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PALAEOANTHROPOLOGICAL RESEARCH AT GONA (ETHIOPIA) AND AIN HANECH (ALGERIA)

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ABSTRACT

The Gona study area in the Afar, Ethiopia; and the Ain Hanech/Ain Boucherit study area, and other Pleistocene sites in Algeria have produced important early Oldowan, Acheulian and Late Pleistocene archaeological materials. The Gona early Oldowan is dated to c. 2.6 million years ago (Ma), and the earliest Oldowan at Ain Boucherit is dated to ca. 2.4 Ma. The archaeological evidence from the two geographically widely separated areas suggests the possibility that the beginnings of systematic manufacture of early Oldowan stone artifacts may have begun in both East and North Africa at the same time or the manufacture and use of stone tools may have spread quickly from East to North Africa. Faunal remains associated with the early Oldowan from Gona and Ain Boucherit bear evidence of cutmarks, providing direct evidence that ancestral humans used these early stone artifacts for processing animal carcasses for meat.

Furthermore, Acheulian Large Cutting tools (LCTs) with similar age were recovered in both the Gona and Ain Hanech study areas. A number of sites at Gona yielded Acheulian LCTs dated > 1.6 Ma (close to 1.7 Ma), and similar technology was documented in the capping strata at Ain Hanech and dated to ca. 1.67 Ma. At Gona two sites document co-occurrence of Mode 1 (Oldowan) and Mode II artifacts (Acheulian), both associated with *Homo erectus* crania (dated to 1.6-1.5 Ma, and 1.2 Ma, respectively). Tighennif (formerly Ternifine) in Algeria is an important site where several hominin fossils assigned to *Homo erectus* have been recovered at the end of the 19th Century. Recent excavations at the site have yielded LCTs estimated to ca. 1.2 Ma. The younger Mid-Late Pleistocene deposits at Gona and a number of other sites in Algeria, including Errayah, and Tablelbala Tachengit are known for producing Late Acheulian implements made with the Kombewa technique. Recent investigations at Gona have revealed the presence of numerous Middle Stone Age (MSA) and Late Stone Age (LSA) sites dated to intervals within the last 200,000 yrs ago (Ka). The youngest archaeological site with microliths, ostrich eggshell beads and groundstones at Gona is dated to 13 Ka.

In addition to *Homo erectus*, Gona is also known for yielding important early hominins including *Ardipithecus kadabba* dated to ~6.3 Ma and *Ardipithecus ramidus* dated to 4.7-4.3 Ma. *Ardipithecus* is known only in two study areas in Africa, at Gona and in the Middle Awash, where it was first identified.

Thus, the major discoveries made from the Gona and the Algerian sites have contributed enormously for our understanding of the emergence of hominins, and the beginnings of stone tool technology. The evidence combined is key for investigating and understanding the biological and cultural evolution of our ancestors over the past > 6.0 Ma. This paper highlights the major archaeological and hominin discoveries from the Gona and Ain Hanech/Ain Boucherit and Ternifine study areas.

RESUMEN

Las zonas de estudio de Gona en Afar (Etiopía), y de Ain Hanech/Ain Boucherit, así como otros yacimientos pleistocenos de Argelia, han producido importantes restos arqueológicosque incluyen el Oldowayense antiguo, el Achelense y del Pleistoceno superior. El Oldowayense antiguo de Gona está datado de 2,6 millones de años (Ma), y de Ain Boucherit de 2,4 Ma. Las evidencias arqueológicas de las dos áreas de estudio, muy separadas geográficamente, sugieren la posibilidad de que los inicios de la fabricación sistemática de artifactos líticos del Oldowayense antiguo pudieran haber comenzado tanto en el este como en el norte de África al mismo tiempo, o que la fabricación y el uso de herramientas líticas pudieran haberse extendido rápidamente del este al norte de África.

Además, en ambas zonas de estudio se recuperaron grandes herramientas de corte (*Large Cutting Tools*) achelenses de edad similar. Varios yacimientos de Gona produjeron LCT achelenses datadas de más de 1,6 Ma (cerca de 1,7 Ma), y se documentó una tecnología similar en las capas estratigráficas de recubrimiento de Ain Hanech, datada en aproximadamente 1,67 Ma. En Gona, dos yacimientos documentan la coexistencia de artifactos del Modo 1 (Oldowayen) y del Modo II (Achelense), ambos asociados a cráneos de *Homo erectus* (datados de 1,6-1,5 Ma y de 1,2 Ma, respectivamente). Tighennif (antiguamente Ternifine), en Argelia, es un yacimiento importante donde se recuperaron a finales del siglo XIX varios fósiles de homínidos asignados a *Homo erectus*. Excavaciones recientes en el yacimiento han proporcionado LCT estimados en aproximadamente 1,0 Ma. Los yacimientos más jóvenes del Pleistoceno (inferior final, medio y superior) de Gona y de otros yacimientos de Argelia, como Errayah y Tablelbala Tachenghit, son conocidos por la producción de utensilios del Achelense superior fabricados con la técnica Kombewa. Recientes investigaciones en Gona han revelado la presencia de numerosos yacimientos de la Edad de Piedra Media (Middle Stone Age) y de la Edad de Piedra Tardía (Late Stone Age) datados en los últimos 200.000 años (Ka). El yacimiento arqueológico más joven de Gona está datado de 13 Ka, con microlitos, cuentas de cáscara de huevo de avestruz y piedras talladas.

Además del *Homo erectus*, Gona también es conocida por la presencia de importantes homínidos primitivos, como el *Ardipithecus kadabba*, datado de ~ 6,3 Ma, y el *Ardipithecus ramidus*, datado de 4,7-4,3 Ma. El *Ardipithecus* sólo se conoce en dos zonas de estudio en África, en Gona y en el Awash Medio, donde fue identificado por primera vez.

Así pues, los importantes descubrimientos realizados en los yacimientos de Gona y de Argelia han contribuido enormemente a nuestra comprensión de la aparición de los homínidos y de los inicios de la tecnología litica. Las pruebas combinadas son clave para investigar y comprender la evolución biológica y cultural de nuestros antepasados en los últimos 6 millones de años. Este artículo destaca los principales descubrimientos arqueológicos y de homínidos de las zonas de estudio de Gona y Ain Hanech/Ain Boucherit.

1. INTRODUCTION

The Gona palaeoanthropological Research Project in the Afar State of Ethiopia, and the Ain Hanech/Ain Boucherit, and Ternifine sites, and other Early to Late Pleistocene sites in Algeria have contributed enormously to our understanding of the beginnings of ancestral human stone tool technology (Figure 1). Gona and the Ain Hanech/Ain Boucherit sites have produced the earliest hominin stone technology by yielding a treasure trove of unambiguous evidence of flaked stones used for processing animal carcasses for meat. The Gona early Oldowan is dated to c. 2.6 million years ago (Ma) (Semaw, 2000; Semaw et al., 1997, 2003), and the earliest Oldowan at Ain Boucherit is dated to ca. 2.4 Ma (Sahnouni et al., 2018). The archaeological evidence from the two geographically widely separated penecontemporaneous study areas may suggest the possibility that the beginnings of systematic manufacture of early Oldowan stone artifacts may have begun in both East and North Africa at the same time or it may have spread quickly from East to North Africa (Sahnouni et al., 2018).

Gona and Ain Hanech also have produced early Acheulian stone assemblages dated close to 1.7 Ma (Semaw et al., 2018, 2020; Duval et al., 2021). The earliest documented Acheulian in Africa is known from Konso in Ethiopia and Kokiselei 4 in Kenya, both dated to 1.75 (Beyene et al., 2013; Lepre et al., 2011). Slightly younger Acheulian dated to 1.7 Ma are also known from Olduvai Gorge in Tanzania (Diez-Martin et al., 2015). Duke et al., (2021) reported excavated materials dated to 1.8 Ma at Kokiselei 6, that consist of roughly worked bifacial Mode 1 large cores showing incipient Acheulian technology. A recent claim for 2.0 Ma Acheulian occurrences was reported from Melka Kunture in the highlands of Ethiopia (Mussi et al., 2023), though the age of the site has been questioned by Gossa et al., (2023).

