Chapter 21:

Fauna and Paleoenvironments of the Homa Peninsula, Western Kenya

Laura C. Bishop, Thomas W. Plummer, David R. Braun, Peter W. Ditchfield,
Emily Goble Early, Fritz Hertel, Cristina Lemorini,
James S. Oliver, Rick Potts, Thomas Vincent, Elizabeth Whitfield and Rahab N. Kinyanjui

Abstract

This chapter examines the fauna and environments of numerous fossil and archeological occurrences on the Homa Peninsula, in Kenya. Fieldwork on the peninsula has been ongoing for over a century, and there are numerous localities that have produced important mammalian type fossils and evidence of hominin activity. Past work has focussed particularly on the older, Late Miocene and Early Pliocene sediments of the Kanam and Homa Formations, which have yielded an extensive macromammalian fauna and a controversial hominin, the Kanam mandible. More recently, our team has uncovered abundant evidence of hominin behaviour in the early Pleistocene, showing that hominins were active in open grassland habitats, and exploited small and medium-sized gazelles, frequently juvenile, with a mixed hunting and scavenging strategy. Research into artefactual raw material procurement and use demonstrates that hominins were capable of complex behaviours to maximise the usefulness of high quality raw materials with provenances indicating relatively long transport distances. Recent work on use-wear also shows the diversity of activities for which hominins used their stone artifacts. There is evidence for hominin exploitation of the peninsula for a long time interval, both by virtue of hominin fossils themselves and by the common presence of hominin trace fossils in the form of manufactured stone tools. Because of this, the Homa Peninsula offers us the ability to examine the environments of hominin evolution over a considerable time frame, within a relatively constrained geographical region.

Background

The Homa Peninsula has been known to science since 1911, and fossil specimens from the area comprise many type specimens for common African mammalian paleospecies. Here we discuss the fauna and the paleoenvironmental information from the Homa Peninsula. The Homa Peninsula is a 200 km^2 area in Homa Bay County, situated on the southern margin of the Winam Gulf of Lake

Victoria in Kenya (Figure 1). Lake Victoria is estimated to be the third largest lake in the world, with a surface area of 68,900 km^2 and a maximum length of approximately 616 km. Although its catchment is extensive, it is shallow with a maximum depth of 84 m, it is relatively shallow compare to any other lake of similar size. Lake Victoria is located in a depression formed by the western and eastern branches of the East African Rift System (EARS), and is at an average elevation of 1135 m ASL (DAHITI, 2017).

The easternmost extension of Lake Victoria is the Winam (formerly Kavirondo) Gulf, into which the peninsula juts. The Gulf is approximately 25 km wide and extends for 64 km from Rusinga Island in the west to Kisumu and Sondu in the East. The Winam Gulf is formed in the western half of the Nyanza Rift, a depression extending from the Kenya Dome, on which the eastern branch of EARS, the Gregory Rift, is also centred. There are extensive Neogene deposits in this valley, with Miocene sediments cropping out around their source volcanoes and more recent sediments accumulating on the floor of the valley. Numerous sources of evidence point to a relatively recent origin for the modern Lake Victoria (approximately 200 Kya [Meyer et al., 1990] although there is evidence for more recent drying events [e.g., Verheyen et al., 2003].) Many of the fossiliferous sediments of the Homa Peninsula have more ancient origins, with lacustrine deposits up to 225 m above current lake level (Plummer, 1992).

The landscape of the peninsula is dominated by Homa Mountain (Latitude 0.38°S, Longitude 34.5°E, elevation 1751 m), a carbonatite volcano complex that was active from the Late Miocene to the Pleistocene (Le Bas, 1977). Volcanic activity in the region began approximately 13 Ma, with doming of the mountain commencing approximately 11-10 million years ago (Ma) and continuing until 5 Ma (Le Bas, 1977). Later volcanic activity persisted, centring on peripheral vents and continues today at active geothermal hot springs at Kanjera and Kanam. The peninsula has a varied topography, and the exposures to the north of Homa Mountain vary in relief from several metres to cliffs of 20 m and higher. The published fossiliferous exposures occur in a series of gullies radiating towards the lake from Homa Mountain in the south, shaped by modern river activity. These are Rawi, Kanam West, Kanam Central, Kanam East, and Kanjera, named from west to east. The Kokoth exposures are oriented as an east-west cliff of sediments located between the Kanam East and Kanjera gully systems. Homa Peninsula sedimentary stratigraphy from the Late Miocene to the Pleistocene preserves a range of depositional environments formed under varied fluvial-lacustrine and subaerial regimes, with many sediments and clasts sourced from the eruption products of Homa Mountain and underlying basement rock. Recent exploration of the western and southwestern flanks of Homa Mountain has discovered new fossil and artefact-bearing deposits that are currently under investigation, and beyond the scope of this chapter.

Geology of the Homa Peninsula

Sedimentary strata preserved in the region north of Homa Mountain have been defined as the Kanam, Homa, Rawi, Abundu, Kasibos, and Kanjera Formations (Ditchfield et al., 1999). The Apoko Formation (Fm) was defined by Pickford (1984) as a series of paleosols and fluviatile sediments sitting unconformably above the other deposits. The Apoko Fm is time transgressive, incorporating sediments that vary in age from the late Middle Pleistocene to the Late Pleistocene or even Holocene. The fossiliferous Kanam Fm (Kent, 1942; refined by Pickford 1984, 1987) forms the base of the sequence with outcrops best exposed in the Kanam West, Kanam Central, and Kanam East gullies. The Kanam Fm is comprised of six beds of alternating clay/silt and tuffaceous deposits, as summarized by Pickford (1984, 1987), and named (from oldest to youngest) beds K1 to K6. The Homa Fm lies unconformably on the Kanam Fm, with this relationship observable in the Kanam West gully system; geological trenches on the eastern side of the Kanam East gully (~20 m south of the main road that cuts across the gully) also show the unconformable superposition of Homa on Kanam Fm. The Homa Fm is best exposed and most fossiliferous in the Kanam West inland gullies, where the relationships among the sedimentary beds are complicated due to ancient infilling of complex paleoerosion surfaces, probable falls and displacements of former sedimentary cliffs, and also deformed by faulting and subsidence related to the later eruptive stages of the Homa Mounting volcanic complex. Pickford (1984, 1987) defined the Homa Agglomerate [now considered to be part of the Homa Fm] which unconformably overlies the Kanam Fm and is exposed in all three of the Kanam gullies.

