The Paleolithic of Hadar, Ethiopia

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The Paleolithic of Africa
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June 1, 2010
Introduction & Site Overview

Well known for its early contributions to the characterization of the pre-Paleolithic australopithecine species *A. afarensi*, the Hadar archaeological site has more recently yielded major discoveries on the early development of the *Homo* genus and the origin of stone artifact manufacture.

The Afar region of eastern Ethiopia, in which Hadar is located, has been an important source of knowledge about human origins, spanning from the earliest possible hominins about 6 million years ago (mya) to the appearance of anatomically-modern humans around 150,000 BP. In 1968, Tunisian-born geologist Maurice Taieb investigated the Afar region for its fossil potential and discovered the fossil-rich sediments of the Hadar and Busidima\(^1\) Formations. Several years later, Taieb revisited the site with several others – Yves Coppens (paleontology), Jon Kalb (geology), and Don Johanson (paleoanthropology). Their initial survey led to the establishment of excavations at Hadar that would continue for nearly a decade.

Johanson, in his 30-year review of the early Hadar excavations, outlined seven major observations that led to the establishment of their excavations (Johnason 2004). First, the yet-to-be named Hadar and Busidima Formation geology spanned 200 meters of strata, indicating preservation of a lengthy prehistoric time span. Second, in their preliminary investigations of the area they found that the lacustrine and fluvial sediments appeared to be from low-energy deposition and consequently was full of well-preserved fossils. Third, initial dating based on Elephantidae and Suidae fossils found indicated an age of greater than 3 Ma, a time period for which there existed only few and fragmentary hominin remains. Fourth, the nature of the geologic deposits – alternating fluvial and lacustrine sediments and volcanic horizons – made for greater confidence in dating and geographical correlation than other sites. Fifth, the volcanic horizons were particularly rich in feldspars and volcanic glass valuable for radiometric dating. Sixth, the geological formation appeared to lack any significant

\(^1\) The sediments Taieb studies were at that time considered part of just the Hadar formation but are now considered part of the Busidima Formation as well.
disconformities, enabling confident characterization of the geological setting over the represented time span. Finally, the rich and varied faunal assemblage present provided opportunities to build a database of information from which to reconstruct the paleoenvironment, and the nature of the assemblage also indicated the likely presence of fossil hominins. These observations led to the establishment of the International Afar Research Expedition (IARE), which would operate from 1973 to 1978, providing tens of thousands of vertebrate fossils and more than 250 hominin fossils during that time (Johanson et al. 1982). Most notable of the 1970s discoveries were the forty percent complete A. afarensis skeleton nicknamed Lucy (A.L. 288, 3.18 Ma) and the localized fossil remains of at least 13 A. afarensis individuals dubbed the “First Family” (A.L. 333, 3.18-3.22 Ma) (Johanson 1996).

After a decade-long hiatus, Johanson returned to Hadar with William Kimbel (paleoanthropologist) and Robert C. Walter (geologist) as the renamed Hadar Research Project (HRP) with the stated goal of refining their knowledge of the context of earlier discovered sites as well as investigating new strata in the hopes of extending the known temporal range of hominins at Hadar (Johnason 2004). In November, 1994, the team discovered a hominin maxilla, later determined to be Homo genus, at A.L. 666 in the Makaamitalu Basin in the Busidima Formation. In situ lithics were found associated with the specimen, providing the oldest known co-occurrence of stone tools and Homo (2.36 +/- 0.06 Ma), and possibly the earliest “well-dated” occurrence of Homo (Kimbel et al. 1996). More recently, several thousand lithics and a few hundred bone fragments have been found at a nearby site, A.L. 894 (Hovers 2003). Minimal post-depositional disturbance has made these artifacts particularly useful for the study of early stone tool manufacture (Hovers 2003, Goldman-Neumann 2009) as well as the paleoenvironment as reconstructed.
from the faunal evidence (Domínguez-Rodrigo 2010). This paper will deal primarily with the current state of research and interpretation of the Paleolithic sites (A.L. 666 and A.L. 894).