At Gona, the Ounda Gona South (OGS12) Acheulian locality is dated to > 1.6 Ma (likely close to 1.7 Ma), and the Dana Aoule North (DAN5) locality has produced Acheulian artifacts dated to ca. 1.6-1.5 Ma (Semaw et al., 2018, 2020). Further, the Busidima North (BSN12) locality at Gona contains Acheulian dated to ca. 1.2 Ma (Semaw et al., 2018, 2020), and Ternifine (formerly Tighennif) in Algeria has yielded similar age Acheulian artifacts associated with fossil fauna bearing evidence of cutmarks (Sahnouni, 2012, Chelli Cheheb, 2018). Remarkably, both the DAN5 and BSN12 localities yielded Oldowan-type artifacts and Acheulian associated with *Homo erectus* crania (Semaw et al., 2020). Ternifine has a long history of research that resulted in the discovery of important hominin fossils assigned to *Homo erectus* (Arambourg & Hoffstetter, 1963). M. Sahnouni resumed excavations at Ternifine and recovered a considerable amount of Acheulian artifacts currently under study. Therefore, the evidence from both the Gona and Ain Hanech study areas is complementary and the sites are key for investigating the biocultural evolution of ancestral humans in East and North Africa, and comparative technological studies are priority for understanding the biocultural evolution of early Homo and *Homo erectus* in East and North Africa.

The younger Mid-Late Pleistocene deposits at Gona, at Gawis South (GWS2), and the Tabelbala Tashengit sites in Algeria have yielded Late Acheulian stone assemblages dated to 0.3-0.2 Ma (Rogers et al., 2023; Sahnouni, 2012). Gona in particular, has much younger fossil and artifact rich deposits with Middle Stone Age (MSA) and Late Stone Age (LSA) artifacts all associated with fossil fauna dated from 0.2 Ma up to 13,000 ka (Rogers et al., 2023).

This paper highlights the major Oldowan and Acheulian discoveries from the Gona and Ain Hanech/Ain Boucherit, Ternifine and other sites in Algeria, and provides details on the implications for the biocultural evolution of our ancestors from these geographically widely separated areas in East and North Africa. Further, brief discussions are provided on the archaeological materials known in the younger Mid-Late Pleistocene deposits at Gona and in Algeria.

Figure 1: A map of Africa showing the location of the Early Stone Age sites in Ethiopia and North Africa discussed in the text.

2. THE SEARCH FOR THE EARLIEST ARCHAEOLOGICAL MATERIALS IN AFRICA

Dated to 3.3 Ma, the stone assemblages documented at Lomekwi 3, in West Turkana, Kenya are currently being cited as the earliest known stone tools (Harmond et al., 2015). However, the geological context and the artifactual authenticity of the stone assemblages from Lomekwi 3, particularly the cores is questioned (Dominguez-Rodrigo & Alcala, 2019; Archer et al., 2020). Lewis and Harmand (2016) published additional excavated artifacts, but hard to decipher the artifactual authenticity of the two/three excavated ‘artifacts’ from the photos provided in their publication. Although with no associated stone artifacts, cutmarked bones contemporaneous to Lomekwi 3 were reported earlier by McPherron et al., (2010) from Dikika in Ethiopia. Again, the Dikika discovery was heavily criticized for uncertainty of its geological context and age, as well as the authenticity of the cutmarks (Dominguez-Rodrigo et al., Sahle et al., 2017). Therefore, the presence of artifacts made prior to 3.0 Ma needs further convincing primary contextual archaeological data from either Dikika and Lomekwi, and/or other well dated sites. Another claim for stone artifacts older than those recovered from Gona comes from Ledi-Geraru in the Afar of Ethiopia (Braun et al., 2019). As clearly noted in the critique by Sahle and Gossa (2019), the argument for identification of the Gauss Chron above the Ledi-Geraru excavations makes the proposed age of 2.58 Ma dubious.

The stone artifacts recently reported from Nyayanga in Kenya and dated to 2.9-2.6 Ma appear to be artifactual, though the dating needs to be firmly resolved due to the wide margin (Plummer et al., 2023). It would be relevant here to mention that despite years of systematic surveys in some pockets of deposits at Gona dated to 2.9-2.6 Ma, the archaeology team was not able to find any traces of stone artifacts.

Interestingly, a recent report by Eren et al., (2025) hypothesizes for possible use of stones earlier than 3.3 Ma. They argue that accidentally created sharp-edged flakes naturally available on the landscape, that they refer to as ‘naturaliths,’ may have been used by hominins, which through time may have led to intentional knapping via emulative processes (Eren et al., 2025). How one can prove such a hypothesis archaeologically is the big challenge. Eren et al., further argue that stone tool use may have begun ‘hundreds of thousands or even millions of years’ before the beginnings of intentional knapping to create sharp-edged flaked stones like those discovered at Gona, ‘that appear relatively advanced.’ In their conclusion, Eren et al., urge archaeologists to look for artifacts that may be older than the 3.3 Ma “Lomekwian”. However, archaeological confirmation is required to prove the likelihood of the use of naturally modified stones by ancestral humans prior to 3.0 Ma. All that said, the earliest securely dated and confirmed flaked stones to date appear to be those excavated from Gona and dated to 2.6 Ma. The stone artifacts from Nyayanga, Kenya are artifactual, and to date the earliest known Oldowan i.e., given confirmation of their age with further dating (Plummer et al., 2023).

It seems relevant to mention here an earlier history of the search for the oldest stone tools in East Africa. In the 1920s E.J. Wayland, a British geologist, named the “Kafuan Culture” for so called “pebble tools” he discovered in the Kafu Valley in Uganda (Wayland, 1934, in Gowlett, 1990). At the time the “Kafuan Culture” represented the earliest “pebble culture,” though later in 1959 these were confirmed to be ‘geofacts” and rejected (Bishop, 1959; see Gowlett, 1990 for details of the history of the search for the earliest stone artifacts in East Africa.) This history seems to be relevant here and it is presented as a cautionary note for archaeologists to carry on thorough research on the context and geochronology of sites before naming industries for unconfirmed lithic materials recovered in deposits that are older than 3.0 Ma. The “Oldowan,” as the earliest stone industry was first proposed by Louis Leakey (1936, quoted in Gowlett, 1990, p.22) for flaked stones he discovered at Olduvai Gorge during the 1930s, which we still consider as a viable stone industry. Further, based on archaeological investigations undertaken in East Africa during the 1970s/1980s, some researchers named a “Pre-Oldowan” phase for artifacts found in deposits that are older than 2.0 Ma (e.g., Roche, 1989). The “Pre-Oldowan” was abandoned after the discovery of a large number of excavated stone artifacts at Gona which proved that ancestral humans were skilled knappers as early as 2.6 Ma (Semaw et al., 1997, 2003).

3. PALEOANTHROPOLOGICAL INVESTIGATIONS AT GONA

The Gona Paleoanthropological Study Area in the Afar, Ethiopia is well known for yielding early Oldowan stone artifacts dated to 2.6 Ma (Semaw, 2000; Semaw et al., 1997, 2003). Gona is located in the west-central part of the Afar, and encompasses an area of about 500 Km^2 (Figure 2). Much of the Gona area is covered by modern day flatlands with fossiliferous and artifact rich exposures limited only to the main tributaries of the Awash, east to west, the Kada Gona, Ounda Gona, Dana Aoule, Busidima, Asbole North, Gawis, Ya'alu and Odele drainages, and the streams feeding into these rivers (Figure 2). The Asduma fault to the west forms a dividing line with the Late Miocene/Early Pliocene deposits that yielded fossil rich hominin and associated fauna documented in the uplifted mountains in the Western Escarpment and the Western Margin. Here, important hominins including *Ardipithecus kadabba* dated to ~ 6.3 Ma, and *Ardipithecus ramidus* dated to 4.7-4.3 Ma have been documented (Semaw et al., 2005; Simpson et al., 2015).

