A Brief History of Research at Koobi Fora, Northern Kenya

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Abstract. Lake Turkana itself is a geologically recent phenomenon, but what is now the Lake Turkana basin has an archaeological record that stretches back 2.5 million years and a paleontological record that extends back to the Cretaceous Period. Vertebrate fossils were first discovered in the lower Omo Valley at the beginning of the twentieth century, but the first multidisciplinary international expedition to investigate the region was that of the International Omo Research Expedition in 1967. The National Museums of Kenya participated in the first IORE but thereafter mounted their own multinational and multidisciplinary expeditions to the Kenyan part of the Lake Turkana basin. The Koobi Fora sand spit on the east side of the lake served as the National Museums' field headquarters for the Koobi Fora Research Project on that side of the lake, the subsequent West Turkana Project, more recent fieldwork at Lothagam and Kanapoi, and ongoing field research today. The fossils and artifacts recovered from the Lake Turkana basin have contributed much to our current understanding of early human origins.

The Turkana depression of northern Kenya is a triangular lowland lying between the Kenyan and Ethiopian domal uplifts in the middle sector of the East African rift system. Although the paleontological history of the Lake Turkana basin stretches back into the Mesozoic Era, it is now well known for the wealth of Plio-Pleistocene fossils and artifacts that have been recovered from various localities in the region. The basin's most prominent feature is a geologically recent phenomenon: the elongate Lake Turkana (formerly Lake Rudolf). Just north of a large sand spit projecting into the lake at the north end of Allia Bay are some small conical hills known as Koobi Fora (Borana for "small hill of a satellite camp"). The Koobi Fora sand spit has been used as the field headquarters of National Museums of Kenya field expeditions since 1969.

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Geological History

Today Lake Turkana is the third largest lake in Africa. It lies in a closed basin that is fed year-round from the north by the Omo River, whose source lies in the Ethiopian highlands, and seasonally from the southwest by the Turkwel and Kerio rivers and by other smaller ephemeral rivers around its periphery. A large lake has been an intermittent feature of the basin since about 4 million years ago (~4 Ma), when what is now termed the Lonyumun Lake occupied an area considerably more extensive than the present Lake Turkana. Paleogeographic reconstructions by Frank Brown and Craig Feibel (1991) indicate that, for much of the Pliocene, the Omo River was the principal drainage of the region, flowing through the basin and then into the Indian Ocean, but occasional tectonic activity disrupted the outflow and resulted in short-lived temporary lakes. After about 1.9 Ma, a lake seems to have become a permanent feature of the basin, although it varied in size. The Omo River outlet through the southeastern part of the basin may have been blocked by tectonic activity, but mollusks flourished in the lake until at least 0.7 Ma—implying that the lake's waters were not as alkaline as they are at present. Indeed, mollusk-packed sands were reasonably common until at least 1.3 Ma (Harris, Brown, and Leakey 1988), so the basin may have remained open until that time. After the basin became closed, the lake occasionally overflowed to the northwest through Sanderson's Gulf into the Nile catchment.

The Plio-Pleistocene fossil-bearing terrestrial and lacustrine strata from the northern half of the basin (fig. 1) belong to the Omo Group (Brown and Feibel 1986) and are represented by the Shungura, Mursi, Nkalabong, and Usno formations in the lower Omo Valley (Butzer 1976; de Heinzelin 1983), the Koobi Fora Formation on the northeast side of the lake (Brown and Feibel 1991), and the Nachukui Formation on the northwest side of the lake (Harris, Brown, and Leakey 1988). The Nachukui Formation extends to the southwest of the lake, where, at Lothagam, it overlies the late Miocene Nawata Formation (Feibel 2003a) and to the southeastern margin of the lake near Loiyengalani.

The Lonyumun Lake, the oldest paleolake recognized in the basin, is documented by lacustrine sediments of the Lonyumun Member, which was defined as the basal unit of the Koobi Fora Formation (Brown and Feibel 1986) but also forms the basal unit of the Nachukui Formation on what was the lake's west side (Harris, Brown, and Leakey 1988). The Lonyumun Lake is represented in the southwest part of the basin by the upper Apak and Muruongori members of the Nachukui Formation (Feibel 2003a). Fossiliferous strata from Kanapoi include a short-lived lacustrine episode that cor-

