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The Origins of the Acheulean at Olduvai Gorge (Tanzania): A New Paleoanthropological Project in East Africa

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The disappearance of the earliest human culture, the Oldowan, and its substitution by a new technology, the Acheulean, is one of the main topics in modern Paleoanthropology. Recent research has established that the Acheulean emerged originally in East Africa around 1.7–1.6 million years ago, and from that area expanded across the rest of Africa, Europe and parts of Asia. Despite the great relevance of the Oldowan-Acheulean transition, little is known about the biological and cultural evolutionary mechanisms underlying this process. Traditionally, it has been assumed that this major cultural change was ignited by the emergence of a new human species, *Homo ergaster/erectus,* and that there was a steady technological evolution during the Oldowan that eventually led to the emergence of the Acheulean handaxes. However, these assumptions are not grounded in the current available evidence, but rooted in cultural-history paradigms that should now be superseded.

Olduvai Gorge (Tanzania) is the site where the traditional view of the Oldowan-Acheulean transition was established. The aim of the recently launched Olduvai Geochronology and Archaeology Project is to tackle this question by conducting a comprehensive research program at Olduvai, based on the retrieval of fresh data derived from new laboratory and fieldwork research. The multidisciplinary character of this ongoing study is providing an integrative perspective to the analysis of the paleoecology, archaeology, geology and geochronology of the transition to the Acheulean at Olduvai. Using an innovative theoretical perspective that combines interests in cultural change, ecological adaptations, and biological evolution, and state-of-the-art methods in archaeology, geology and taphonomy, this project aims to make Olduvai one of the world's best references for the understanding of the evolutionary processes that led to the emergence of the Acheulean, the longest lasting culture in the history of humankind.

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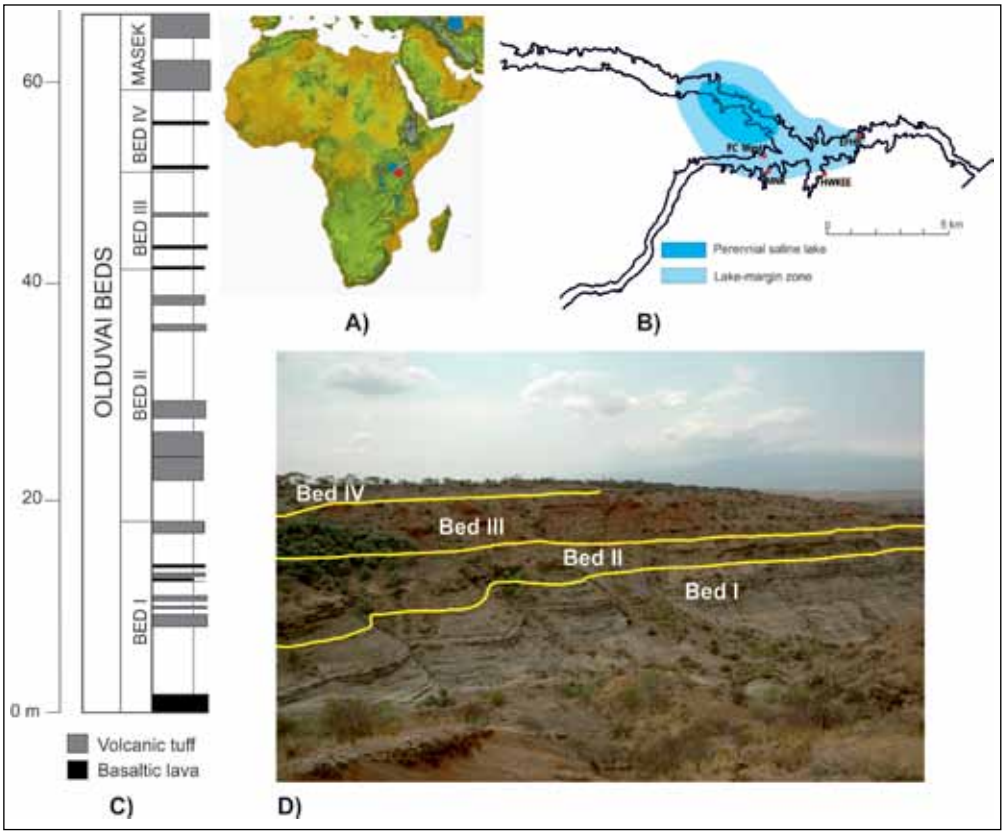

