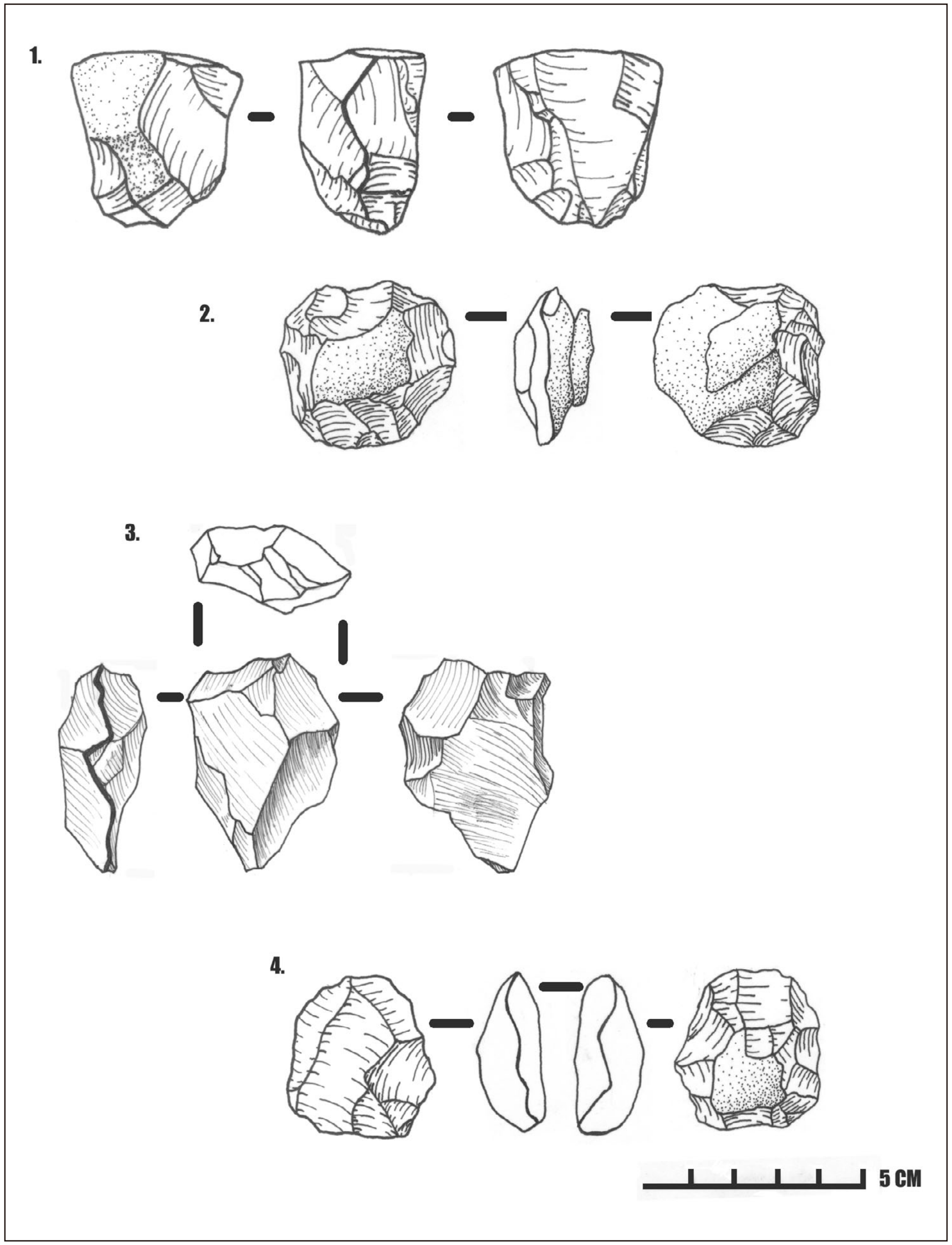

Figure 8. Aduma lithics.. 1. (site A5) core, blade, 2. (A1) core, discoidal, 3. (A5) core discoid partial, 4. (A5) core, Levallois.

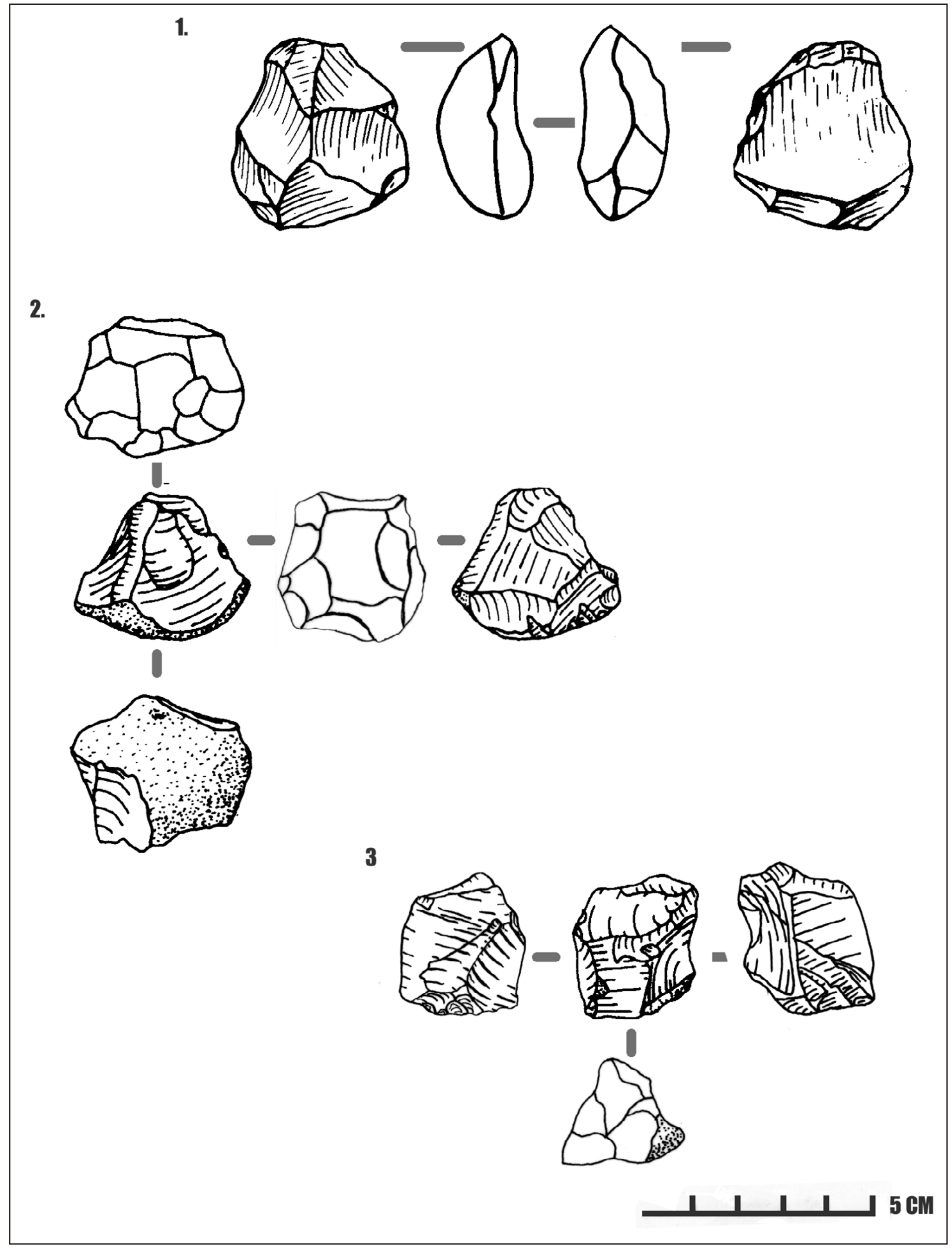

Figure 9. Aduma lithics. 1. (A5) core, Nubian, 2. (A4), 3. (A8) core, multidirectional.

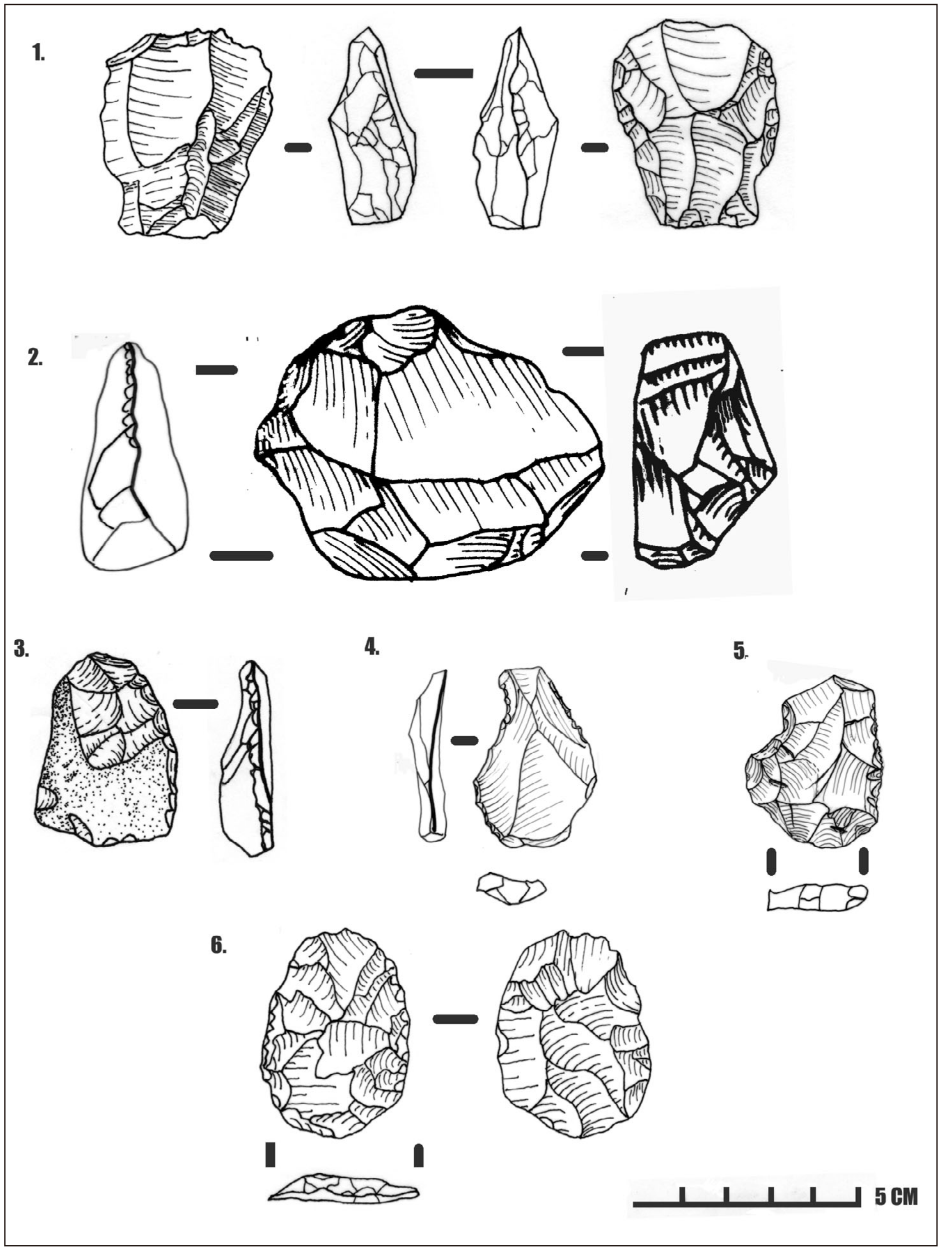

Figure 10. Aduma lithics. 1. (A8A) scraper, core, 2. (A5) scraper, end, 3. (A5) scraper, side, 4, 5. (both A5) notched flake, 6. (A4) ovate.