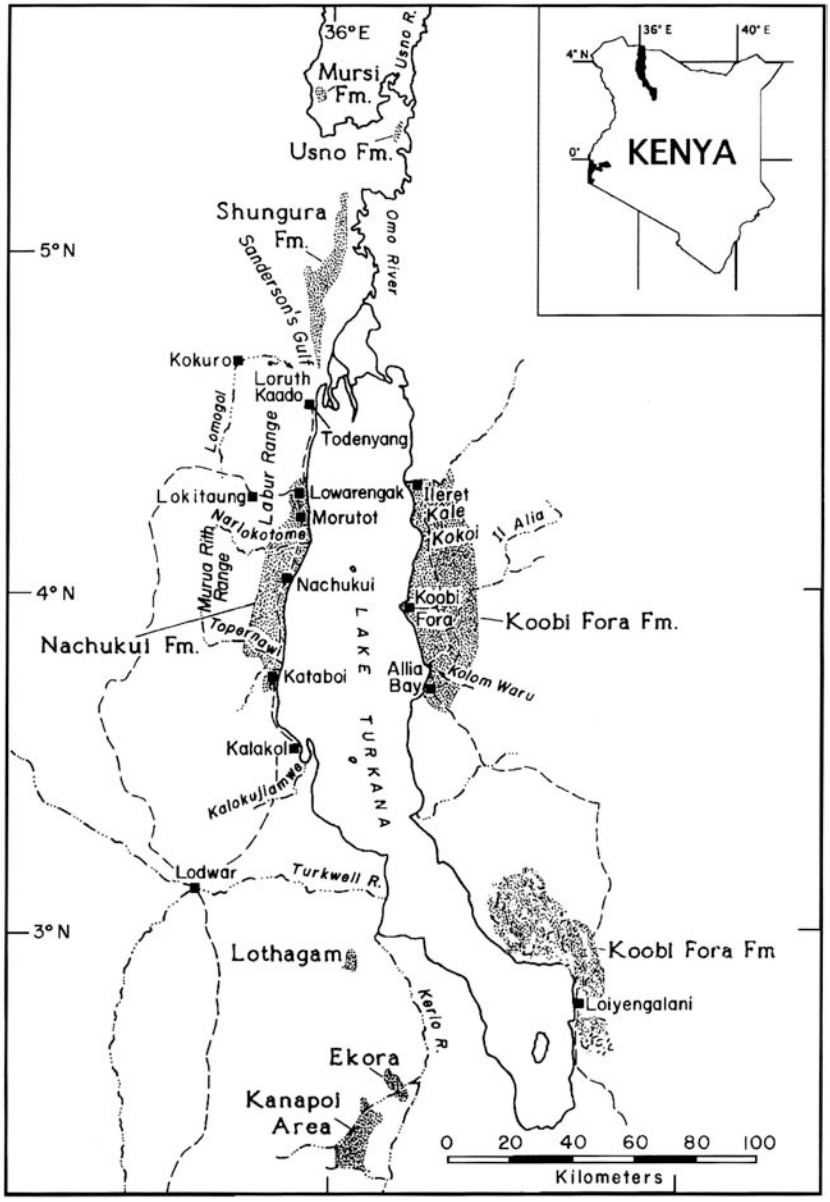

Figure 1. Map of Lake Turkana Basin showing the fossiliferous areas investigated by National Museums of Kenya expeditions and the International Omo Research Expedition (from Harris and Leakey 2003).

responds to the Lonyumun lacustrine interval. Feibel (2003b) interprets the fluvial sediments that enclose the lacustrine phase to have been deposited by the Kerio River and has named the sequence the Kanapoi Formation. The Pliocene strata of Kanapoi thus provide the oldest record of fluvial sediments deposited by the Kerio River and include a deltaic tongue that extended into the Lonyumun Lake. They thereby complement the fluvial sediments of the Kaiyumung member of the Nachukui Formation at the nearby locality of Lothagam that were evidently deposited by the Turkwel River (Feibel 2003a). The areal extent of the Lonyumun Lake is matched only by the high stands of the lake in the late Pleistocene and Holocene (ten thousand to four thousand years ago) that resulted in the draping of the Galana Boi Formation over the older sedimentary units up to several kilometers distal to the current lake shoreline. Similar but perhaps less extensive overlaps are seen several times in the history of the basin (for example, in the upper Burgi Member of the Koobi Fora Formation).

History of Exploration

The Lake Turkana basin (formerly the Lake Rudolf basin), which straddles the border of northern Kenya and southern Ethiopia, has been an important source of Neogene terrestrial vertebrate fossils since the early part of the twentieth century (Coppens and Howell 1983). In 1888, Count Samuel Teleki and Sir Ludwig von Höhnel were the first European explorers to reach the lake (Höhnel 1938), which they named Lake Rudolf after Crown Prince Rudolf of Austria-Hungary. Subsequent visitors included the second Bottego Expedition in 1896 (Vannutelli and Citerni 1897), Arthur Donaldson Smith (1896, 1897, 1900), Henry Cavendish (1898), and Arthur Neumann (1898). Surveying and/or military expeditions included those of Herbert Austin (1899, 1902a, 1902b), Alexander Bulatovich (1900), J. W. Brooke (1905), Charles Gwynn (1911), James Harrison (1901), Phillip Maud (1904), Chauncey Stigand (1910), and Montague Wellby (1900). These travelers documented the wildlife of and human settlement in the area, as well as fluctuations in the shoreline and delta. During the early part of the twentieth century, the frontier between Kenya and southwestern Ethiopia was unstable and mostly closed. Reports during this time included those of A. C. Hoey (1911), Geoffrey Archer (1913), W. P. Holland (1926), and Arnold Hodson (1929).

The French expedition of Bourg de Bozas in 1902–3 was the first to recover vertebrate fossils from Plio-Pleistocene exposures in the lower Omo Valley (Haug 1912; Joleaud 1920a, 1920b, 1928, 1930, 1933; Boulenger 1920). This discovery prompted the Mission Scientifique de l'Omo, which

further documented the geology and paleontology of the area to the north of the Omo Delta in 1932 and 1933 (Arambourg 1935, 1943, 1947).

The Cambridge Expedition to the East African Lakes (1930–31) included hydrological and biological research in the Lake Turkana basin (S. Worthington 1932; E. B. Worthington 1932; Worthington and Worthington 1933). Geological studies were initiated by Sir Vivian Fuchs (1934), subsequently expanded (Fuchs 1935), and ultimately resulted in a broad geologic history of the basin (Fuchs 1939). Arthur Champion (1937) documented the physiography south of the lake and the volcanic centers at its southern end (Champion 1935; Champion and Smith 1937; Smith 1938). In 1939, the Sagan-Omo biological mission contributed further information about the geology and biology of the region (Zavattari 1941, 1942, 1946).

Allied military forces occupied southern Ethiopia during World War II, and vertebrate fossils collected during the occupation were forwarded to the Coryndon Museum in Nairobi (now the National Museums of Kenya). In 1942 Louis Leakey (then honorary curator of the Coryndon Museum) sent his Kenyan staff under Heslon Mukiri to collect from the southern Ethiopian Omo deposits (L. S. B. Leakey 1943a, 1943b); they reached as far north as Todenyang. Leakey had received a letter from the district commissioner of Marsabit that referred to reports of fossil bones from a place called Kubi Fur, but no follow-up was made at the time (M. G. Leakey and R. E. Leakey 1978).

Sir Frank Dixey (1948) undertook an extensive geological and hydrological survey of the north Turkana area. Vertebrate fossils were recovered from Miocene beds in south Turkana (Dixey 1945) and from old lacustrine sediments west of Marsabit Mountain. T. Whitworth (1965) pursued paleontological studies of Miocene sediments and later Pleistocene lakebeds along the western margin of the lake, but the fossiliferous exposures east of Lake Turkana continued to go unrecognized.