Fig. 1: (A) Position of Olduvai Gorge in Africa; (B) location of the four main sites currently under excavation by OGAP, with Middle Bed II paleo-lake margin indicated (reconstruction after Hay, 1976); (C) generalized stratigraphy of Olduvai Gorge; and (D) a section of Olduvai Gorge with the position of the main sedimentary beds.

Introduction

Olduvai Gorge, in northern Tanzania, is internationally recognized for its famous discoveries of early humans and magnificent antiquities documenting the evolutionary history of our stone tool-using ancestors, fauna, and environments over the last two million years (**Fig. 1**). Research at Olduvai began almost a century ago, producing an unparalleled wealth of archaeological and paleontological data for the study of some key phases of early human evolution. Olduvai was the first place where traces of an early stone tool culture were discovered, and gave its name to the Oldowan, currently considered as the earliest human technology. Olduvai was also the site where the transition from the Oldowan (a simple core-and-flake technology) to the Acheulean (defined by the appearance of handaxes, i.e. large pointed stone tools with heavy duty edges) was first documented, and where the earliest archaeological evidence of this new Acheulean technology was discovered. Despite the relevance of Olduvai to the understanding of the origins of the Acheulean and the demise of the Oldowan around 1.6–1.5 Ma (million years) ago, few investigations of this question at this site have been conducted since the 1960s. In 2008, the Olduvai Geochronology and Archaeology Project (OGAP) launched a new research programme on the origins of the Acheulean at Olduvai. This renewed research is crucial not only for the understanding of the archaeological record of

Fig. 2: Classic viewpoint of Olduvai Gorge, with the Naibor Soit hills in the distance and the so-called 'castle' (made of red sediments belonging to Bed III) to the bottom right.

Olduvai (by itself a key paleoanthropological sequence), but also for the general knowledge of the Acheulean culture in Africa and beyond.

The origins of the Acheulean in Africa

The transition from the Oldowan to the Acheulean is one of the most debated topics in modern Paleoanthropology. The Acheulean was the first human culture to be widely spread across the Old World, and persisted for 1.5 million years. Due to these worldwide implications, much effort has been invested in recent years to trace the earliest Acheulean, and presently evidence places the origins of this technology in East Africa at 1.76–1.6 Ma (Asfaw *et al.*, 1992; Lepre *et al.*, 2011; Quade *et al.*, 2004). However, the biological and cultural processes that led to the emergence of the Acheulean are still poorly understood.

The emergence of the Acheulean has traditionally been linked to the origins of a new human species, *Homo erectus*, whereas the Oldowan was associated with *Homo habilis*. However, current evidence (Spoor *et al.*, 2007) indicates that *Homo erectus* may have evolved before the first evidence of Acheulean stone tools, and that *Homo habilis* endured in East Africa for hundreds of thousands of years after the Acheulean emerged. It is therefore, at present, unclear whether there are effective causal links between the appearance of a new species, *Homo erectus*, and the emergence of the Acheulean as a technology, and their relation to the extinction of *Homo habilis* and the disappearance of the Oldowan culture.

Cultural mechanisms that led to the emergence of the Acheulean are also poorly understood. In the first place, it is unclear how and why unstructured core-and-flake methods of knapping, typical of the Oldowan, gave way to Acheulean technology based on the production of huge flakes made into handaxes. Further complicating the issue is the presence of stone tool industries that lack handaxes after the emergence of the Acheulean. Leakey (1971) coined the term of Developed Oldowan B to describe these industries. Her concept of the Developed Oldowan provided a straightforward way in which to categorize assemblages and assign them to different cultural (Acheulean versus Developed Oldowan) and biological

(*Homo erectus* versus *Homo habilis*) phyla. Nonetheless, this hypothesis of cultural and biological coexistence, modelled in Olduvai (Leakey, 1971), shows many inconsistencies and constitutes one of the main problems to be addressed by OGAP.