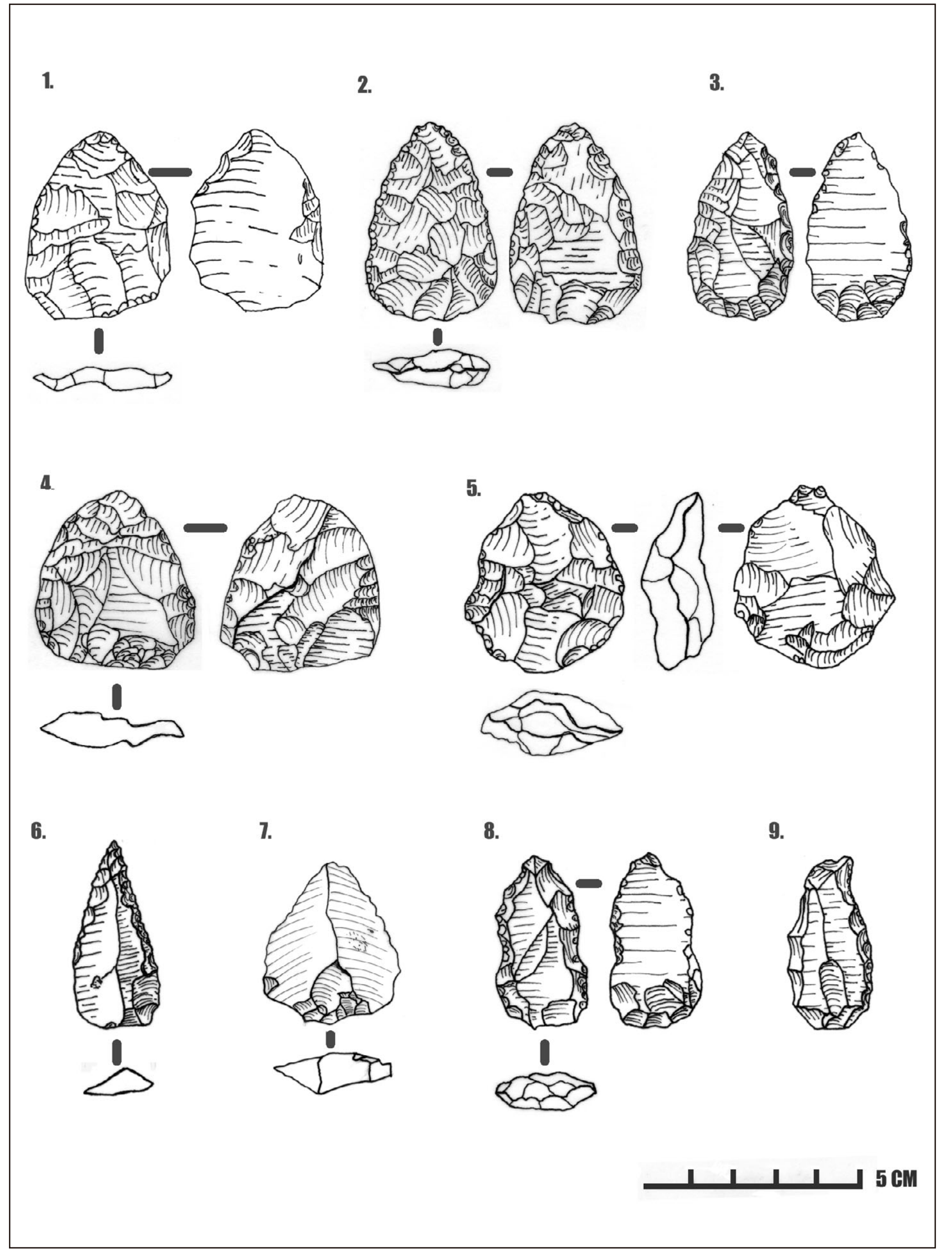

Figure 11. Aduma lithics. 1 (site A4) , 2 (A8), 3 (A8A) , point, classic MSA, 4, 5. (both A4) point, short broad, 6. (VP1/3) point, acute tip, 7. (A5) point, Levallois, 8, 9. (both A8A) perforator.

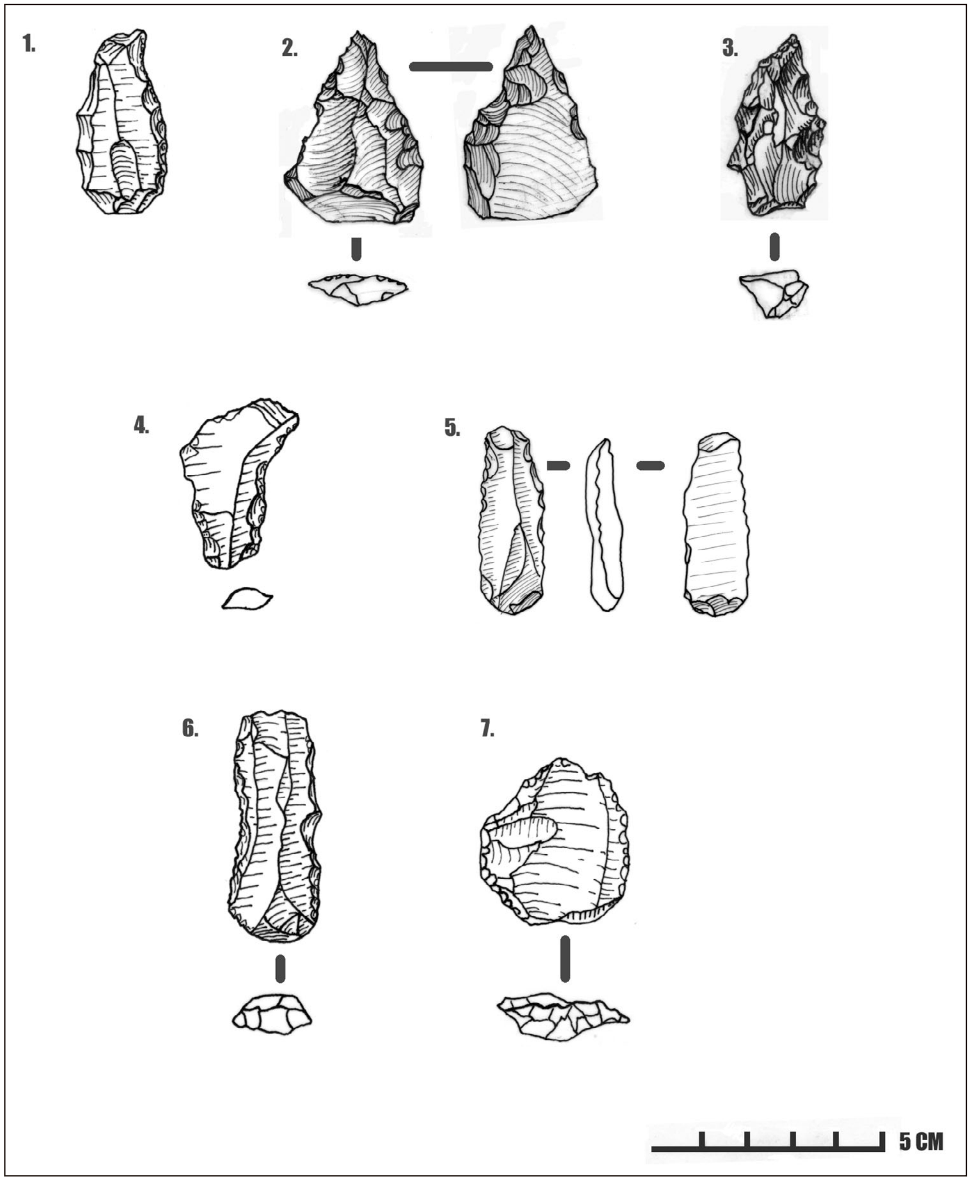

Figure 12. Aduma lithics. 1. (A8A) perforator, 2. (A8A) point/perforator, 3. (A8A) point/borer, 4 (A5), 5 (VP1/3), 6 (VP1/3). blade, retouched, 7. (A8A) flake, retouched.

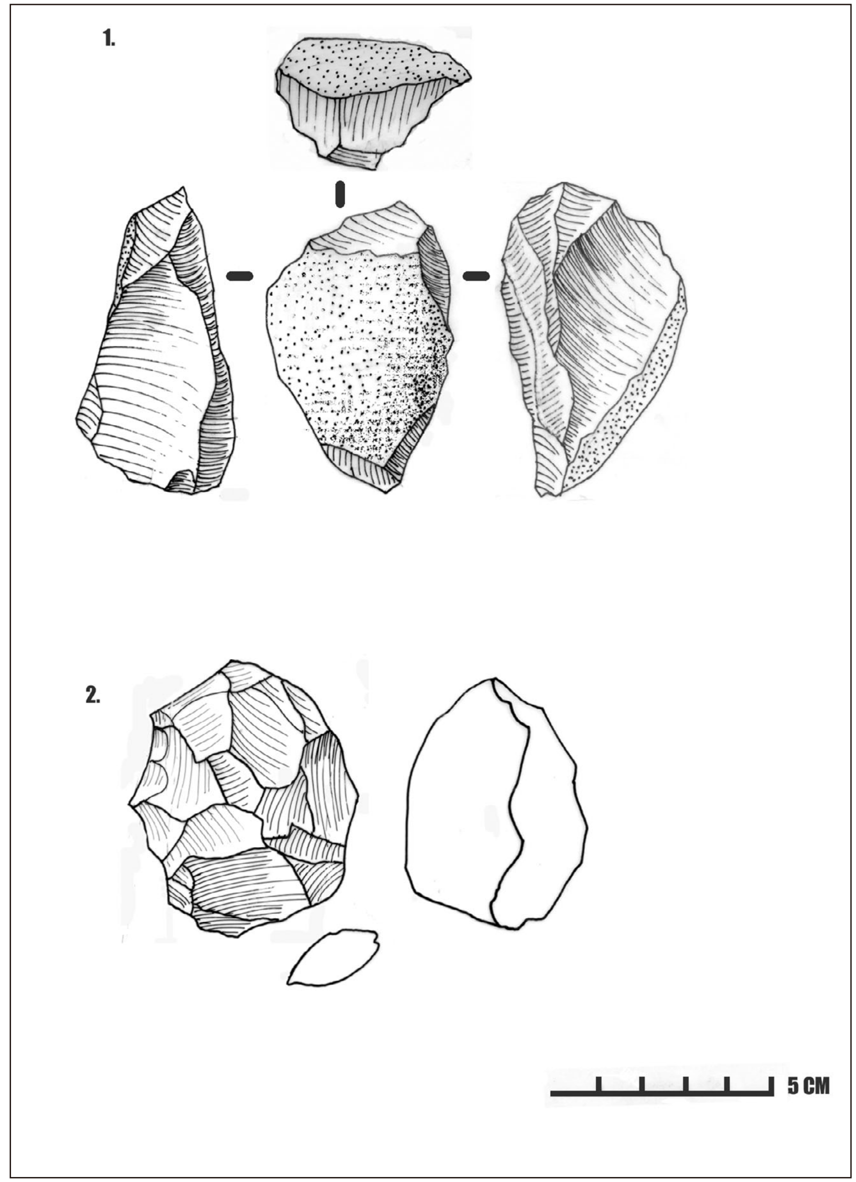

Figure 13. Aduma lithics. 1. (site A5) core, amorphous, 2. (A1) core, discoidal.