**Geographical Setting**

The Hadar archaeological site is located in the Maka’amitalu Basin in the west central Afar region of Ethiopia, on the Kada Hadar of the Awash River, approximately 300 km northeast of Addis Ababa (11°06’ to 11°09’ N, 40°35’ to 40°39’ E) (Johanson et al. 1982). See Appendix A.1 for detailed maps. Due to the remoteness of the location and inhospitable terrain, the area was rarely surveyed prior to Maurice Taeib in 1968 – only English explorer L.M. Nesbitt described his 1935 trip through the area in his book *The Hell-Hole of Creation* (Johanson 2004). The Afar region contains many other fossil sites of similar age, including nearby Gona and the Middle Awash.

On a larger scale, the Afar Depression, approximately 200,000 km² in area, is the northeasternmost terminus of the African Rift Valley, along which there are such major sites as Olduvai Gorge and the Lake Turkana region, extending all the way down to Malawi.

The present-day climate of the region is tropical, semiarid to subdesert, with less than 500 mm of annual precipitation. Daily temperatures typically exceed 35-40°C. Vegetation in the foothill regions consists of “xerophytic thorn shrub, savanna, open woodland, and bush” (Johanson et al. 1982). The Awash River, which flows nearby the site, terminates in the northern central Afar in marshy lakes and swamps.

**Geological Setting**

NOTE: The sediments bearing A.L. 666 and A.L. 894 have recently been reassigned to the overlying Busidima Formation (Campisano 2007, Klein 2009). Most discussions and papers on the Hadar until 2008 discuss them as part of the Hadar Formation, however, and the only significant change is the name and not the actual geology or dating. For reference, the Hadar Formation is now determined to give way to the Busidima Formation circa 2.9 Ma.

Located as it is in a depression caused by the spreading of the rift valley, the geology of the site consists of primarily alternating fluvial and lacustrine sediments with interbedded volcanic horizons. For all geologic maps and diagrams, see Appendix A.2. The majority of the 150-300 meter thick sedimentary
sequence containing the Hadar archaeological and paleontological sites is known as the Hadar Formation, and has been separated into four members, each separated by tuff horizons. The formation is exposed along the Awash River, as well as certain tributaries in the area: Kada Gona, Sidi Hakima, Denen Dora, Kada Hadar, Ounda Hadar, and Ourda on the left bank, Oudaleigta, Andedo, and Kabara on the right. The four members of the formation are, in order of succession and as described by geologist J.J. Tiercelin: the Basal Member (BM), 40 m exposed; the Sidi Hakoma Member (SH), 45-130 m thick, defined at the base by a series of white tuff and volcaniclastic sands (Sidi Hakoma Tuff – SHT); the Denen Dora Member (DD), 20-35 m thick, with a series of 3-5 thin tuffs at its base (Triple Tuff – TT) (Tiercelin 1986); and the Kada Hadar Member (KH), 30 m thick with a single tuff at the base (Kada Hadar Tuff – KHT). Overlying the Kada Hadar Member – and thus the entire Hadar Formation – is the Busidima Formation (2.7-0.81 Ma), containing both A.L. 666 and A.L. 894.

During the period from 4.2 Ma to about 2.9 Ma, the primary geologic range of the Hadar Formation, the area was inundated by alternating fluvio-lacustrine sediments and volcanic tuffs. At the beginning of this period, the area was at the western edge of prehistoric “Hadar Lake”, at this time smaller and shallower yet distinct from nearby Lake Bodo. Rippled and cross-bedded sands containing plant fossils in the Basal Member support this. At 4.0 Ma, nearby Ida Ale volcano erupted, spreading SHT tuffs and distinguishing the Basal Member from the Sidi Hakoma Member. From 4.0 Ma to 3.65 Ma, fluvial activity persisted along the shores, while the marshy area surrounding the lake spread out slightly in to a delta along the eastern shore and a possible abandoned “lobe” off the lake, as evidenced by the deposition of silty clays and shales with abundant gastropod fauna, root marks, and coals (Tiercelin 1986). As the lake expanded, and towards 3.65 Ma, the Kada Damoum basalt erupted. Around this time, the lake expanded to cover the shorelines and marshes in the whole Hadar region. Periodic volcanic activity continued, and around 3.6 Ma the TT tuffs were laid down, again probably by the Ida

