Vertebrate Paleobiology and Paleoanthropology Series

Rosalia Gallotti
Margherita Mussi *Editors*

The Emergence of the Acheulean in East Africa and Beyond

Contributions in Honor of Jean Chavaillon

Springer

The Emergence of the Acheulean in East Africa and Beyond

Vertebrate Paleobiology and Paleoanthropology Series

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Cover illustration: The upper Awash Valley at Melka Kunture, with the Awash River in the foreground and the Wochacha volcano in the background; inset, obsidian massive scraper (early Acheulean, Garba IVD, Melka Kunture) (photos by Rosalia Gallotti).

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This volume is dedicated to the memory of Jean Chavaillon (March 25, 1925–December 21, 2013), the leading archaeologist and Quaternary geologist who researched with unfailing enthusiasm the African Pleistocene and directed from 1965 to 1995 the French Archaeological Mission at Melka Kunture.

Jean Chavaillon (front row center) at Melka Kunture in 1969, with workers and collaborators. Next to him his wife Nicole, also an archaeologist, with the little Florence, one of their daughters. Next to Nicole another archaeologist, Françoise Hivernel, and slightly behind and between them, Jean Gire, in charge of the archaeological drawings

Foreword

Jean Chavaillon: The Scientist, The Teacher, and The Colleague

Very few professionals have marked their paths on the scene of prehistoric research as vividly as Professor Jean Chavaillon. Prehistoric research in Africa was in its infancy, and very few sites were known in East Africa when this scientist joined the quest for knowledge about early man's environment and cultures. In his earlier professional career in Africa, his interest was focused on North Africa, where he studied the Quaternary formations of the northwestern Sahara, culminating in a 393-page monograph published in 1964, i.e., just before he turned his gaze toward Ethiopia.

The discovery of the Melka Kunture paleoanthropological site in 1963 by G. Dekker and results of a reconnaissance survey in the following months by G. Bailloud showed the great potential of the site. Subsequently, Jean Chavaillon took charge and assumed the task of planning and undertaking a multiyear research project at Melka Kunture; where from 1965 until 1995 he led a multidisciplinary paleoanthropological research program.

Professor Jean Chavaillon was also among the first prehistorians to work in the Lower Omo paleoanthropological sites. In the Omo Shungura sites, he conducted geological and archaeological investigations between 1967 and 1976. There he discovered, with his team, the world's oldest stone artifacts known at the time, dated to $\sim$2.3 million years old (Ma). In doing so, he pushed back the antiquity of stone tool making by a half million years vis-a-vis the previously known oldest discoveries, dated to 1.8 Ma at Olduvai Gorge in Tanzania. During these years, he was working for the Institut d'Archéologie in Addis Ababa and was appointed by the Ethiopian Government as coordinator of the Omo International Research Group which was composed of French, American, and Kenyan research teams. The French contingent was initially led by Professor Camille Arambourg who was later replaced by Yves Coppens. F. Clark Howell organized the American team, and Richard Leakey (representing his father Louis Leakey) led the Kenyan team. The Omo paleoanthropological research laid the foundation for later multidisciplinary approaches in paleoanthropology. Successful results of this multicomponent approach served as yardsticks for biochronological dating at sites where secure radiometric dates are lacking. The discoveries made in the Lower Omo remain among the most important scientific milestones in human biological and cultural evolution, as well as the paleoenvironmental contexts of these important discoveries. Jean Chavaillon's contribution in this regard is paramount. The discoveries he made in the Lower Omo were published in several scientific journals and still serve as major references for understanding the behavioral evolution of our ancestors.

While working in the Omo, Professor Jean Chavaillon was also deeply engaged in paleoanthropological research at Melka Kunture. He organized there a multidisciplinary research team which also included young students of Quaternary research. Since 1965, this resulted in the discovery of multiple layers of human occupation at various localities, among which the

most famous are Karre, Garba IV, Gombore I and II, and Simbiro. Discoveries from these sites have opened up new discussions among prehistorians, providing additional knowledge as well as a paradigm shift in our understanding of both the beginnings and evolution of stone tool technologies and early human behavior in relation to the paleoenvironment.

Jean Chavaillon demonstrated at Melka Kunture that all known stages of prehistoric stone technologies are represented in a well-defined and dated stratigraphic sequence. The main occurrences of these technologies are: the Oldowan from Karre I, Gombore I, Gombore Iγ, and Garba IVG-E; Acheulean lithic production from Garba IVD, Garba XII, Simbiro III, Gombore II, Garba I, Garba IIIE-B; the Middle Stone Age from Garba IIIA-B; and the Late Stone Age from Wofi II, Wofi III, and Kella I. In addition to these, the Balchit site was a quarry source for obsidian in both prehistoric and historical times. The Melka Kunture site is unique in the world in presenting such an extended sequence of human stone technologies and continuous site use over the last 1.8 Myr. This became evident in the archaeological record, thanks to the unreserved and continuous research efforts of Jean Chavaillon and his team. In addition to the evolution of the various stages of stone technologies and geological sequences, his research at Melka Kunture has also produced evidence on space management and land use by prehistoric people.

During his early years of research at Melka Kunture, Jean Chavaillon was encouraging young students to work on the Ethiopian Quaternary. Among many, he supported the geological work of Maurice Taieb in the Awash Basin, which eventually resulted, on top of the vast knowledge generated about the basin itself, in the discovery of the Hadar, Middle Awash, and Gona paleoanthropological sites, which became crucial locations for understanding our biological and cultural evolution.

A modest man who never advertised his great accomplishments, honest to his career, and in love with the site in which he worked, Jean Chavaillon was a great site protector. On several occasions, he fought against the actions of clandestine fossil collectors. In 1972, he advocated for the delineation of the Melka Kunture site within an area of 800 hectares of Archaeological Park. This was finally achieved in the 1990s (although not all of the area he envisaged to be protected was included in the park). In his plan, he proposed a site museum at Melka Kunture to showcase the finds, which came into reality in collaboration with his colleague Marcello Piperno late in the 1990s.

