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Paleoanthropology of the Kibish Formation, southern Ethiopia: Introduction

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A B S T R A C T

Cranial and skeletal remains of modern humans, *Homo sapiens*, were discovered in the Kibish Formation in 1967 by a team from the Kenya National Museums directed by Richard Leakey. Omo I, from Kamoya's Hominid Site (KHS), consists of much of a skeleton, including most of the cranial vault, parts of the face and mandible, and many postcranial elements. Omo II, from Paul's Hominid Site (PHS), is a virtually complete calvaria. Only a limited fauna and a few stone artifacts attributed to the Middle Stone Age were recovered in conjunction with the fossil hominids. The available dating techniques suggested a very early age, over 100 ka, for Member I, from which the Omo I and Omo II fossils were recovered. However, in subsequent decades, the reliability of the dates and the provenance of the Kibish hominids were repeatedly questioned. The papers in this volume provide a detailed stratigraphic analysis of the Kibish Formation and a series of new radiometric dates that indicate an age of 196 ± 2 ka for Member I and 104 ± 1 for Member III, confirming the antiquity of the lower parts of the Kibish Formation and, in turn, the fossils from Member I. Studies of the postcranial remains of Omo I indicate an overall modern human morphology with a number of primitive features. Studies of an extensive lithic record from Members I and III indicate a Middle Stone Age technology comparable to assemblages of similar age elsewhere in Ethiopia. Studies of the mammalian, avian, and fish faunas indicate overall similarities to those found in the region today, with a few distinctive differences.

In 1967, as part of the International Paleontological Research Expedition to the Omo River, a team from the Kenya National Museums, under the direction of Richard Leakey, recovered three fossil hominid specimens from the Kibish Formation of southern Ethiopia (Leakey, 1969). Omo III consists of a few fragments of the anterior part of the neurocranium and the upper face and has received relatively little attention (Day, 1969). However, the other two specimens, Omo I and Omo II (Fig. 1), have occupied a critical but controversial role in our understanding of the timing and geography of modern human origins throughout the forty years since their initial discovery and description (e.g., Stringer and McKie, 1996).

Omo I consists of numerous fragments of the cranium, dentition, and mandible, as well as much of the postcranial skeleton. It was recovered by Kamoya Kimeu from the site of KHS (Kamoya's Hominid Site; Fig. 2) in Member I of the Kibish Formation (Butzer, 1969; Butzer et al., 1969). According to the original description, "excavation of site KHS yielded some material *in situ* and established the provenance of the Omo I skeleton in terms of the stratigraphy of the Kibish deposits" (Leakey, 1969: 1132). Both the cranial remains and the postcranial remains have been considered by virtually all researchers to represent anatomically modern *Homo sapiens* (e.g., Day, 1969; Stringer, 1978; Day and Stringer, 1982; Rightmire, 1976; but see Bartsiokas, 2002).

Omo II consists of a nearly complete neurocranium. It was recovered as a surface find by Dr. Paul Abell (Fig. 3) at the site of PHS (Paul's Hominid Site), also in the upper part of Member I of the Kibish Formation (Butzer, 1969; Butzer et al., 1969). In the initial description, Day (1969) attributed the Omo II neurocranium to *Homo sapiens* along with the Omo I specimen. However, in contrast to the Omo I cranial remains, which have generally been considered anatomically modern, the Omo II neurocranium has been regularly described as more primitive, with many similarities to *Homo erectus* (e.g., Day, 1969; Rightmire, 1976; Stringer, 1978; Day and Stringer, 1982; White et al., 2003). The anatomical differences between the two crania led to considerable debate in the subsequent literature about the actual stratigraphic provenance of the two fossils.

The absolute age of the Omo hominids was difficult to establish, largely because of the technological limitations of isotopic dating in the late 1960s. In the same year as the original description, papers describing the geology of the Kibish Formation and the hominid sites, including a series of radiometric dates, were published by