In the mid-1960s, Larry Robbins (1967, 1972, 1975) investigated the terminal Pleistocene and Holocene archaeology of the southwestern portion of the Lake Turkana basin. Robbins let it be known that the region also contained somewhat older fossils, and in 1964 Bryan Patterson initiated a series of Harvard University expeditions to the region between the lower Kerio and Turkwel rivers. Patterson's expeditions focused initially on the Kanapoi region (1965–67) and subsequently on Lothagam (1967–72). Assemblages from the two localities shed much light on the late Miocene–early Pliocene vertebrate biota of sub-Saharan Africa and provided the basis for monographic revisions of proboscideans (Maglio 1973), rhinos (Hooijer and Patterson 1972), horses (Hooijer and Maglio 1974), and pigs (Cooke and Ewer 1972). The Patterson expeditions recovered few primate fossils

but documented a hominid mandible from Lothagam (Patterson, Behrensmeyer, and Sill 1970; M. G. Leakey and Walker 2003) and a hominin humerus from Kanapoi (Patterson and Howells 1967; Ward et al. 2001). Some stone artifacts were collected (M. D. Leakey 1966), but these postdated the early human remains. Kay Behrensmeyer accompanied the Patterson expedition to Lothagam as a geologist. Later, Dennis Powers (1980) recorded the stratigraphy of both Kanapoi and Lothagam in his doctoral dissertation.

In 1967 a joint French, American, and Kenyan expedition (International Omo Research Expedition or IORE) resumed exploration of Plio-Pleistocene exposures in the lower Omo Valley. The exposures were divided up between the participants. The French contingent, headed by Camille Arambourg and Yves Coppens, concentrated on the exposures of the Shungura Formation on the west bank of the Omo that had been prospected by Arambourg's expeditions in the 1930s. The American contingent, headed by F. Clark Howell, was based in the adjoining area to the north, and the Kenyan contingent, headed by Richard Leakey (in lieu of his father Louis), concentrated on the older exposures of the Mursi Formation and the younger exposures of the Kibish Formation that were east of the river. The expedition was mounted from Nairobi and traveled to the lower Omo Valley via Kitale, Amudat, Lodwar, and Lokitaung, where the convoy descended the gorge and emerged near the north end of the west side of the lake. Traveling from Nairobi via light aircraft, Richard Leakey noted extensive areas of sediments exposed on the east side of the lake (even though these areas were marked as lava on the ordnance survey map of Lake Rudolf). Borrowing a helicopter from the American contingent, he was able to make a ground check of the area and noted Plio-Pleistocene fossils weathering out from sediments exposed for a distance of about one hundred kilometers south of the Ethiopian border.

In 1968 the Kenyan contingent withdrew from the IORE to prospect the northeast shore of Lake Rudolf, but the French and American parties continued to work in the lower Omo Valley through the 1974 season. Many noted paleontologists, including Basil Cooke, Dick Hooijer, and Alan Gentry, visited the Omo camps to view fossils firsthand. The result was an immense collection of fossil vertebrates (the American computerized database alone contains over twenty-two thousand fossils) that documents evolutionary and paleoenvironmental change in the region between 1 and 3.4 million years ago. Monographic treatment of material from the Omo Shungura sequence was published in the "Cahiers de paléontologie" series edited by Yves Coppens and F. Clark Howell (e.g., Eisenmann 1985; Gentry 1985; Eck and Jablonski 1987). More recently, these collections have

been reexamined for evidence of environmental change and patterns of abundance and diversity (Bobe 1996, 1997; Bobe and Behrensmeyer 1999; Bobe, Behrensmeyer, and Chapman 2002).

The National Museums of Kenya mounted an exploratory expedition to the east side of the lake in 1968 to determine the general distribution and potential of the fossiliferous sediments that had been observed from the air and spot-checked by helicopter the previous year (M. G. Leakey and R. E. Leakey 1978). The initial East Rudolf Expedition consisted of Richard and Margaret Leakey, Paul Abell of the University of Rhode Island (who had previously worked with the Leakeys in the Baringo Basin and at the Omo), graduate students Bernard Wood and John Harris, *National Geographic* photographer Bob Campbell, and Kamoya Kimeu, who headed the crew of Kenyan field assistants that were eventually to achieve notoriety as "the Hominid Gang" (Willis 1989). Much of the one thousand square kilometers that constituted the "East Rudolf" site was reconnoitered during the initial season and the sediments were found to be remarkably rich in fossils over a large part of the area. Only a few fossils were collected in the initial season, but these included four fragmentary hominid specimens (two edentulous mandibles, an edentulous maxilla, and a cranial fragment). The recovery of hominids and the obvious potential for further important discoveries generated sufficient interest and support to warrant returning to the area the following year.

The base camp at the Koobi Fora sand spit was established in 1969 (fig. 2). Koobi Fora is more or less at the center of the region; its sandy beach provided a safe mooring for the expedition boat and a convenient landing strip for light aircraft. New participants in 1969 included Kay Behrensmeyer, who joined the expedition as its geologist, and Meave Leakey. The exposures along the Koobi Fora ridge were prospected in detail and Oldowan-type artifacts were recovered in situ from a volcanic ash that was subsequently named the Kay Behrensmeyer's Site (KBS) Tuff (M. D. Leakey 1970). Samples of the tuff that were sent to F. M. Consultants for dating yielded an age of 2.6 Ma (Fitch and Miller 1970). Fieldwork in the Ileret region resulted in the first two hominin crania from the area, both representing the hyper-robust *Paranthropus boisei* (KNM-ER 406 [fig. 3a], 407). Glynn Isaac from the University of California, Berkeley, visited the locality toward the end of the season and agreed to become coleader of the East Rudolf Expedition with responsibility for archaeological research.