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2 To follow along with schematic representations of the relevant geographical features at each time period, see Appendix A.2.
Ale volcano (Aronson et al. 1980). Shortly afterwards, marked lacustrine regression and an increase in fluvial activity is seen in the deposition of silty clays and the Denen Dora conglomerate. The area then became mostly marshy, with some fluvial activity, likely due to tectonic uplift of the Afar basement. Further eruptions of the Ida Ale volcano produced numerous tuffs, most importantly KHT, which accumulated in the area and provided the base for the Kada Hadar Member (Tiercelin 1986). Finally, the appearance of thick conglomerate-sand-silt sequences in the area indicates alluvial fan and fan-delta environments along the western edge near the Ethiopian escarpment (Bluck 1964).

Between 4.2 and 2.9 Ma, there were rapid changes in the lake level and extent, possibly related to the volcanic activity along its edge, and mainly fed by rivers and floods originating at the Ethiopian escarpment. This resulted in the alternating sandy conglomerates, fine silts, and tuffs of the Hadar Formation sequence. The eastern edge appears to have seen little tectonic activity during this period, the western edge slightly more, but overall there are very few noteworthy disconformities in the geology of the Hadar Formation (Tiercelin 1986), particularly in the area of the archaeological site (Johanson et al. 1982). Between 2.9 Ma and 2.45 Ma, however, the region was less stable and the recently designated Busidima Formation overlying the Hadar Formation is distinguished by numerous disconformities. An in-depth study of the tephr stratigraphy of the area found that many of the tephras of both formations correlated well between Hadar and nearby archaeological sites, specifically Dikka and Gona, although the exact horizon containing both Paleolithic sites did not (Campisano 2007).

As mentioned before, it is the volcanic layers that allow dating of the sequence. Numerous geologic surveys have been done employing a variety of methods to establish, refine and confirm dating of the Formation, including: geochronologic and paleomagnetic analysis (Aronson et al. 1977), isotopic analysis of the sediments (Hillaire-Marcel et al. 1982), $^{40}$Ar/$^{39}$Ar dating of the Denen Dora and lower Kada Hadar members (Walter 1994), and geochemistry and lithological studies (Campisano 2007) as well as more general surveys done by geologists attached to the IARE and HRE (Johanson et al. 1982,
Figure 2: Schematic stratigraphic column of the Hadar Formation, based on Kada Hadar and Ounda Hadar drainages, with sites labeled. B = Basal Member, SH = Sidi Hakoma Member, DD = Denen Dora Member, KH = Kada Hadar Member (Kimbel et al. 1996). Modified to show A.L. 894 as well as the Busidima Formation horizon at 2.9 Ma.
Johanson 1996, Kimbel et al. 1996). Overall, the well-characterized and undisturbed sedimentary stratigraphy allows for very accurate dating of in situ artifacts and specimens uncovered at the site, as well as relatively accurate dating for surface finds. The geology also allows for confident reconstruction of the paleoenvironment, as will be described later.

**Chronology**

The geology of the site allows, as stated earlier, for very specific geochronology. With such an opportunity for precise dating, both relative and absolute, a quick overview of the chronology of the archaeological and paleontological sites within the Hadar research area is desirable. Figure 2 shows a schematic representation of the stratigraphy of the Hadar Formation (including, before it was known, part of the Busidima Formation) as relevant to the investigated sites. The layers of primary importance are the BKT tephras 1-3, as they delimit the Paleolithic Homo and stone artifacts, and the SHT tuff, as with the BKT 1 it brackets the temporal range of *A. afarensis*. For this paper, the sites of importance are the relatively recent, Paleolithic sites of A.L. 894 and A.L. 666 in the upper Kada Hadar Member, although the importance of Hadar’s *A. afarensis* fossils will be touched upon briefly.