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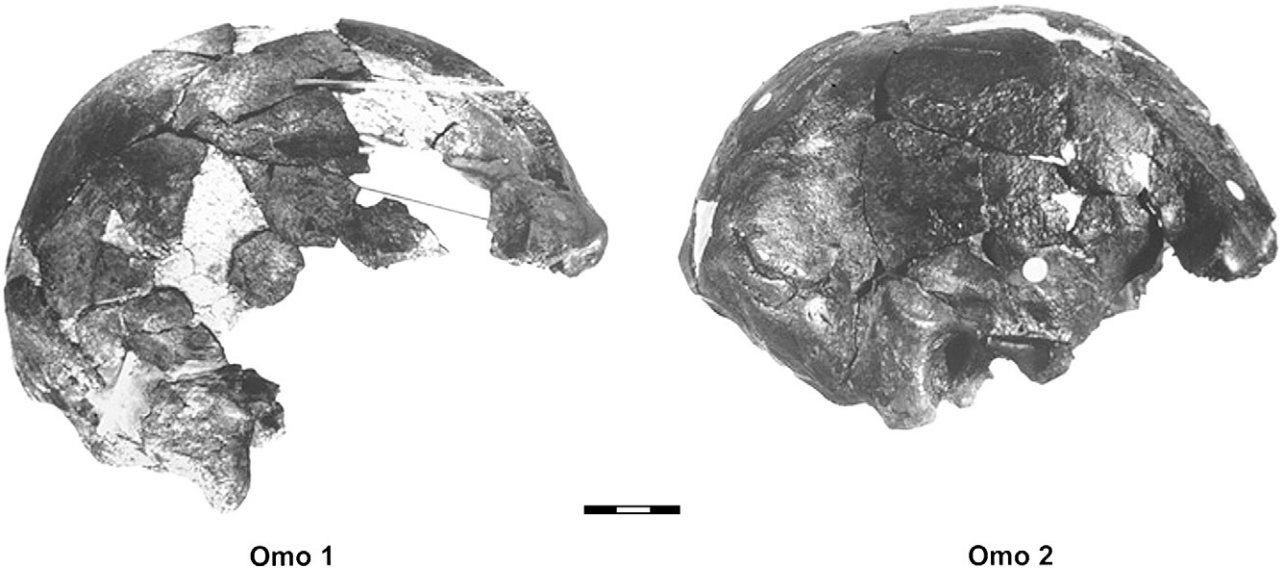

Fig. 1. The fossil crania Omo I and Omo II from the Kibish Formation (photo courtesy of Michael Day).

Butzer and Thurber (1969) and Butzer et al. (1969). In the latter paper, the authors presented the results of several radiometric dates on shells from a Nile oyster (*Etheria elliptica*) bank in unit f (just above the fossiliferous horizon) of Member I, yielding two ^{14}C dates of "greater than 39,900 yr." and a Th^{230}/U^{234} date of "around 130,000." In a footnote, the authors noted that:

> molluscs have been shown to have open chemical systems with respect to uranium and its daughter products. Thus the accuracy of "ages" calculated from Th^{230}/U^{234} ratios is difficult to determine, and perhaps impossible, even with much more detailed work. The "age" reported here should perhaps be considered only as confirming the antiquity of the shells as indicated by radiocarbon and as some substantiation of the geologic interpretation. It should not be considered too seriously as an "age" (Butzer et al., 1969: 19; see also Schwarcz and Blackwell, 1992).

The antiquity of Member I was also confirmed by dates from Member III. These included an *Etheria* unit dated at greater than 37,000 yr by ^{14}C and around 130,000 yr by Th^{230}/U^{234}. Thus, the fossils from Member I were clearly older than the analytical limits of