The expedition personnel were augmented further in 1970 when Carl Vondra of Iowa State University and his graduate students Gary Johnson and Bruce Bowen took over the mapping and much of the geological

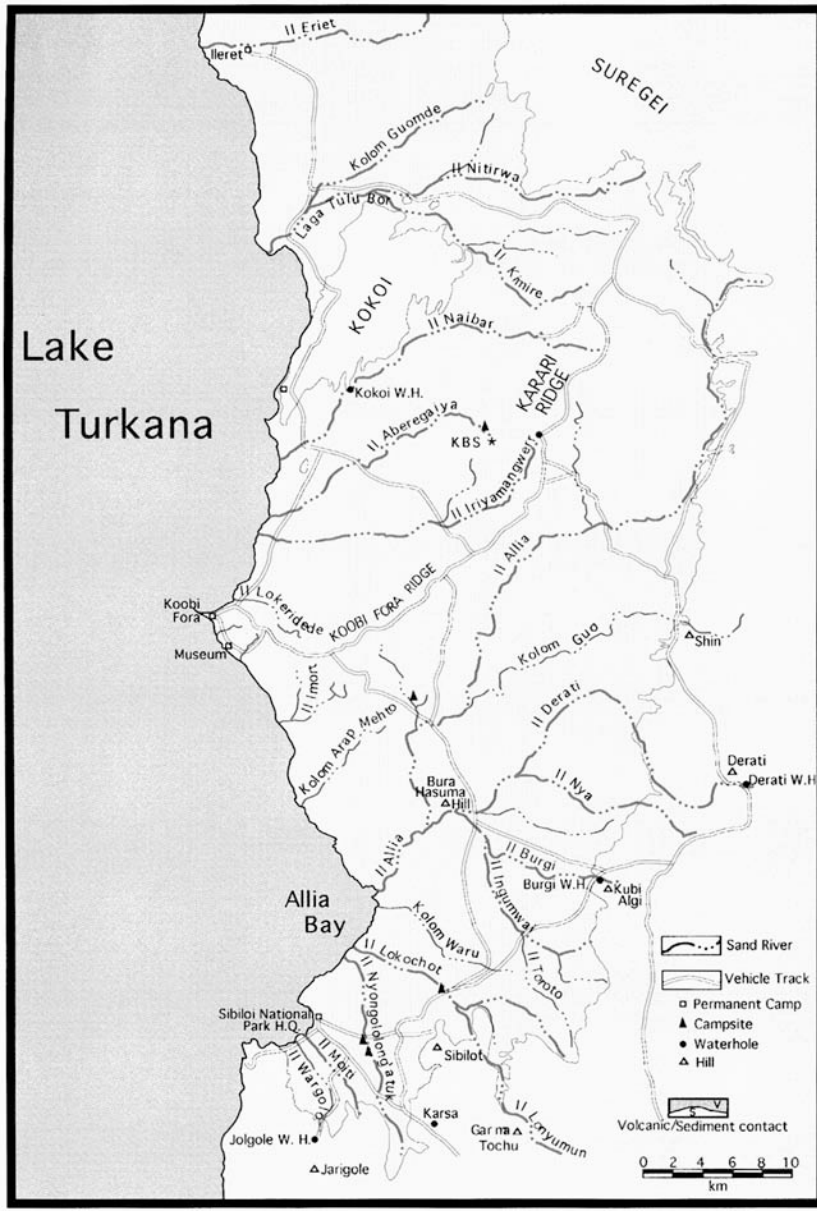

Figure 2. Map of the Koobi Fora region.

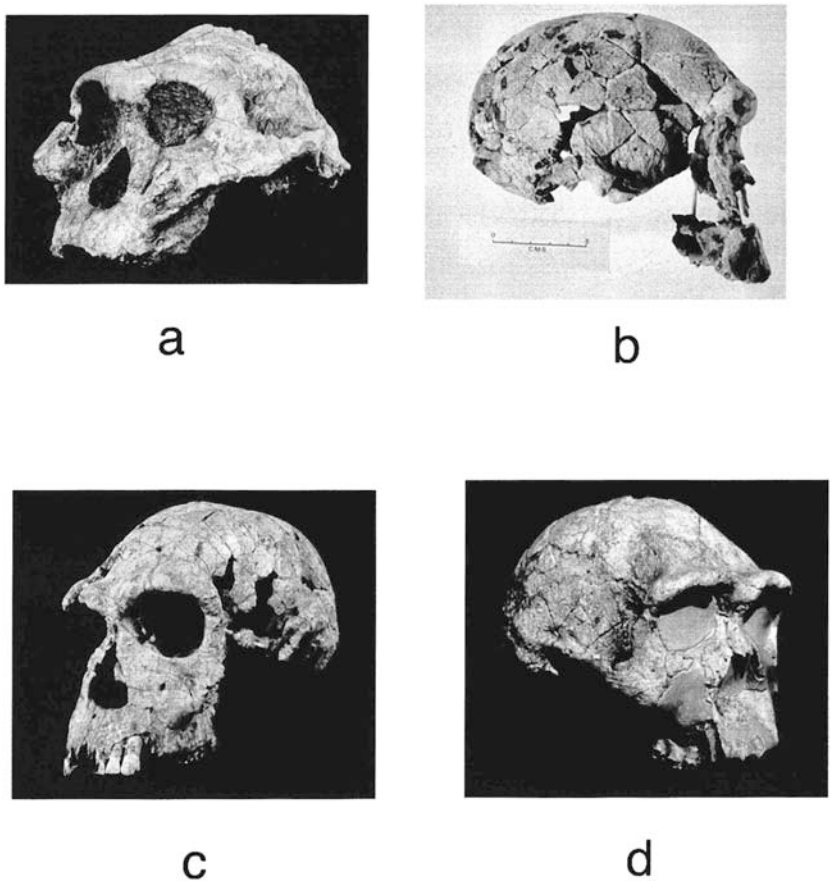

Figure 3. Important hominid crania discovered by the Koobi Fora Research Project. Images copyright the National Museums of Kenya. (a) KNM-ER 406, *Australopithecus boisei* from the Ileret region, discovered by Richard and Meave Leakey in 1969. (b) KNM-ER 1470, *Homo rudolfensis* from the Karari Ridge, discovered by Bernard Ngeneo in 1972. (c) KNM-ER 1805, *Homo habilis* from the Bura Hasuma region, discovered by Kamoya Kimeu in 1973. (d) KNM-ER 3733, *Homo ergaster* from the Koobi Fora Ridge, discovered by Bernard Ngeneo in 1975.

