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-

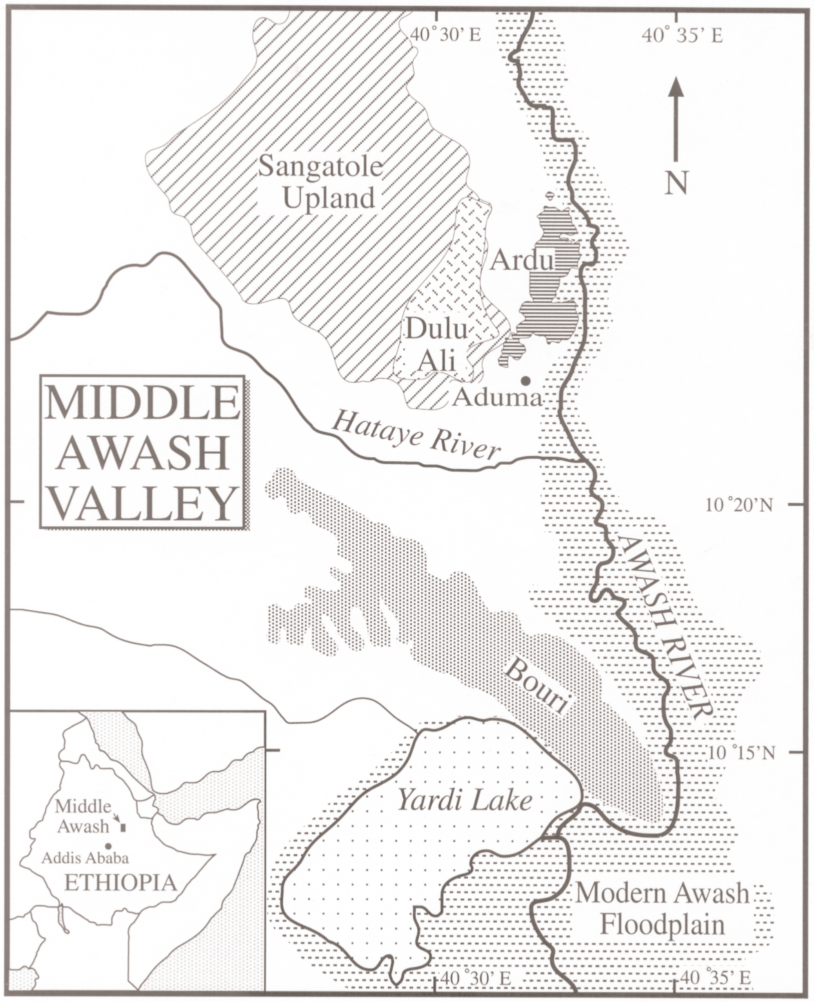

Figure 1. Location of the Middle Awash region, Aduma and the Ardu sediments. The area from Aduma village North to the furthermost Ardu sediment is denoted in this article as "Aduma."

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

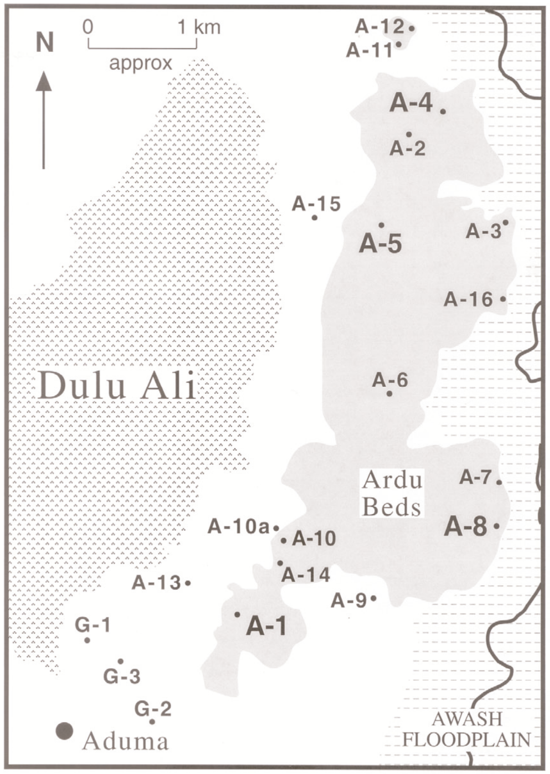

Figure 2. Location of Aduma-related sites. The "A" designation denotes "archaeology", the "G", locations at which geological samples were collected.

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

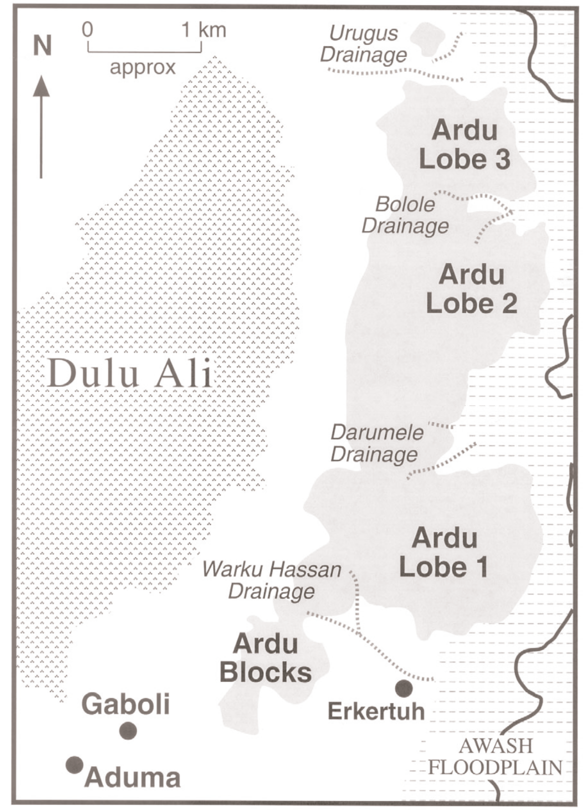

Figure 3. Distribution of Ardu sediments into three "lobes."

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) (OSL & TL)	1.045 (2.4%) 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	12–13cm	13–14cm	14–15cm
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.