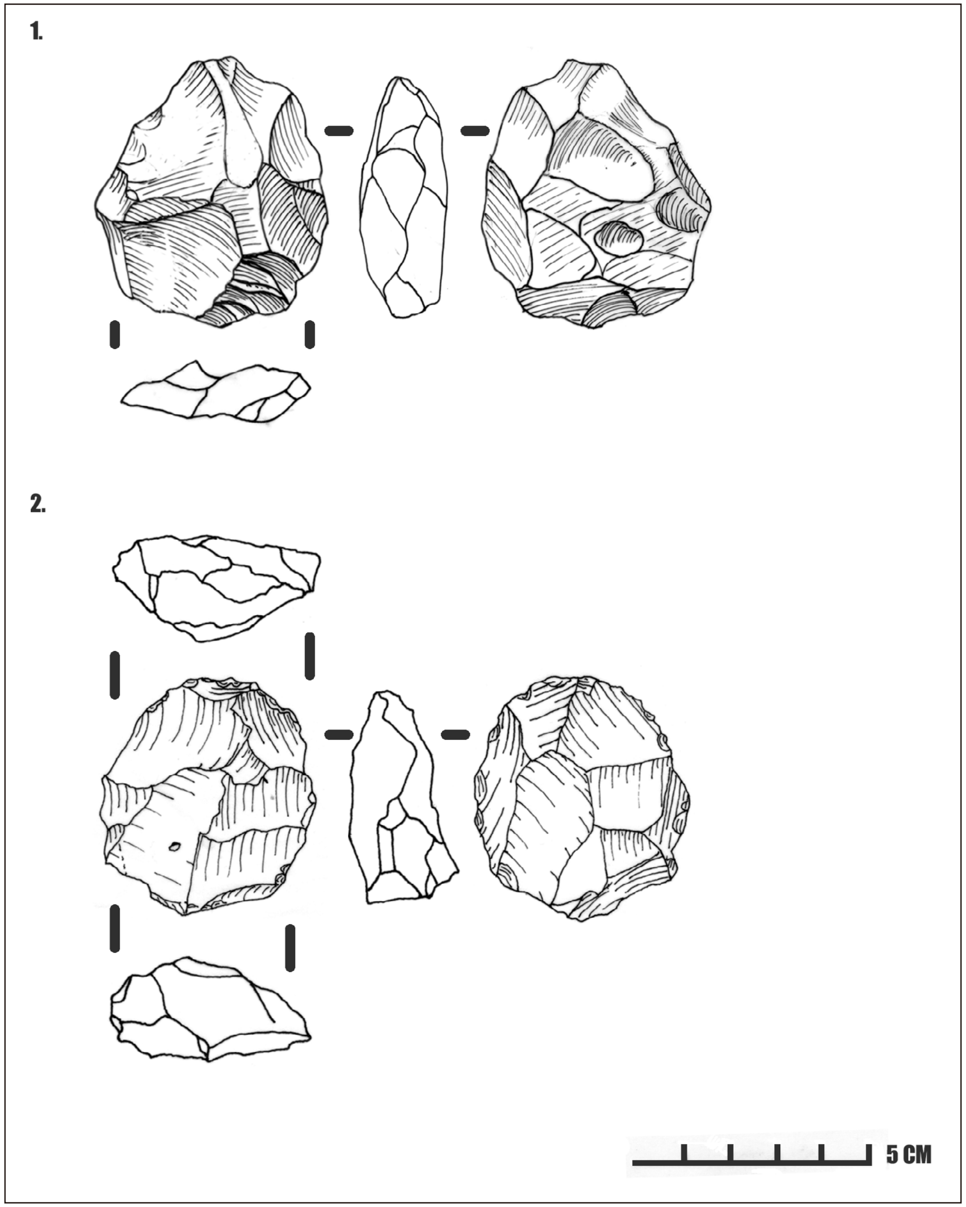

Figure 14. Aduma lithics. 1. (A1) core, Levallois, 2. (A4) core, discoidal.

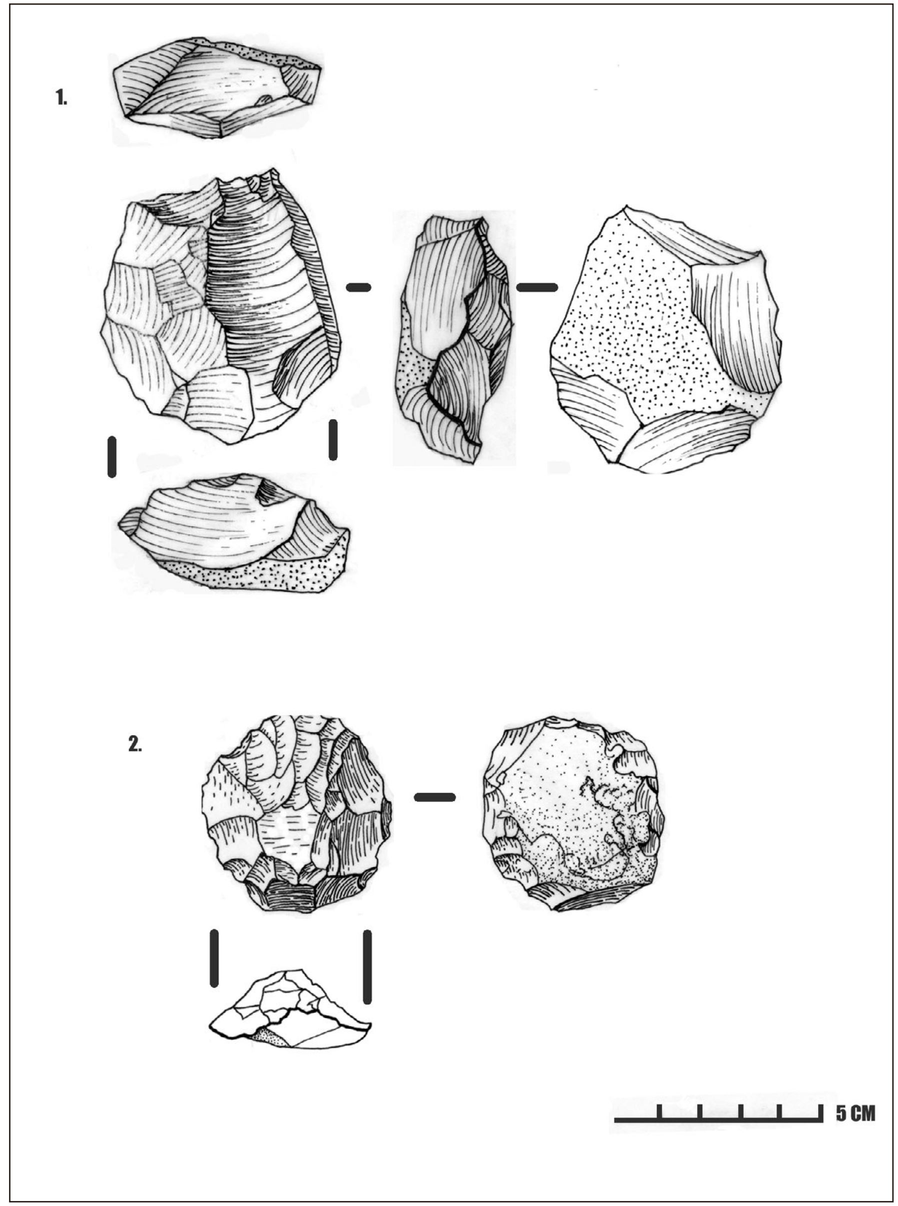

Figure 15. Aduma lithics. 1. (A5) core, Levallois blade, 2, (VP1/3) core, Levallois.

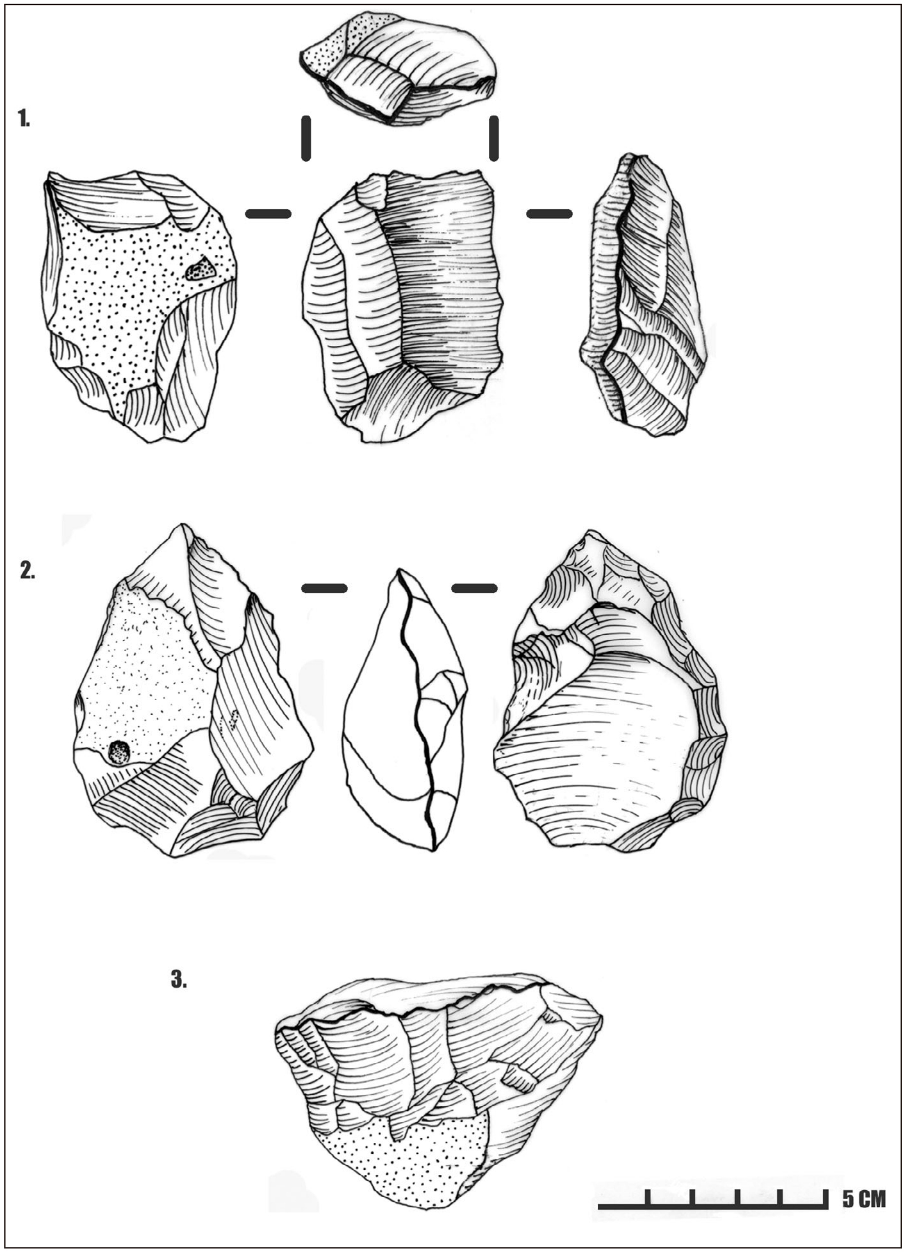

Figure 16. Aduma lithics. 1. (A5) core, Levallois blade, 2. (VP1/3) core, Nubian, 3. (A1) core, attempt blade.