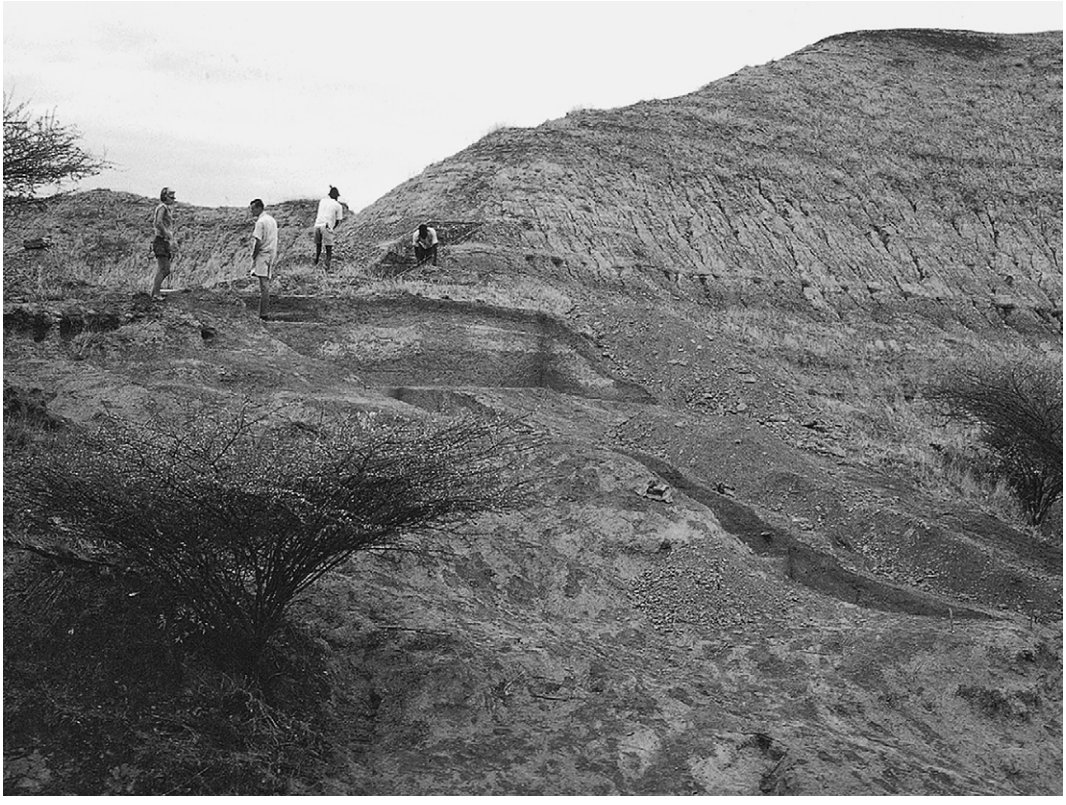

Fig. 2. The 1967 excavation at the KHS site where Omo I was recovered (photo by Paul Abell).

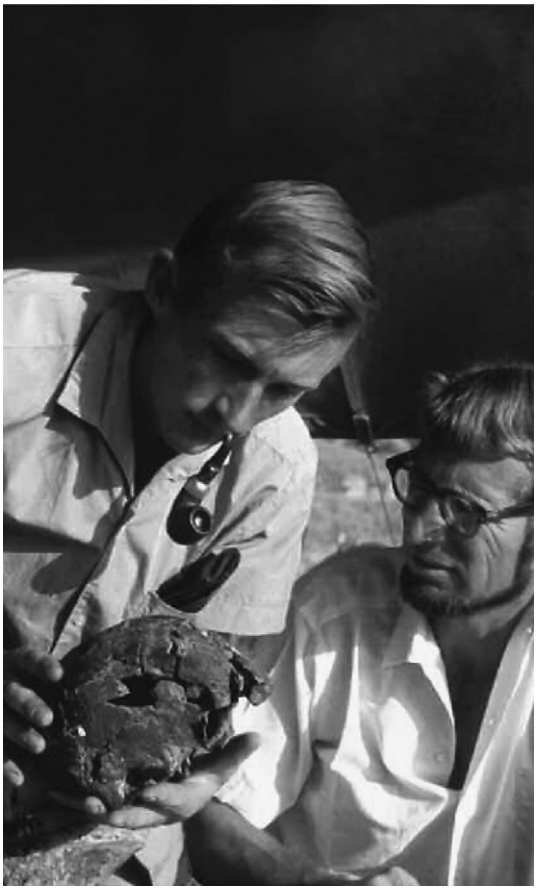

Fig. 3. Richard Leakey (above) and Paul Abell (right) examining the Omo II cranium recovered by Abell in 1967 (photo by Bob Campbell).

radiocarbon dating (30–40,000 yr) at the time and there were suggestions that they may be over 100,000 years old, but that date was not supported very enthusiastically. The very limited fauna offered no useful information about the age of the hominids (Leakey, 1969).