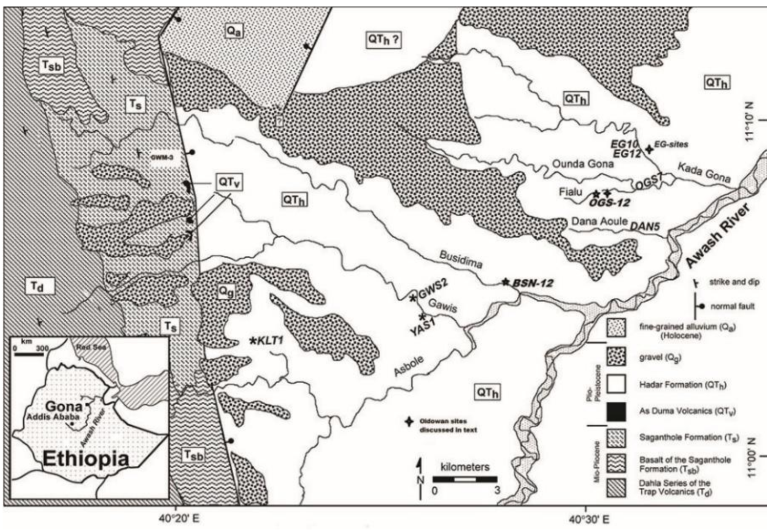

Figure 2. A map of the Gona study area showing the archaeological sites discussed in the text.

The Gona research team over the past twenty-five years has conducted extensive surveys and excavations revealing that the fossil rich deposits to the west extend back to over 6.0 Ma. As mentioned above, ongoing investigations in the Gona Escarpment and Western Margin produced important fossil hominins including *Ardipithecus kadabba* dated to 6.3 Ma (Simpson et al., 2015) and *Ardipithecus ramidus* dated to 4.7 - 3.5 Ma (Semaw et al., 2005; Nugsse et al., in submission). The Early Pleistocene deposits in the eastern part of Gona yielded two *Homo erectus* craina dated to 1.5 Ma and 1.2 Ma, respectively (Semaw et al., 2020). The Gona deposits document a complete archaeological record from 2.6 Ma up to the Late Pleistocene dated to ~13,000 (Ka) (Rogers et. al, (2023). However, to date much of our investigations were limited in the older deposits that yielded Oldowan and Acheulian artifacts. It is only over the past ten years that we began focused research in the deposits that are younger than 100 Ka, where important Middle Stone Age and Late Stone Age sites and associated fauna and hominins were documented.

Context and Geochronology of the Gona Archaeology

A tuff found in 1993 just above the EG13 locality, which is located a few meters from EG10 and EG12, and within the same stratigraphic section was dated to 2.52 Ma by $^{39}Ar/^{40}Ar$; and the Gauss-Matuyama transition dated to 2.58 Ma was traced just below the archaeological horizon at the EG10, EG12 and EG13 localities. Therefore, the Gona early Oldowan stone artifacts were securely dated to 2.6 Ma based on $^{39}Ar/^{40}Ar$ and paleomagnetism (Semaw, 2000; Semaw et al., 1997, 2003). With the same geological settings and stratigraphic sequence as the EG sites, the OGS6 and the OGS7 localities, found ca. 5 Kms away to the south east, yielded artifacts that are of exact same age. A prominent volcanic ash found above the OGS7 locality yielded an $^{39}Ar/^{40}Ar$ age of 2.53 Ma, and the Gauss-Matuyama transition was traced immediately below the OGS7 locality. The same dating results were also repeated later at another locality named DAN1 in the Dana Aoule drainage to the east. Stone tool cutmarks were identified on an equus calcaneum recovered from OGS6, located a few meters from OGS7 (Dominguez-Rodrigo et al., 2005). Therefore, the evidence clearly shows that the Gona Oldowan artifacts were made for processing animal carcasses for meat.

Two lithofacies named Type I and Type II are identified in the Gona sequence. Type 1 consists of clasts in the upward fining sequence deposited by the ancestral Awash River, and Type II lithofacies are contained in the tributaries of the Awash (Quade et al., 2008). The Lower Busidima Formation is dominated by Type I, also the possible sources of stone raw materials used for making the tools, whereas Type II is featured mainly in the Upper Busidima Formation (1.26- Ma to c. 0.5 Ma). Gona also documents among the most complete stable carbon isotopic composition of soil carbonates (δ13Csc) demonstrating terrestrial paleoenvironmental changes during Pleistocene East Africa. Based on the stable isotope composition, increased presence of c4 vegetation has been documented throughout the Pleistocene (Levin et al., 2004).

The Oldowan at Gona

Gona documents extensive evidence of early Oldowan stone technology at 2.6 Ma (Semaw et al., 1997, 2003). The first excavation was carried out at East Gona (EG10 and EG12) in 1992. Here more than 3,000 surface and excavated stone artifacts including cores, flakes and flaking debris were recovered. Following the first large multidisciplinary expedition to Gona, in 2000 MJR discovered the Ounda Gona South locality named OGS7. The EG and OGS discoveries debunked the long-held view for the argument that hominins were not skilled knappers prior to 2.0 Ma (e.g., Roche, 1989). The Gona Oldowan stone tools are testimony to hominin sophisticated skill and understanding of conchoidal fractures with extensive bold flaking of cobbles at 2.6 Ma.

Table 1: Artifact composition of the OGS7, EG10 and EG12 Oldowan artifacts. Please note the variety of raw materials used at OGS7 (after Semaw et al., 2006).

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

Because of the sophisticated skills of manipulating shown on the stones, we suggested the likelihood for the beginnings of the use of stone artifacts to predate 2.6 Ma (Rogers and Semaw, 2009; Semaw, 2009). However, still puzzling is the fact that the hominins at the EG sites primarily practiced unifacial flaking of cores, whereas at the OGS localities we see mainly bifacial/multifacial working of the cores. In addition, the EG assemblages were dominated by trachyte and rhyolite cobbles whereas at the OGS6 and OGS7 localities a more variety of raw materials including vitreous volcanics, rhyolite, trachyte, etc. were used (Figure 3). Why the use of a more variety and raw material selectivity at the OGS localities has yet to be investigated and understood (Stout et al., 2005, 2010).

Figure 3. The 2.6 Ma Oldowan artifacts from Gona, 1) Cores and flakes from the EG sites; and 2) Whole flakes made of a variety of raw materials from OGS7.

Despite systematic surveys, the exact source of the OGS raw materials, especially the vitreous volcanics, has yet to be identified. However, the EG toolmakers had easy access to river cobbles which are also accessible in nearby ancient streams, currently visible in the conglomerates immediately below the archaeological horizon at the EG localities. The excavated stone artifacts at the EG and OGS localities were preserved in fine-grained sediments, with all sizes of artifacts including large cores, whole flakes and a large number of small size angular fragments, proving that the artifacts were in primary geological context.

The Acheulian at Gona

As discussed in the introduction, the earliest Acheulian artifacts dated to 1.75 Ma are known from Konso in southern Ethiopia, and at Kokiselei 4, West Turkana in Kenya (Lepre et al., 2011; Beyene et al., 2013). Slightly younger Acheulian occurrences dated to ca. 1.7 Ma are known from Olduvai Gorge (Diez-Martin et al., 2015), Ain Hanech, and at OGS12 at Gona. Further, Duke et al., (2021) reported excavated materials dated to 1.8 Ma at Kokiselei 6 in Kenya that consist of roughly worked bifacial Mode 1 large cores showing incipient Acheulian technology. A recent publication by Mussi et al., (2023) argues for the discovery of even earlier Acheulian implements at Garba IV in Melka Kunture, in Ethiopia dated to 1.95 Ma; with the underlying deposits yielding an infant mandible identified as *Homo erectus* and associated with Oldowan artifacts dated to ca. 2.0 Ma. The age of the Garba IV Acheulian was contested by Gossa et al. (2023), and if its age is confirmed Garba IV could represent the earliest Acheulian documented in Africa, and most importantly among the earliest evidence for *Homo erectus* to venture into the highlands.