investigation, enabling Kay Behrensmeyer to concentrate on taphonomic and microstratigraphic studies. Vince Maglio (1971) joined the expedition and instituted a rigorous system of relating the fossil discoveries to aerial photographs—a practice that was continued and augmented in subsequent seasons. Glynn Isaac and his students began the excavation of the KBS site

and discovered rich artifact-bearing localities associated with the Okote Tuff along the Karari escarpment. Frank Fitch (Birkbeck College, London) and Jack Miller (University of Cambridge) amassed additional material for dating and sixteen more hominin specimens were collected, including the first postcranial specimens. At the end of the 1970 season, stereo-pair aerial photographic coverage of the entire region at the scale of 1:23,000 was obtained from Hunting Surveys Ltd.

By the end of the 1970 season, the East Rudolf Research Project had become established with Richard Leakey and Glynn Isaac as coleaders responsible, respectively, for the paleontological and archaeological investigations but sharing the administrative burden. Aspects of the geological studies were divided between Carl Vondra, whose students undertook much of the basic mapping of the area, and Frank Fitch, who was responsible for the dating studies. Systematic study of the fossil vertebrates was offered to Vince Maglio (elephants), John Harris (antelopes), Shirley Savage (hippos), Basil Cooke (pigs), and Meave Leakey (carnivores and nonhominid primates). Michael Day, Joe Mungai, Alan Walker, and Bernard Wood were invited to join Richard Leakey in the study of the human remains. Preliminary studies of the fossil pigs and elephants suggested that the KBS Tuff might not be as old as the date obtained by Fitch and Miller (Cooke and Maglio 1972).

The interval from 1971 to 1973 saw continuation of the established field programs. The mandible KNM-ER 992, which was to become the type specimen of *Homo ergaster* (Groves and Mazak 1975), was discovered in 1971. (The catalog acronym KNM-ER stands for Kenya National Museum–East Rudolf.) John Harris took over the supervision of the paleontological collecting from Vince Maglio at the end of the 1971 season. In 1972, Vondra's student Thure Cerling (1976) investigated the oxygen isotopes of the tuffs, while Fitch's student Ian Findlater (1976) joined the project to map out marker horizons across the basin. Glynn Isaac, assisted by his wife, Barbara (a museum conservator), and accompanied by students John Barthelme, Jack (J. W. K.) Harris, Dina Crader, Dan Stiles, and John Onyango-Abuje, completed excavations at the KBS Site (FxJj1) and the Hippo and Artifact site (FxJj3) and documented an abundant archaeological record along the Karari Escarpment. KNM-ER 1470, at one time attributed to *Homo habilis* but now considered to represent the separate species *H. rudolfensis* (fig. 3b), was discovered in 1972 (R. E. Leakey, M. G. Leakey, and Behrensmeyer 1978).

In 1973, the government of Kenya created the Sibiloi National Park, effectively closing the area between Allia Bay and Ileret to domestic livestock. That year the emphasis of archaeological fieldwork shifted from the

Koobi Fora Ridge to the Karari Escarpment, where Jack Harris and Ingrid Herbich worked on a diverse range of sites, while John Barthelme and Mike Mehlman excavated at Ileret. Also in 1973, Peter Williamson, a student from the University of Bristol, initiated the collection and study of the fossil invertebrates. Two small enigmatic hominin crania, KNM-ER 1805 (with a sagittal crest) and KNM-ER 1813 (fig. 3c), were discovered in 1973.

In the late summer of 1973 a Wenner-Gren symposium titled "Earliest Man and Environments in the Lake Rudolf Basin" (Coppens et al. 1976) was convened in Nairobi as a forum for comparing results of field and research work at Koobi Fora, in the lower Omo Valley, and also at Lothagam and Kanapoi—sites that had been discovered by Bryan Patterson and were being investigated by his students after his death. The interchange of information was very productive, but it became clear that the 2.6 Ma date attributed to the KBS Tuff was controversial. If the date was accurate, stone artifacts from the KBS Tuff were the oldest known to science and the hominid fossils from below that tuff included the oldest representatives of the genus *Homo*. However, the fauna from the Omo sequence, and particularly the pigs, suggested that the fossils associated with the "2.6-million-year-old artifacts" from Koobi Fora occurred instead at somewhat younger horizons in the Omo succession. This controversy stimulated much discussion at the symposium and during the ensuing two years. After the end of the symposium Michel Beden of the Université de Poitiers was invited to describe the Koobi Fora elephantids and Vera Eisenmann, of the Institut de Paléontologie, the Koobi Fora horses.

The problems of isotopic dating continued to be widely debated during the next two years. Ron Watkins incorporated a search for the sources of the tephra in his study of the volcanics of the Suregei Plateau, to the northeast of the lake margin (Fitch et al. 1985; Watkins 1983). Andrew Brock from the University of Nairobi initiated paleomagnetic studies in 1974 in conjunction with his graduate student Joab Ndombi and Glynn Isaac. Jack Hillhouse contributed to later stages of this project under the supervision of Alan Cox of Stanford University. Also in 1974, Craig Black led a team from the Carnegie Museum to prospect for microvertebrate remains, and Tim White, then a graduate student from the University of Michigan, joined John Harris, Kamoya Kimeu, and the "Hominid Gang" in the paleontological survey. Thure Cerling returned to investigate the paleochemistry of Lake Turkana and the diagenesis of its sediments as a dissertation project. At the end of the 1974 season a moratorium was declared on further archaeological fieldwork until the results of the previous five field seasons could be fully investigated.

In February 1975, a three-day symposium was convened by the Geo-

logical Society of London to explore the geologic background to fossil man in the Gregory Rift Valley. A variety of topics pertinent to the Koobi Fora region were discussed, including the early history of the Turkana depression (Savage and Williamson 1978), aspects of the stratigraphy (Vondra and Bowen 1978; Findlater 1978; Behrensmeyer 1978), and aspects of early hominid behavior (G. L. Isaac 1978; J. W. K. Harris and Herbich 1978). However, the controversy over the age of the KBS Tuff continued (Shuey et al. 1978; Fitch, Hooker, and Miller 1978; Curtis et al. 1978; Brown, Howell, and Eck 1978).