Dating of the A.L. 666 site was done using the radiometric date of the BKT-3 tephra (see Fig. 2) as the primary constraint. This provided a minimum age for the artifacts and maxilla, which was desirable as the maxilla was determined to be one of the oldest Homo specimens and the oldest association of stone artifacts with hominin remains. The artifact-bearing horizon was located ~80 cm below BKT-3, and the maxilla located slightly downslope. The maxilla was determined to be eroded from the same silt horizon as the artifacts because: (1) the silt matrix filled the sinus cavities and anterior tooth alveoli on both sides; (2) a root cast was present in one sinus; and (3) the maxilla showed similar patina to in situ bone fragments (Kimbel et al. 1996). As he notes, however, BKT-3 is not a primary deposit, but rather a secondary sedimentary deposit, and therefore conventional K/AR and $^{40}\text{Ar}/^{39}\text{Ar}$ dating analyses were useless, as they need thousands of grain. Instead, to obtain the age of
the tephra, they employed single-crystal laser microprobe methods, resulting in a narrow range of dates for several crystals from across the site (Kimbel et al. 1996). A.L. 666 was therefore dated to 2.33 +/- 0.07 Ma based on the geochronology, although recent geochemical analysis pushes that back to 2.36 +/- 0.06 Ma (Campisano 2007). Analysis of the faunal remains correlates well with and appears to confirm these dates (Klein 2009).

The A.L. 894 site lies stratigraphically just under the silt-clay sediments in which A.L. 666 sits. It is typically given the same minimum age, as the two share BKT-3 as the closest datable horizon, but stratigraphically is slightly older. The A.L. 894 assemblage was found primarily in situ, resulting in confident stratigraphic chronology (Goldman-Neumann 2009).

The chronology of this site is of particular importance in the discussion of the development of modern humans for several reasons. First, A.L. 666 is one of the oldest early Homo sites, along with the Shungura Formation, Lower Omo, Ethiopia (2.3 Ma), Nachukui Formation, West Turkana, Kenya (2.3 Ma), Chemeron Formation, Lake Baringo, Kenya (2.4 Ma) and Chiwondo Beds, Uraha, Malawi (2.4 Ma) (Klein 2009). More importantly, all of those other oldest sites only represent *H. rudolfensis*. Hadar, and A.L. 666 in particular, is therefore the oldest evidence for *H. habilis* (tentatively identified). Furthermore, it is the oldest confidently dated site with association of hominin remains and stone artifacts. A.L. 894, slightly lower stratigraphically but generally temporally associated, confirms this early appearance of manufactured stone artifacts.

**Stone Tool Assemblages**

Both of the Late Pliocene Paleolithic sites at Hadar (A.L. 666 and A.L. 894) contain stone tool assemblages representative of the Oldowan Industrial Complex

**A.L. 666:**

Thirty-four stone tools were found at the A.L. 666 site during the initial excavation in 1994. Fourteen out of the total were discovered in situ while the rest were located on the surface slightly
downhill from the others. While the degree of association between the two groups is not firmly established, the described lack of abraded edges and “fresh condition” of the group of surface artifacts indicate that they were recently eroded from the original matrix – that they were “neither exposed on the surface for a long time nor transported over nontrivial distances” (Kimbel et al. 1996).

The raw materials represented in the tools from A.L. 666 are exclusively volcanic and sedimentary, primarily basalt and chert. All but three of the specimens from the entire assemblage are “typical” Oldowan flakes (Toth 1985, Roche et al. 2009), with cortical and semi-cortical features and plain striking platforms, and technologically all of the flakes were classified as “KBS Industry” Oldowan by their flaking characteristics (see Appendix B.1). This majority of flakes varies over a range of lengths, have “irregular lenticular” cross-sections and simple scar patterns. The three exceptions in the assemblage have a more complex scarring pattern indicative of rotation of the core during knapping. Most of the flakes appear to have been struck from round river cobbles, and three of the surface artifacts found, also struck from round cobbles(Kimbel et al. 1996), were bifacial “end-choppers” (Fig. 3c), as defined by Leakey (Leakey 1971). The site appears to follow the standard early Oldowan pattern of selective but localized raw material use.