The ecological niche occupied by early Acheulean tool-makers and the food procurement strategies on which they based their subsistence are also practically unknown. Paleobiological studies of human fossils suggest that *Homo erectus* occupied more open and arid environments than early *Homo*, and also that their ecological niche was substantially larger and more diverse than that of their Oldowan ancestors. However, archaeological evidence supporting these inferences is almost non-existent, and empirical data is needed to reconstruct the paleoecological background of the early Acheulean. Likewise, little is known about the subsistence strategies of early Acheulean hominins. The debate over whether early members of the genus *Homo* were hunters or scavengers was until recently based solely upon the behaviour of Oldowan hominins, while the diet of Acheulean hominins had been largely ignored due to the sparse empirical record for this period.

Research questions

Olduvai Gorge, located in the Ngorongoro Conservation area (recently listed as a World Heritage Site by UNESCO), is the basis for much of what is known about the origins of the Acheulean (**Fig. 2**). Our project aims to address the foundational problems outlined above by posing the following research questions:

- What are the technological characteristics of the late classic Oldowan at Olduvai?
- Can the differences between the Developed Oldowan and Acheulean be explained by different use of the space, or do they correspond to actual separate cultural traditions or biological species?
- Are there differences in the food procurement strategies of late Oldowan and early Acheulean hominins?
- What are the differences in the ecological adaptations and land-use behaviours of late Oldowan and early Acheulean hominins?
- Are the Developed Oldowan and Acheulean stratigraphically contemporary, or is there a chronological gradation?
- When did *Homo erectus* appear at Olduvai, and is there any direct link between its emergence and the origins of the Acheulean?
- When, exactly, did the Acheulean first appear at Olduvai, and how does this compare to other early Acheulean sites in Africa?

The transition from the Oldowan to the Acheulean: is there a Developed Oldowan?

The traditional view of the technological change from the Oldowan to the Acheulean portrayed a transitional period, the Developed Oldowan (phases A and B), in which lithics were argued to evolve into more sophisticated shaped tools that would eventually lead to the Acheulean. Leakey (1971) used several factors to assign assemblages either to the Developed Oldowan B (DOB) or the Acheulean, such as rock types used to shape handaxes, biface size and morphology, and relative frequencies of handaxes.

At present, the ambiguities of the term Developed Oldowan have been noted, but the term remains prominent in literature. While a number of studies have used Leakey's published data to discuss this issue, lithics from Leakey's excavations must be re-studied using modern standards of technological analysis, and new unbiased assemblages must be recovered to put this record in the context of inter-assemblage variability during the Early Stone Age. That is one of the top priorities of OGAP.

The ecological niche of the early Acheulean

The ecology and land use patterns of early Acheulean hominins remains poorly understood despite the wealth of such studies

concerning those of Oldowan hominins (e.g. Blumenschine *et al.*, 2012). Global climate trends towards more arid systems lead many to assume that *Homo erectus* was adapted to more open environments than *Homo habilis*, but the fact is that little archaeological evidence supports such a proposition. Explanations proposed for possible differences between the 'Developed Oldowan' and the Acheulean include variations in the activities that were conducted and also ecological variables. For example, Hay (1976) hypothesized that the location of most Developed Oldowan sites near the lake shore at Olduvai, in contrast to the inland-riverine environments of early Acheulean sites, could indicate that the lithics were employed for different activities in a variety of ecological settings by the same groups of hominins. This perspective is essential if we are to ascertain possible differences between the toolkits of the Developed Oldowan and the early Acheulean, and to explain the paleobiology of *Homo erectus* in the light of their cultural and ecological adaptations. The variable ecological settings preserved in the Pleistocene of the Olduvai basin allow us to tackle this problem archaeologically. For example, all of the early Acheulean sites excavated at Olduvai by Leakey (1971) are located in the eastern part of the paleo-lakeshore, and no evidence has been recovered from the western side of the basin, which surely had a different ecological setting. OGAP is emphasizing the study of paleo-environmental settings of early Acheulean sites at Olduvai, as they prove to be essential for the understanding of the home range and the ecological niche occupied by *Homo erectus*.