In 1975 the government of Kenya decreed that Lake Rudolf would henceforth be called Lake Turkana. As a result, the East Rudolf Research Project was renamed the Koobi Fora Research Project (KFRP). KNM-ER 3733, the first complete cranium of *Homo ergaster* (fig. 3d) was collected in 1975 as vertebrate, microvertebrate, and invertebrate fossil prospecting continued in the hope that biostratigraphic correlation could resolve the controversy over the age of the KBS Tuff. Noncontiguous fossiliferous areas had been correlated on the sequence of exposed tuffs, but based on their interpretation of the large sample of fossil suids collected in 1974 and 1975, John Harris and Tim White were able to identify several instances in which tuffs had been miscorrelated. This led to the adoption of a temporary and cumbersome "tuff-numbering scheme" (J. M. Harris 1978; J. M. Harris, ed. 1983; J. M. Harris and White 1979) until the tuff correlation issue could be resolved. Further geochemical analysis by Thure Cerling et al. (1979) and dating of the KBS Tuff by Ian McDougall et al. (1980) at 1.89 ± 0.01 Ma was supported by dating results of Bob Drake et al. (1980) and Andy Gleadow (1980), and led Dick Hay (1980) to pronounce that the controversy over the age of the KBS Tuff was ended.

Archaeological work continued in the Koobi Fora region from 1977 until 1979 under Glynn Isaac's leadership and introduced new students to the area. Thesis work included artifact replication by Nicholas Toth, studies of site formation processes by Kathy Schick, analysis of faunal elements, bone breakage, and cut marks by Henry Bunn, refitting and spatial distribution of artifacts by Ellen Kroll, and assessment of plant food resources by Jeanne Sept. Annie Vincens (a student of Raymonde Bonnefille of the Centre National de la Recherche Scientifique in Marseille) focused on underground storage organs such as tubers. Over this period a number of archaeologists, many of whom would later rise to prominence, visited the sites. Among these individuals were Rick Potts, John Speth, Francis Masonda, Peter Jones, Yusuf Juwayeyi, and Wilfrid Shawcross.

In 1979, Frank Brown of the University of Utah was invited to study the tuffs from the Koobi Fora region. Geochemical correlations by Brown

and Cerling (1982), Cerling and Brown (1982), and Brown and Feibel (1985, 1986, 1991) resulted in a consistent stratigraphic framework throughout the northern half of the basin.

Beginning in 1981, National Museums of Kenya expeditions under the leadership of Richard Leakey temporarily abandoned Koobi Fora to explore sedimentary exposures on the west side of Lake Turkana (J. M. Harris and Brown 1985; Harris et al. 1988; Harris, Brown, and Leakey 1988). Small but significant Plio-Pleistocene vertebrate assemblages included the first cranium of *Paranthropus aethiopicus* (Walker et al. 1986) and a relatively complete skeleton of *Homo ergaster* (Brown et al. 1985; Walker and R. E. Leakey 1993). Early Miocene exposures toward the south end of the lake yielded two new species of ape (R. E. Leakey and M. G. Leakey 1986a, 1986b). *Kamoyapithecus hamiltonii*, the genus named after Hominid Gang leader Kamoya Kimeu, was recovered from the late Oligocene site of Lothidok (M. G. Leakey, Ungar, and Walker 1995).

In the early 1980s, Kay Behrensmeyer and Leo Laporte (University of California, Santa Cruz) undertook lateral facies analysis of the Koobi Fora formation (Behrensmeyer and Laporte 1982) and in so doing discovered hominid footprints (Behrensmeyer and Laporte 1981). Some archaeological projects continued on the east side of the lake, including Zefe Kaufulu's (1983, 1987) study of the sedimentary context of the Okote member sites, Kathy Schick's (1986) experimental study of site formation processes, Jeanne Sept's (1986, 1994) research on the vegetation of the early site locales, and Nicky Stern's (1991, 1993, 1995, 2002) studies of early hominid land-use patterns in the Turkana Basin. Beginning in 1985, the Koobi Fora camp was also used as the field headquarters of the Koobi Fora Field School, originally organized by Harry Merrick and Richard Leakey as a joint National Museums of Kenya and Harvard University Summer School field program. This association changed to Rutgers University in 1997. Sadly, Glynn Isaac died in 1985.

During the 1990s, National Museums of Kenya expeditions, now under the leadership of Meave Leakey, concentrated on the southwest portion of the Lake Turkana basin, discovering new localities (Ward et al. 1999) as well as revisiting Lothagam and Kanapoi. They were joined by geologist Craig Feibel, who had worked at Koobi Fora since 1980. Lothagam was reworked from 1989 to 1993, and monographic treatment of the biota has now been published (M. G. Leakey and J. M. Harris 2003). The Kanapoi locality was reprospected from 1994 to 1997 (M. G. Leakey et al. 1995, 1998). Hominin material recovered by the National Museums of Kenya expeditions has been described in detail (Ward, Leakey, and Walker 2001); other recently recovered vertebrate species and their geologic setting now

also have been documented (J. M. Harris and M. G. Leakey 2003). Small expeditions to the northeast corner of the basin yielded further Miocene fossils on the northern edge of Suregei Plateau (Fleagle et al. 1997, 2000) and Pleistocene hominids across the border in Ethiopia (Fleagle et al. 1991).

Since completion of the work at Kanapoi, National Museums of Kenya expeditions under the leadership of Meave and Louise Leakey have reprospected the Plio-Pleistocene horizons of the Nachukui Formation, discovering some exciting new material (Jablonski et al. 2002), including the new hominin *Kenyanthropus platyops* (M. G. Leakey et al. 2001). Most recently, the National Museums team has returned to the east side of the lake to concentrate on the exposures at Ileret, where Patrick Gathogo (2003), a graduate student from the University of Utah, concomitantly mapped the geology. Subsequently, the geologic work has been extended to the border with Ethiopia. Fieldwork is expected to continue for some years.