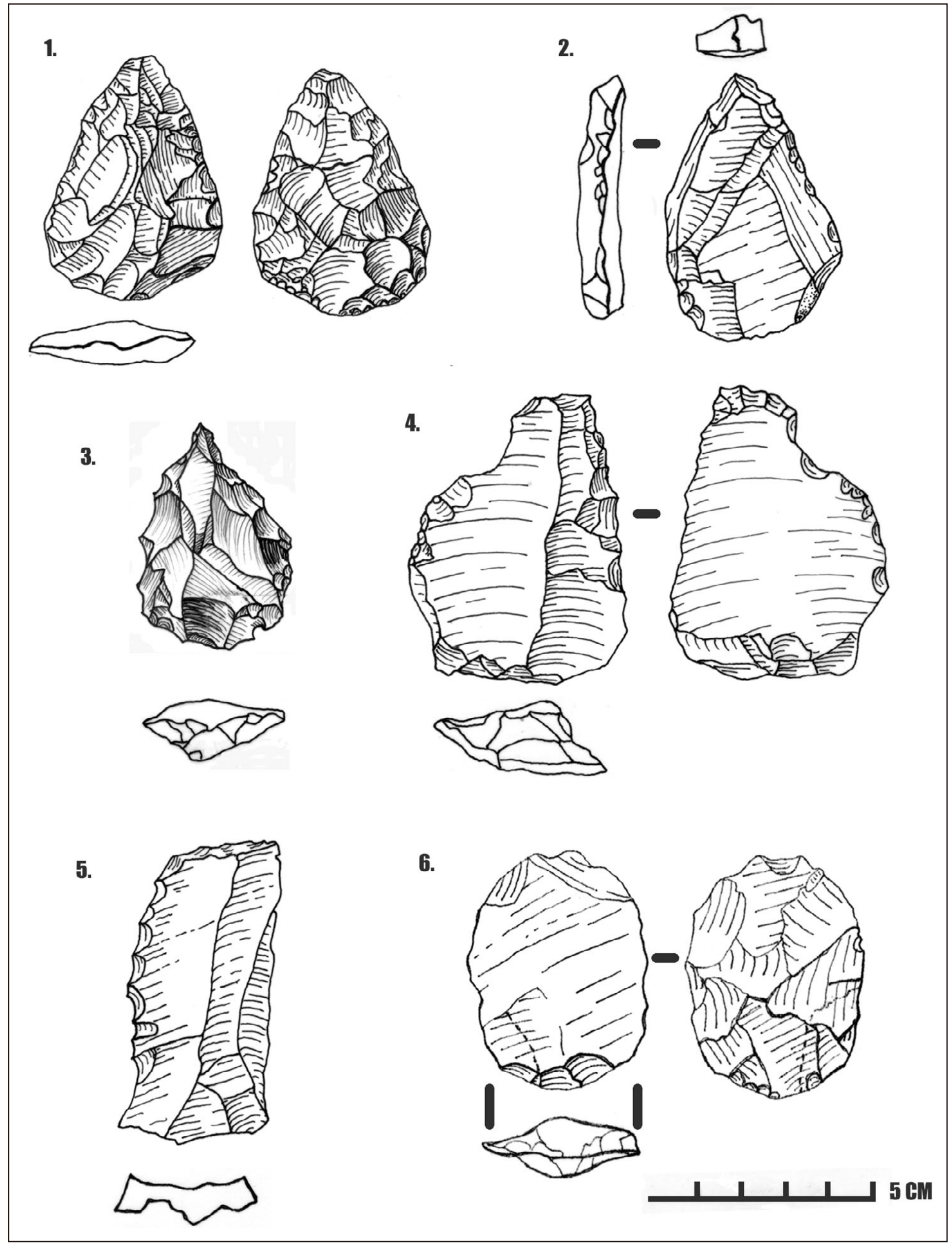

Figure 17. Aduma lithics. 1. (site VP1/3) point, classic MSA, 2. (VP1/1) point, Levallois, 3. (A8A) point/perforator, 4. (A8A) scraper, side, 5. (A8A) blade, denticulate, 6. (A4) ovate.

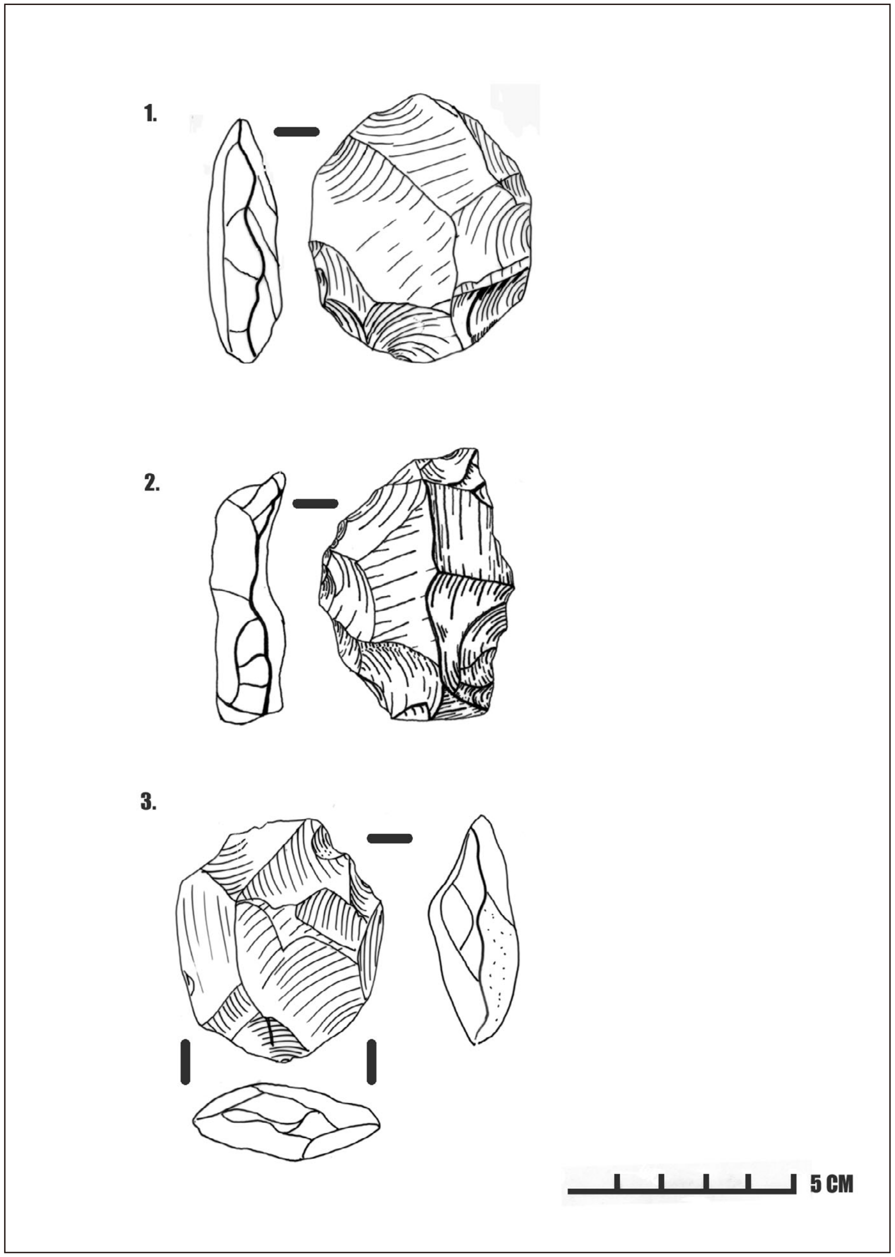

Figure 18. Aduma lithics 1, (VP1/1) 2 (A5), 3. (VP1/1) core, Aduma.

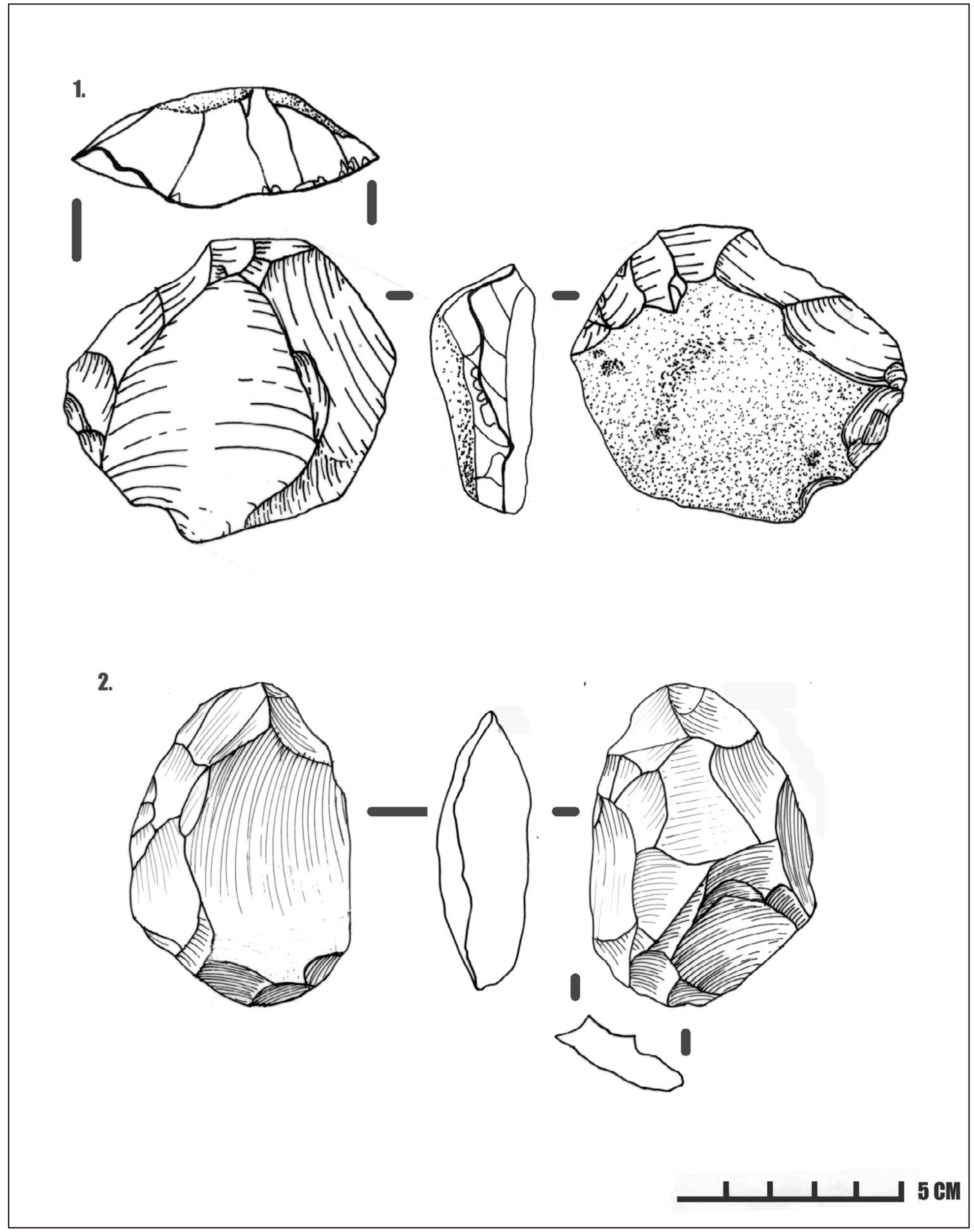

Figure 19. Aduma lithics.. 1, 2. (both site A1) core, Levallois.