Jean Chavaillon had also helped save the Melka Kunture site from irreversible damage by bringing the issue to the attention of the relevant decision makers in 1972–1973. His interest was not limited just to the protection of the site. In 1979, after discussions with the relevant Ethiopian authorities, and following their approval, he raised funds for the construction in Addis Ababa of a repository for paleoanthropological findings and also built a laboratory facility where the materials were stored and studied. This facility, which was put in place and organized by Chavaillon, has served the task for which it was designed during more than 30 years. I was honored to work in this facility, using his old office, as Head of Archaeology and Paleontology of the Ministry of Culture and Sports (now Culture and Tourism) of Ethiopia for 15 years. Most importantly, the establishment of this facility inspired other researchers (led by the late J. D. Clark) to build and organize additional facilities. This culminated in the construction of the new "state-of-the-art" research facility built by the Ethiopian Government on the premises of the National Museum, where all of the paleoanthropological and archaeological findings from across the country are housed.

The results of Chavaillon's monumental work at Melka Kunture have been published in more than 60 articles and books and known worldwide. Students of archaeology have benefited and continue to benefit from knowledge acquired through his research endeavors. In Ethiopia, his findings were included in the educational curriculum; and during my high school days, I was one of those students who benefited from learning the results of his impressive research which were fit into the curriculum. My undergraduate archaeology courses in prehistory were enriched by the results of his research at Melka Kunture and Omo. Much later, in the early 1980s, I had the benefit of learning not only from his work but personally from him

in the National Museum of Ethiopia collection rooms; even later, I formally attended his lectures while a student at the Institut de Paleontologie Humaine in Paris. He was always keen on his advice and openhearted, providing me with invaluable advice while I was working on my Ph.D. thesis. As a member of my Examining Board, he honestly and professionally commented on my work. Students who benefited from his wisdom and research works are currently thriving all over the world.

Professor Jean Chavaillion's scientific works were not limited to Melka Kunture or Omo. He also worked in several other areas including Gotera (a Middle Stone Age site in Southern Ethiopia) and late Acheulean sites around Lake Ziway (again in Ethiopia). Jean Chavaillon was an unflagging prehistorian of great intelligence. He was farsighted in his planning for the sites he loved so much. This selfless great prehistorian gallantly handed over the task of the leadership of the research work of his beloved Melka Kunture in 1996 to his longtime friend and colleague Professor Marcello Piperno. Despite that, he continued to work year after year with the new team leader, and together they undertook in 2004 the publication of a monumental monograph on Melka Kunture. And again, after the transfer of the research leadership at Melka Kunture to Professor Margherita Mussi, he was always supportive of her efforts, until unfortunately he left us for the last time. His work will continue to inspire us all for many more years to come.

The international workshop on "The Emergence of the Acheulean in East Africa" organized by Margherita Mussi and Rosalia Gallotti to commemorate the 50th anniversary of Melka Kunture and to celebrate the lifetime achievements of Professor Jean Chavaillon has brought together scholars working on the East African Acheulean at Università di Roma Sapienza on September 12–13, 2013. I would like to seize this opportunity to thank Margherita Mussi and Rosalia Gallotti for inviting me to take part in this important workshop and to celebrate the life of this great prehistorian.

Yonas Beyene
Association for Research and Conservation of Culture (ARCC)
and French Center for Ethiopian Studies (CFEE), Ethiopia

Preface

In 2013 an international roundtable was held in Rome, discussing "The Emergence of the Acheulean in East Africa" to celebrate the 50th anniversary of the discovery of Melka Kunture (Upper Awash valley, Ethiopia).

The theme had been carefully selected. During the second half of the last century, the archaeological research at Melka Kunture directed by Jean Chavaillon, head of the French archaeological mission, had led to the discovery of Oldowan sites and of an impressive sequence of Acheulean layers—plus some important Middle Stone Age and Late Stone Age sites. From 1999 to 2010, the Italian archaeological mission, under the direction of Marcello Piperno, further focused on the Oldowan of Garba IV, also opening for display to the general public a new Acheulean area, Gombore II OAM. Since 2011, under the direction of one of the editors (MM), new fieldwork has been aimed at updating and completing previous research.

Accordingly, both the Oldowan and the Acheulean are extremely well documented at Melka Kunture. However, while workshops specifically addressing the earliest developments in lithic technology had been held since the beginning of the century, such as the "First Hominid Technology Workshop" (Bellaterra, Spain, 2003) and the "Conference on Early Stone Tools and Cognitive Evolution" (Stanford University, USA, 2010), the origin of the Acheulean in East Africa, and its relationships with the Oldowan, had not been collectively discussed in a decade. Thanks to the Wenner-Gren Foundation, which generously sponsored the meeting (grant no. CONF-626), we were able to fill this gap. Researchers who were working on the earliest Acheulean were asked to present recent results and share their experiences, allowing fruitful discussion. The program, list of participants, and abstracts of the communications are available at http://melkakunture.it/research/fifty_years.

A volume of proceedings was the obvious outcome of this collective effort. The Vertebrate Paleobiology and Paleoanthropology Series—which already included "Interdisciplinary Approaches to the Oldowan" edited by Erella Hovers and David R. Braun—was the perfect option. We gladly acknowledge the support given to this project ever since the beginning by the Series Editors, Eric Delson and Eric Sargis. This new volume reflects fairly well the roundtable of 2013, but there are also differences. For various reasons some of the original participants were eventually unable to produce a paper, as always happens with proceedings. Vice versa, we expanded the volume with some chapters on the preceding Oldowan, on the African fauna, on the Acheulean in Asia and, eventually, on the Acheulean in Europe, where it develops later than elsewhere.

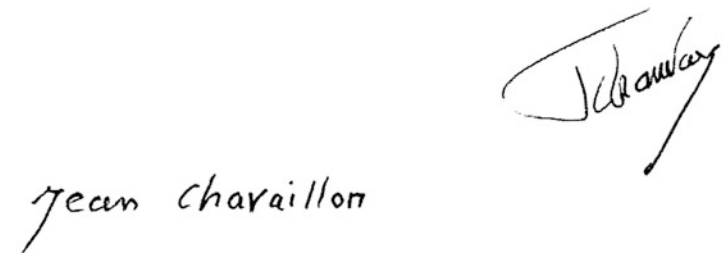
In doing so, we contacted tens of colleagues who were asked to review the papers, definitely improving the quality of the final versions. While they will remain anonymous, they must be assured that we are most grateful to them for their time and dedication. We also thank Università di Roma Sapienza, and especially Dipartimento di Scienze dell'Antichità, which provided the venue where the 2013 meeting was held.