The Kanam and Homa Formations are unconformably overlain by the Rawi Fm, which is equivalent to Kent's (1942) Rawe Beds and Pickford's (1984, 1987) Rawi Member. Outcrops of the Rawi Fm are exposed in the Rawi Gulley, where its lower member has a relatively planar, weakly erosive contact overlying the Homa Fm, and in Kanam Central gully, where the formations are separated by a pronounced angular unconformity (Ditchfield et al., 1999). The sediments of the lower member of the Rawi Fm, show a fining upwards sequence from pebble- to granule-grade matrix-supported conglomerates to a fine-to medium-grained micaceous sandstone, suggesting that it was formed by a fluvial system, which might have been intermittently active with only seasonal flow (for detailed sedimentological descriptions, see Ditchfield et al 1999). The upper member of the Rawi Fm, which is exposed in the 'Fish Cliffs' in the Rawi Gully and Kanam Central (Kent, 1942) consists of very fine sand and silt that occur in centimetre thick couplets with laterally continuous horizontal laminations 1-2 mm thick. These couplets are interbedded with thin, tabular, fine- to medium-grade sandstones which, along with the commonly preserved fish remains and evaporate crystal pseudomorphs, suggest a rapidly forming, shallow lake environment that periodically dried, causing mass mortality of fish and evaporate formation (Ditchfield et al., 1999).

The Abundu Fm crops out in the Kanam East and Kanam Central Gullies. It has two members which directly overly the Homa Fm and interdigitate with coarse-grained biotite-rich debris from a small volcanic vent in the southern part of the Kanam East gully. The lower member is characterised by a 3-7 m thick moderately well-sorted and well cemented medium-coarse grained yellow to orange sandstone, in planar beds of between 10-60 cm thickness, with occasional outsized clasts (Ditchfield et al., 1999). Their depositional environment is uncertain because they are poorly exposed and, where visible, lack sufficient internal structure for this to be determined. The upper member of the Abundu Fm is up to 25 m thick and consists of interbedded poorly sorted conglomerates that vary in clast size from pebble to boulder. The pebbly conglomerates are clast-supported and the conglomerates with larger clast sizes are matrix supported. The regional geology makes it difficult to determine the precise stratigraphic position of the Abundu Fm, and it is possible that its lower member is a lateral equivalent of the lower Rawi Fm.

The Kasibos Fm is only exposed in the Kanam East gully, where it unconformably overlies the Abundu Fm and oversteps the more ancient Kanam Fm (Ditchfield et al., 1999). Its thickness of up to 7 m is comprised of fine-grained poorly consolidated red clays and siltstones, interbedded with 10 – 20 cm thick pebble-grade conglomerate horizons, which are occasionally cemented with coarse-grained carbonate cement. Few sedimentary structures have been observed in the Kasibos Fm, but one location in Kanam East, Felid Hill, preserves large-scale cross-bedding defined by thin pebble layers in an otherwise clay-dominated sequence. This may represent lateral accretion surfaces on point-bars within a moderately-sized fluvial system. Elsewhere in Kanam East gully (Equid Tooth Site) the red clay facies dominates, and may represent floodplain or overbank deposits of the fluvial system. The volcanic vent that interfingers with the Abundu Fm and exhibits dips of up to 25°, is overlain by Kasibos Fm strata having horizontal bedding, suggesting this as the temporal limit to the activity of this volcanic vent and its effect on the local topography.

The Kanjera Fm is exposed at Kanjera, in the Southern, Northern, and Middle Exposures (Behrensmeyer et al., 1995; Ditchfield et al., 1999; Plummer et al., 1999, Ditchfield et al., 2019). The oldest units, Beds KS-1 to KS-5, make up the Kanjera South Member and are exposed at the Kanjera South locality (Figure 1). They have been the subject of extensive archeological enquiry (Plummer et al., 1999; Plummer, 2004; Braun et al., 2008; 2009; Plummer et al., 2009a,b; Ferraro et al., 2013; Lemorini et al., 2014, 2019; Plummer & Bishop, 2016; Oliver et al., 2019). These beds are gently dipping to the north and are affected to a minor extent by normal faults down-stepping to the north, and associated minor folding. The Kanjera South Member is overlain unconformably by the beds of the Kanjera North Member (Beds KN1-KN5), which also dip northwards but are more intensively deformed by faulting associated with the Winam Gulf graben. These members were previously informally referred to as Kanjera Fm (S) and Kanjera Fm (N) (Plummer et al., 1999; Ditchfield et al., 2019). Both Kanjera South and Kanjera North Members are unconformably overlain by the Kanjera Middle Exposure Member (KME-1 to KME-3), which seems to represent a west-to-east directed alluvial fan sequence, which is erosive into both underlying members.

The Kanjera South Member in the southern exposures of the Kanjera gully system is subdivided into five beds, KS-1 through KS-5. All beds yield fossils, though the densest concentrations of fossils and artefacts are found in Beds KS-1 to KS-3. Sandy silts and fine sands characterise KS-1. KS-2 has two facies, one a pebbly fine to medium sand and the other a discontinuous patchy conglomerate. Further sandy silts and patchy conglomerates characterise the KS-3 deposits. The lower sequence suggests deposition in a floodplain environment, by low aspect channels with diffuse flow. These are overlain by KS-4 clays deposited in a low-energy lacustrine or swamp environment, which is in turn overlain by KS-5, which includes both gravel facies and clay facies with paleosol carbonates indicative of the formation of stable land surfaces. The sequence ends with a clay grading upwards into gravelly clay and capped with an irregular, massive limestone containing plant casts. This terminal unit had been designated KS-6 in Behrensmeyer et al. (1995), but is considered the top of KS-5 here. This suggests a range of depositional phases, including low-energy and fluvial deposits, and ultimately consolidation of sediments cemented by calcium-saturated water from a spring.