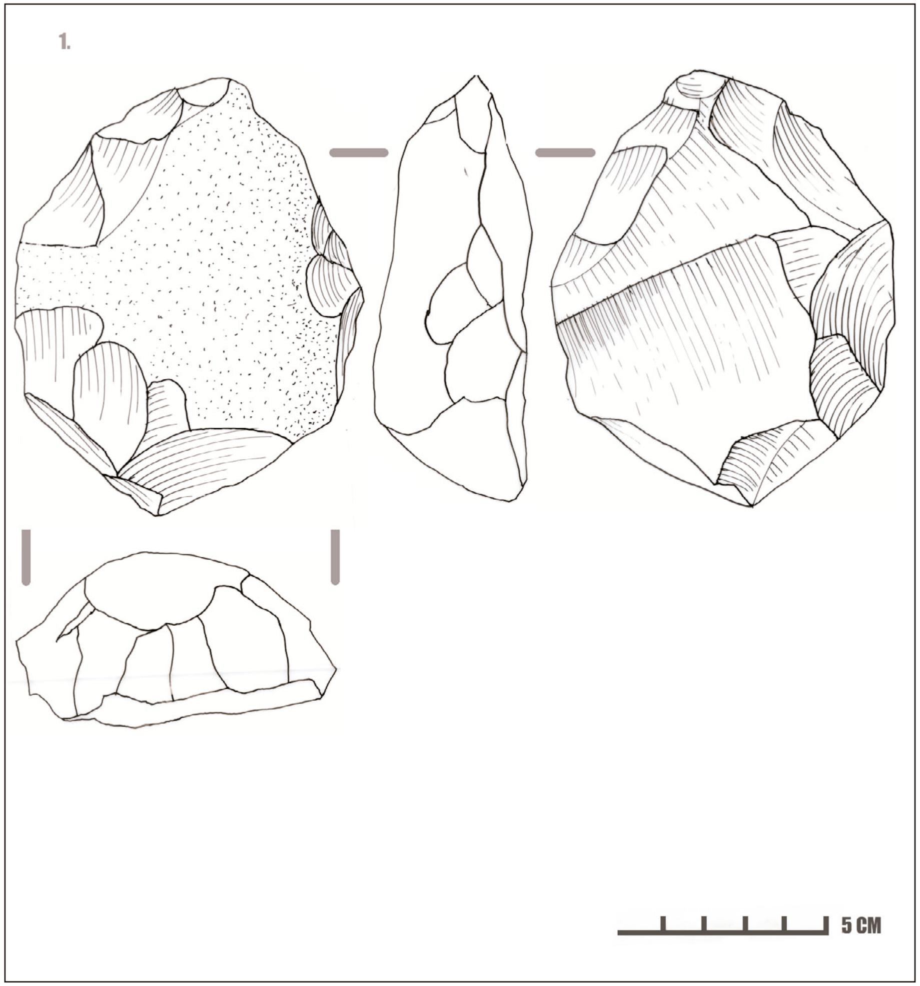

Figure 20. Aduma lithics. 3. (A1) core, Levallois approach.

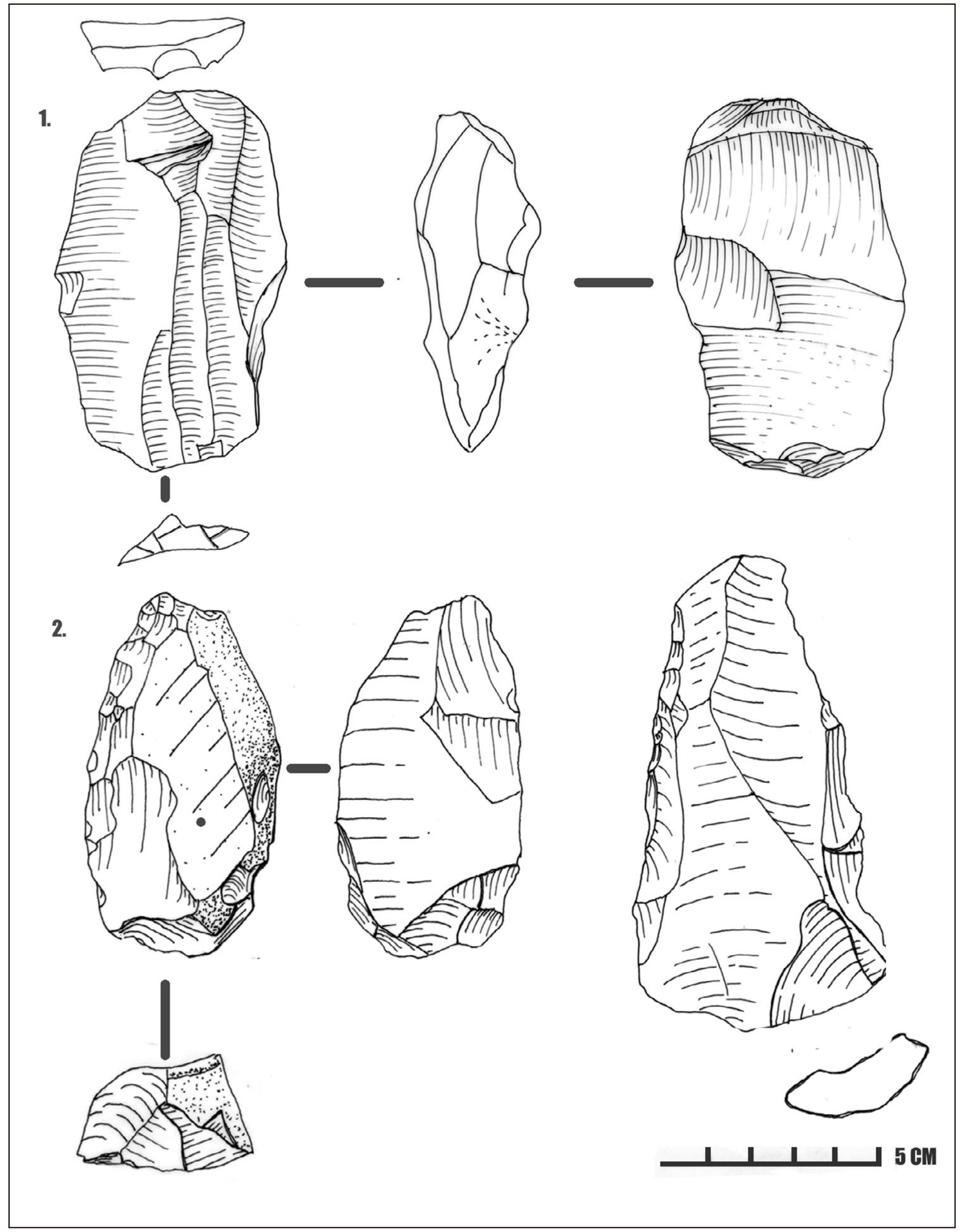

Figure 21. Aduma lithics. 1. (A8B) core, flat reversed, 2. (VP1/3) scraper, side, 3 (A4), Scraper, double side.

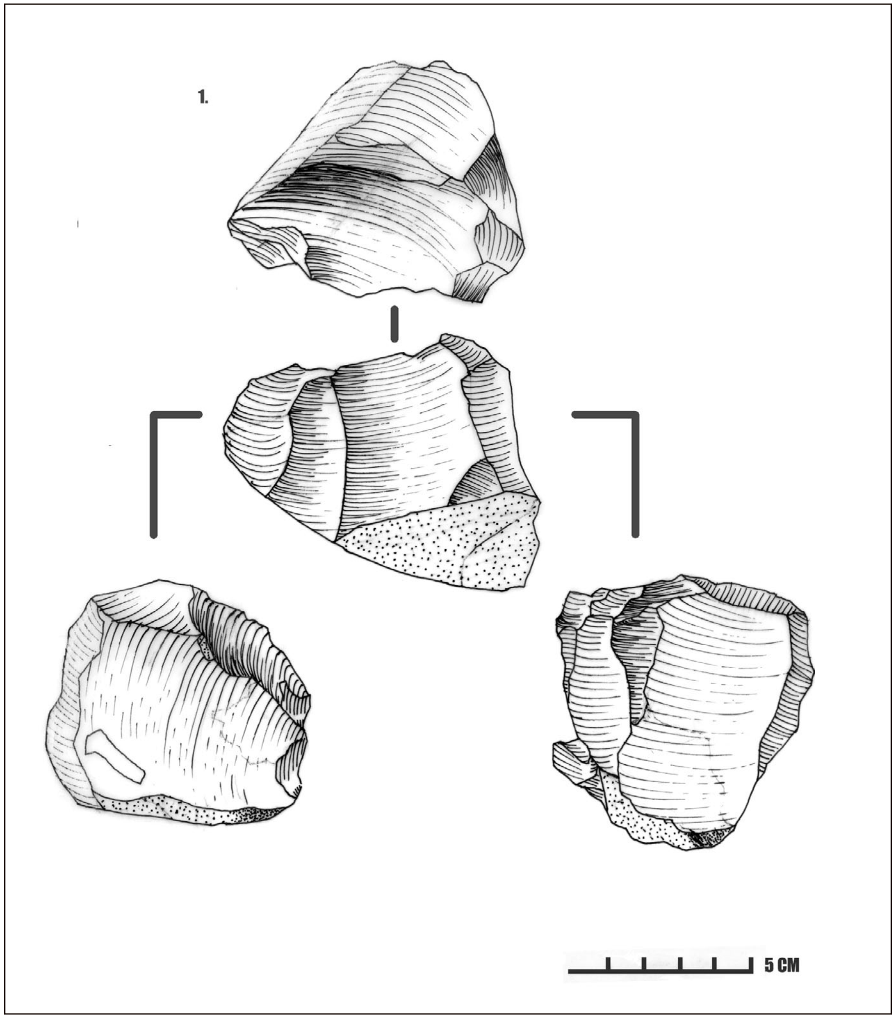

Figure 22. Aduma lithics. 1. (A5) core, single platform.

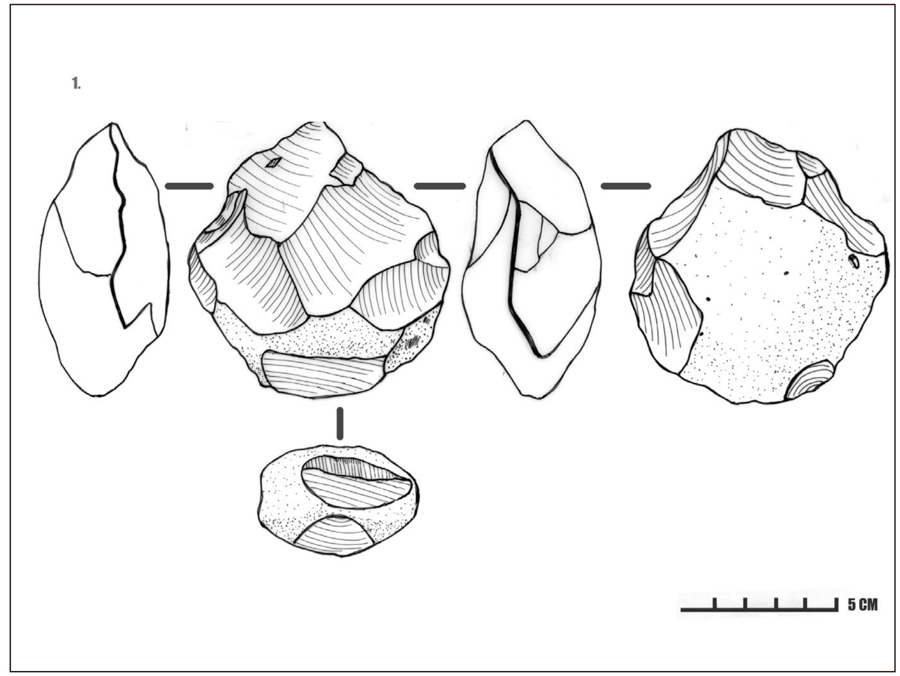

Figure 23. Aduma lithics. 1. (A5) core, chopper.