These doubts over the actual age of the Kibish fossils were echoed by subsequent reviews of the material for several decades. In a review of African hominids in 1978, F.C. Howell noted:

> Human cranial remains and some associated postcrania, were recovered (in 1967) from a situation considered to represent the lower part (Member 1) of the Kibish Formation, lower Omo Basin, southwestern Ethiopia (R.E.F. Leakey, Butzer, and Day, 1969). This unit of the Kibish Formation was accumulated when Lake Turkana stood some 60 m higher than its present (+375 m) level, and flooded the whole of the lower Omo valley (Butzer et al., 1972). At least two (of three) specimens are thought to derive from different localities related to the upper sedimentary units (5 and/or 6, or 7 units) of that member. As they have comparable N and U values they are considered to be broadly contemporaneous. An age as old as ~130,000 years has been suggested for the specimens on the basis of Th/U measurements (Butzer et al., 1969). However, the reliability of this method has still to be adequately demonstrated; even if this determination appears reasonable, it is nonetheless unconfirmed. The radiocarbon determinations (on shell) from overlying members, with a minimum age 37,000 years, have also been questioned. The mammal fauna associated with one (No. 1) of the specimens, with few species represented and none of them extinct, is frankly unhelpful and also unconvincing of any very remote antiquity (Howell, 1978: 216).

Similarly, in describing "The Omo Specimens," Wolpoff (1980: 256) stated:

> Date determination is a continuing problem for the African remains. The oldest Upper Pleistocene East African specimens with any hope of fairly accurate dating come from the Kibish formation at Omo (in Ethiopia)…. Radiometric dating of the later hominid remains … has been beset with problems. The faunal date of 60,000 years BP appears likely, making the Omo specimens roughly contemporary with the early Würm glaciation in Europe. Numerous Levallois (prepared core) flakes are found in the deposits, although there is no direct association with the hominids.

Wolpoff's date of 60,000 years BP apparently comes from a comment that Michael Day made in a UNESCO symposium published in 1972: "The fauna associated with the remains is said to be of Middle Pleistocene type. On this basis, it seems likely that the dating of these remains should be Upper Middle Pleistocene, possibly 60,000 years B.P." (Day, 1972: 35). However, we have no idea where Day obtained this assessment.

A decade later, Wolpoff (1989: 65) again summarized the age of the Kibish fossils:

> The Omo radiometric dates have been continuously disputed ever since their first publication because radiocarbon determinations based on shells are notoriously inaccurate, and recent Uranium/Thorium dates are problematic. Various faunal and stratigraphic 'dates' have been suggested as replacements for these radiometric estimates (Day, 1972; Stringer, 1989) and according to these the age of the three fossils could range between 40,000 and 130,000 years. However, which of the various date estimates may be correct cannot be established, and the fact is that there is no particular reason to accept any of them as valid!

Likewise, Smith (1992: 240–241) stated:

> Unfortunately, although the morphology of these remains is not open to serious question, the geological ages claimed for the adult remains are very questionable. The Omo I skeleton was found partially *in situ* in member 1 of the Kibish formation. This level was dated to 130 ka ago by uranium-thorium applied to mollusc shell (Day and Stringer, 1982). However, shell-derived uranium-thorium dates are generally considered dubious (H.P. Schwarcz, personal communication). Errors usually involve underestimates of age because of uranium uptake into the shell (Aitkin, 1990) but it may be also possible that leaching might produce erroneously older ages (as is the case with bone). The associated fauna and a greater than 37 ka conventional radiocarbon date for the overlying member 3 deposits in the Kibish Formation (Day and Stringer, 1982) do indicate some antiquity for Omo I, but it is impossible to confidently determine the precise antiquity of this specimen at the present time.

Similar doubts were expressed by Smith et al. (1989, p. 45).

In contrast, on the basis of the same data, Bräuer (1989: 127) suggested:

> There is good reason to assume a high age for the anatomically-modern Omo I hominid, which was found at the base of member I of the Kibish Formation. The hominid level is situated much lower in the stratigraphy (cf. the section in Day and Stringer, 1982) than upper level of member III for which a radiocarbon date of 37,000 BP was obtained. Butzer (pers. comm.) even assumes that the entire member III lies beyond the range of conventional radiocarbon dating. Therefore, an age much greater than 40,000 years appears very reasonable. According to Butzer (pers. comm.), it is most probable that members I, II and III all belong to oxygen isotope stage 5 (a non-glacial period), and are thus older than 75,000 years. Summarizing all the available

evidence, including the Uranium/Thorium date of about 130,000 BP for member I, an age of at least about 100,000 years seems well established for Omo I.