The Kanjera North Member is exposed in the Middle and Northern Exposures of the Kanjera Gully. North of the locality, a shallow saline lake or playa, unrelated to modern Lake Victoria, was present during Kanjera North Member deposition (Behrensmeyer et al., 1995). Five beds have been identified, that were deposited by alternating delta, lake and mud-flat systems. The basal beds are KN-1 and KN-2, which have alluvial fan deposits (KN-1a and KN-2a) that interfinger with lacustrine silts and clays (KN-1b and KN-2b). The lacustrine layers preserve mudcracks and evaporitic layers, which suggest that the lake was saline and occasionally dried up. KN-3 silts and clay alternate with sands, suggesting quiet water alternating with fluvial deposition. The sandy silts of KN-4 were deposited under more subaerial conditions, most likely in a mudflat environment. The thick, homogenous KN-5 clays unconformably overlie KN-4, and suggest swamp or lacustrine deposition at the base of the unit, returning to subaerial mudflat deposition towards its top.

Age of Homa Peninsula formations

It has been difficult to use radiometric methods to determine absolute ages of the Homa Peninsula strata and for the fauna and archeological occurrences recovered from these contexts. Primarily this has been because of a lack of igneous rocks suitable for these methods. Most known tuffs are altered, and other igneous occurrences and layers derived from the Homa Mountain carbonatite complex have chemical compositions that are not amenable to radiometric methods. Therefore, field observations covering conformable and unconformable contacts between formations exposed in the Homa Peninsula gullies inform the interpretation of the overall lithostratigraphic sequence in the region. These observations are further informed by biostratigraphy and magnetostratigraphy. A composite stratigraphy based on field observations, bio- and magnetostratigraphy is shown in Figure 2.

Vertebrate Paleontology

The Kanam Formation and Homa Formation

The Kanam and Homa formations are currently recognized as the oldest sedimentary units along the northern rim of the Homa Peninsula and are mainly exposed in the Kanam West, Kanam Central, and Kanam East gullies. During field research in the Kanam gullies over the past century, mammalian fossils have been surface collected, recovered on steeply eroded slopes of superposed sedimentary units that are potentially as old as 6 million years. The early expeditions organized by Louis Leakey had poor control over spatial locations and left no field documentation. An expedition by David Pilbeam in 1974 and later research visits by Martin Pickford provided sedimentary descriptions and sketch maps that assist in provenancing some of their surface finds (Pilbeam, 1974; Pickford, 1984). In general, though, the lack of precise coordinates makes it difficult to make definitive associations between fossils collected during the past expeditions and specific geological units. Until the 1990s, provenances of surface collected fossils were rarely tested by excavation or geochemical methods [see Plummer et al. (1994) for an example of the latter research at Kanjera].

Excavations carried out by the Smithsonian-National Museums of Kenya (SI-NMK) research group since 1985 demonstrate that in situ fossils of the Kanam and Homa Fms are typically fragmentary and found in isolation rather than in bone concentrations. As a means of recovering fossil samples, therefore, in situ recovery is less effective than collecting surface fossils following seasonal rains.

Unpublished age estimates have been reported to the authors as ~6.12 Ma for Kanam Fm Bed K2 and 6.06 Ma for K6 (Alan Deino, Robert Drake, pers. comm.); however, the chronological analyses are not definitive and are considered preliminary estimates until refined analyses are published. Fossils in this formation have been recovered mainly from Kanam West, which encompasses northern lakeside exposures and a southern inland gully system. Proboscidean taxa from Kanam West include *Paleaoloxodon (Elephas) recki* and *Stegotetrabelodon* sp., both from bed K5, which have biostratigraphic ranges of ~5.0 to 0.5 Ma, and 7.4 to 4.2 Ma, respectively. In Kanam East, fauna associated with sediments mapped by Pickford as Kanam Fm include *Kolpochoerus heseloni*, which has a biostratigraphic range of 3.26 to 0.7 Ma, and *Phacochoerus* sp., which is likely derived from eroded remnants of the Middle/Late Pleistocene Apoko Fm. Kanam Central does not include specimens from the Kanam Fm that are identifiable to a useful level for biostratigraphic or chronological purposes.

As defined in the Kanam West gullies, the odd-numbered beds of the Kanam Fm are fossil-bearing (K5, K3, and K1, in decreasing abundance). The even-numbered beds are typically tuffaceous and less fossiliferous except in pedogenic units intercalated with tuff horizons. Sedimentary facies are consistently fluvial channel and floodplain with reworked airfall tuffs. The six beds of the Kanam Fm are visible in limited exposures in the southeastern branch of Kanam Central, where recent erosion has begun to expose strata potentially lower than K1; and in limited exposures on the eastern side of the Kanam East gully.

The richest fossil-bearing strata of the Homa Fm occur in the southeastern portion of the Kanam West inland gullies, ~50 to 10 m north of the southern erosional lip of the gully. In this location a prominent, fossil-bearing, orange pebbly conglomerate (PC) bed overlies a fossil-rich dark concretionary clay (DCC) unit. An orange-banded sand/silt (OBS) bed appears on the surface to underlie DCC; however, test trenching shows that OBS is either a very steep channel that cuts into the lower part of DCC or the two beds are in contact at a fault. Geological observations in test trenches further illustrate the complications in attributing some surface-eroded fossils to particular geological beds: near the southern lip of this area, the DCC unit of the Homa Fm lies on top of bed K4 of the Kanam Fm, whereas 30 meters northeast, bed K4 is overlain by a draping of dark concretionary gritty clay that is only slightly distinct from the Homa-DCC bed, but is likely Middle/Late Pleistocene Apoko Fm. In some instances, it is feasible to mistake the Homa-OBS bed to be laterally equivalent to the banded Homa Agglomerate (HA), which is prominent in the mid-to-westernmost exposures of the Kanam West inland gullies and appears to represent the oldest bed of the Homa Fm, stratigraphically beneath the OBS, DCC, and PC beds. The HA preserves fragmented fossil mammals and plants.

For the reasons noted here, taxa claimed historically to derive from the Kanam and Homa Formations must be treated with utmost caution as to their actual provenance. Type specimens attributed to these formations include the suids *Nyanzachoerus kanamensis* (Kanam West) and *Metridiochoerus andrewsi* (locality unrecorded), and the gomphotherid *Anancus kenyensis* (Kanam

East). Table 1 provides a provisional faunal list by formation (Potts et al., 1997) based on Pickford (1984) supplemented by SI-NMK field research in 1994 and 1996. Fossil identifications from field geological studies at Kanam West and careful surface collecting of the Homa Fm in 2012 and 2014 are in progress.