Table 2: Artifact composition of the Acheulian LCTs from BSN12 and OGS12 (after Semaw et al., 2018)

	BSN12		OGS12	
	Surface	In context	Surface	In context
Handaxes	3	0	12	1
Picks	0	1	11	2
Cleavers	0	0	1	0
Cores/choppers	25	7	10	5
Discoids	5	0	0	0
Whole Flakes	95	4	77	31
Broken flakes and Angular fragments	49	0	56	25
Modified flakes	0	0	4	4
Modified Cobbles	0	3	3	7
Unmodified Cobbles	0	3	0	1
Split Cobbles	0	0	1	0
Hammerstones	0	0	2	1
Total	177	18	177	77

The earliest Acheulian in the Ounda Gona North area at OGS12 is dated close to 1.7 Ma (1.69 Ma). The OGS12 excavation yielded crudely made handaxes, cleavers and picks made on a variety of stone raw materials associated with fauna bearing evidence of stone tool cutmarks (Caceres et al. 2017). A majority of the Acheulian artifacts were made on basalt, a raw material type with the sources yet to be traced. Most remarkable, it is unlikely that the Acheulian toolmakers at Gona sought for fine-grained stone raw materials. The main emphasis for the toolmakers appears to be choosing large size cobbles/flakes for making large picks, handaxes and cleavers (Figure 4).

Figure 4. Acheulian LCTs recovered from OGS12 (left) and BSN12 (right), after Semaw et al., 2018.

The evidence shows that the toolmakers made stone artifacts on a variety of raw materials with a majority made on basalt, the source of which again has yet to be determined. Despite the introduction of the Acheulian in the archaeological record, a site named DAN16 estimated to c. 1.1 Ma, yielded only Mode I stone artifacts, which is puzzling. Despite the numerous surface handaxes exposed at the site, the DAN16 excavation yielded only Mode I cores, flakes and flaking debris. As previously argued, Mode I stone artifacts were manufactured after the emergence of the Acheulian (e.g., DAN16), actually remaining ubiquitous throughout the Paleolithic.

Among important contributions of the research at DAN5 and BSN12 at Gona is the discovery of two *Homo erectus* crania, both associated with Oldowan and Acheuian stone artifacts, a rare co-occurrence of artifacts and hominins in the archaeological record (Semaw et al., 2020). The older cranium was discovered at DAN5 (Dana Aoule North) and dated to 1.6 - 1.5 Ma, and the younger from BSN12 (Busidima North) was dated to c. 1.2 Ma. The DAN5 cranium is smaller and the one from BSN12 larger and robust, possibly implying sexual dimorphism. The DAN5 *H. erectus* cranium shows morphological similarity to the 1.85- to 1.76-Ma *Homo erectus/ergaster* crania known from Dmanisi, the Republic of Georgia (Rightmire et al., 2018; Lordkipanidze et al., 2013), the 1.6- to 1.5-Ma KNM-ER 42700 juvenile cranium from Ileret (Spoor et al., 2007), and the 0.95-Ma small cranium (KNM-OL 45500) from Olorgesailie, both from Kenya (Potts et al., 2004). Remarkably, a recent reconstruction of the face of DAN5 by Baab et al. (2023) shows that it represents the first complete early Pleistocene *Homo* cranium from the Horn of Africa.

Late Acheulian, MSA and LSA at Gona

Only cursory surveys were carried out in the Gona Mid-Late Pleistocene deposits. Here, stone artifacts are sparse, and thorough and systematic surveys/investigations are needed. A number of sites have been documented north of the Asbole drainage in the Gona study area where surface Mode II artifacts and fossil faunas estimated to 0.9-0.5 Ma have been collected (Rogers et al., 2023). Compared to earlier Acheulian, the handaxes from this area show more symmetry and they are relatively thinner. A high concentration of fossil fauna and artifacts in the archaeological record at Gona picks up again in the deposits that are younger than ~300 Ka. The major site with Late Acheulian concentrations was documented in the Gawis South drainage at locality GWS2, estimated to 300-200 Ka (Rogers et al. 2023). Here, Kombewa cleavers, smaller ovate handaxes and discoidal cores with the inception of the Levallois technique were excavated and collected from the surface.

Artifact rich and fossiliferous deposits continue further to the west and southwest part of the Gona study area that produced MSA and LSA artifacts and associated fauna younger than 100 Ka (Rogers et al., 2023). Among the most important are YAS1 where a high-density concentration of MSA artifacts and fauna have been excavated. MSA and LSA sites have been also documented in the southwestern part of the study area within the newly designated Odele Member (Stinchcomb et al., 2023, 2025). A variety of stone artifacts with heavy duty cores, Levallois cores, microlithic cores blades, and grindstones have been discovered and collected. Kilaitoli, located further west is the youngest archaeological site at Gona. Dated to c. 13 Ka, the site yielded thousands of excavated microliths made of obsidian cores and bladelets, including grindstones, ostrich eggshell and gastropod beads.

Gona is among the most important Palaeoanthropological study areas with a wealth of fossil fauna and hominins with the earliest dated to > 6.0 Ma. The site documents continuous artifact rich deposits from the earliest Oldowan dated to 2.6 Ma up to the Late Pleistocene/early Holocene LSA. The only time interval least represented in the archaeological record at Gona is between 0.9 - 0.3 Ma, where the archaeology team begun to undertake focused survey in the past few years.

4. PALEOANTHROPOLOGICAL INVESTIGATIONS AT AIN BOUCHERIT-AIN HANECH, TIGHENNIF AND NORTH AFRICAN ACHEULIAN SITES

Beginning in 1992, the first multidisciplinary archaeological investigations begun in the Ain Boucherit-Ain Hanech study area in northeastern Algeria (Figure 1). Major focus of the research was to address the following questions: When did early humans first inhabit North Africa? What kind of environment did they live in? What kind of lithic technology did they use? What food items were incorporated in their diet? To answer these questions, the research focused on detailed investigation of the Ain Boucherit and Ain Hanech Paleolithic sites. Our investigations included study of the stratigraphy and chronology, reconstruction of the physical environment, and highlighting the significance of hominin behavioral and adaptive strategies via taphonomic studies. First, the work focused on the lower Pleistocene archaeological deposits of Ain Hanech and El Kherba, that revealed multiple Oldowan occupations dated to 1.8 million years ago (Ma) (Sahnouni and de Heinzelin, 1998; Sahnouni et al., 2002, 2013). Subsequent exploration of the fossil bearing deposits at Ain Boucherit led to the discovery of stone tools associated with cutmarked animal bones dated to 2.4 Ma, substantially older than those of Ain Hanech and El Kherba, excavated from two distinct archaeological layers. The beginning and development of the Acheulian occupation in North Africa at the Ain Hanech and El Kherba sites, and the hominin site of Tighennif is discussed here, and summary of other major Mid-Late Pleistocene sites in Morocco and Algeria is provided.

The Oldowan sites and their chronostratigraphic framework

The Oldowan occupations in the Ain Boucherit/Ain Hanech study area are located near Sétif on the High Plateaus of eastern Algeria. The area consists of a succession of Plio-Pleistocene fossiliferous and archaeological deposits including Ain Boucherit, Ain Hanech, and El Kherba. Acheulian stone tools estimated to 1.67 Ma, encased in a calcrete deposit, cap the sequence. Below Ain Boucherit there is a succession of three distinct fossiliferous strata estimated to 3.78 Ma, 3.49 Ma and 3.17 Ma, respectively (Duval et al., 2021). The Ain Boucherit site is located on the west bank of the intermittent Oued Boucherit and contains two distinct archaeological layers: the lower archaeological level (AB-Lw) and the upper archaeological level (AB-Up) (Figure 5). The AB-Lw (36.204°N; 5.653°E) refers to the fossiliferous bearing stratum exposed lower in the stratigraphy and attributed to the Villafranchian (~ early Pleistocene) by Pomel (1895; 1897). Sahnouni et al (2002; 2018) revisited the stratum and discovered Oldowan stone tools associated with mammalian fossil bones, some with butchery marks. The stratum belongs to the upper part of Member P of the Ain Hanech Formation (see below) and consists of fine-grained sediments made up mainly of silts (83%), fine sands (14%) and clays (2%), suggestive of a floodplain environment. The AB-Up (36.204°N; 5.653°E) is a newly discovered archaeological deposit that lies a few hundred meters south of AB-Lw and 9 meters higher up in the stratigraphy than AB-Lw. Fossil bones and associated stone tools excavated from this archaeological deposit derives from a sedimentary matrix composed primarily of silt (78%) and clay (18%) suggesting floodplain environmental settings (Sahnouni et al., 2018).