Koobi Fora's Scientific Contributions

The results of the multidisciplinary research fostered by the KFRP have been widely disseminated in the literature and summarized in a series of scientific monographs published by Clarendon Press (M. G. Leakey and R. E. Leakey, eds. 1978; J. M. Harris, ed. 1983, 1991; Wood 1994; G. L. Isaac and B. Isaac, eds. 1997).

Work by Behrensmeyer (1975a, 1975b) and by Carl Vondra's students from Iowa State University documented the disposition of Pliocene and Pleistocene fluviatile and lacustrine sediments in the northeastern part of the Lake Turkana basin that are now attributed to the Koobi Fora Formation (Acuff 1976; Bowen 1974; Burggraf 1976; Burggraf et al. 1981; Feibel 1983, 1988; Johnson and Raynolds 1976; Tindall 1985; White 1976; White et al. 1981). Bob Raynolds (1973) and Bernhart Owen and Robin Renaut (1986) documented and defined the Galana Boi Formation. Lynne Frostick and Ian Reid (1982, 1983) investigated subaerial sediment transport. Geochemical studies of the tuffs by Frank Brown, Thure Cerling, and Bereket Haileab have permitted the correlation with the Shungura and Usno Formations north of the lake and with the Nachukui Formation on the eastern part of the lake (Brown 1982; Brown and Cerling 1982; Brown and Feibel 1985, 1986; Cerling et al. 1975). Brown has extended the southern extent of the Koobi Fora Formation nearly to the southern end of the lake. Ron Watkins mapped Miocene and earlier volcanics of Suregei Plateau, which lies to the east of the Koobi Fora region, and in so doing discovered early Miocene fossiliferous localities (J. M. Harris and Watkins 1974; R. E. F. Leakey and Walker 1985; McDougall and Watkins 1985). Bob Savage and

Peter Williamson (1978) documented early Miocene localities of the Kajong Formation, northeast of Loiyengalani. The Kajong Formation overlies the sedimentary sequence of the Sera Iltomia Formation, from which fossils have yet to be recovered but which may be as old as the dinosaur-bearing Turkana Grits on the west side of the lake.

Studies of volcanic ash geochemistry allowed correlation of the sequence of strata in the Turkana Basin with a similar sequence of strata in Awash Valley at Hadar (Brown 1982; Haileab and Brown 1992, 1994). This permitted the first reasonable estimates of the age of Lucy and associated fossils of *A. afarensis* at that site, and it showed that fossils of that taxon were among the youngest representatives of that lineage. Much older examples derive from Laetoli in Tanzania (M. D. Leakey and J. M. Harris 1987). Also, correlations of ashes to deep-sea cores in the Gulf of Aden, and later to the Arabian Sea, provide direct links between the record of paleoclimate in marine settings and the hominid sites on land (Sarna-Wojcicki et al. 1985; Brown et al. 1992; DeMenocal and Brown 1999). Yet again, the precise ages measured by Ian McDougall (McDougall 1981, 1985; McDougall et al. 1985) and the magnetostratigraphic work of Jack Hillhouse (Hillhouse 1977; Hillhouse, Cerling, and Brown 1986) allowed recalibration of the Geomagnetic Polarity Time Scale, with very broad implications (McDougall et al. 1992). Additional magnetostratigraphic work at Koobi Fora was undertaken by Robert Kamau.

The archaeological team led by Glynn Isaac documented two new early stone industries from the Koobi Fora region—the KBS industry, and the Karari industry (J. W. K. Harris and G. L. Isaac 1976; J. W. K. Harris 1978). They also used Koobi Fora as a sounding board from which to explore aspects of early Pleistocene hominid behavior (see contributions in Isaac and Isaac 1997; and Rogers, Harris, and Feibel 1994). The preponderance of effort was expended on the early Pleistocene portion of the section, but aspects of the late Pleistocene record were also explored (J. Barthelme 1977; J. W. Barthelme 1981, 1985; Owen et al. 1982) as were those of modern occupation sites (Gifford and Behrensmeyer 1977; Gifford-Gonzalez 1984; Gifford-Gonzalez, Stewart, and Rybczynski 1999). Although not widely recognized, archaeological excavations by Harry Merrick and Jean Chavaillon in the Shungura Formation provided the oldest evidence then available that hominids manufactured tools (Chavaillon 1970; H. V. Merrick and J. P. S. Merrick 1976; H. V. Merrick et al. 1973). This was added to by Mzalendo Kibunjia and Hélène Roche with their excavations at Lokalalei (Kibunjia 1990, 1994, 1998; Kibunjia et al. 1992; Roche and Kibunjia 1994, Roche et al. 1999). Though Paleolithic archaeology had long been investigated in East Africa, the work at Koobi Fora represented some of the

first intensive systematic studies of a group of sites, study of site formation, bone damage, analysis of artifact distribution, and replication of African types of artifacts.

Whereas most of the paleontological investigations have concentrated on the larger terrestrial vertebrates, nonvertebrates have received some attention. Gary Johnson (1974) and Paul Abell (1982; Abell et al. 1982) described the stromatolites. Palynological studies were undertaken by Raymonde Bonnefille and Annie Vincens (Bonnefille 1976, 1979, 1995; Bonnefille and Vincens 1977; Vincens 1979, 1982, 1984, 1987). Andrew Cohen discussed the significance of fossil root casts (Cohen 1979a) and changes in the benthic invertebrate communities of Lake Turkana (Cohen 1979b, 1980, 1981). Peter Williamson (1978, 1981, 1982a, 1982b) documented important evolutionary implications of the fossil mollusks from Koobi Fora.

The paleoecological implications of the Plio-Pleistocene fish were described in Hilde Schwartz's (1983) PhD dissertation, and Craig Feibel (1994) reported freshwater stingrays as well as fish nests that had been identified by Lokwawi Lokademu, a Dhasaanac worker (Feibel 1987). Craig Black and Leonard Krishtalka (1986) documented rodents, bats, and insectivores.