In Kanam West the Homa-OBS bed yielded *Tragelaphus* cf. *kyaloi*, which has an age range of ~6.5 to 3.4 Ma. From the Homa-DCC/PC beds, a single specimen of *Parapapio ado* was collected in situ, which has a range of ~4.1 to 3.5 Ma. The Homa Fm surface collection includes another example of *Parapapio ado*, as well as *Kolpochoerus* cf. *K. heseloni*, currently known from ~3.3 to 0.7 Ma and *Anancus* cf. *A. progressus* at ~5.0 to 3.5 Ma. It is likely therefore that the Homa Fm surface collection represents material from approximately 3.5 Ma. Mammalian taxa associated with the Homa-OBS bed in the Kanam Central gully overlap in age from ~4.2 to 1.6 Ma. At Kanam East a fossil of *Aepyceros* cf *A. melampus* was associated with the mapped HA bed; yet its biostratigraphic range of ~2 Ma to present suggests a spurious spatial association with a geological unit that is at least 3.3 to 3.5 Ma. All biostratigraphic ranges are from Werdelin and Sanders (2010) augmented by field and laboratory research by E.G.E. as part of the Baringo Paleontological Research Project study of the Chemeron Fm, Tugen Hills, Kenya.

The Rawi Formation

The Rawi Fm is highly fossiliferous in patches, and as such was one of the earliest areas in the peninsula to receive concentrated and systematic attention from scientific researchers. In the 1930's Louis Leakey's expeditions extensively trenched the Rawi Fm in the area of the Fish Cliffs in the Rawi Gully. A diverse fauna was recovered then, including the holotype skeleton of *Giraffa jumae*, a skeleton of the rhinoceros *Ceratotherium simum*, a cranium and mandible of *Metridiochoerus andrewsi*, remains of *Hippopotamus gorgops*, and a pygmy hippopotamus mandible (cf *Hexaprotodon imagunculus*), all of which are currently housed in the Natural History Museum, London. These specimens are exceptionally well-preserved and complete, preserving the platy sand matrix from which our expedition also surface collected fossils near the Fish Cliffs. In 1994 we were aided in relocating two of Leakey's trenches by a local informant who was at Leakey's excavations as a child. Subsequently, the SI-NMK team has recovered additional taxa from one of the trench sites, including *Notochoerus*, and some hippo and bovid remains, as well as a partial cranium of *Cercopithecoides kimeui* from the base of the main Fish Cliffs sequence. The primate specimen conjoins with a mandibular fragment collected in the 1970s by Pilbeam (1974) and is likely from the same individual as mandibular fragments in the NHM's Rawi collection found by Leakey's expedition (Frost et al., 2003).

Numerous taxa recovered from Rawi have biostratigraphic relevance (Table 2). *Cercopithecoides kimeui* has a documented age range between 2.6 – 1.5 Ma in eastern Africa (Frost et al., 2003; Jablonski and Frost, 2010). The Suidae are also relevant, with *Metridiochoerus andrewsi* known in East Africa from at least 2.95 Ma until 1.7 Ma, and *Notochoerus* known from the Pliocene until 1.8 Ma, although it is both rare and derived after 2 Ma (Bishop, 1994; 2010; Ditchfield et al., 1999; White, 1995;). The height, length and complexity of the *M. andrewsi* and *Notochoerus* teeth are suggestive of an age older than 2 Ma (Bishop, pers. obs.), making the most likely biostratigraphic interval from 2.6 – 2 Ma. Magnetostratigraphy of the Rawi Fm sampled in two localities showed a completely normal sequence, excepting one short antipodal reversed site (Ditchfield et al., 1999). The bio- and magnetostratigraphy are concordant with several possible dates: the Rawi Fm was deposited either during the Olduvai Subchron (1.922 – 1.775 Ma) or during the C2An1n Subchron (3.05-2.59 Ma) of the Gauss Chron. The latter, Gauss Chron date is more concordant with the biostratigraphic data.

The Abundu Formation

The Abundu Fm was described as a separate geological sequence in 1999; earlier reports considered it to be part of the Rawi Fm (Kent, 1942; Pickford, 1984; Ditchfield et al., 1999). Its age is not well constrained and currently few taxa can be attributed to it. Those that have been recovered are not very informative as to the Abundu Fm.'s biostratigraphic age (Table 2). Hyenidae, Hippopotamidae, Rhinocerotidae, *Paleaoloxodon (Elephas) recki* and the Bovidae Tragelaphini, Kobus sp. and Alcelaphini sp. have been attributed to the Abundu Fm since its recognition and definition. However, these taxa are not particularly informative because they mostly lack species-level taxonomic attribution, and those that are identifiable have long known time ranges (e.g. *P. recki* 4.1 Ma – 0.3 Ma, Todd 2006). No in situ artefacts have been recovered from the Abundu Fm. Attempts to attain a meaningful magnetostratigraphic result have not been successful to date (Ditchfield et al 1999). Therefore the stratigraphic succession is our best guide to the age of this formation, which overlies the Rawi Fm and is in turn overlain by the Kasibos Fm.

The Kasibos Formation

The only known outcrops of the Kasibos Fm are found in the Kanam East gullies, unconformably overlying the Abundu Fm. In this setting the Kasibos exposures show up to 7 m of thickness that consist of fine-grained, poorly consolidated red clays and siltstones with occasional pink paleosol nodules, in beds from 40-150 cm thick. These are interbedded with thin, pebble-grade conglomerate horizons that comprise angular to subangular clasts of carbonatite lavas with very occasional rounded clasts of basement schists in occasionally cemented horizons approximately 20 cm thick.