For the opening of the roundtable in September 2013, Jean Chavaillon sent a touching letter in his own hand, ending with the following words "Chers Amis, bon courage, belles et

fructueuses découvertes. Avanti!" At the time he was a frail, 88-year-old gentleman, but the enthusiasm of this great prehistorian for archaeological research was unshaken. Sadly, he died the same year, just 3 months later. This volume is dedicated to his memory, as an outstanding researcher who focused most of his work on Melka Kunture.

Rome, Italy

Margherita Mussi
Italian Archeological Mission at Melka Kunture and Balchit



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Chapter 1
The Emergence of the Acheulean in East Africa: Historical Perspectives and Current Issues

Rosalia Gallotti and Margherita Mussi

Abstract We review below the Acheulean of East Africa from two perspectives: the history of research and the current state of the art. The definition of Acheulean industries has changed considerably over 150 years and since the earliest research in Africa. A brief presentation of the main discoveries, of the many theories, and of the various methods used in Acheulean archaeological research will help in understanding the current debate and the topics addressed in this volume.

Keywords History of archaeological research • Current issues • Typology • Technology

The Acheulean developed over more than 1.5 million years and is the longest lasting Palaeolithic culture. It is also the one with the widest geographical distribution, spreading over Africa and Eurasia.

Gabriel de Mortillet recognized the Acheulean as such in Europe, at the end of the nineteenth century. He was a geologist who later became a leading archaeologist (Nicole 1901). Following a geological methodology, he used tool types as index fossils, relating them to the best-known and most typical locality. This allowed him to characterize prehistoric periods and to put them in a chronological sequence. In 1872, in his "Classification des diverses périodes de l'âge de la pierre", he described a number of prehistoric lithic collections from northern France, taking St. Acheul as a type site. Accordingly, he defined an "Époque de St. Acheul", with a characteristic implement, or index fossil: the "coup-de-poing" (de Mortillet 1872). "Biface", which refers to the same tool type, was first used later by Vayson de Pradenne (1920).

This iconic tool had even attracted attention before de Mortillet's time, and well before Boucher de Perthes (1847) and Lyell (1863) established the antiquity of humans in Europe. In 1797 John Frere sent a letter to the Society of Antiquaries of London describing "…weapons of war, fabricated and used by a people who had not the use of metals… The situation in which these weapons were found may tempt us to refer them to a very remote period indeed, even beyond that of the present world…". The letter came with two handaxes from Hoxne (Suffolk), which are now on display at the British Museum, and was published in Frere (1800). Admittedly, the finds of John Frere did not attract much attention at the time, and de Mortillet remains the founding father of the Acheulean (Mussi 2014).

Ten years after the first publication, G. de Mortillet choose Chelles as type site and changed his original nomenclature: the term "Chellean" was introduced (de Mortillet 1883). The term "Acheuléen", translated in English as Acheulean or Acheulian, was introduced in the 1920s. Through time, Acheulean superseded previous terminologies and came to include "Chellean" and "Abbevillian". The latter names had been in use for some time for industries with rougher and "more primitive" bifacial tools, apparently belonging to an earlier stage of human development—stages which were eventually found to lack stratigraphic consistency (Déchelette 1924; Breuil 1932). While other parts of de Mortillet's nomenclature became obsolete, the "Époque de St Acheul", renamed "Acheulean", has ever since remained in full use (Mussi 2014).

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Around 1880, some years after the introduction of the "Époque de St Acheul", the first African handaxes were found near Temassinine, in Algeria, and Rivière (1896) made formal reference to a Lower Paleolithic industry from the site of Boul Baba, in Tunisia. Several "Chellean biface sites" were then discovered in North Africa at the beginning of the twentieth century (Flamand and Laquière 1906; Chantre 1908; Pallary 1911; Seligman 1921; Breuil 1930; Roffo 1934; Biberson 1961). In East Africa, collections including handaxes were similarly made since the last decade of the nineteenth century, when they were shipped back to European museums (Leakey 1931; Mussi 1973). Around 1905, handaxes, compared to those of France, were also collected at Stellenbosch, close to Cape Town (Péringuey 1911).

In East Africa, Gregory (1896, 1921), a trained geologist, discovered Olorgesailie, a major Acheulean site, but its location was lost for a further forty years. Since 1926, Louis Leakey made expeditions that set the foundations of East African prehistory. As a result of the first two expeditions, he published the handaxes from Kariandusi (Leakey 1931). From 1931 to 1951 he worked at Olduvai, attracted there by the discovery made by Reck of mammalian fossil assemblages (Reck 1914, 1926). His research aimed at defining the evolutionary cultural stages within the exposed geological horizons of the gorge (Leakey 1965). By 1932 he was able to report to the first IUPPS congress (held in London) a sequence from Olduvai ranging from the "pre-Chellean" to the "Aurignacian" (Leakey 1934, 1936). This is when he introduced the name "Oldowan" to identify the "pre-Chellean" industries. During the World War II, together with his wife Mary, he rediscovered Olorgesailie (Gowlett 1990). Then in 1947 he organized in Nairobi the First Pan-African Congress, which marked the beginning of "the time of the Acheulean" in Africa. Several communications provided support to this theme, e.g., those of Leakey himself on Olorgesailie and Kariandusi; of J. Desmond Clark on Acheulean sites from the Somalilands; and of H. Breuil on the survey of raised beaches all around Africa (Breuil 1952; Clark 1952; Leakey 1952). As already summarized at the time by van Riet Lowe (1952: 167) "While it is now widely held that the essential home of the Hand-Axe Culture is to be sought in Africa, we find, when we set out in the search of its roots that as soon as we leave this continent we flounder in mists of uncertainty. If, on the other hand, we remain here, we find that here—and here only—we have a long series of earlier well-stratified cultures which led us naturally and directly to the establishment of the Hand-Axe Culture".