The initial excavation at A.L. 666 was limited to a 1.25x2.0 m grid reaching 80 cm below the surface. Density of lithics was only 11/m³, typical of Plio-Pleistocene sites, within the grid. In situ flakes were all, with one exception, within a 90x80x9 cm block within the grid, and neither horizontal nor vertical clustering appeared significant. The excavators also claim that the excavated sample was morphologically similar to that from the surface and lacks “utilized and retouched” flakes. The single core from the excavated sample shows removal scars indicating a variation in striking platforms during knapping, and by refitting this core to a flake recovered 1.6 m away, they demonstrated some degree of horizontal dispersion, although it is uncertain whether this was due to discard or post-depositional processes (Kimbel et al. 1996).
The relatively small assemblage at A.L. 666 is, apart from the three flakes with more complex flaking patterns, seemingly straightforward early Oldowan, although perhaps slightly more advanced than the very early age would suggest.

**A.L. 894**

The A.L. 894 stone artifact assemblage, while not associated with hominin remains, is far more extensive than that at A.L. 666. Over three field seasons (2000-2002) and an excavated area of 21.5 m\(^2\), ca. 5000 artifacts were found within a 30 cm thick horizon. The artifacts were clustered primarily within 10 m\(^2\) at the center of the excavation, with that high-density cluster surrounded by lower-density areas. While a few of the artifacts were found on the surface, the substantial number of refits with *in situ* pieces was determined to attest to the “integrity” of the assemblage and relatively mild post-depositional disturbances (Hovers 2003). Similar to the A.L. 666 site, the assemblage consists mainly of unretouched flakes, a few cores and, very rarely, retouched flakes. The A.L. 894 flakes are also characterized by the low scar counts, occurrence of cortex on the outer faces and untreated or lightly treated striking platforms, exactly in the pattern seen at A.L. 666. Also, the primary raw material used was, again, volcanic materials (rhyolites, trachytes and basalts), determined to have come from the nearby KH-7 conglomerate (Goldman-Neumann 2009).

An extensive analysis of the raw material selectivity at A.L. 894 was recently published (Goldman-Neumann 2009), the results of which appear to confirm the idea of Late Pliocene localized opportunistic raw material selection. Figure 3 shows the relative distribution of volcanic raw material as present in both the local cobble-source conglomerate (KH-7) and the lithic assemblage from A.L. 894 (n = ca. 5000). See Figure 1 for the relative positioning of

![Figure 3: Concentrations of rock types in KH-7 cobble source and A.L. 894 archaeological collection (Goldman-Neumann 2009)](image-url)
the KH-7 source conglomerate and both A.L. 894 and the spatiotemporally related A.L. 666. While rock type does not seem to have been a factor in material selection, it was found that there was an underlying selection for finer-grained relatively homogenous rocks of “better” quality for knapping. A study of the grain size and fracturing characteristics of the cobbles present in the source conglomerate and the flakes present in the archaeological assemblage found that the flakes were relatively fine-grained compared to the majority of KH-7 cobbles (Goldman-Neumann 2009). This appears to have been the predominant factor in material selection, as distance from the source seems to be negligible and there was no observed technological difference in how each specific type of raw material was worked.

The number of in situ angular fragments present in the assemblage can be explained by post-depositional processes. An investigation of the mechanism by which shattered flakes at the site, typically found with all the pieces still touching, were broken, determined that the breakage was likely due mainly to trampling. However, the pieces (see Appendix B.2) were missing the characteristic edge damage, and the main conclusion was that further study with the specific material from the site was needed (Hovers 2003).