Slightly younger Oldowan settlements occur at the sites of Ain Hanech and El Kherba. The Ain Hanech site was discovered in 1947 by Arambourg (1970). It is located on the east bank overlooking the deep Oued Boucherit ravine. Sahnouni (1998) launched new systematic investigations that revealed the existence of multiple early Pleistocene localities extending over a vast area including Ain Hanech (36.204°N; 5.657°E), El-Kherba (36.202°N; 5.658°E), and El Kherba-Puits (36.201°N; 5.658°E). El Kherba and El Kherba-Puits are located respectively 350 m and 450 m from the classic locality of Ain Hanech. To date, the excavations have yielded 1,793 fossil bones and 1,082 lithic artifacts at Ain Hanech, and 1,536 fossil bones and 811 lithic artifacts at El Kherba, contained in three distinct archaeological levels, from top to bottom, A, B and C (Sahnouni et al. 2002).

Stratigraphy and dating

The Ain Boucherit and Ain-Hanech sites are contained in the Ain Hanech Formation (Fm) formed in the Mio-Plio-Pleistocene sub-basin of Beni Fouda located to the northeast of the Sétif region (eastern Algeria). The Ain Hanech Fm is 29 m thick and includes, from bottom to top, 6 members (Mb): P, Q, R, S, T and U, which seals the formation (Figure 5) (Sahnouni et al. 2017; Sahnouni et al 2018). At the basal end of the Ain Hanech Fm is Member P overlying the top of Oued Laatach Fm (O). The Ain Boucherit lower archaeological level (AB-Lw) is encased in the muddy upper part of Mb P. The overlain Mb Q is 7 m thick and consists of a monotonous series of floodplain light/brown sediments with high clay content and fine-grained upwards sequence. Above Q, rests Mb R that consists of 10-15 cm thick light brown sandy mud and scatter pebbles overlain by 25 cm thick very pale brown sandy mud. The Mb R contains the Ain Boucherit upper archaeological level (AB-Up) that yielded an Oldowan lithic industry and fossil fauna. These deposits are associated with fluvial gravels and floodplain facies under seasonal flooding conditions. The top of the formation includes Members T and U. Member T encases the younger Oldowan horizons of Ain Hanech and El Kherba. It is 4 m thick light brown or pink muddy unit with very hard $CaCO_3$ nodulations in its upper part. Member U is about 0.80 m thick and is composed of detrital facies of sands and gravels of fluvial origin indurated by carbonates, which gave rise to a K horizon that stands out in the landscape. This member yielded Acheulian stone tools. In summary, the Ain Hanech Fm represents a fluvial sequence with a lower part consisting of floodplain deposits with very shallow lagoons and courses of small rivers that carried sands and small pebbles. The upper part of the formation is also fluvial with the development of a powerful edaphic horizon of carbonates (Sahnouni & de Heinzelin 1998; Sahnouni et al., 2018; Duval et al., 2021).

The dating of the Ain Boucherit-Ain Hanech Oldowan sequence is based on an approach combining magnetostratigraphy and biochronology of large mammals. A thorough paleomagnetic study of two stratigraphic columns and geomagnetic correlations established a synthetic magnetostratigraphic sequence approximately 50 m thick, where a succession of intervals of normal and reverse magnetic polarities have been identified (Figure 5). The successive archaeological horizons are positioned in an interval of reverse and normal polarity within the upper part of the sedimentary sequence. As a result, AB-Lw in Mb P falls within the lower Matuyama chron, whereas AB-Up correlates to the bottom of the Olduvai subchron. The Ain Hanech and El Kherba deposits, stratigraphically situated in Mb T, are near the top of the Olduvai subchron (1.78 Ma) (Pares et al 2014; Sahnouni et al 2018). Taxa of biostratigraphic interest corroborated the paleomagnetic interpretation. For example, the suid *Kolpochoerus heseloni* (= *K. limnetes*) is present at Ain Hanech and El Kherba with its last occurrence dated to around 1.7 Ma. Likewise, the Proboscidean *Anancus* has been identified in AB-Lw as well as at Ain Hanech, and its most recent occurrence in East, South and North Africa dated to around 3.8-3.5 and <3.1-2.5 Ma (Sahnouni et al 2018). The presence of these taxa in the AB-Lw, AB-Up, and at both Ain Hanech and El Kherba is consistent with their respective correlations with the early Matuyama chron (2.58-1.95 Ma) and the Olduvai subchron (1.95-1.77 Ma). This first chronological interpretation is further refined by sediment accumulation rates (SAR). Thus, AB-Up and AB-Lw are estimated to 1.92 Ma and 2.44 Ma, respectively. Ain Hanech and El Kherba, located higher up in Mb T, date to 1.78 Ma. (Pares et al 2014; Sahnouni et al 2018). Further, an Electron Spin Resonance (ESR) dating age of 1.83 Ma, recently obtained for Ain Hanech (Duval et al., 2023), confirms the paleomagnetic results and the SAR age estimates.

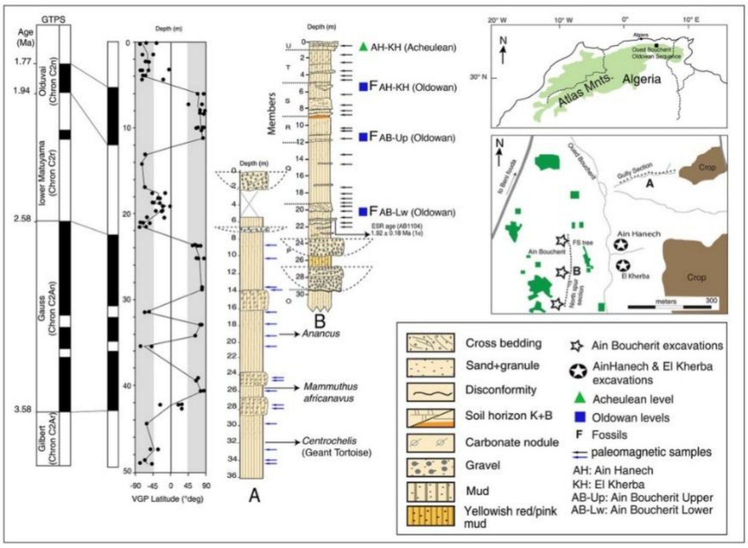

Figure 5: A map showing the location of the Ain Boucherit, Ain Hanech, and El Kherba sites; and their stratigraphic and magnetostratigraphic data. All the archaeological sites are contained in the Ain Hanech Fm. AB-Lw, in Mb P, are dated to the Matuyama lower Subchron (> 2 Ma), AB-Up in Mb R is dated to the onset of the Olduvai Subchron (~1.95 Ma), and the Ain Hanech and El Kherba Oldowan sites are dated to the end of the Olduvai Subchron (1.78 Ma). The later sites are overlain by the Acheulian level encased in the calcrete deposit sealing the formation (modified after Sahnouni et al., 2018).

Paleoenvironmental settings

Stratigraphic, faunal, sedimentological and isotopic studies were carried out to reconstruct the paleoenvironmental settings of the Plio-Pleistocene deposits at the Ain Hanech research area.

Stratigraphic and sedimentological evidence indicate that the Ain Boucherit, Ain Hanech, and El Kherba sites were formed in fluvial floodplain environments with shallow lagoons and courses of small channels. Ain Hanech and El Kherba are stratigraphically complementary, varying laterally from a shallow river embankment at Ain Hanech to a marshy edge at El Kherba (Abdessadok et al., 2022, Sahnouni & de Heinzelin, 1998; Sahnouni et al., 2011; Sahnouni et al., 2018).

All of the three sites have yielded rich faunal assemblages. The faunas are savanna adapted and include proboscideans, equids, rhinoceroses, hippopotamuses, small and large bovids, giraffids, suids and carnivores, lagomorphs, crocodiles and turtles (see detailed lists of species in Sahnouni et al., 2011; 2018; Van der Made & Sahnouni, 2013). The Ain Hanech and El Kherba faunal assemblages differ from the older ones at Ain Boucherit. The most noted difference is the presence of *Giraffa pomeli* at Ain Hanech and the absence of *Parantidorcas* at the same site. *Equus*, a grazer adapted to open landscapes, is scarce at Ain Boucherit but is abundant at Ain Hanech and El Kherba. *Parantidorcas*, a mainly grazing small bovid that tends to live in a relatively close habitat, is present at Ain Boucherit and absent at Ain Hanech and El Kherba. Overall, the faunas suggest a slightly open landscape at Ain Boucherit between 2.44 and 1.92 Ma that over time became increasingly open at Ain Hanech and El Kherba ca. 1.83 Ma ago. This evidence is also corroborated by isotopic studies of pedogenetic carbonates (Sahnouni et al. 2011). Yet, water was permanently present as indicated by hippopotamus remains as well as other aquatic remains (e.g., crocodiles and turtles).