In addition to questions about the dating of the Kibish fossils, the morphological differences between the Omo I and Omo II cranial remains led to continued questioning about the provenance of the bones. Most of the attention paid to the Kibish fossils concentrated on the date of Omo I in the context of the origin of modern humans, and the Omo II specimen was often ignored (e.g., Smith et al., 1989). However, those authors that addressed the morphological differences between the specimens took a wide range of approaches. Most (e.g., Rightmire, 1976) accepted the original geological results and noted that they must represent either a considerable amount of morphological variation within a taxon (Day, 1969; see also Trinkaus, 2005) or that the Kibish fossils sampled two different, contemporary populations (Day and Stringer, 1982). Others were more creative. In a series of papers, Bräuer and colleagues (Bräuer et al., 1997; Bräuer, 2001) published diagrams showing the Omo II specimen as older than the Omo I specimen, while Klein (1999: 397) suggested that "a stark morphological contrast between Omo-Kibish 1 and Omo-Kibish 2 may mean that one (or both) were intrusive into the stratigraphic unit they derive from, and Omo 1 (more modern) may be much more recent." To our knowledge, there is no geological or taphonomic evidence for either of these views.

Thus, by the end of the second millennium, the significance of the Kibish hominids for our understanding of modern human origins was surrounded by considerable confusion and speculation about the age and provenance of the Omo I and Omo II specimens. In addition, from the original fieldwork, there was very little information in the form of either other fauna or archaeological materials that might help put the Kibish hominids in a broader archaeological or paleontological context.

In 1999, we began a series of expeditions designed to clarify the many ambiguities about provenance and age of the fossils from 1967, as well as to recover additional paleontological and archaeological material from the Kibish Formation. We conducted field research in southern Ethiopia under the auspices of the Authority for Research and Conservation of Cultural Heritage in 1999, 2001, 2002, and 2003. In addition, the participants spent many additional months working in the National Museum of Ethiopia, Addis Ababa. The papers in this special issue of *Journal of Human Evolution* describe the results of this project. Further information can be found at: http://turkanabasin.org/research/omo-kibish.

Our recent studies of the stratigraphy and geochronometry of the Kibish Formation have corroborated and expanded the original studies by Butzer and colleagues (Brown and Fuller, 2008; McDougall et al., 2005, 2008). Brown and Fuller (2008) confirm Butzer's division of the Kibish Formation into four distinct members and report maximum thicknesses for the individual members that are similar to those reported by Butzer and colleagues. However, they find that the stratigraphy of Member III is more complex and divisible into several distinct parts. The basal parts of each member of the Kibish Formation appear to have been laid down very rapidly, probably as a series of annual layers, with overlying parts of each member deposited somewhat less rapidly. Thus, the formation seems to record short intervals of deposition separated by long stretches of time. McDougall et al. (2008; see also McDougall et al., 2005) report a weighted mean age of 196 ± 2 ka for tephra in Member I and a weighted mean age of 104 ± 1 ka for Member III. These are concordant with the dates provided by Butzer and colleagues in 1969, and confirm a considerable antiquity for the lower three members of the Kibish Formation. In addition, the dates for individual members of the Kibish Formation coincide with the dates of sapropels in the Mediterranean Sea. Both the sapropels formed by outflow from the Nile, and the Kibish Formation formed by the flow on the Omo River, are driven by peaks of rainfall in the Ethiopian highlands associated with climate cycles of roughly 23 kyr in conjunction with precessional cycles of the earth's rotation around the sun (e.g., Maslin and Christensen, 2007).

Questions about the provenance and relative ages of the Omo I and Omo II fossils are addressed by Brown and Fuller (2008) and by Feibel (2008). Although the site from which Omo II was recovered (PHS) was incorrectly mapped in the publications from earlier decades (Butzer, 1969; Day and Stringer, 1982), all evidence supports the original reports by Butzer (1969) that both Omo I and Omo II came from the upper part of Member I and are of approximately the same age.

While the cranial remains of Omo I and Omo II have been discussed extensively in the literature, the numerous postcranial remains of Omo I have received very little attention (Day, 1969; Day et al., 1991). Pearson et al. (2008a) provide a more detailed description and preliminary analysis of the Omo I postcranial remains. This study includes both the specimens recovered in 1967 and additional elements recovered during recent fieldwork. Their descriptions agree with earlier notes on the the Omo I postcranial remains, describing them as modern in overall appearance, but they note various primitive features. Primate and human fossil clavicles are rare, but the Omo I specimen includes a nearly complete left clavicle. Voisin (2008) finds that it shows a modern human pattern of curvature. Pearson et al. (2008b) describe additional hominid remains from the Kibish Formation, including a nearly complete tibia and several cranial fragments. The new tibia, also from Member I, is very similar to tibial remains of Omo I.