Foremost among the fossil vertebrate remains from Koobi Fora is the astounding array of more than two hundred early hominin specimens representing at least five species. The announcement of these discoveries was chronicled in a series of collaborative essays by Richard Leakey, Joe Mungai, Alan Walker, and Bernard Wood. The wealth of material garnered through the skills of the fossil-collecting team from the National Museums of Kenya has documented the diversity of African hominids during the Plio-Pleistocene. Dental and postcranial remains of the earliest australopithecine, *Australopithecus anamensis*, have been recovered from the Allia Bay region (Coffing et al. 1994; Ward et al. 2001), while the cranial remains of *Paranthropus boisei*, *Homo habilis*, *Homo rudolfensis*, and *Homo ergaster* have been reported in monographic detail by Bernard Wood (1994). Holocene representatives of *Homo sapiens* have been described by Emma Mbua (2001) and Gunter Bräuer (Bräuer, R. E. Leakey, and Mbua 1992; Bräuer et al. 1997).

Many of the ungulates have now been described in monographic detail, including the proboscideans (Beden 1983; J. M. Harris 1983a), horses (Eisenmann 1983), rhinos (J. M. Harris 1983b), hippos (J. M. Harris 1991d), pigs (J. M. Harris 1983c), camels (J. M. Harris 1991b), giraffes (J. M. Harris 1991c), and antelopes (J. M. Harris 1991a). Evolutionary changes in the elephant and pig lineages have proved useful for both intra- and extrabasinal correlation (Cooke and Maglio 1972; Maglio 1972, 1973; White and J. M.

Harris 1977; J. M. Harris and White 1979) and the distribution of antelope species has proved useful for identifying the Plio-Pleistocene habitats that the hominids exploited (e.g., Shipman and J. M. Harris 1988; Bobe and Eck 2001; and Bobe and Behrensmeyer 1999). Isotopic studies of the fossil and extant vertebrates from the Lake Turkana basin have provided much information about dietary adaptations and paleoenvironmental change during the past seven million years (Cerling and J. M. Harris 1999; Cerling, J. M. Harris, and M. G. Leakey 1991, 2003; Cerling et al. 2003; J. M. Harris and Cerling 2003). Based largely on multidisciplinary studies in the Koobi Fora region, Craig Feibel, John Harris, and Frank Brown (1991) provided a detailed appraisal of the paleoenvironmental context for the Late Neogene strata of the Turkana Basin.

Gerald Eck and Frank Brown created the first computerized faunal catalog of the Omo fauna, which was at the time a real innovation. It presaged a new method of record keeping for paleontological and anthropological specimens. This has been used as a basis for examining faunal and environmental change in the late Pliocene (Bobe 1996, 1997; Bobe and Behrensmeyer 1999; Bobe and Eck 2001) and has been expanded to incorporate the faunal inventory from Koobi Fora, West Turkana, Lothagam, and Kanapoi by paleontologists from the Smithsonian Institution.

Modern ecological studies in the basin were begun by Claudia J. Carr (1975, 1976, 1977, 1998), at the invitation of F. Clark Howell. These were amplified by Raymonde Bonnefille, who collected the modern pollen rain. The pollen trap that she used successfully for so many years now serves as a perch for ravens on a small rise south of the main *banda* (hut) at Koobi Fora.

Work by geophysicists exploring for oil in the basin has yielded a superb set of seismic profiles that illuminate the structure of the region underlying Lake Turkana, and also broad areas west of the lake (Morley et al. 1992, 1999). These structures are of considerable significance to deposition within the basin (Haileab et al. 2004) and to the fossil record that it contains.

Summary

Multinational interdisciplinary fieldwork and research in the Koobi Fora region has contributed much to our current understanding of the timing and context of human origins. A superb suite of hominin specimens, accompanied by a diverse array of vertebrate fossils, testifies to the skill and diligence of the National Museums of Kenya's hominid hunters. However, it is the extended family of geologists, archaeologists, and paleontologists

associated with the KFRP who have explored the ramifications and documented the far-reaching significance of these materials and events. Equally significant, though more recent, has been the emergence of internationally known Kenyan archaeologists, paleontologists, and geologists through training opportunities in Turkana Basin projects.

Expansion of the scope of the KFRP to other Kenyan portions of the basin and collaboration with the IORE and subsequent allied projects in the lower Omo Valley have resulted in the Turkana Basin's becoming the continental keystone for interpreting the tempo and mode of early human evolution. The outstanding success of this endeavor owes much to the stimulating leadership of Richard Leakey, Clark Howell, Glynn Isaac, and Yves Coppens, all of whom, albeit in very different styles, have encouraged a generation of scholars to compete and collaborate in multifaceted approaches in order to explore innovative techniques for generating new answers to old questions and formulating new questions about our origins.

Note

Each person mentioned in this article has contributed to research at Koobi Fora in a significant manner, but five deserve special mention. Richard Leakey was the first to discover fossils on the east side of Lake Turkana. For two decades in his capacity of director of the National Museums of Kenya, he generated funding and recruited researchers to support investigation of all aspects of prehistory in the Kenyan portion of the Lake Turkana basin while at the same time expediting the professional training of Kenyan prehistorians and prompting legislation to protect the national prehistoric resources for posterity. Louis and Mary Leakey were only peripherally involved in investigations in the Lake Turkana basin but shared their expertise with, and provided inspiration and encouragement to, many of the people that worked there. F. Clark Howell organized the American contingent of the International Omo Research Expedition as a multidisciplinary project that was a model for comparable projects throughout the world. Kamoya Kimeu, leader of the "Hominid Gang" and participant in the Koobi Fora, West Turkana, Lothagam, and Kanapoi projects, was a leader in the discovery of early humans from the Lake Turkana basin. Fieldwork in the Lake Turkana basin would have been more difficult and much less productive without the assistance of all the Kenyan field staff who organized the camps, undertook the excavations, and prospected for and prepared the fossils. The authors are also grateful to Harry V. Merrick II, Kathy Schick, Chris Shaw, and Nick Toth, who assisted with the compilation of this article.

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