The Pan-African Congresses gradually started to address issues related to terminology and typology, prompting useful debates. At first, and throughout the first half of the twentieth century, developments in African archaeological research were strongly linked to those in Europe. Attempts were made to discard the imported terminology and forge a local nomenclature, most notably in South Africa (Goodwin and Van Riet Lowe 1929; Van Riet Lowe 1952), where "Stellenbosch" was introduced in 1925 as an alternative label. In East Africa, Leakey (1931) described a "Kenya Chellean" (later to be dismissed, just as was the European "Chellean") and a "Kenya Acheulean" as well. However, at the time of the Fourth Pan-African Congress of Prehistory in 1959, Kleindienst (1962: 81) makes clear that "work in Africa is an outgrowth of the European tradition of prehistory".

In 1953, J.D. Clark had started excavating at Kalambo Falls (Clark 1969, 1974). The Isimila site complex was also discovered (Howell et al. 1962). The lithic assemblages from these two sites were pivotal in a major study by Kleindienst (1961, 1962).

In North Africa too this was a time of chronological and typological refinements, and of new discoveries. Investigations started in the impressive costal sequence around Casablanca and in the Acheulean site of Ternifine (Arambourg 1955; Balout et al. 1967). In 1961, Biberson proposed to subdivide the Acheulean of North Africa into eight phases (Biberson 1961). His model of typological progression was a reference for L.S.B. Leakey in East Africa. Balout (1955) and Tixier (1956) furthermore carried out major studies of bifacial tool typology (especially cleavers). The outcome of scientific activity all over Africa was published in three monumental works on the prehistory of East, South, and North Africa, respectively (Cole 1954; Clark 1959; McBurney 1960).

In the 1960s, archaeological teams routinely included researchers from a number of countries, involved in large interdisciplinary projects, as is well reflected in the collective volume "Background to Evolution in Africa", edited by W. W. Bishop and J.D. Clark in 1967. It included formal recommendations in order to update the African terminology, notably abandoning the obsolete "Chellean", and the improperly defined "Hand-Axe Culture". "Acheulian" was instead recommended.

This was also the time when a major advance in field research became widely accepted: the punctual data recording of archaeological excavations, championed in Europe by Leroi-Gourhan (1950). Although the importance of careful stratigraphic study had long been recognized, recording artifact distribution was just beginning. When in 1960 Mary Leakey started large-scale excavations at Olduvai, she was paying attention to the study of living floors. Further theoretical and methodological advances rest on the work of Glynn Isaac at Olorgesailie, also in the early 1960s. In the Olorgesailie monograph (Isaac 1977), he revised and simplified Kleindienst's typology, adding a metrical approach to artifact analysis. He also introduced a landscape approach and was the first to pay attention to site formation processes.

New field activity and new dating techniques began to establish the antiquity of the African Acheulean. The Leakeys

led expeditions on the west side of Lake Natron at Peninj (Gowlett 1990). This new project was followed by R. Leakey and Gl. Isaac. In 1964, an age of 1.4 million years was assessed for the very early Acheulean at Peninj (Isaac 1967; Isaac and Curtis 1974). In 1963, Mary Leakey had excavated EF-HR at Olduvai, where a similar age was established for the early Acheulean (Leakey 1971, 1975). In L.S.B. Leakey's opinion the Acheulean had emerged from the Oldowan (Leakey 1936), while Mary Leakey regarded it instead as an intrusive phenomenon. In 1967 she proposed a model based on large-scale excavations in four sites of Bed I and in nine of Bed II. The interpretation of Bed I remained largely unchanged, but the sequence of Bed II was thoroughly modified (de la Torre and Mora 2014). In Middle and Upper Bed II, she differentiated the Lower Acheulean from the Developed Oldowan, basing her observations on handaxe frequencies (Leakey 1971, 1975). In her opinion, those were two different but coexisting cultures. This model was most probably influenced by Breuil's (1932) in Europe, i.e., by the supposed parallel evolution there of Clactonian and Chellean. While in L.S.B. Leakey's model (1951) the first evidence of specific tools or techniques were the main proxy for cultural change in an evolutionary sequence, Mary Leakey's (1971) hypothesis was based on the frequencies of types. As the term suggests, the Developed Oldowan was a local evolution of the Oldowan. The Lower Acheulean appeared as intrusive and unrelated to any preceding lithic complex. Leakey (1967) also speculated on links between cultures and hominins, suggesting the equation Oldowan = *Homo habilis* and Acheulean = *Homo erectus*.

M. Leakey subsequently divided the Developed Oldowan into Developed Oldowan A (DOA) and Developed Oldowan B (DOB). They were stratigraphically located respectively below and above Tuff IIB (Leakey 1971). The DOA included mostly Oldowan artifacts, although the frequency of spheroids, subspheroids, and light-duty tools increased. In the DOB the main difference is the addition of some handaxes. She also established that handaxes had to be c. 40% of the tool types in any Acheulean assemblage. Then, in 1975, after excavating in Beds III, IV, and in the Masek Beds (1968–1971), she came to the conclusion that at Olduvai there was no evidence of handaxes becoming more refined through time, and that the Oldowan persisted in Bed IV as a parallel tradition (Developed Oldowan C, or DOC; Leakey and Roe 1994).

M. Leakey's model became an issue of discussion as soon as proposed. Research in Olduvai's Beds I and II became the milestone for all subsequent investigations on the Early Stone Age.

In 1969, Isaac put forward a functional/ecological explanation for the coexisting Developed Oldowan and Acheulean (Isaac 1969). He pointed out that Developed Oldowan sites were located close to the Olduvai paleolake margins, while Acheulean sites apparently were in a fluvial environment—as Hay's research further supported some years later (1976, 1990). Besides, in Isaac's opinion, the main Acheulean innovation was the ability to detach large flake blanks for handaxe manufacture. The need of accessing large boulders for flaking regulated the landscape distribution of Developed Oldowan/Lower Acheulean sites. Accordingly, the Developed Oldowan was just a facies of the Lower Acheulean.