Despite its rare exposure, the Kasibos Fm can be very fossiliferous when it is exposed. Several sites have been identified, with Felid Hill and the *Equus* Tooth Site the most important. Geochronology is established by studies of paleomagnetism in conjunction with the biostratigraphic estimates for this site. Kasibos Fm sediments demonstrate normal polarity but, along with the magnetostratigraphy, the fauna recovered suggest that the age of these deposits best corresponds with the Jaramillo Subchron (1.070-0.990 Ma), with a maximum age of approximately 1.8 Ma circumscribed by the first appearance datum (FAD) of *Kolpochoerus majus* (Table 2; Ditchfield et al., 1999). Another consideration is the skeleton of *Dinofelis piveteaui* recovered from the Kasibos Fm site at Felid Hill over successive expeditions, most notably in the conjoinable ulna fragments of this specimen recovered in 1974 and 1994 (KNM-KE 21, Ditchfield et al., 1999). The Kasibos specimen shows more derived morphology than material from the Okote Member, suggesting a later date for the former specimen (Werdelin, pers. comm.). Another major consideration supporting a Jaramillo Subchon age for the Kasibos Fm deposits is the known temporal distribution of *D. piveteaui*, which does not extend into the Middle Pleistocene (Turner, 1990; Werdelin pers.comm.). A Jaramillo Subchron age for the Kasibos *D. piveteaui* would make it the most recent known specimen of this taxon from Africa (Ditchfield et al., 1999).

Felid Hill has yielded a wide range of faunal specimens, which along with representatives of the taxa above include Cercopithecidae, Canidae, Felidae, *Equus*, specimens from six bovid tribes*, K heseloni, Metridiochoerus cf modestus*, hippopotamus, elephantid, lizard and bird fossils. Considering the limited distribution of Kasibos Fm sediments, the fauna recovered has been quite diverse (Table 2). As is true for the Abundu Fm, no in situ artefacts have been recovered from the Kasibos Fm; however, surface artefacts including Acheulean bifaces reported by Pickford (1987) and Ditchfield et al. (1999) from the Kanam East gully may ultimately be found in situ in either the Abundu or Kasibos formations.

The Kanjera localities

Kanjera has been the focus of the most recent scientific investigations on the Homa Peninsula. Sediments outcrop in three exposures over a distance of approximately 0.5 km. The Northern and Southern Exposures are separated by the Middle Exposures, which are lower in height and less well exposed. Between them, the sediments of the localities of Kanjera South and Kanjera North preserve archeology and fauna intermittently sampling the past two million years. Kanjera South is older, with sediments estimated to cover the period from approximately 2 million to older than 1.775 Ma, since the preserved sediments cap out before reaching the top of the Olduvai Subchron (Ditchfield et al., 2019). Sedimentation in Kanjera North is more recent, with excavations recovering material dating from just over 1 million year ago to the Middle Pleistocene. There are more recent, undated occurrences in the latest part of the sequence, the Apoko Fm and black cotton soils of the Kanjera North Member.

Kanjera South Member

Although the Kanjera localities have been known to science since 1911, it was relatively recently that the temporal differences between the Southern and Northern Exposures (and the related geological formations) have come to light (Ditchfield et al., 1999; Plummer et al., 1999). Repeated attempts to date overlying volcanics at Kanjera South using Ar-Ar methods have been unsuccessful. However, a combination of paleomagnetic and biostratigraphic studies using the abundant mammalian fauna allows us to delimit the age of the archeological deposits. The proboscidean *Deinotherium* sp., the suids *Metridiochoerus modestus* and *M. andrewsi*, and the extant genus of equid *Equus* have all been recovered. The earliest African appearance of *Equus* dates to 2.3 Ma as does the FAD for *M. modestus* (Cooke, 2007). *Metridiochoerus andrewsi* is known from 3.36 Ma – 1.7 Ma elsewhere in Africa and *Deinotherium* sp. is known from deposits older than 1.5 Ma. These taxa indicate that archeological materials were deposited between 2.3 -1.7 Ma. Moreover, the Olduvai Subchron (1.922 – 1.775 Ma; Singer, 2014) has been detected in the sediments of Beds KS-4 and KS-5 (Ditchfield et al., 1999, 2019). The underlying archeological occurrences in Beds KS-1 to KS-3 must therefore predate the base of the Olduvai Subchron at 1.92 Ma, yielding a date of between 2.3 and 1.92 Ma for hominin activity. Given the apparent rapidity of deposition, it seems likely that the archeological occurrences are closer to the younger end of this time interval, with an approximate age of ~2 Ma. Table 3 shows the fauna recovered from the Kanjera South and Kanjera North Members.

Kanjera North Member

A combination of paleomagnetic determinations and biostratigraphy suggest that the Kanjera North Member deposition spans a relatively long interval. At the base of the sequence, the polarity is reversed (Behrensmeyer et al., 1995). KN-1 is not fossiliferous and has a reversed polarity, which almost certainly post-dates the Olduvai Subchron based on the prevalence of the derived suid *Metridiochoerus compactus* in Beds KN-2 to KN-4. Beds KN-3 and KN-4 are reversed at their bases and normal at their tops. The upper normals in these units were originally attributed to the Jaramillo Subchron (0·99–1·07 Ma) for KN-3 and the Brunhes/Matuyama boundary (0·780 Ma) for

KN-4 (Behrensmeyer et al., 1995). However, it now appears that KN-3 and KN-4 are laterally equivalent, and that normal samples in each likely correspond to the Jaramillo (Ditchfield, pers. obs.). Thus, the KN-1 to KN-4 sequence largely predates the Jaramillo, and the fauna and artefacts from these beds largely predate ca. 1.1 Ma. The contact between KN-5 and the underlying units is downfaulted and so cannot be seen, but the abundant fauna from this bed is similar to Bed IV Olduvai (Plummer, 1992). Its magnetostratigraphy is consistently normal, indicating a Middle Pleistocene (Brunhes Chron) age for its deposition (Plummer, 1992; Leakey and Roe, 1994; Behrensmeyer et al., 1995; Ditchfield et al., 1999).

The Apoko Formation

The ~4m of clay and gravel channel facies of the Apoko Fm unconformably overlies the other formations found on the Homa Peninsula (Pickford, 1984; Ditchfield et al., 1999). Because of its unconformable nature, normal polarity, and a fauna that is dominated by modern or recently extinct taxa, it is likely that nowhere is the Apoko Fm older than the late Middle Pleistocene (Pickford, 1984; Behrensmeyer et al., 1995, Ditchfield et al., 1999). The Apoko Fm has been best explored at Kanjera, particularly in the Northern Exposures, where it is very fossiliferous (see Table 2 for faunal taxa recovered from the Apoko Fm). The Apoko Fm has yielded remains of an anatomically modern human in addition to a wide range of mammalian taxa, all of which were well fossilised (Ditchfield et al., 1999). The Apoko *Homo sapiens* may pre-date the other remains of modern *Homo* from Kanjera North (Plummer and Potts, 1995), or it could represent a more recent burial into an Apoko outcrop.