Overall, it appears that both the raw material selection and manufacture methods of the stone artifacts found at A.L. 666 and A.L. 894, despite the vast difference in sample size, were significantly comparable. Each assemblage contained relatively few flaked cores, almost no retouched flakes, and a vast majority of unretouched flakes. Preparation of the striking platforms appears to have been minimal, if present at all, and flakes were determined to have been made primarily by single hard-hammer percussion blows. The technological sophistication of both assemblages fits well with their stratigraphically determined minimum age of approximately 2.3 Ma, as it exhibits classic characteristics of early Oldowan technology.
Acheulean Artifacts

In addition to the very early stone tool assemblages of A.L. 666 and A.L. 894, early surface surveys of the Hadar area, conducted in 1974, found a variety of Acheulean-type artifacts (see Appendix B.3) from all across the survey area. The artifacts, as catalogued, fall into “five categories...choppers, polyhedral and modified pebbles, crude flakes, protohandaxes...and bifaces of the Middle Acheulean type” (Corvinus 1975). It was postulated that the artifacts represent two different types of industry – an early Acheulean transitional from Oldowan and producing large, irregular flakes and protohandaxes from largely unprepared cores, and a Middle Acheulean typology consisting of well-made, shallow-flaked bifaces with secondary trimming. This second assemblage also includes prepared cores, with basal preparation, as well as flakes from prepared cores (Corvinus 1975).

Unfortunately, these artifacts were mainly discovered on the surface with evidence of post-depositional wear. At best, several artifacts were found in only recently exposed gravel beds. Due to the lack of stratigraphic and geologic context, dating the manufacture proved impossible. It was stated early in the paper that “Middle Stone Age (MSA) [sic] flakes and cores have been found together with Late Stone Age (LSA) [sic] flakes, cores and waste” (Corvinus 1975). Because of their lack of context, however, these artifacts cannot tell us anything of significance. The early Paleolithic sites of A.L. 666 and A.L. 894 are, therefore, far more relevant and important to the expansion of our understanding of the evolution of stone tool manufacture and related cognition.

Hominin Record (Paleolithic)

The Paleolithic hominin record of the Hadar research area is minimal, identifiably consisting of a single maxilla from A.L. 666. It is, however, an incredibly important (if small) find, as it is the earliest known association of hominin remains and stone tool manufacture (Klein 2009). The A.L. 894 site, despite its large stone tool assemblage, does not contain hominin remains.
The hominin maxilla from A.L. 666 (see Appendix C for pictures) was actually found on the surface in several freshly-broken pieces. Because of the relative lack of overburden, the accumulation of silt matrix within the sinuses and alveoli of the maxilla, and the similar patina and preservation detail to that of in situ bone fragments from the site, it was determined by the excavators that the maxilla had only recently eroded from the matrix of A.L. 666. By comparison with standardized Homo and Australopithecus samples, it was determined that the maxilla belongs to the former group. The relatively wide and deep palate, the mild subnasal prognathism, the absence of superomedial tapering of the midface in the anterior aspect common in australopithecines, and the shapes of the present tooth crowns (M$^1$ and M$^2$) all point to Homo as the most likely genus. Which species of Homo the maxilla belongs too, however, has been elusive. The small sample sizes and internal variation of conventionally delineated taxa makes it difficult to place the maxilla into any one specific species, especially because many of the characteristics present have proven to be amorphic for Homo as a whole (Kimbel et al. 1996). More recently, the maxilla has become widely accepted as H. habilis, based primarily on dental morphological similarities to other specimens of that species, particularly from Olduvai Gorge.

As laid out earlier, the site has been confidently dated by a variety of methods to approximately 2.35 Ma. This, combined with the identification of the maxilla specimen as Homo, places this site as one of the oldest known occurrences of Homo, and the tentative identification as H. habilis makes it the oldest known for that species – all earlier sites were identified as H. rudolfensis. Not only is this maxilla significant as the oldest known H. habilis, but it is also the oldest known association of any hominin with stone tools, providing evidence for the co-occurrence of Homo and stone tool manufacture.

Finally, the maxilla was identified as male due to expansive maxillary sinus cavities, long palate and a fairly large canine (Kimbel et al. 1996).
Faunal Assemblage

The known Paleolithic-associated late Pliocene faunal fossil assemblage at the Hadar research area comes primarily from the A.L. 894 excavation. The presence of fragmentary faunal fossils at A.L. 666 was noted and discussed in context of the paleoenvironment, but not recorded in great detail, apart from a single bovid scapula fragment with what “may be” a stone tool cut mark, isolated *Theropithecus oswaldi* (baboons) teeth, and a bovid horn core (*Raphicerus* sp. – small antelopes) (Kimbel et al. 1996).