In 1963, J. Dekker discovered Melka Kunture and in 1964 G. Bailloud started investigating there. From the next year on, J. Chavaillon carried out large-scale excavations, revealing an impressive Early-Middle Pleistocene sequence and producing a different scenario (Bailloud 1965; Chavaillon et al. 1979; Chavaillon and Piperno 2004). Chavaillon et al. (1979) stated that the Acheulean had emerged there at c. 1.0 Ma, i.e., later than elsewhere in East Africa (Leakey 1971, 1975) and divided the local sequence into four stages: ancient (1.0 Ma), middle (0.8–0.5 Ma), upper (0.4–0.3 Ma), and final Acheulean (0.25–0.15 Ma). They concluded that the dichotomy Developed Oldowan/Lower Acheulean suggested by Leakey (1971, 1975) at Olduvai did not exist on the Ethiopian plateau. The cultural change happened locally as a gradual evolution of the technical equipment within a unilineal sequence from Oldowan to Acheulean (Chavaillon 1980; Chavaillon and Chavaillon 1980).

In the mid-1970s archaeological investigation flourished in the Ethiopian Rift, where Hadar and Gadeb were discovered (Clark and Kurashina 1979; Kalb et al. 1982; Clark et al. 1984). In the meantime, R. Leakey was working at Koobi Fora in collaboration with Gl. Isaac. Further south, L. C. King and W.W. Bishop were researching around Lake Baringo, discovering Chesowanja and Kilombe (Bishop et al. 1978; Harris and Gowlett 1980; Gowlett et al. 1981; Gowlett 1991, 1993). Discoveries made in South Africa did not have the same impact as those in East Africa, mostly because of the lack of datable volcanic deposits, but remarkable work was conducted at Amanzi Springs, Montagu Cave, and Cave of Hearths (Mason 1962, 1966; Deacon 1970, 1975; Keller 1973). Large series of Acheulean artifacts were also studied by Stiles (1979a, b) and compared to those of Olduvai Bed II.

In the 1970–1990s, several scholars revised Olduvai assemblages using typological and metrical approaches. Stiles (1977, 1980, 1991) studied those from the Middle and Upper Bed II concluding that all of them were early Acheulean. Jones (1979, 1994) focused on Bed IV artifacts, coupling his typological study with an intense experimental program. He eventually agreed with Leakey (1975) that no diachronic evolution in handaxe refinement existed from Middle Bed II to Bed IV. Nevertheless, he recognized higher reduction intensity in the handaxe shaping of DOC assemblages compared to those of the Bed IV Acheulean, probably because of more resharpening (Jones 1994). In Bed IV he

differentiated DOC and Acheulean: DOC sites were devoted to varied functional activities, while Acheulean sites corresponded to discard areas.

More revision was based on published data. Davis (1980) supported the validity of M. Leakey's original model and the Developed Oldowan as a distinctive industry, criticizing Stiles (1977) for focusing instead on a single tool type. Gowlett (1988) identified disparities between the DOB and the Acheulean handaxes through statistical analysis, although he argued that morphometric dissimilarities did not necessarily correspond to two cultural phyla. To the contrary, both Callow (1994) and Roe (1994) underlined that there were substantial metrical differences when comparing DOB/DOC and Acheulean handaxes. This, in their opinion, validated the distinction between Developed Oldowan and Acheulean. Although M. Leakey's cultural model was discussed again and again, her methodology and typology were widely accepted. However, Toth (1982), Gl. Isaac (1986), Potts (1991) and later I. de la Torre and Mora (2005) as well as Semaw et al. (2009) all revised her typology.

A different theoretical approach was introduced after the excavations in 1983 at Isenya on the Kenyan highlands (Roche et al. 1988). The study of the artifact assemblages is a hallmark in East African archaeological research. P.-J. Texier and H. Roche carried out a systematic analysis following the technological approach based on the chaîne opératoire concept, developed in France since the early 1960s (Roche and Texier 1991; Texier and Roche 1995a, b; Texier 1996). This approach supersedes the study of the final state of the artifact, analyzing all of the technical sequences performed as well as the technical and cognitive skills involved in tool production (Leroi-Gourhan 1964, 1971; Pelegrin 1985; Geneste 1989, 1991; Perlès 1991; Inizan et al. 1999). This multiplies the observable production patterns and allows the researcher to investigate variations at different levels.

Although the technological approach played a minor role in 1990s, in recent years it has been frequently used for both Oldowan and Acheulean complex studies. A technological approach characterizes the revision of lithic collections excavated in previous decades at Peninj, Olduvai, Melka Kunture, and Gadeb (de la Torre et al. 2003, 2008; de la Torre and Mora 2005; de la Torre 2009, 2011; Gallotti et al. 2010, 2014; Gallotti 2013; Diez-Martín et al. 2014a, b; Gallotti and Mussi 2017; Sánchez Yustos et al. 2017) as well as the study of new assemblages from Konso, Gona, and West Turkana (Quade et al. 2004, 2008; Lepre et al. 2011; Chevrier 2012; Beyene et al. 2013, 2015).

The research developments of the last two decades provided much of the rationale for this volume. Many topics were discussed in the 2013 workshop "The Early Acheulean in East Africa" in Rome, from which this book stems. The workshop included research projects addressed to study the nature of the early Acheulean as a lithic production system(s) in a technological perspective and at microregional scale.

Over the last two decades, much effort was also aimed at redating the earliest Acheulean, whose age increased at Kokiselei 4, West Turkana (1.76 Ma; Lepre et al. 2011); KGA6-A1 (1.75 Ma) and KGA4-A2 (1.6 Ma) in Konso (Beyene et al. 2013; Suwa et al. 2015); FLK West at Olduvai (~1.7 Ma; Diez-Martín et al. 2015); BSN-12 and OGS-12 at Gona (~1.6 Ma; Quade et al. 2004); and Garba IVD at Melka Kunture (~1.6 Ma; Gallotti and Mussi 2018). Currently, solid geochronological data place the early Acheulean in East Africa between 1.76 and ~1.30 Ma (Leakey 1971; Asfaw et al. 1992; Katoh et al. 2000; Beyene 2003; Roche et al. 2003; Quade et al. 2004, 2008; Nagaoka et al. 2005; de la Torre et al. 2008; Semaw et al. 2009; Lepre et al. 2011; Beyene et al. 2013; Gallotti 2013; Diez-Martín et al. 2015). Accordingly, the emergence of the Acheulean gets closer to the late Oldowan, supporting the idea that the Oldowan–Acheulean transition corresponds to a rapid change rather than the outcome of evolutionary trends (e.g., Semaw et al. 2018). This also rekindled the debate about the existence of a Developed Oldowan, as well as about the paradigm that the early Acheulean is the cultural product of *Homo erectus sensu lato*.