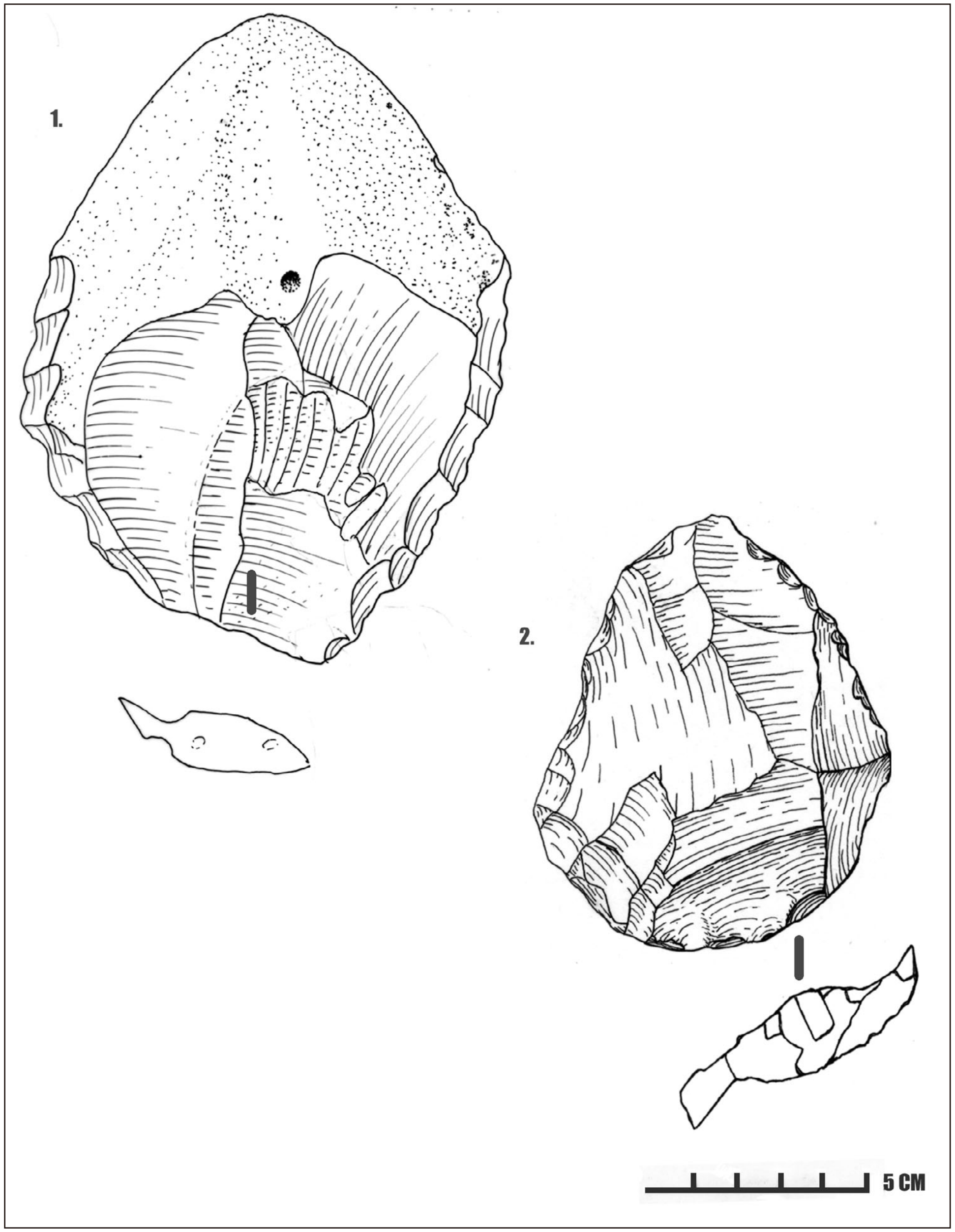

Figure 24. Aduma lithics. 1. (A8B) scraper, double side, 2. (A1) flake, retouched.

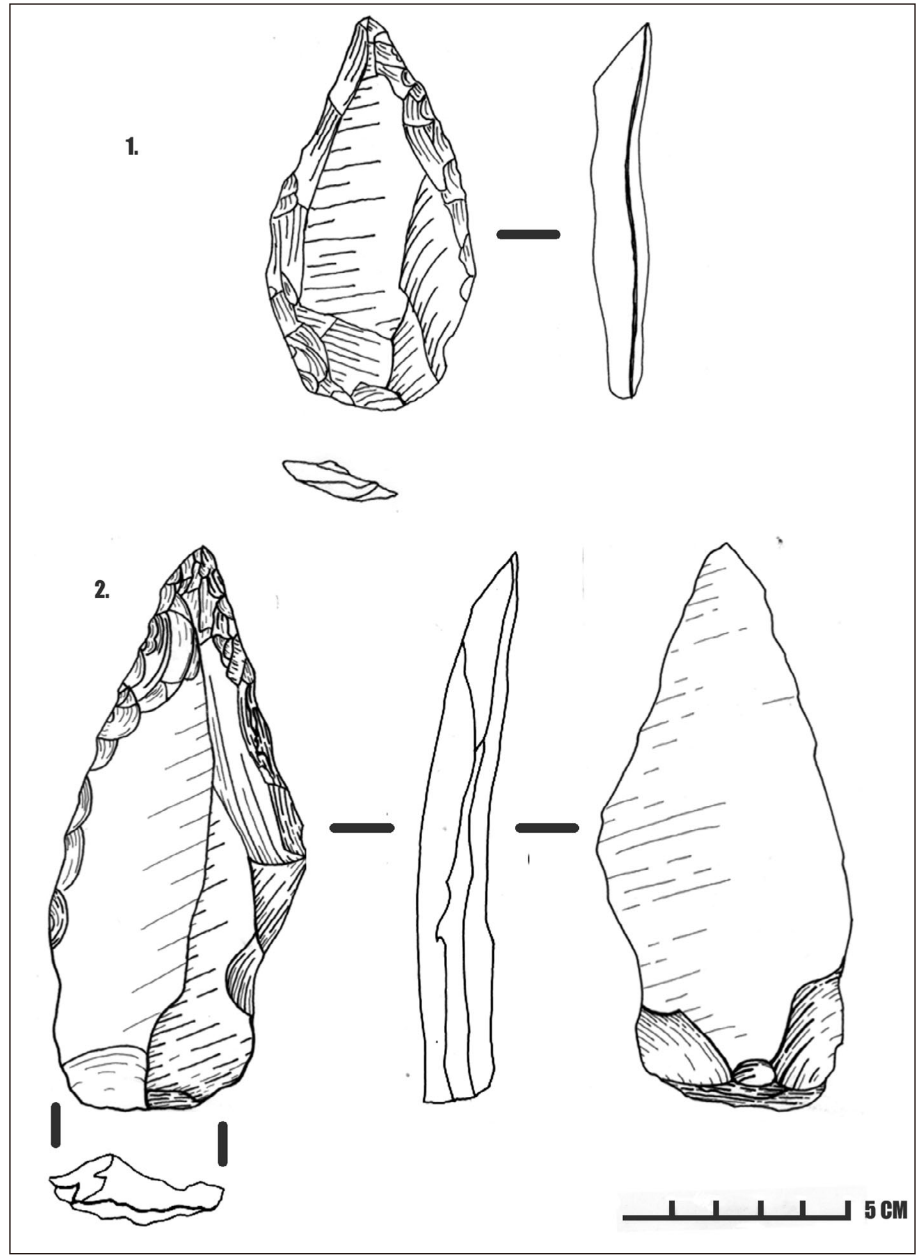

Figure 25. Aduma lithics.. 1, 2, (both site A1) point, Mousterian.

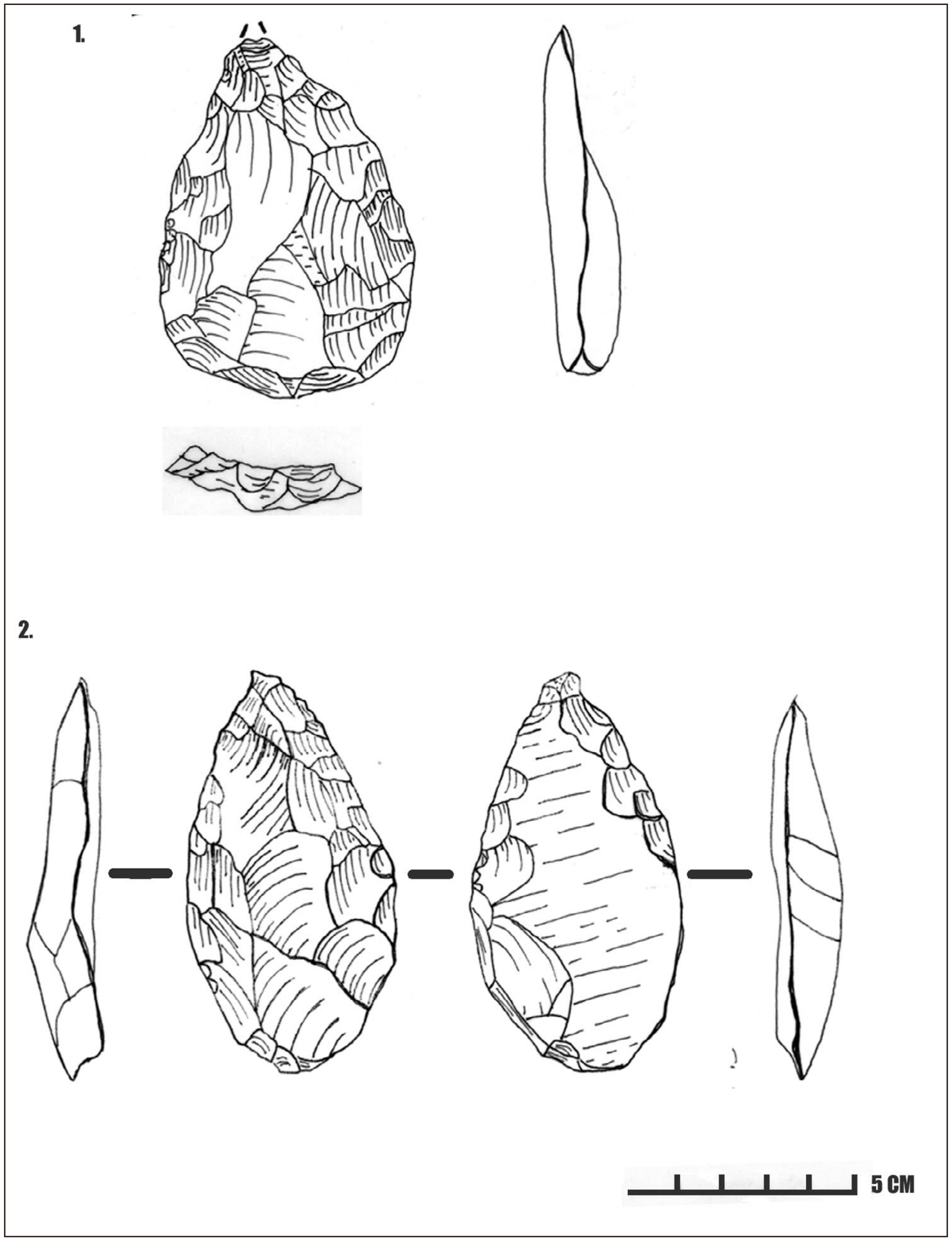

Figure 26. Aduma lithics. 1. (A1) point, Mousterian, 2. (A1) point, classic MSA.