Hominin behaviour and ecology on the Homa Peninsula

Although stone artefacts are found on the surface of deposits all over the Homa Peninsula, their relationship to the underlying in situ sediments has not always been straightforward. Kanjera South and Kanjera North have extensive, dense surface accumulations of artefacts and fossil fauna. Excavations at these sites provide the best evidence of hominin behaviour and ecology on the Peninsula. As noted above, extensive investigations at the Kanjera locality have shown that the north and south are temporally distinct, and thus reveal the details of hominin occupation of the region over hundreds of thousands of years. Analysis of well-preserved in situ and surface collected finds has allowed reconstruction of hominin behaviour in detail, and several lines of evidence have put this behaviour into a well-evidenced environmental setting (Plummer et al., 1999; Plummer et al., 2009a,b; Ferraro et al., 2013; Lemorini et al., 2014, 2019; Ditchfield et al., 2019; Oliver et al., 2019).

Kanjera South

Kanjera South is older than many known Oldowan sites from which large assemblages of artefacts and well-preserved faunal remains have been recovered. Our interdisciplinary team of paleontologists, archeologists and geologists has been excavating at Kanjera South since 1995, when it was recognised that these sediments pre-dated those at Kanjera North, where previous research was concentrated (Behrensmeyer et al., 1995). The largest excavation is a 169 m^2 area (Excavation 1) from which approximately 3700 fossils and 2900 artefacts have been recovered and individually piece plotted using a laser transit system, making it one of the largest collections of Oldowan archeological material from a single site. Artefacts and bones are found successively in three beds (from oldest to youngest, KS-1 through KS-3) that occur over a 3 m depth of sediment. Analysis confirms that the primary agent of accumulation of the archeological material at Kanjera South was hominin activity (Plummer et al., 1999; Ferraro et al., 2013, Ditchfield et al., 2019).

Oldowan hominin habitats

At Kanjera, isotopic and faunal data document an Oldowan site complex formed in an open habitat within a grass-dominated ecosystem (Plummer et al., 2009a;b). Repeated deposition of artefacts and bones from butchered macromammals provide the first clear evidence of recurrent hominin activities in such an open setting. Whereas the hominin fossil record suggests that some evolutionary innovations in the human genus *Homo* reflect an increased reliance on relatively open, arid savanna environments, direct evidence of grass-dominated settings and of early *Homo* within these open settings during the Plio-Pleistocene (2.5 – 1.5 million years ago (Ma)) had been lacking until Kanjera South paleoenvironments were reconstructed (Plummer et al., 2009a). Activities in this open habitat and their comparison to activities undertaken in more closed habitats, e.g., the woodlands of FLK-Zinj, has implications for understanding early Homo behavioural ecology (Oliver et al., 2019).

The KS-2 fauna from Excavation 1, for example, is composed of a variety of taxa, indicating a range of inferred habitat preferences and diets (Table 3). One indication that the secondary grassland component of the floral community was significant is the relative proportion of taxa preferring open grasslands versus other habitat types. Bovids make up 82.6% of the 886 KS-2 fossils attributable to macromammalian families (Ferraro et al., 2013). Ninety-two percent of the KS-2 bovid specimens attributable to tribe (n=143) fall into the Alcelaphini and Antilopini, which in modern settings are good indicators of open grassland ecosystems (Vrba, 1980; Bobe and Behrensmeyer, 2004). Moreover, the high frequency of equids in KS-2 (11.6%) is similar to the relative abundance of zebras in modern, grassland-dominated ecosystems such as the Serengeti, Tanzania (Potts, 1988; Plummer et al., 1999).

In modern ecosystems, trees, shrubs, herbs and high-altitude grasses preferring cool, wet growing seasons use the C3 photosynthetic pathway, which strongly discriminates against ^{13}C Ehleringer et al., 1997; Plummer et al., 2009a, b). Grasses and sedges in warm, arid, open environments, such as those commonly found in Sub-Saharan Africa, predominantly use the C4 photosynthetic pathway. Terrestrial plants using these photosynthetic pathways can thus be identified by the relative abundance of ^{12}C and ^{13}C in their tissues. The isotopic composition of pedogenic carbonates reflects the relative proportion of surface vegetation using each photosynthetic pathway. Thus the isotopic signature of pedogenic carbonates found associated with large concentrations of archeological debris can be used to reconstruct the habitat structure at points on the landscape recurrently visited by hominins (Sikes, 1994; Levin et al., 2004; Quinn et al., 2007). This is one of the few available ways to make linkages between hominin activities and specific habitat-types. Stable carbon isotope studies of pedogenic carbonates from Beds KS-1 and KS-2 at Kanjera indicate that site formation occurred in an open (wooded grassland to open grassland) setting (Plummer et al., 1999; Plummer et al., 2009a, b; Ditchfield et al., 2019). Paleoenvironmental context is also assessed using taxon-free faunal analyses including ecomorphic analysis of long bones and tarsals (Plummer & Bishop 1994; Kappelman et al., 1997), and isotopic analyses of tooth enamel (Plummer et al., 2009a, b). The limb element ecomorphic analyses (Plummer et al., 2006) indicate that the bovid postcranial sample is dominated by individuals with open- and light-cover habitat preferences.

Assessment of the carbon isotopic ratios in the teeth from the Kanjera excavations allows us to assess the diets of specific taxa, as well as the relative proportion of browsing versus grazing strategies (Morgan et al., 1994; Cerling et al., 2003; Kingston and Harrison, 2007). By sampling a wide range of herbivores, general dietary preferences of the fauna can be used to infer microhabitats and vegetation present in the region. Stable carbon isotopic analysis of herbivore tooth enamel shows that all taxa except some surface collected tooth fragments of the proboscidean *Deinotherium* subsisted largely or entirely on grass (Table 4), (Ditchfield et al., 2006; Kingston et al., 2006; Plummer et al., 2009a,b). This finding is striking, as taxa such as the tragelaphine bovids and the Cercopithecinae indet. (Table 3) were assumed to have consumed predominantly C3 plant products based on comparison with living relatives. There is a strong C4 dietary signal across the spectrum of animals found at Kanjera South, including non-migratory taxa such as the monkeys, rhinos, tragelaphine antelopes, and pigs. This makes it unlikely that the grassland dietary signal results from a prevalence of mobile grazing herbivores at the lake edge overwhelming the signal from the resident mammalian community, since these latter also show a preference for C4 diets.