The first contribution of this volume is devoted to the Oldowan techno-complexes: it is a report on the current state of our knowledge in East Africa. It will help evaluating if the early Acheulean originates, or not, from earlier technologies (Gallotti 2018). Reviewing the outcome of fifteen years of techno-economic studies allows the author to identify two main Oldowan chronological horizons, an earlier one (2.6–2.3 Ma) and a later one (2.0–1.6 Ma), thus separated by a gap of 300 thousand years. In both periods, Oldowan lithic productions show a high intra- and inter-site variability, which are the outcome of multiple experiments aimed at finding the technical solutions allowing to properly exploit the available lithic resources. The various attempts happen to be alike or diverse at different levels. Furthermore, according to multiple factors they are linked to different paleoenvironments and subsistence strategies. Accordingly, Gallotti (2018) finds little empirical support for notions such as "technological stasis" and "uniformity", or for a progressive development. However, she underlines that the late Oldowan shows more intra-site as well as inter-site flaking method variability.

Unfortunately, very few East African sequences have yielded both late Oldowan and early Acheulean assemblages, complicating a detailed comparative evaluation of the technical innovations and/or traditions defining the emerging Acheulean and the status of DOB.

Texier (2018) assesses that in West Turkana the late Oldowan industry of Kokiselei 5 (KS5; 1.87 Ma) shows the full technical control of three-dimensional space, which is

the prerequisite of the bifacial shaping concept later developed in the early Acheulean of Kokiselei 4 (KS4; 1.76 Ma). The diversification of flaking methods identified at KS5 confirmed that the late Oldowan knappers of West Turkana were able to exploit a wider range of raw materials than those of Lokalalei 2C (2.34 Ma). The same variability of flaking methods characterizes both the late Oldowan (Garba IVE-F, ~1.7 Ma) and the early Acheulean (Garba IVD, ~1.6 Ma) at Melka Kunture, as well as the oldest Acheulean industry of Olduvai (Diez-Martín et al. 2015). Nevertheless, the knappers of Garba IVD provide evidence of a technological leap: they acquired an incipient ability to configure the raw material geometry thanks to the preparation of the striking platform, the management of volume/convexity during flaking, and the setting of a hierarchy among surfaces. The same innovations appear both in small–medium and in large flake extraction, representing the central technical advancement of the early Acheulean in the Ethiopian highlands. Cores showing a radial or centripetal exploitation are also frequent at earlier sites, such as DK in Olduvai (de la Torre and Mora 2005) and Gona (Stout et al. 2010). However, this happens within methods where core volume and convexity configuration are not fully managed, and there is no hierarchy between a flaking surface and a prepared striking platform.

Prepared methods appear systematically around 1.6–1.3 Ma, associated or not with large tool productions. At Nyabusosi (~1.5 Ma), the centripetal exploitation of one surface from a natural or prepared striking platform is the only flaking method for small flake production (Texier 2005). At Gadeb 2E, there are examples of well-structured exploitation sequences, such as hierarchical centripetal and discoid methods (de la Torre 2011). At Olduvai BK and TK Upper Floor (~1.35 Ma), in some cases the centripetal hierarchical method is implemented, which corresponds to a change in the flaking modalities in the Olduvai sequence (de la Torre and Mora 2005). As argued by de la Torre et al. (2008), the adoption of these flaking criteria is relevant in cultural terms, because the same technological knowledge seems shared by knappers at Peninj both in the ST complex and in the Escarpment, regardless of the presence of large tools. Thus, this technical feature was used by de la Torre et al. (2008) to assign the ST complex to the early Acheulean, while it was previously classified as Oldowan (de la Torre et al. 2003). Nevertheless, the reanalysis (Diez-Martín et al. 2012, 2018) of some of the cores studied by de la Torre et al. (2003) questions the existence of the bifacial hierarchical centripetal exploitation at Type Section. New criteria are suggested to assign this assemblage to the early Acheulean, i.e., the presence of large flakes and of resharpening/configuration flakes from large tool shaping.

Core preparation as a proxy for the emergence of the Acheulean has been recently reinvestigated in Olduvai at SHK (~1.5 Ma) and BK. Sánches Yustos et al. (2017) recognize that core preparation allows producing serviceable striking angles, when the latter are not available in the original core blank. Summing up, core preparation, volume management in a three-dimensional space, and hierarchy among surfaces all occur in a variety of operative schemes. By commanding these technical solutions and gaining the ability to exploit a wider range of geometries, the toolmakers freed themselves for the first time from the constraints of the natural blanks. This advancement is present both in DOB and in early Acheulean assemblages, suggesting a close relationship between them.

The ambiguous status of the DOB has been a matter of debate ever since its first definition. Several authors criticized the dichotomy between DOB and early Acheulean and proposed instead to assign DOB industries lacking handaxes to the early Acheulean. This means that the two industries are interrelated within the same cultural tradition (de la Torre and Mora 2005, 2014; de la Torre et al. 2008; Semaw et al. 2009, 2018; de la Torre 2011, 2016; Diez-Martín and Eren 2012; Gallotti 2013). Nevertheless, although a technological approach has been systematically adopted in the last two decades, early technology paradigms are often rooted in previous typological postulates. This epistemological contradiction constrained the DOB/early Acheulean debate (Sánchez-Yustos et al. 2017), while there is not yet a formal redefinition of the DOB status in technological terms. Besides, the DOA is not properly discriminated from the early Acheulean. At Olduvai the DOA is stratigraphically located below and above Tuff IIB, dated to ~1.6 Ma, while the early Acheulean has been recently discovered at FLK West (~1.7 Ma; Diez-Martín et al. 2015).