The Ain Boucherit and Ain Hanech Oldowan stone tools

The Oldowan stone tools excavated from the Ain Boucherit AB-Lw and AB-Up, Ain Hanech and El Kherba Oldowan sites total 2146 (Table 3) specimens. A majority are made of limestone with substantial flint and include the following categories: cores and core forms, whole flakes, retouched pieces, and fragments. The stone tools, excavated from the Ain Boucherit lower archaeological level (AB-Lw) (Figure 6 [1-3 & 7-9]), represent a small assemblage totaling 17 specimens which were recovered from limited trench excavations from steep-walled exposures and ~20m sediment of overburden (Sahnouni et al., 2018). The lithic artifacts are fresh and include 7 cores, 9 flakes and a single retouched piece. The cores (mean dimensions: 85.7 x 67.0 x 55.8 mm, 502.8 gr) are primarily polyhedral and irregularly flaked with variable scar counts (2-8 scars). Only one core is extensively flaked. Half of the associated flakes have cortical dorsal faces and butts. The only retouched piece, measuring 25 x 23 x 10 mm, is a notched scraper made of flint.

The Ain Boucherit upper archaeological level (AB-Up) (Figure 6 [4-6 & 10-12]) is richer with stone artifacts as it is the product of a large-scale horizontal excavation (Table 3). Based on a number of indications, the bulk of the archaeological materials are in primary geological context, within fine-grained sedimentary matrix; including high representation of debitage; and absence of preferred orientation, as well as high inclination, and noticeable size sorting of artifacts. The lithic assemblage totals 236 artifacts incorporating cores and core forms: 121 (51.27%), whole flakes: 65 (27.54%), fragments: 47 (19.91%), and retouched pieces: 3 (1.27%). Most of the cores and core forms were made on limestone than on flint (95.8% vs 4.13%), and are variably flaked including light (37.19%), moderate (41.32%), and heavy (21.48%); with 50% of the cores still retaining cortex. The core forms include unifacial and bifacial choppers (16.94% and 8.05%, respectively), polyhedron (23.05%), subspheroids (1.69%), and spheroids (0.84%). Most of the flakes were made on limestone (58.46%) versus on flint (41.53%). The three retouched pieces are in flint and include two simple scrapers and one notched scraper.

The younger Ain Hanech and El Kherba Oldowan occurrences produced a total of 1,893 stone artifacts (Figure 6 [13-22]). Out of this total, 1082 were recovered at Ain Hanech and 811 at El Kherba (Table 3). The total breakdown of the artifacts is as follows: 1) Ain Hanech: 280 (25.8%) cores and core forms, 272 (25.13%) whole flakes, 216 (19.96%) retouched pieces; and 314 (29.02%) fragments; 2) El Kherba: core and core forms: 222 (27.37%), whole flakes: 256 (31.56%), retouched pieces: 122 (15.04%), and fragments: 211 (26.01%). Level B is the richest at both Ain Hanech and El Kherba. For instance, at Ain Hanech Level B totals 809 (74.76%) artifacts versus 242 (22.36%) for Level A, while Level C yielded only 31 (2.82%) artifacts. Similarly, at El Kherba Level B yielded 428 (52.77%) specimens versus 286 (35.26%) for Level A. Level C has produced a slightly higher number of artifacts totaling 97 (11.96%) than the same level at Ain Hanech, probably due to the larger excavated area.

Table 3: Overall presentation of the stone tool assemblages of the Ain Boucherit-Ain Hanech Oldowan sequence including Ain Boucherit AB-Lw and AB-Up, Ain Hanech, and El Kherba (excluding small debitage <2 cm of maximum dimension) (modified from Sahnouni et al., 2017).

Categories of artifact	Ain Boucherit AB-Lw		Ain Boucherit AB-Up		Ain Hanech		El Kherba		Total	
	N	%	N	%	N	%	N	%	N	%
Cores/Core forms	7	41,17	121	51,27	280	25,87	222	27,37	630	29,35
Whole flakes	9	52,94	65	27,54	272	25,13	256	31,56	602	28,05
Retouched pieces	1	5,88	3	1,27	216	19,96	122	15,04	342	15,93
Fragments	-	-	47	19,91	314	29,02	211	26,01	572	26,65
Total	17	100	236	100	1082	100	811	100	2146	100

Figure 6: Oldowan stone tools made of limestone and flint from Ain Boucherit, Ain Hanech, and El Kherba. Ain Boucherit Ab-Lw, Ab-Up: 1-6: flaked cobbles (unifacial and bifacial choppers, polyhedrons, facetted subspheroids, and cores); 7-8 and 10-11: flakes; 9 and 12: retouched pieces (notched scrapers). Ain Hanech and El Kherba: 14-16: flaked cobbles and cores (unifacial chopper, polyhedron, facetted spheroid, and core); 17-19: flakes; 20-22: retouched pieces (scrapers and denticulates-like).

Evidence of Oldowan hominin butchery activities

Evidence of cutmarks and hammerstone percussion marks is documented on fossil bone surfaces excavated from Ain Boucherit (AB-Lw and AB-Up) and El-Kherba. The Ain Boucherit faunal assemblages total 573 specimens, including 296 (MNI=19) from AB-Lw and 277 (MNI=14) from AB-Up. The fossil assemblages incorporate primarily small sized bovids (e.g., gazelles) and equids. The appendicular elements are the most represented in both archaeological levels but dominated by the lower limbs (metapodial, phalanges and carpal-tarsal) (Caceres et al., 2023; Sahnouni et al., 2018). Evidence of cutmarked and hammerstone-percussed bones is documented in both assemblages (Figure 7 [1-2]). The AB-Lw assemblage yielded 17 cutmarked bones and 4 percussed bones. The cutmarks consist of isolated or clustered incisions characterized by a strait or oblique trajectory and transversal orientations; and many of them are V-shaped in cross sections with clear internal microstriation and Hertzian cones. Half of the cutmarked specimens belong to small-sized animals representing primarily limb bones, ribs, and cranial remains. The hominin-induced percussion marks include pits, medullary or cortical notches, and a bone flake indicative of marrow extraction. In the AB-Up faunal assemblage, two cutmarked bones (an equid tibia and medium-sized long bone) and seven hammerstone-percussed long bones (of an equid and a medium-sized animal, and a tibia of a small-sized animal) are recognized. The Ain Boucherit cutmarked bones and intentional bone breakage patterns imply that Oldowan hominins consumed meat and marrow from several ungulates, mainly small-sized bovids and equids. The bone modifications on the fauna suggest skinning, evisceration, defleshing activities, as well as bone marrow processing. These activities, especially evisceration, suggest a primary early hominin access to animal carcasses (Sahnouni et al 2018; Caceres et al., 2023).

The El Kherba Oldowan site yielded 619 bone remains. The Minimum Number of Individuals (MNI) total 24 individuals, dominated by 11 equid individuals. Adult specimens are the most common. The most represented anatomical parts are cranial and limb bones. Twelve cutmarked bones with clear cutmarks are recognized at El Kherba (Figure 7 [5]) (Sahnouni et al 2013). Some incisions still retain characteristic morphologies such as the V-shaped section accompanied by secondary lines. They are isolated or in groups of two or four. Most of the cutmarks are located primarily on limb bone mid-shafts and on pelvic bones of large and medium-sized animals. In addition, there is a bone fragment of a large animal (probably a hippopotamus), which features a cutmark overlain by a carnivore U-shaped section tooth mark suggesting hominin primary access to animal carcasses (Sahnouni et al., 2013).

Evidence of intentional bone breakage is also present at El Kherba (Figure 7 [6]), including on limb bone shaft fragments and impact flakes. The limb bone shafts include two medium sized-animal humeri, a small-sized animal radius, and an indeterminate shaft fragment. They are longitudinally fractured with clear percussion notches and inner conchoidal percussion scars. The impact flakes display conchoidal features of percussion similar to those present on knapped flakes made of fine-grained rocks, including platforms and percussion bulbs. These bone breakage patterns suggest extracting marrow by hominins.