Oldowan hominin faunal acquisition

Generally, debate on the mode of carcass acquisition has been based on data from Bed I Olduvai, particularly FLK-Zinj, and focused on whether Oldowan hominins were primarily scavenging or hunting prey, and if they were scavenging whether it was active or passive (Plummer, 2004). Because medium-sized mammals are the most common within the Bed I faunas, discussion of carcass acquisition strategies has focused on this size class (e.g. Bunn & Kroll, 1986; Oliver 1994; Blumenschine 1995; Dominguez-Rodrigo et al., 2007; Bunn and Pickering 2010; though see Fernandez-Jalvo et al., 1998). A dichotomy of scavenging versus hunting oversimplifies and artificially partitions what is likely to have been a complex, flexible foraging strategy. Moreover, it presupposes that scavenging and hunting would be equally visible in the archeological record. This seems unlikely, given the taphonomic biases acting on the animals most likely to have been hunted (i.e. small mammals) versus those most likely to have been scavenged (i.e. medium and large mammals) and potential differences in transport behavior based on carcass size (Lyman, 1994; Plummer & Stanford, 2000; Ferraro et al., 2013).

Although there is evidence of both hominin and carnivore involvement with excavated faunal remains from Excavation 1 (NISP=3600+, macro-mammal MNI=80+ for the KS-1 to KS-3 sequence), analysis of site sedimentology and bone taphonomy clearly indicate that hominins were the primary agent of assemblage formation (Ferraro et al., 2013; Ditchfield et al., 2019). Furthermore, research indicates that hominins had early access, likely through hunting, to many small (size 1-2) bovids (Ferraro et al., 2013; Parkinson, 2013;Oliver et al., 2019). At the five Bed I Oldowan levels studied by Potts (1988), size 1 and 2 mammals make up an average of only 20% of the assemblage total, compared to 36% from Excavation 1. The proportion of juvenile individuals within the KS-1 and KS-2 small size class is also high relative to the only other large Oldowan assemblage, FLK-Zinj, [50%, versus an average of 14% for FLK-Zinj (Bunn and Pickering, 2010; Oliver et al., 2019)]. The overall sense of the Excavation 1 faunal samples is that they contain a higher proportion of small, frequently immature mammals than do the Bed I Olduvai assemblages. Two other Early Pleistocene Oldowan samples, Lokalalei and FwJj20, from west and east of Lake Turkana in Kenya, also have a high proportion of size 1 and 2 mammals (Kibunjia, 1994; Braun et al., 2010), suggesting that as sampling extends beyond Olduvai a better sense of variation in Oldowan faunal acquisition strategies will be obtained.

Analyses of skeletal part frequencies suggest that these size 1 and 2 animals were frequently transported whole to the site (Ferraro et al., 2013). Cut and percussion mark frequencies, although low [4% and 7%, respectively, (Parkinson 2013)], are similar to those of other Oldowan assemblages (Ferraro et al., 2013), and show patterns consistent with carcass exploitation for meat, organ and marrow resources. In contrast, hominins were at least at times passively scavenging large bovid and equid carcasses (size 3-4; wildebeest/buffalo size), which are best represented by skulls and distal limb bones. With respect to carnivore involvement, the fauna generally reflects low-to-moderate levels of carnivore activity [9.8% (Ferraro et al., 2013: Table S2); to 13.8% (Parkinson, 2013: Table 3.4)]. Most carnivore bone modifications are plausibly related to gaining access to the marrow. Notably, the intensity of carnivore activity differs dramatically from that modeled in the modern Serengeti (Blumenschine, 1987). Taken together, the record suggests marked variability in the carnivorous foraging behaviors of hominins making Oldowan tools (Ferraro et al., 2013; Oliver et al., 2019). It also suggests that by ca. 2.0 Ma some hominins had at least occasional access to substantial amounts of meat and within-bone resources (marrow, brains, etc.), resources which, some have argued, fueled dramatic anatomical and social adaptations in the genus *Homo* (Isaac, 1978; Plummer, 2004). The Kanjera data further demonstrate that Oldowan hominins possessed the cognitive, behavioral, and technological abilities to forage in a diversity of habitats.

Early Pleistocene hominin technology and behavioral ecology

Combining the intensive studies of past environments with analyses of hominin technology has enabled us to examine how these factors interact. In particular, our studies of hominin raw material sourcing, manufacture and curation have enabled us to examine how hominins have used their capabilities to ensure efficient use of hard-won commodities (Braun et al. 2008). Furthermore, by looking at use wear on Oldowan stone tools, we can understand what materials were processed by tool-using hominins.

Studies of Oldowan behavior have suggested that transport of resources was a major factor in hominin technological organization (Schick, 1987; Potts, 1991). The diversity of raw materials used by Oldowan hominins on the Homa Peninsula greatly exceeds that documented for other Oldowan localities, and many of the artefacts recovered during excavations were made from materials not available locally (Braun, 2006; Braun, et al. 2008). Extensive raw material surveys sampled over 300 potential primary and secondary sources for tool stone on the Homa Peninsula and in the surrounding region. Samples at each primary source and some secondary sources were analysed using geochemical and material sciences techniques. Raw material samples from primary and secondary sources were analyzed both destructively and non-destructively, and specific sets of elements were identified to distinguish the different raw material types. We used EDXRF (Energy Dispersive X-Ray Fluorescence) (Latham et al., 1992) to accurately and nondestructively determine the elemental composition of a large sample of Kanjera artefacts. Local raw materials associated with the Homa Mountain carbonatite complex (e.g., carbonatite, fenetized rocks) were used in the manufacture of approximately 70% of the artefacts, but a substantial proportion of artefacts (25-30%) were made of materials sourced off the peninsula. These "non-local" raw materials were transported a minimum of 10 km, a level of raw material transport not previously documented for the Oldowan (Braun, 2006; Braun et al., 2008; Plummer, 2004).