The chronology of the early Acheulean

From the time of their discovery in the 1960s through the 1990s, the early Acheulean sites at Olduvai were considered to be the oldest in Africa and beyond, around 1.6–1.5 Ma. More recently, new sites in East Africa indicate that the emergence of the Acheulean could be older, between 1.76–1.6 Ma. Although the Olduvai assemblages are still a key reference, the dating and stratigraphic position of these sites is actually uncertain. In fact, the upper beds at Olduvai remain among the most poorly dated palaeoanthropological strata in East Africa, despite previous attempts at radiometric dating. Tuff IF (base of Bed II) has been dated to 1.803±0.002 Ma using a single-crystal laser-fusion 40Ar/39Ar technique (Deino 2012). However no reliable radiometric dates are available from tuffs in Bed II or above. Dates for Tuff IIA, the boundary between Lower and Middle Bed II vary from 1.71 Ma to 1.66±0.1 to 1.74±0.03 Ma, but so far it has been impossible to narrow down this range or confirm this age.

The same applies to the tephrostratigraphy of the region; tuffs are often used as stratigraphic markers in archaeological settings. Many tuffs can be uniquely identified using the major and trace element concentrations of their volcanic glass and minerals, and these 'fingerprints' can be used to identify individual ash layers over broad geographic areas. OGAP's geochemical research will help solidify our knowledge of Bed II stratigraphy and provide a solid stratigraphic and radiometric background to the archaeological assemblages of this part of the Olduvai sequence.

The subsistence strategies of early Acheulean hominins

One of the most important events in human evolution was the dietary shift towards carnivory, that for the first time put our stone tool wielding ancestors in competition with large carnivores which also remained dangerous predators. While most current discussions focus on the subsistence activities of *Homo habilis*, we know little about the carnivorous component of the diet of *Homo erectus*, a species characterized by its more human-like brain and body proportions. It has been suggested that *Homo erectus* may have incorporated more animal products into its diet, affording individuals the necessary intake of energy to manage increasing metabolic costs. However, the common assumption that the species was more preda-

Fig. 3: OGAP's excavations at HWKEE, an Oldowan site in the lower part of Middle Bed II.

tory than its Oldowan hominin predecessors was, until recently, only supported by the more sophisticated stone tool technology associated with the species, a skeletal morphology that may have been adapted to long-distance running, and the alpha predatory role of its modern descendants. Currently, the best test of this hypothesis is to examine the fossil assemblages associated with *Homo erectus* for traces of hominin and carnivore carcass consumption. However, the precise timing of this dietary shift and the means by which it occurred remain largely unknown due to our limited sample of fossil assemblages associated with early *Homo erectus* during the emergence of Acheulean technology. OGAP's analysis of Bed II fossil assemblages will bridge a significant gap in our understanding of human carnivory and help to determine whether the advent of hunting was coincident with the first appearance of *Homo erectus* or a subsistence strategy that was evolved much later in time.

Current fieldwork by the Olduvai Geochronology Archaeology Project

The bulk of the research activities currently conducted by OGAP is concentrated on the deposits of Middle and Upper Bed II, including archaeological excavations, surveys and stratigraphic and geochemical studies. Fieldwork aims to fulfil diachronic goals by sampling different time intervals, and paleoecological purposes by targeting variable environmental settings. We are applying complementary approaches, ranging from an on-site perspective, focused on the reconstruction of punctual assemblages, to a landscape approach, where test-pitting in different time intervals and environments will allow us to gain a regional view of the Olduvai basin at 1.7–1.5 Ma. Our fieldwork activities at Olduvai include (**Figs 3** & **4**):

1. *Site-oriented excavation of targeted assemblages.* Preliminary fieldwork at four sites previously excavated by Mary Leakey, HWKEE, EFHR, MNK and FC West (see map in **Fig. 1**), has proved the potential of these sites for further excavation. Horizontal exposure of large paleo-surfaces in these sites is allowing us to study the spatial patterning of remains and possible functional and taphonomic elements contributing to the formation of assemblages.