In addition to cutmarked bones, evidence of usewear is also present on whole flakes (Sahnouni et al., 2013). These trace-bearing tools are medium and small-sized flakes. Five specimens show only one used edge while two flakes have two active edges, one of which was used predominantly. The traces are localized along the lateral edges and concentrated on the straight and sharp parts. Overall, the polish extends scantily inside the face of the artifacts decreasing from the edge to the inner part. This poor polish penetration into both faces is suggestive of a high angle of work consistent with cutting actions of butchery activities. Further, the polishes are uniform as they do not show other types of actions such as transversal marks of scraping or plant polishes. All these features clearly represent butchery traces indicative of processing meat, which is also observed on experiments (Verges, 2002). Usewear traces have also been documented on several Ain Hanech flint artifacts including 16 predominantly simple flakes displaying meat polishes, and the same use pattern observed in the El Kherba used specimens (Sahnouni & de Heinzelin, 1998).

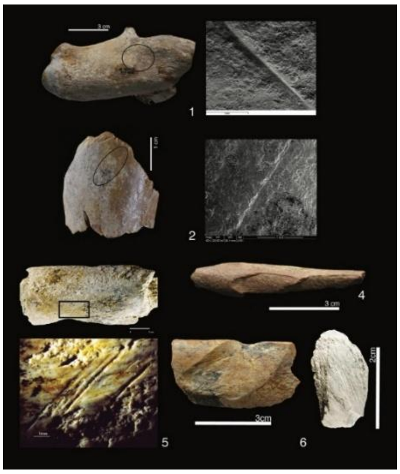

Figure 7: Examples of hominin modified animal bones including: cutmarked bones from Ain Boucherit (1-2) and from El Kherba (5); hammerstone percussed bones from Ain Boucherit (4) and from El Kherba (5-6).

The earliest Acheulian settlement in North Africa

Archaeological surveys of the calcrete deposits in the vicinity of Ain Hanech and El Kherba led to the discovery of Acheulian artifacts, documenting a younger phase of hominin occupation in the area with an advanced lithic technology compared to the Oldowan technology (Sahnouni & de Heinzelin, 1998). Stratigraphically, the Acheulian occurrences are entirely independent from the Oldowan deposits. They are sealed in the Mb U of the Ain Hanech Fm overlying Mb T that contains the Ain Hanech and El Kherba Oldowan assemblages. Mb U consists of 1m-thick deposits made of detrital facies of sands and gravels of fluvial origin cemented by calcium carbonate. No faunal remains have been found associated with the Acheulian artifacts so far. The assemblage includes diagnostic Acheulian artifacts made of limestone such as trihedrons (picks) and bifaces (handaxes), as well as cores and flakes. The trihedrons (picks) are relatively big and thick (mean of length and of thickness: 135.5 mm; 60.5 mm, respectively). They are characterized by a typical triangular section, a sinuous ridge, and an average of 8 removed scars. The bifaces are numerous (17 specimens) and are overall of big format (mean of length and of breadth: 124.23mm; 80.64mm, respectively) and relatively thick (mean thickness: 40.35 mm). The number of removed scars is higher compared to those on trihedra, but they still preserve cortex. With the exception of few specimens, the symmetry is barely materialized, and the main ridge, separating the biface faces, is quite sinuous. As it is in most African Acheulian assemblages, the flakes are big, especially one specimen that is exceptionally large (length: 226 mm; breadth: 200 mm; thickness: 80 mm; and weighing: 2267 gr) (Duval et al., 2021).

Overall, the Ain Hanech Acheulian is characterized by: 1) presence of trihedra (picks), 2) big and thick artifacts, crudeness and lack of well-materialized symmetry in bifaces, 3) typically large and deeply concave scars and sinuous ridge due to the exclusive use of hard hammerstone, and 4) absence of any predetermination technique for producing relatively advanced artifacts (e.g., Kombewa technique that is common in later Acheulian). All these morphological and technological features are suggestive of an early Acheulian similar to the one documented in East Africa, e.g. Konso Gardula and Gona (Ethiopia) (Beyene et al, 2013; Semaw et al., 2018). The calcrete deposit encasing the Acheulian at Ain Hanech is estimated to 1.67 ± 0.04 Ma (Duval et al., 2021), thus, representing among the earliest Acheulian settlement documented in North Africa.

Homo erectus adaptation in Tighennif

The *Homo erectus* site of Tighennif is located on the High Plateaus of western Algeria (35º 24’57.30” N; 0º 19’21.30” E). It was discovered in 1872 during sand quarry exploitation (Balout, 1955). Subsequently, Arambourg and Hoffstetter(1963) carried out large scale excavations that led to the discovery of the oldest North African hominin fossils. The hominins include three mandibles, an isolated parietal, and several isolated teeth, considered to be reminiscent of Asian *Homo erectus*; and described as *Atlanthropus mauritanicus* (Arambourg & Hoffstetter, 1963). The site also yielded a rich vertebrate fossil fauna associated with an Acheulian assemblage. The most common large faunal taxa consist of *Loxodonta atlantica*, *Cerathotherium simum*, *Equus mauritanicus*, *Metridiochoerus compactus*, *Giraffa* cf. *pomeli*, *Oryx* cf. *gazella*, *Chonochaetes*, *Crocuta crocuta*, *Theropithecus* cf. *oswaldi*, and gazelles (Geraads et al., 1986). The microfossils, largely dominated by small mammals include, in decreasing order, *Gerbillus major* (gerbilid), *Arvicanthis arambourgi* (murid), and *Ellobius africanus* (arvicolid). Other taxa include *Mascaramys medius*, *Gerbillus cingulatus*, *Meriones maximus*, *Paraethomys tighennifae*, *Crocidura* cf. *maghrebiana* (insectivore), *Trischizolagus* sp. (leporid), *Bufonidae* indet., cf. *Mauremys* (amphibians), *Lacertidae* indet., (reptile), *Malpolon* sp., and *Aves* indet (Saidani, 2023). Overall, the fossil fauna suggests an open and arid environment, but *hippopotamus* and other aquatic remains also suggest the presence of perennial water.

New studies have been resumed at Tighennif, involving stratigraphy, dating, and archaeological excavations. Stratigraphically, the mostly sandy sequence is of fluvial origin or associated with floodplain environmental settings. It comprises three major sedimentary deposits including varicolored clays with patches and CaCo3 nodules; in erosive discordance, a thick deposit of sand resting on the varicolored clays, and a thick layer of sandstones of fine to medium sands resting on a disconformity. A caliche soil seals the stratigraphic sequence. As of the dating, Tighennif was estimated to 0.7 Ma in age (Geraads et al. 1986). Sahnouni and Van der Made (2009) suggested an age of around 1.0 Ma based on biostratigraphic grounds. After studying the Tighennif fossil suids, Pickford (2020) concluded that they all belong to *Metridiochoerus andrewsi*, which is dated at Olduvai Upper Bed II to 1.4±0.3 Ma. Comprehensive studies are conducted involving paleomagnetism, Electron Spin Resonance (ESR), Optically Stimulated Luminescence (OSL), and cosmogenic nuclides dating techniques. The preliminary results are compatible with a Lower Pleistocene age (>0.8 Ma) for the sediments.

The ongoing Tighennif excavations yielded additional Acheulian stone artifacts. They are fresh except for some specimens (5.19%) made of sandstone that show disintegration due to their fragile texture and probably to their long sojourn in water; and few others (0.96%) displaying abrasion. The artifacts are made of four types of rocks, including flint (52.53%), sandstone (25.96%), limestone (12.88%), and quartzite (9.61%). The assemblage incorporates cores (14.61%), flaked cobbles/pebbles (2.11%), Large Cutting Tools (LCTs) (bifaces and cleavers) (1.52%), whole flakes (20.76%), retouched pieces (18.07%), fragments (40.96%), percussors (1.15%), and unmodified cobbles/pebbles (2.88%). The technology employed is particularly sophisticated, suggesting a higher level of hominin skill and intelligence. In addition to a fairly materialized symmetry on the bifaces and the successful production of large cutting tools, the hominins used a novel flaking technique called Kombewa. The Kombewa technique involves manufacturing flakes with dual ventral faces, providing the hominins with the advantage of shaping cleavers with a convex edge and large scrapers (Balout, 1967).