The focus on small débitage in the last few years is a relevant analytical development of early technology research. It modifies previously established paradigms and partially supersedes the handaxe "abuse" in Acheulean studies. For decades, analyses focusing on this single component had bolstered the idea of a uniform and static Acheulean, lacking innovation over hundreds of thousands of years and across a number of varied environmental settings (e.g., Nowell and White 2010). The typological features and degree of refinement of handaxes were used to group together lithic assemblages far apart in space and time and then to chart the supposed evolution of Acheulean technology. But, although the outcomes of technical processes might be typologically similar, there are many ways of combining raw material selection and acquisition patterns, percussion motions, and technical sequences (Gallotti 2018). Accordingly, the recent technological studies also shed new

light on the high variability of the large tools in the early Acheulean.

Large tool production definitely is an innovation signaling the emergence of the Acheulean. The presence and frequency of the new chaînes opératoires within 1.76–1.3 Ma East African assemblages show relevant intra- and inter-site variability. Raw material provisioning is frequently based on local secondary sources, as in the case of small débitage (de la Torre et al. 2008; Harmand 2009; Gallotti 2013; Díez-Martin et al. 2018; Gallotti and Mussi 2018; Santonja et al. 2018; Texier 2018), but also on primary sources when specific raw materials are looked for (de la Torre and Mora 2005; de la Torre 2011). Nevertheless, the selection of morphologies and lithotypes is not a new acquisition; although the published evidence is limited, this behavior has been documented at earlier sites (Plummer et al. 1999; Hovers et al. 2002; Stout et al. 2005; Goldman-Neuman and Hovers 2009; Harmand 2009; Gallotti 2018).

Large tools were manufactured on various blanks, such as large cobbles, tabular clasts, and large flakes. The ability to detach large flakes has been considered as the very distinctive trait of the early Acheulean (e.g., Isaac 1969). Unfortunately, the related large cores are very rare or altogether lacking. Most inferences on flaking methods derive from the observation of large tools. At KS4, large flakes were obtained by splitting large cobbles (Texier 2018). At FLK West, large flakes were detached by bifacial or multifacial exploitation when other small- and medium-size flake series were also produced (Diez-Martín et al. 2015). In this case large flakes do not seem the outcome of a chaîne opératoire distinct from small débitage. At Melka Kunture, in contrast, there is marked metrical discontinuity between small–medium and large cores. The Garba IVD early Acheulean site yielded cores documenting a specific flaking process to produce large flakes to be turned into large tools. Such flaking methods involve the systematic preparation of the flaking surface and volume management according to the discoid concept (Gallotti 2013; Gallotti and Mussi 2018). Similar technological patterns have been suggested by de la Torre et al. (2008) at Peninj. On the other hand, Diez-Martín et al. (2018) argue that at Peninj Escarpment sites the technical patterns of large tools, and unmodified large flakes suggest bifacial models based on the orthogonal intersections of the removals. In other instances, as at Olduvai TK, the criterion that guided the selection of slabs, i.e., two natural symmetrical and parallel surfaces, is comparable to that of the flakes, making bifacial reduction easier (Santonja et al. 2018). Overall, the technical parameters followed to select or produce large blanks were inconsistent, just as the retouch/shaping processes. On large tools, unifacial or bifacial retouching is often quite limited and definitely not invasive. It never aims at managing the whole volume, just at modifying edges. If there is shaping at all, it is limited to part of the volume, creating a pointed tip (Diez-Martín et al. 2018; Gallotti and Mussi 2018; Santonja et al. 2018; Semaw et al. 2018; Texier 2018). Such large tools coexist, even in the same assemblage, with highly symmetrical and bifacially flaked large tool types, showing a full management of the blank volume (Diez-Martín et al. 2018; Santonja et al. 2018). In this scenario, cleavers (sensu Tixier 1956) are very rare and do not show the predetermined aspects of the blanks typical of later assemblages (e.g., Gallotti and Mussi 2018; Texier 2018).

In summary, between 1.76 and 1.3 Ma in terms of both final form and the stages of the chaînes opératoires, the large tools are more diverse and variable than usually assumed in the literature.

The contributors to this volume do not speak in one voice, as each chapter discusses the emergence of the Acheulean in a specific site context. The review of past and present perspectives suggests that, after more than a century of research on the East African Acheulean, a large amount of data is now available on its emergence. Nevertheless, efforts are still needed to establish a comprehensive chronostratigraphic framework. Other topics also remain open issues. From a technological perspective, the origin and end, unity or variability at intra and inter-site scale, definition, and even the classical equation Acheulean = handaxe (or in some cases Acheulean = bifacial phenomenon) are all matters of discussion.

The factors that caused the technical innovations leading to the origin of the Acheulean might be linked to changes in biotic/abiotic resources, in climate and in paleoenvironment. Two papers in this volume explore the paleobotanical context of Melka Kunture in the Early/Middle Pleistocene (Bonnefille et al. 2018) and the faunal composition (Geraads 2018) at the Oldowan–Acheulean transition. Bonnefille et al. (2018) argue that in the Ethiopian highlands *Homo erectus sensu lato* adapted to mountain climatic conditions with marked daily temperature contrast. This happened when *Homo erectus* produced both late Oldowan and early Acheulean industries. Geraads (2018) reviews the large mammal record of several major eastern African sites. He concludes that the Oldowan–Acheulean transition, which is a key event in human evolution, does not correspond to any major turnover of large mammal faunas. Both results do not support the paradigm that the cultural and biological changes in human evolution recorded in East Africa between 1.9 and 1.5 Ma are contemporaneous with and possibly fostered by modifications of the natural environment.

Besides, while much research focused on the chronostratigraphic limit of the Acheulean emergence and on its relationship with the Oldowan, the last appearance datum of the early Acheulean and the developments after ~1.3 Ma are still poorly understood. From then up to 0.7 Ma, long stratigraphic sequences are known in East Africa at a limited number of sites, and several actually are of uncertain

age (e.g., Hay 1976; Isaac and Isaac 1997; Roche et al. 2003; Quade et al. 2008; de la Torre 2011; Beyene et al. 2013; Gallotti and Mussi 2017).