On the basis of the 1967 expedition, Leakey and colleagues reported that "very few stone tools were collected, all of which were surface finds with the exception of flake debris from the KHS excavation" (Leakey, 1969: 1132). As reported by Shea (2008) and Sisk and Shea (2008), fieldwork between 1999 and 2003 yielded a large number of stone tools from both surface collections and from three separate excavations (see also Shea et al., 2007), one at the KHS site, one in the lower part of Member III, and Awoke's Hominid Site in Member I. The lithic assemblages from the Kibish Formation exhibit radial-centripetal preparation of cores struck from small clasts, relatively few retouched tools, and a large biface component. These properties align them with Lupemban industries of the Equatorial African Middle Stone Age. The Kibish assemblages are similar to lithic assemblages of roughly equivalent age elsewhere in Ethiopia, such as Aduma in the Middle Awash (Yellen et al., 2005) and Gademotta (Wendorf and Schild, 1974).

The report on the 1967 expedition mentioned only a very limited fauna recovered from the Kibish Formation. However the recent expeditions have yielded large numbers of specimens from Members I, III, and IV, including mammals, birds, and fish. Assefa et al. (2008) provide an analysis of the mammalian fauna from Members I, III, and IV. All of the mammalian fossils from the Kibish belong to extant taxa (at the species level, when so identified), and most are from taxa that currently live in the area today. However, a few of the taxa are now found only in other parts of Africa and suggest that the Kibish Formation formed under wetter conditions than today, a finding that is concordant with the results of geological research (McDougall et al., 2005, 2008; Brown and Fuller, 2008). Analyses of the mammalian fauna indicate a mosaic of environments. Louchart (2008) describes the avian fossils from the Kibish Formation. Most of the fossils are attributed to water birds that are found in the region today. These include pelicans (two species), darters, and herons, as well as the terrestrial guinea fowl. Likewise, the fish fauna described by Trapani (2008) includes species found in the Omo River today and is dominated by catfish and Nile perch. However, many of the fossil specimens are larger than any recorded from the modern fish fauna.

Overall, the papers in this special issue of *Journal of Human Evolution* resolve many of the outstanding questions surrounding the fossil hominids from the Kibish Formation. The exact sites from which the Omo I and Omo II fossils recovered in 1967 have been confirmed by relocating the localities with photos from the original expedition, as well as by recovery of additional remains from the Omo I individual at the KHS site. Geological studies, including both microstratigraphy and tephra correlations, support the original view that both are from the upper part of Member I. The dates for Members I, II, and IV of the Kibish Formation are well constrained by both radiometric dates and by correlations with sapropels from the Mediterranean Sea. Thus, Member I and the fossils from that member can be confidently dated at approximately 196 ± 2 ka. This makes the fossil hominids from the Kibish Formation the earliest documented remains of modern humans (*H. sapiens*) yet recovered. There is now a well-documented archaeological record from the Kibish Formation and a good fauna of mammals, birds, and fish. In addition, the long neglected postcranial remains have now been more thoroughly described, as have several additional hominid fossils.

Nevertheless, it is fair to note that there remain many unanswered questions and opportunities for further research. While there is no evidence to support the view that one or the other of the hominid fossils is intrusive into the Member I deposits (e.g., Klein, 1999; see Feibel, 2008), the significance of the anatomical differences between the Omo I and Omo II crania, such as the higher frontal and more rounded occipital contour in Omo I, remains a subject of debate. One possibility is that this diversity reflects the range of morphological variation found in a single population at that time (e.g., Trinkaus, 2005). Alternatively, the two crania may sample two different, roughly contemporary populations. In any case, further study, including taphonomic analysis, of the Omo hominid remains and comparisons with other early modern human fossils is clearly warranted. There is abundant archaeological material in Members I, III, and IV of the Kibish Formation that offers many opportunities for excavation and research into lithic technology and zooarchaeology during the past 200,000 years of human evolution.

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