Fig. 4: Fossil bones and rocks unearthed from one of the archaeological levels in HWKEE.

Fig. 5: The site of MNK, one of the localities currently under excavation by OGAP.

2. *Trenches in site surroundings.* Excavations at the targeted sites shall not be limited to the exact spots where assemblages concentrate, but test-pits are planned in the surrounding outcrops of EFHR, HWKEE, MNK, FC West and others (**Fig. 5**). This will allow us to assess the off-site distribution of bones and lithics and reconstruct the paleo-environmental surroundings of the main sites under study.

Fig. 6: Excavations in the Acheulean locality of EFHR, with detail of a large quartzite handaxe found at the site.

3. *Targeted and random sampling in disparate paleoecological settings.* Test-pitting is also planned in other locations situated in the stratigraphic interval related to the Oldowan-Acheulean transition. This targeted sampling will provide paleoecological and archaeological data from other local environments that will help to contextualize human adaptations in various intervals in Middle and Upper Bed II.

4. *Location of suitable target horizons for further excavation.* OGAP is currently assessing the potential of previously excavated sites that have been refreshed through erosion over the last 40 years, sites identified by Leakey (1971) but never excavated, or new sites discovered during foot surveys. Fieldwork at these new sites will hopefully expand the geographical and paleoecological distribution of recorded localities and lead us to find older Acheulean sites.

5. *Detailed stratigraphic mapping and tuff sampling.* We are measuring detailed stratigraphic sections at and near the excavation sites to help establish a high-resolution ecological and stratigraphic framework for the sites and intervals of interest. This is essential for determining the relative stratigraphic positions of potentially contemporaneous Developed Oldowan and Acheulean sites, and for providing a temporal context for changes in tool assemblages (**Fig. 6**). Tuff sampling is another priority for both geochemical correlation and radiometric dating.

Conclusions

When and how the Acheulean emerged in the history of human evolution is one of the hottest topics in modern Paleoanthropology. Cultural mechanisms, ecological factors, and biological and behavioural adaptations that led to the disappearance of a culture that had lasted for a million years (the Oldowan), and sparked the emergence of a new one, the Acheulean, are extremely important for human evolution, yet remain very poorly understood.

Olduvai Gorge offers one of the best opportunities to address this problem; the Olduvai basin contains an unparalleled record for the understanding of the last two million years on Earth, and it is particularly significant for the time period when the transition from the Oldowan to the Acheulean took place, 1.7–1.5 Ma. There are very few other places where the wealth of archaeological evidence allows us to situate this transition in a diachronic scale and to contextualize the origins of the Acheulean in a complex paleoenvironmental dimension.

The Olduvai Geochronology and Archaeology Project is an interdisciplinary enterprise into the study of the Olduvai Acheulean, and it aims to integrate data provided by archaeological, paleontological, geochronological, and paleoecological studies. This will allow us to obtain an accurate age for the early Acheulean at Olduvai, understand the ecological contexts of paleoanthropological occurrences, and ultimately to reconstruct hominin activities – the location of their foraging activities, their cultural adaptations and their subsistence behaviour.

OGAP is also committed to promote capacity building and the involvement of local communities, which is essential for the awareness of the importance of Tanzanian heritage. Thus, OGAP participates in several initiatives that include the training of a new generation of Tanzanian and foreign scientists, outreach, and the appropriate conservation of the many paleoanthropological jewels contained in Olduvai Gorge. All of these research, training, education and conservation initiatives aim to promote the unparalleled paleoanthropological record of Olduvai Gorge, a UNESCO World Heritage site called by many, probably rightfully, 'the cradle of humankind'.

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