The faunal assemblage from A.L. 894 consists of 330 macroinvertebrate bone specimens, mostly very fragmentary, although several are identifiable to skeletal part. Furthermore, there are 118 microinvertebrate specimens, mainly rodents and *Aves*, and several eggshell fragments. Of the identifiable macroinvertebrate fragments, there are representatives of *Gazella* sp. (gazelles), *Tragelaphus* sp. (large, antelope-like bovids), *Sivathatherium maursium* (antlered giraffid), and *Crocodilus* sp. (crocodiles) (Dominguez-Rodrigo 2010). The majority of the specimens were left and right hemimandibles with partial teeth and tooth roots preserved, although the *Crocodilus* was identified based on the trabecular structure of the internal surface of two bone fragments. The MNI of each of these taxa is one. The identifiable number of macro-faunal specimens (NISP = 69) makes up only 21 percent of the total assemblage, largely due to a high degree of fragmentation and poor preservation.

The total assemblage shows signs of carnivore ravaging. The proportion of limb bone shafts to ends is much higher than would be expected, likely due to carnivores, which would also explain the dearth of axial skeletal elements (Dominguez-Rodrigo et al. 2007).

Apart from a single polished specimen, the assemblage does not show signs of transportation to the site. However, bone surface preservation is poor in the majority of specimens, mostly due to chemical alteration of the surface and, in some cases, complete covering of the surface with carbonate and concretion, making identification difficult. Only about 19 percent of the assemblage (n = 63) has good enough cortical preservation to identify possible marks. From these, at least seven show evidence
of carnivore tooth marks, indicating that the bones were broken at the site, confirming the hypothesis based on the ratio of limb shaft fragments to ends that carnivores likely deposited the bones. In fact, in the Dominguez-Rodrigo et al. investigation of the faunal assemblage, it was found that none of the bones carried marks identifiable as caused by hominins. Four marks initially suspected were found to be caused by roots of plants growing around the gazelle mandible (Dominguez-Rodrigo 2010).

Based on this most recent taphonomic analysis of the faunal fossil assemblage at A.L. 894, it appears that hominins were not agents for the deposition of these carcasses. All of the evidence points towards carnivore-only action, and the spatial association with the large lithic assemblage is merely coincidence, as most of both the stone tool and fossil specimens were determined to have been found in situ. Because of the relatively small identifiable sample size, and the minimal amount excavated in the area, however, all this analysis can tell us is that these specific bones were not deposited by hominins. The case for early stone tool use based on the association of lithic artifacts and the Homo maxilla of A.L. 666, along with a single suspected cutmark on a fossil specimen from that site, is still far stronger.

**Paleoenvironment**

Based on the faunal fossil assemblages, as well as the geological record extensively surveyed for the area, it is possible to reconstruct the paleoenvironment of the early Paleolithic sites A.L. 894 and A.L. 666 at Hadar, both dated to the same age at roughly 2.36 Ma.

As background, recall that the area was subjected between 4.0 and 2.9 Ma to cycles of sedimentary inundation from alternating lacustrine and fluvial environments. The shores of the prehistoric Hadar Lake grew and receded with these cycles, creating varying amounts of marshy wetlands around the lake margins. Based on faunal analysis of the earlier *A. afarensis*-bearing Hadar sites, the Pliocene paleoenvironment was determined to be relatively closed habitats with dry brush and riparian woodland (Kimbel et al. 1996).
By contrast, we know from the geology that during the A.L. 666 and 894 depositions the area was dominated by alluvial fan and fan-delta environment along the western edge of the Ethiopian escarpment. Relatively small lacustrine elements and larger swampy and marshy surroundings were also major landscape features (see Appendix A.2) (Tiercelin 1986). Confirming this picture of a relatively wet landscape is the presence of fossils from that period of extant cane rats, which inhabit reed beds in standing water, and Hippopotamidae specimens from the general Maka’amitalu Basin faunal record (Kimbel et al. 1996). When combined with the other sparse fossil faunal remains from A.L. 666 as well as the larger fossil record from A.L. 894, primarily bovids, antelope, gazelles and baboons known to inhabit lakesides, we can fully reconstruct the environment. Based on the evidence, the paleohabitat was likely predominantly open, with large wetlands fed by alluvial fans and fan deltas and bushed or lightly wooded grasslands and stands of trees close to the water source or small lake. Pollen analysis confirms the presence of grasslands, as well as the fact that the region was cooler and wetter than the present day, which is currently hot and semi-arid, especially during the tenure of A. afarensis. Further, pollen analysis also confirms the cyclic fluctuations in environment predicted by the sedimentary geologic record (Bonnefille et al. 2004).