In West Turkana, no sites are recovered between Kokiselei 4, dated to 1.76 Ma, and Nadung'a 4, dated to ~0.7 Ma (Roche et al. 2003). A gap of 0.3 Ma is recorded in the Busidima Formation at Gona between ~1.3 Ma and ~1.0 Ma (Quade et al. 2008). At Konso, KGA12-A1 is dated to ~1.25 Ma. After a hiatus of the archaeological record lasting 0.4 Myr, KGA20-A1 and KGA20-A2 are both dated to ~0.85 Ma (Beyene et al. 2013). The Gadeb sites occur within a long and loosely defined time interval between 1.45 and 0.7 Ma, without a specific age for each occurrence (Clark and Kurashina 1979; de la Torre 2011). At Olduvai, Bed II is stratigraphically complex, with facies changes, faulting, and unconformities. Further investigations are definitely required to improve the chrono-stratigraphic framework of the archaeological sites (McHenry et al. 2016). Additionally, sites in Bed III are mostly dated only by paleomagnetism and sedimentation rates (Hay 1994; but Kimbel 1997 reports a date of 1.33 for basal Tuff III-1 from Manega 1993). The age of the contact between Beds II and III has been estimated at ~1.2 Ma (McHenry et al. 2016), but Delson and Van Couvering (2000) suggested an age closer to 1.35 Ma. The age of the top of Bed III was estimated at ca. 0.8 Ma (Hay 1994), but Tamrat et al. (1995) imply a much older date (Delson and Van Couvering 2000). Only one site with a substantial concentration of fauna and stone artifacts is currently known in Bed III, i.e., Juma's Korongo (Pante 2013). Further investigations are definitely required to improve the chrono-stratigraphic framework of the archaeological sites (McHenry et al. 2016). In the Dawaitoli Formation of the Middle Awash a tuff at the base of Member U-2 has been dated to 0.64 Ma. Acheulean sites are located both below and above this tuff, but precise chronometric dates are not available (Schick and Clark 2003).

In contrast with the dearth of evidence in areas with long-established sequences, new areas were settled for the first time around 1 Ma. This is notably the case of Isenya, Olorgesailie, Kariandusi, and Kilombe (Isaac 1977; Gowlett 1993; Gowlett and Crompton 1994; Durkee and Brown 2014).

The reason why the archaeological evidence decreases over time in East Africa, or is altogether lacking, before this fresh surge in the number of sites has not yet been investigated in any detail. In large-scale syntheses, this gap in the record is generally overlooked. To make it even more difficult to properly understand the ongoing changes, human fossils are very rare in this interval (e.g., Manzi 2012; Ghinassi et al. 2015; Profico et al. 2016). This happens in a crucial period of human evolution, when *Homo ergaster/erectus* evolves and disappears, while *Homo heidelbergensis* emerges.

After ~1.5–1.2 Ma a global climate change also occurs. This is the Early/Middle Pleistocene Transition, when the dominant periodicity of glacial/interglacial cycles shifts from 41,000 to 100,000 years, and ice-caps start accumulating at northern latitudes. The change is well documented in the northern hemisphere, between broadly MIS 36 (~1.2 Ma) and MIS 13 (~0.54–0.46 Ma) (e.g., Lisiecki and Raymo 2005). In the Mediterranean, the deposition of hematite-rich aeolian dust from the Sahara increases after ~0.95 Ma, positively suggesting aridity in Africa at 0.87 Ma (MIS 22) (Larrasoaña et al. 2003). More recently, Trauth et al. (2009) evidenced increasing aridity in Africa after ~1.5 Ma, a trend matched south of the Sahara by a shift from C_3 to C_4 vegetation between ~1.5 and ~0.7 Ma, as evidenced by the stable carbon isotope record (Ségalen et al. 2007). As Bonnefille et al. (2018) underlined, at Melka Kunture a dramatic change in vegetation at ~0.8 Ma points to a climate much cooler than today and than ever before. The high elevation, above 2000 m asl, grants more visibility to climatic variation than at lower elevation in the Rift Valley.

The gap in late Early/early Middle Pleistocene record had a causal role in conventionally fixing at ~1.3 Ma the "end point" of the early Acheulean. Sharon (2007, 2010) identifies two stages within the Acheulean techno-complex, based on the systematic use of large flakes as large tool blanks: (1) an early Acheulean, predating 1 Ma, when large flakes are not a primary technological praxis and cleavers are absent; and (2) a subsequent Large Flake Acheulean (LFA), a "distinct segment in the Acheulian techno-complex that is technologically and typologically distinguishable from others" (Sharon 2010: 228). Texier as well as Gallotti and Mussi address this topic in this volume. These authors assess that at ~1.0 Ma a marked change occurs. The predetermination of large tool blank technical aspects, the standardization of large tool types, the systematic provisioning at primary sources, and the consequent fragmentation of the large tool chaînes opératoires are a giant leap in technical productions during the late Early Pleistocene. At Melka Kunture, these technical innovations occur at the time of the gradual emergence of a new and more encephalized type of hominin: *Homo heidelbergensis* (Profico et al. 2016; Gallotti and Mussi 2017, 2018).

Finally, in the last thirty years, a general consensus emerged that "the Acheulian lithic technology was transported out of Africa" (Santonja and Villa 2006: 467). Based on this axiom, several out of Africa models have been suggested and discussed (e.g., Bar-Yosef 1987; Carbonell et al. 1999, 2010; Bar-Yosef and Belfer-Cohen 2001; Rightmire 2001; Mithen and Reed 2002; Kozlowski 2005; Santonja and Villa 2006; Lycett and von Cramon-Taubadel 2008; Despriée et al. 2010; Gallotti 2016). Accordingly, the last two chapters of this volume are devoted to a review of the oldest Acheulean evidence beyond Africa, i.e., in Asia (Dennell 2018) and in Western Europe (Moncel and Ashton 2018).

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