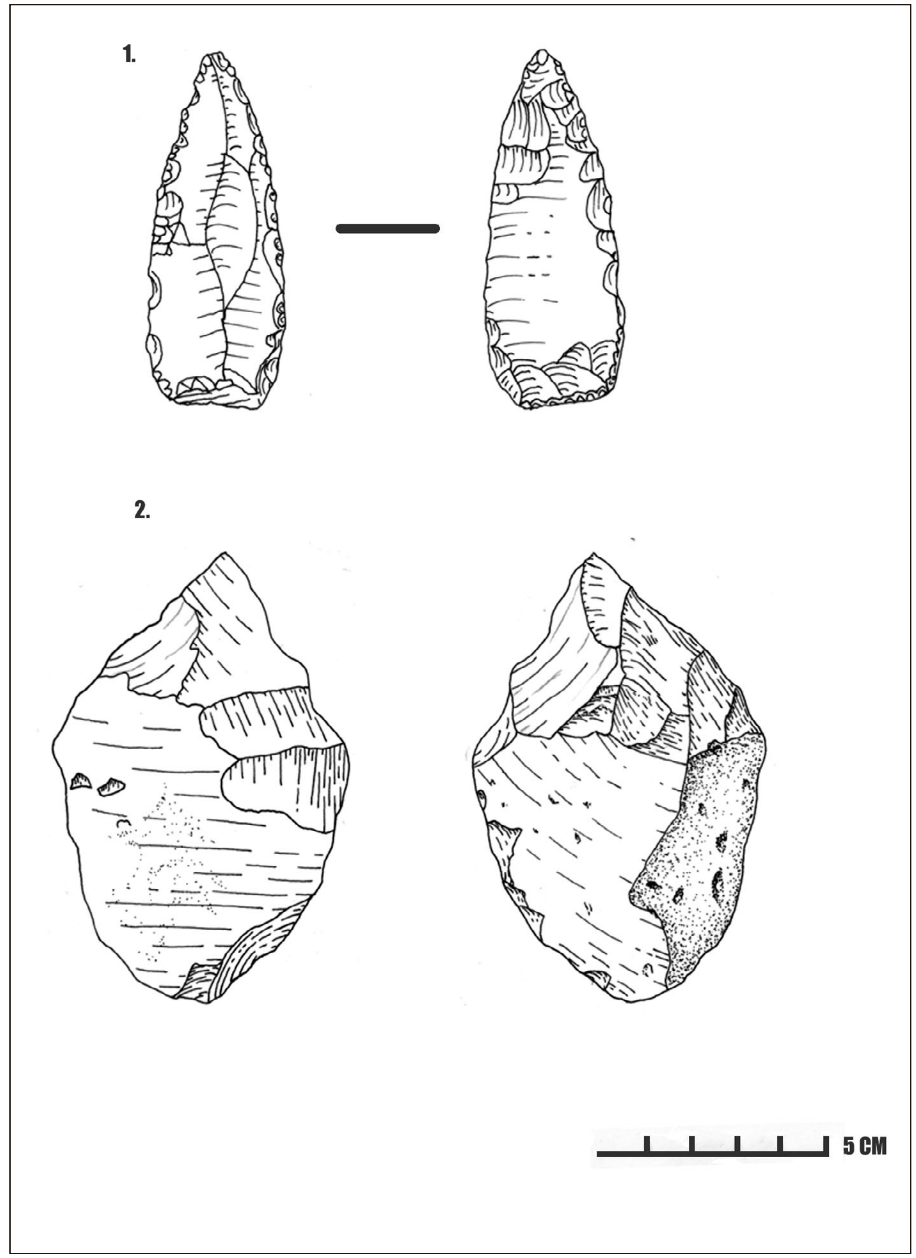

Figure 27. Aduma lithics .1. (A4) pointed blade, 2. (A5) pointed piece.

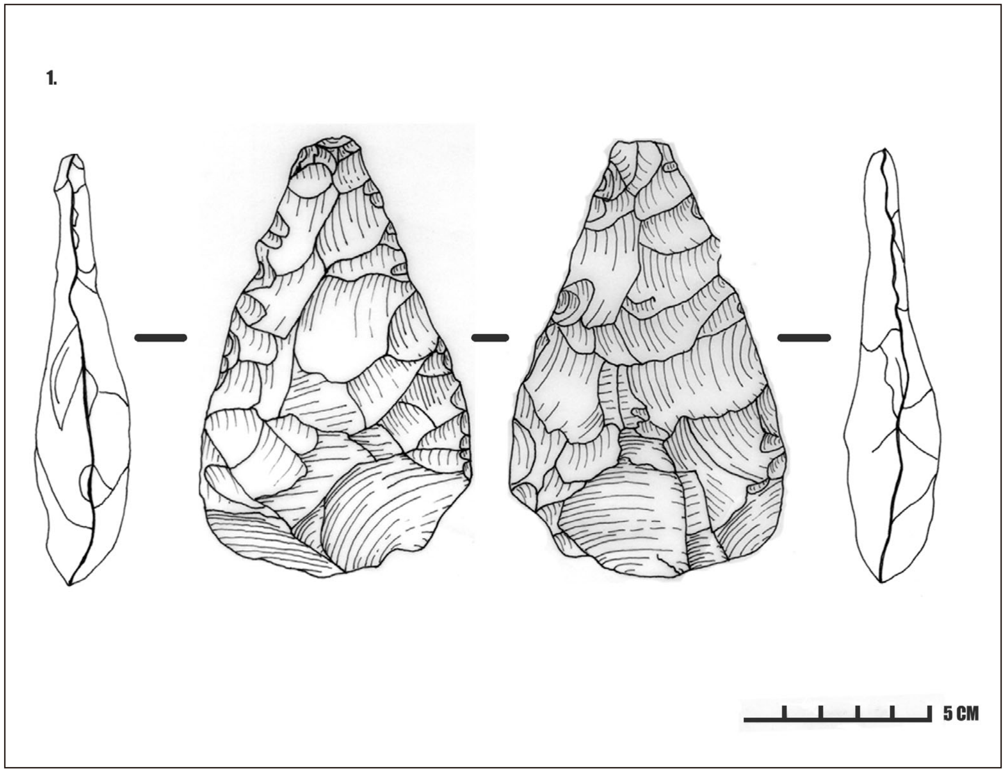

Figure 28. Aduma lithics. 1. (A1) point, biface.

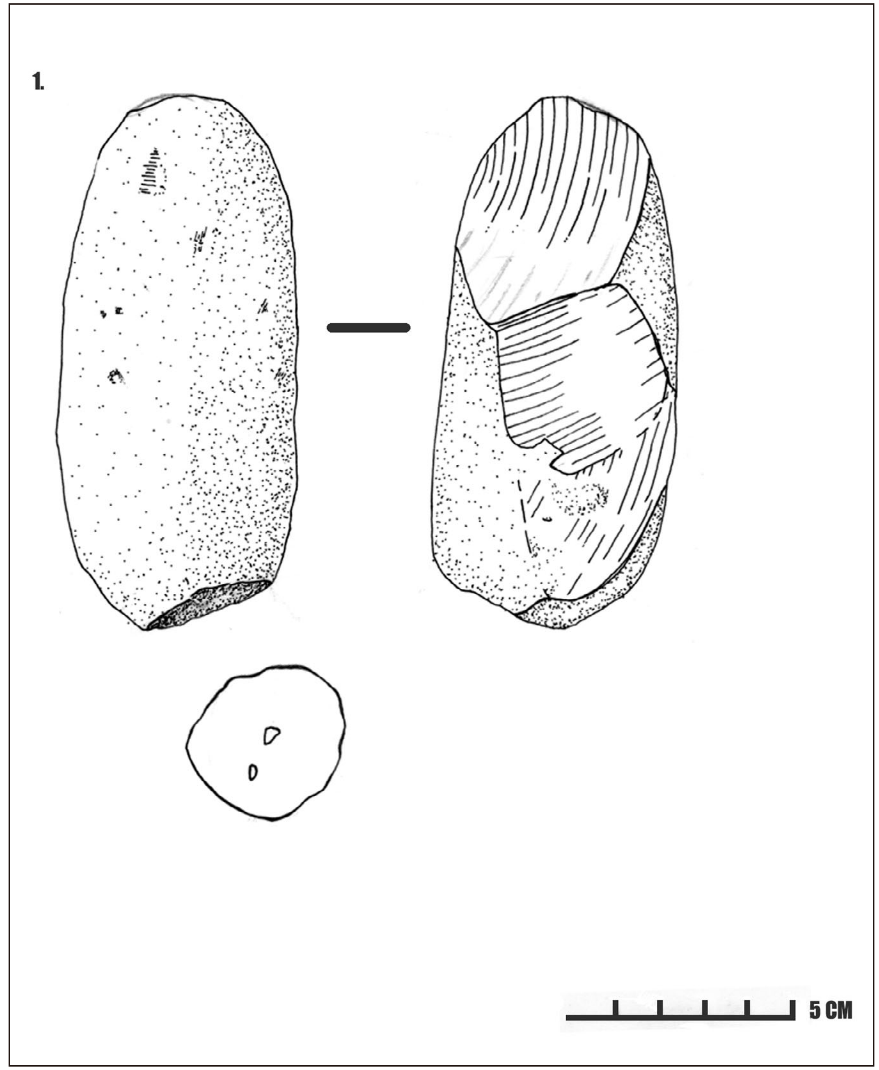

Figure 29. Aduma lithics. 1. (A5) pounding stone.