Acheulian subsistence behavior is documented by the evidence of numerous cutmarks and hammerstone percussed bones (Chelli-Cheheb, 2018). The cutmarks vary in length and are mostly obliquely oriented. The axial and the lower limbs are the main anatomical parts bearing cutmarks, followed by the upper limbs, and the intermediate limbs suggesting that the Tighennif hominins were involved in skinning, defleshing, and evisceration. The hammerstone percussed bones belong to various animal taxa and size classes but those of large and very large-sized animal carcasses are the most dominant. The percussion marks consist of notches, percussion flakes, and percussion impacts. They are indicative of intentional bone breakage by hominins for extracting marrow (Chelli-Cheheb, 2018).

Other major Acheulian North African sites

Other major Acheulian sites in North Africa include a sequence in Atlantic Morocco at Casablanca, in Algeria at Errayeh, and Tabelbala, and in Tunisia Sidi Zin. The Acheulian sequence in Casablanca begins with the Lower Acheulian at the Thomas Quarry 1 Unit L1 where Acheulian artifacts are associated with faunal remains. The stone artifacts, made of quartzite and flint, comprise trihedrons, bifaces, cleavers, and large flakes. Other artifacts include unifacial and bifacial choppers, polyhedrons and spheroids, as well as a few denticulates. OSL dating indicates an age of 989±208 Ka for Unit L1 (Rhodes et al., 2006). The age is consistent with the biochronology of diagnostic elements of the associated large mammalian fauna. However, the age is re-estimated to 1.3 Ma based on Paleomagnetism (Gallotti et al., 2021). The Middle Acheulian is illustrated at Rhinoceros Cave and Thomas Quarry Hominin Cave dated to between 400 ka and 700 ka based on ESR dating of rhino tooth enamel (Rhodes et al., 2006). This cave site yielded a faunal assemblage with white rhino remains being abundant suggesting 'specialized hunting' by hominins (Raynal et al., 2002). The associated lithic assemblage is characterized by an increase of discoidal cores, flakes, rare cleavers and large bifaces. The site of Sidi Abederrahman-Extension, dated to 376±34 ka, represents the Upper Acheulian in the region.

Errayeh is located in western Algeria and consists of a sequence of several archaeological levels showing a development of the Acheulian industry over time. The industry incorporates choppers, polyhedrons, simple cores, cleavers, bifaces, as well as large and small flakes made from quartzite, sandstone and flint (Derradji, 2006). Recent excavations at Sidi Zin in north-western Tunisia revealed, in addition to a Mousterian assemblage, a Late Acheulian industry composed of limestone handaxes and cleavers, cores, and flakes in flint associated with fragmented animal fossil bones. The site is dated to a minimum of 120 ka based on Uranium-Series dating technique (Ben Arous et al., 2025).

Tabelbala in the Algerian Sahara has a long sequence of Acheulian sites, especially at the Saoura and Tabelbala-Tachenghit region. The sequence consists of three major periods. The earliest Acheulian period is characterized by Oldowan like artifacts, crude trihedrons, rare bifaces, nucleus and flakes. The second Acheulian period comprises a small percentage of Oldowan-like stone tools, refined bifaces, cleavers, and Levallois flakes. The third period includes finely made bifaces and cleavers that predominate the assemblages followed by retouched flakes which were mainly scrapers (Alimen, 1978). Of particular interest are the cleavers from Tabelbala-Tachenghit manufactured using a novel technique of core preparation and flake detachment (Figure 8). The technique entails predetermining the shape of the cleaver before knocking it off the core (Tixier, 1957).

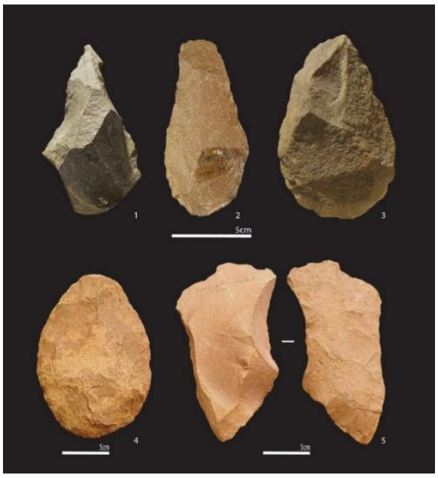

Figure 8: Examples of North African Acheulian stone tools including trihedron (1), bifaces (2-3) from Tighennif (Algeria); and a finely made biface (4) and a Type IV cleaver from Tabelbala (Algerian Sahara).

5. CONCLUSIONS

The Gona and Ain Boucherit/Ain Hanech sites document the earliest evidence for hominin stone tool use and carnivory in East and North Africa, quasi-contemporaneous sites dated to 2.6 Ma and 2.4 Ma, respectively. Both sites contain a succession of multiple Oldowan occupations, at Gona dated 2.6 - c. 1.1 Ma, and at Ain Hanech within the 2.44 Ma and 1.83 Ma time interval. Despite the considerable distance from Gona in East Africa, the evidence from Ain Boucherit/Ain Hanech suggests two possible scenarios, either a rapid expansion of stone technology from East Africa to other parts of the African continent, or a multiple-origin scenario of ancestral hominins and stone technology in both East and North Africa.

Palaeoecologically, multiple lines of evidence indicate that the Gona, and Ain Boucherit and Ain Hanech area featured riparian habitats supporting a savanna fauna that changed through time into an open and dry landscape. Oldowan hominins lived close to river embankment, a choice probably directed by the abundance of raw materials in a nearby riverbed and a passage of game favorable for meat procurement. They manufactured choppers and sharp-edged flakes, which they used in meat processing and bone marrow extractions.

At both Gona and Ain Hanech, the Oldowan occupations are followed by a fairly long Acheulian tradition spanning roughly 1.67 Ma to 200 - 100 Ka. The Acheulian in both areas exhibit technological innovations and a continuous development/advancement of the morphology of the artifacts. An excellent illustration is the manufacture of Kombewa flake, which is characterized by dual ventral faces offering the hominins the advantage of shaping sharp flakes and cleavers. Meat also likely constituted a major part of Acheulian hominin diet as indicated by hominin-inflicted butchery marks on fossil animal bones from the *H. erectus* sites of DAN5 and Tighennif (Semaw et al., 2020; Chelli Cheheb, 2018).

In the Late Acheulian the technological progress is even more evident, such as the use of soft hammerstone for more precision on thinning and shaping bifaces with a well-defined symmetry, and predetermined flaking techniques for manufacturing standardized artifacts. A good example of the latter are the artifacts from GWS2 (Gawis North) at Gona and the Tabelbala-Tachenghit in Algeria. Remarkably, the Tabelbala-Tachenghit technique entails pre-shaping of the cleaver prior to detaching it from the core, which is also seen in the assemblages recovered from GWS2. This innovative technique is a variant of the Proto-Levallois prepared core technique. Its use and generalization probably coincided with the expansion of early *Homo sapiens* throughout Africa around 400–300 Ka.

Remarkably, the discovery of *Sahelanthropus tchadensis*, the earliest known hominin in Africa dated to c. 7.0 Ma (Brunet et al., 1995), and *Australopithecus bahrelghazali* (Brunet et al., 1995) in Tchad in the middle of the African continent is a testimony for the long presence of ancestral humans not far from Algeria. Obviously, palaeoanthropological research over the past century focused in East and South Africa and further investigations in West, Central and North Africa can reveal further fossils and archaeology. Therefore, the discovery of 2.4 Ma archaeology at Ain Hanech/Ain Boucherit is no longer a surprise. The Gona and Ain Hanech/Ain Boucherit study areas have produced complementary evidence for the beginnings of ancestral human manufacture and use of stone artifacts and comparative studies are underway. More interesting, both study areas contain similar age deposits with Oldowan, Acheulian and comparable Mid-Late Pleistocene archaeological materials for investigating the emergence and evolution of *Homo sapiens* across East and North Africa. Therefore, the evidence from Gona and the Algerian sites combined has demonstrably contributed enormously to our understanding of the biocultural evolution of our ancestors for the past >6.0 Ma.

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