**Australopithecus Afarensis**

Discussion of the Hadar research area, even from a Paleolithic standpoint, would be incomplete without mention of the considerable contributions made by discoveries there to the characterization of the A. afarensis species and its role as a link in the human evolutionary chain (Klein 2009). The A.L. 666 and A.L. 894 Paleolithic sites only occupy a tiny range of the hominin fossil record – from the earliest A.L. 137 fossils, to the 13 individuals of the A.L. 333 “First Family” site, to A.L. 288-1 – the 40 percent complete skeleton of “Lucy”, the broad range of the hominin fossil record at Hadar is incredible (Kimbel et al. 1994, Johanson 2004). Over 400,000 years and 325 specimens of A. afarensis have been excavated there, allowing the greatest characterization of any pre-Pleistocene hominin species and their
locomotive abilities (Hillenbrand 2009, Stern et al. 1983). The discoveries there have afforded paleontologists a chance to investigate variation in the species both temporally and as concurrent dimorphism (typically sexual). Ranging from A.L. 137 at 3.4 Ma to middle Acheulean artifacts discovered on the surface in 1974 (Corvinus 1975), the fossil hominin record at Hadar goes far beyond just Homo and the early Oldowan.

**Conclusion**

The Paleolithic sites of the Hadar research area are incredibly important to our understanding of human evolution, the development of stone tool manufacture and the development of human cognition in general. The two sites, A.L. 666 and A.L. 894, are closely related both temporally and spatially, and can be considered to represent the same period of human development. The A.L. 666 site is one of the earliest known Homo occurrences, possibly of H. habilis, that has been excavated. Furthermore, and even more significantly, it is the oldest co-occurrence of stone tools and hominin remains. This evidence for the coincidental emergence of Homo and early stone tool manufacture suggests that Homo may be responsible for the initial development of stone tools.

The extent and potential of the Hadar and Busidima sedimentary Formations are equally vast, providing the possibility of further evidence on the development of stone tool making and human evolution with future fieldwork. Considering the vast contributions to the characterization of the A. afarensis species afforded by the large number of specimens found at Hadar, and the minimal amount of potential fossil-bearing sediments excavated in the area, there are plenty of opportunities for further discoveries of equal and greater significance to be made.
Appendix A - Maps

A.1 Geography

Map showing the geographical location of the Hadar research area (Kimbel et al. 2004).

A.2 Geology

Hadar Region, Afar Depression (Tiercelin 1986)
Simplified geologic map of Hadar Formation (Tiercelin 1986)

Hadar region at 2.9-2.4 Ma (Tiercelin 1986)
Hadar region at 2.9 Ma (Tiercelin 1986)

Hadar region at 3.0 Ma (Tiercelin 1986)

Hadar region at 3.5-3.15 Ma (Tiercelin 1986)
A.L. 666 Lithics – (a) Upper row: *in situ* core and flake conjoined. Lower row: flake from the *in situ* assemblage. (b) Flakes from the *in situ* assemblage. (c) Bifacially flaked “end chopper” from the surface collection (Kimbel et al. 1996)
Cracked flakes from A.L. 894, Hadar (Hovers 2003)
B.3 – Acheulean artifacts

Acheulean artifacts from Hadar region (Corvinus 1975)
Appendix C – Hominin maxilla, A.L. 666

Homo maxilla from A.L. 666. Clockwise from top left: superior, palatal, left medial, right lateral (Kimbel et al. 1996)
References