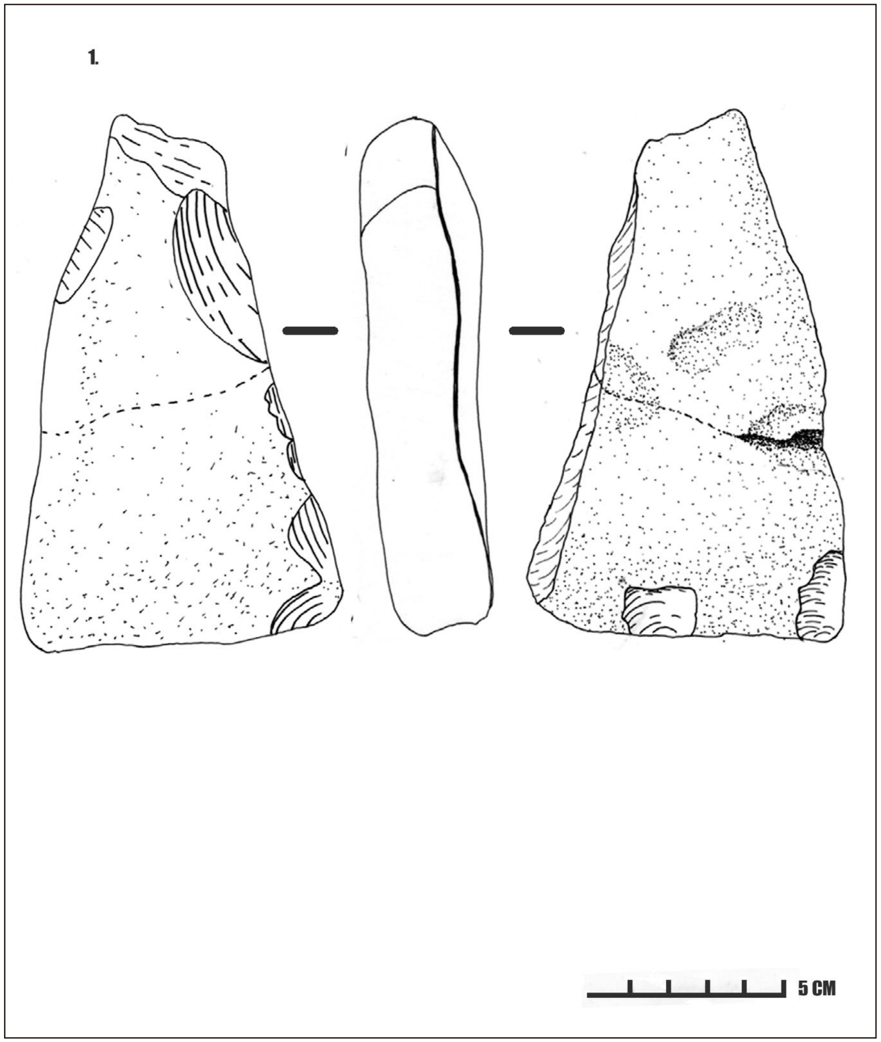

Figure 30. Aduma lithics. 1. (A4) grindstone.

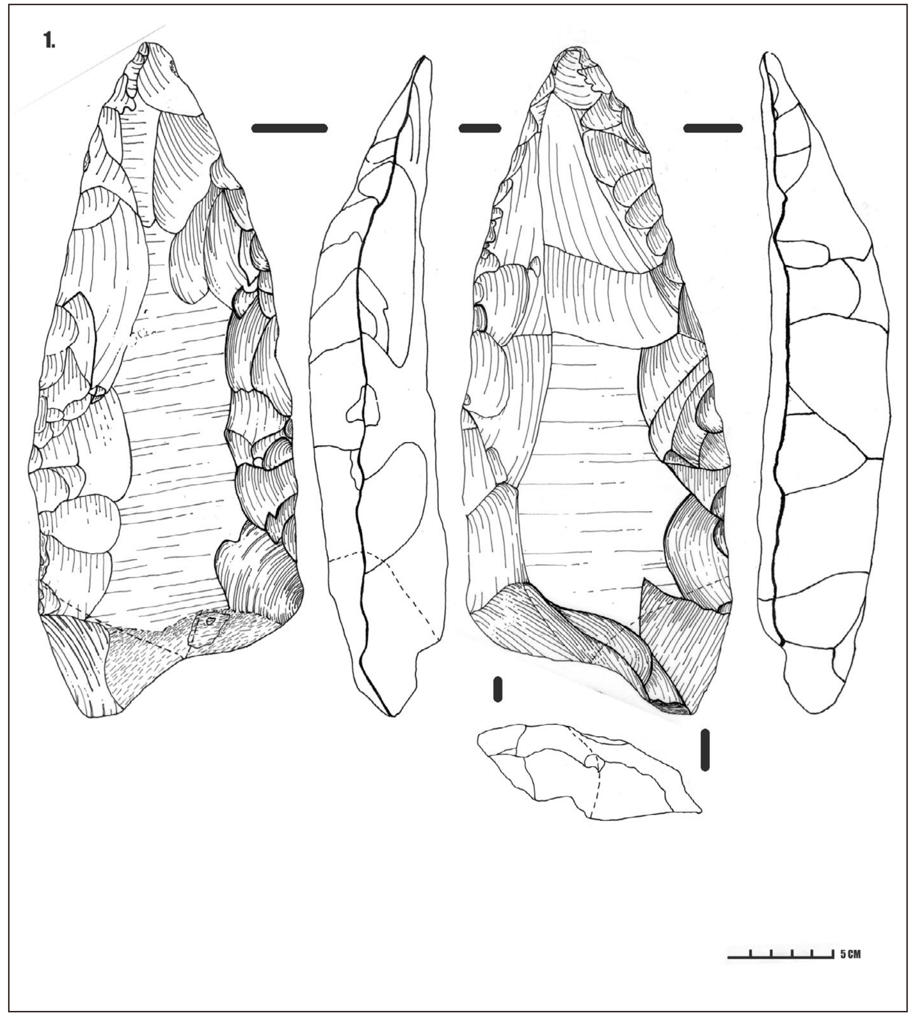

Figure 31. Aduma lithics. 1. (A1) core, biface.

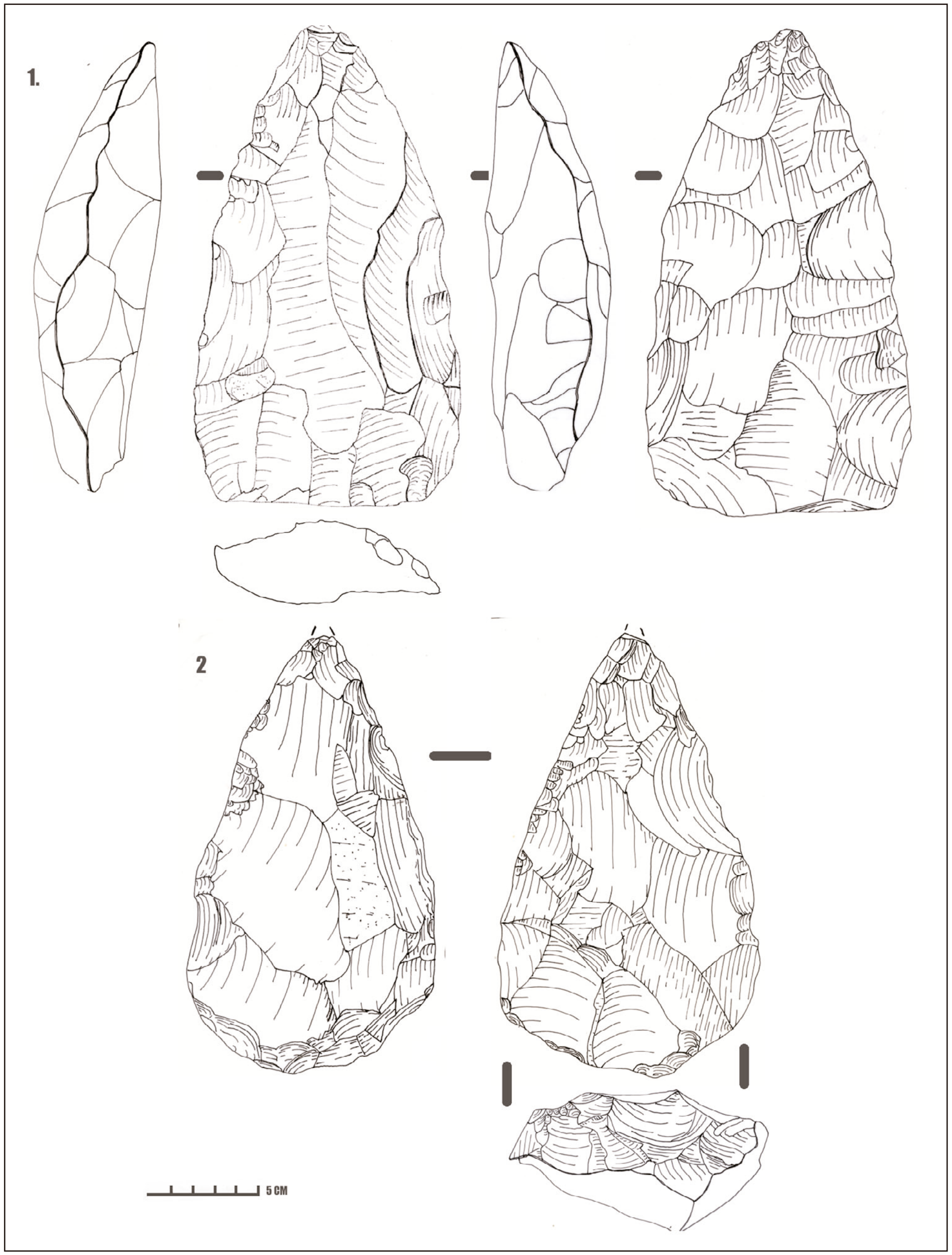

Figure 32. Aduma lithics. 1, 2.. (both site A1) core, biface.

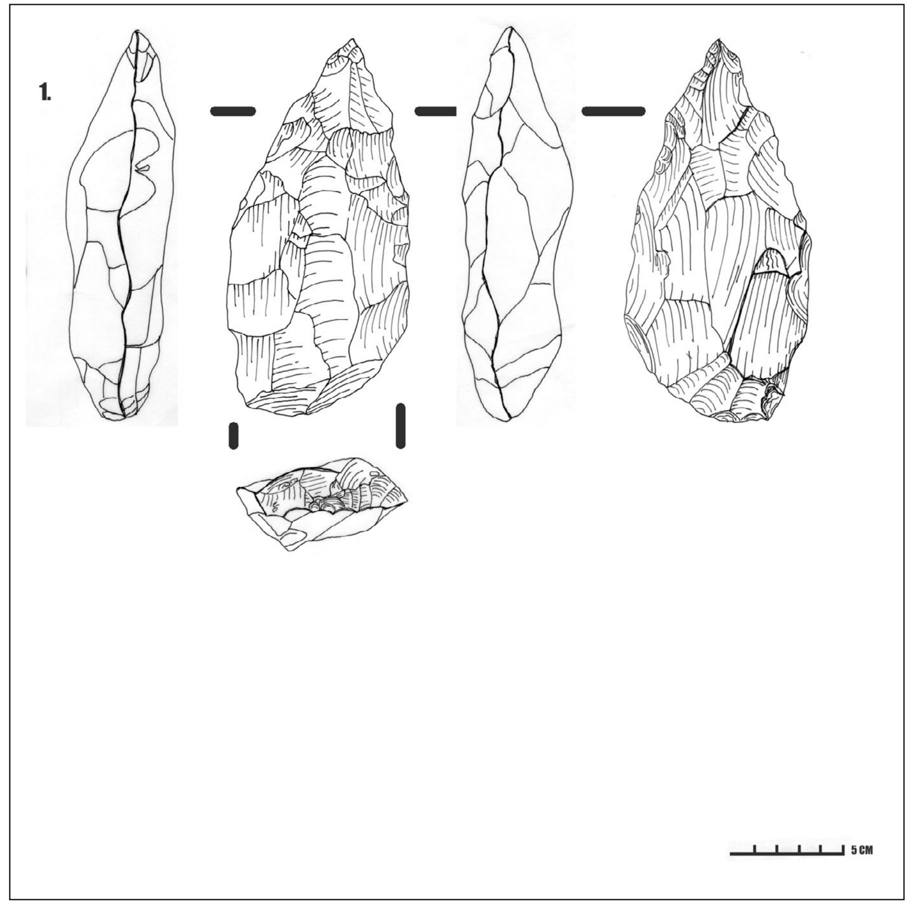

Figure 33. Aduma lithics. 1. (A1) core, biface.