Material sciences analyses suggest that this relatively high degree of transport occurred because the "non-local" raw materials were of much higher quality for artefact manufacture and use than the "local" ones. Tests assessed fracture predictability (the consistency with which a particular type of stone fractures,) and edge durability (the ability of an edge to resist degradation by a static or dynamic force) (Braun et al., 2009). Analyses of the raw materials at Kanjera demonstrate that the stones used to make artefacts display a great deal of variation in raw material "quality." Specifically, raw materials originating off the peninsula are harder and tend to fracture moreconsistently than those deriving from the carbonatite complex.

Edge durability is another critical aspect of raw material quality, particularly when tasks increase raw material consumption (Brantingham, 2003). Studies show that the capacity of tool edges in the Kanjera raw material assemblage to resist wear ranges from some of the lowest possible (carbonatite) to the highest possible values (quartzite). As with fracture predictability, the "non-local" raw materials were more suited for artefact manufacture as they generally hold an edge longer than the "local" raw materials (Braun et al., 2009). Technological analysis is consistent with the idea of preferential transport of non-local raw materials. The non-local raw materials are more extensively and carefully flaked than the local ones (e.g., flakes were thinner, providing more perimeter per unit mass) and they were more frequently retouched. This study suggests that very early in stone tool use hominins had a keen understanding of raw material source distributions and raw material quality, and incorporated an economy of resources into their behavioral repertoire (Braun, 2006; Braun et al., 2008).

Analysis of the Kanjera South Oldowan assemblage initially identified traces of use-wear (Lemorini et al., 2014; 2019). A series of controlled experiments with replicated artefacts made from raw materials used at Kanjera was undertaken to help interpret these. Experiments involved butchery (skinning, defleshing), woodworking (hard and soft wood), cutting of grass, and peeling and sectioning of tubers and roots including wild African tubers by Hadza women foraging in Tanzania. Analysis of the experimental assemblage allowed creation of a use-wear framework linking the processing of specific materials and tool motions to their resultant use-wear patterns. Sixty-three of 87 archeological artefacts sampled from Kanjera South showed use-wear that was attributable to the processing of specific materials. On ten of these (12%), use-wear corresponded to animal tissue processing, providing additional evidence to corroborate zooarcheological studies demonstrating that butchery took place at the site. The processing of plant tissues, including wood, grit-covered plant tissues (underground storage organs or USOs), and stems of grass or sedges accounted for the use-wear on 33 tools (40%). The rest of the tools show use-wear attributable to generic soft or medium material processing.

Use-wear analysis demonstrates that hominins used artefacts to process materials that otherwise would be invisible to standard archeological methods, such as the cutting and scraping of wood, which may represent the production and/or maintenance of wooden tools. Evidence that USOs were processed shows that hominins acquired and processed this resource 1.5 Ma earlier than previously known (Lemorini et al., 2014; 2019). It is unclear the extent to which use-wear indicating the cutting of grasses, sedges or reeds is subsistence (e.g., grass seed harvesting, cutting out papyrus culm for consumption) or non-subsistence (e.g., production of ‘twine,’ simple carrying devices, or bedding) related. To date, the Kanjera South artefacts are the earliest known tools on which this type of analysis has been successfully carried out. Use-wear highlights the adaptive significance that using lithic technology had for Kanjera South Oldowan hominins (Lemorini et al., 2014; 2019).

Although several analyses are still underway, our studies demonstrate that hominins were transporting artefactual raw materials which were superior to those available locally to Kanjera South over relatively long distances. Once brought to the locality, hominins were carefully curating the resources so as to maximize their utility. Use-wear analysis, which has so far concentrated on the tools made from transported raw materials, shows that these artefacts were used on a range of animal and plant substances. The overall picture is one which shows that hominins exercised considerable cognitive awareness and behavioural flexibility (Lemorini et al., 2014, 2018). The reasons for the recurrent use of the Kanjera South locality, for what was likely hundreds of years, is poorly understood. The use-wear and zooarcheological evidence indicate that that hominins were butchering whole young gazelles and processing tubers through the 3m KS-1 to KS-3 sequence. This suggests that both of these resources were available nearby, and perhaps it was foraging for these resources and the local availability of potable water that repeatedly drew the hominins back to this locale.

Kanjera North

As discussed above, the Kanjera North sediments postdate those in the south (Plummer et al., 1999; Ditchfield et al., 1999). The evidence from Kanjera North also preserves bones and artefacts in spatial association, but none of the excavated or surface occurrences found so far have similar density or persistence as the Kanjera South Excavation 1 assemblage. The Kanjera North site formation took place under a slightly different sedimentary regime than did the deposits in the south, with alternating deltaic, lake and mud-flat systems (Plummer, 1992; Behrensmeyer et al., 1995).

Evidence from carbon stable isotope analyses of soil carbonates suggests that the local environment at Kanjera North exhibited a greater degree of habitat heterogeneity than found at Kanjera South, with elements of both grassland and C3 plants in more equal balance (Ditchfield, unpublished data). Results are suggestive of mixed vegetational habitats with considerable variability across the landscape (Nicholson, 2003). Many of the δ3C values fall within the range usually associated with grassy woodland (Cerling, 1992; Plummer et al., 1999). This is consonant with the mixed depositional environments which are suggested by the sedimentary regimes that prevailed during Kanjera North deposition.

Although fossil fauna are common at Kanjera North, the extensive collection of *Theropithecus oswaldi* is notable. These fossils derive from the KN-2A "Island," a small, circumscribed outcrop that produces a unique chemical signature high in uranium, rubidium, radon, zirconium and yttrium in fossils preserved there (Plummer et al., 1994). Eighty-five skeletal elements representing 13 individuals are housed in the collections of the National Museums of Kenya and The Natural History Museum, London (Plummer, 1992). Kanjera is the type locality for this species, first described in 1916, which is now known to be widespread and characterised by both geographic and temporal variation (e.g. Jablonski, 2002).

Hominin occupation of the Homa Peninsula during the Kanjera North deposition is evidenced by the artefacts recovered from each site where there are major accumulations of fossils (Plummer 1992). Kanjera North artefacts can be described as Developed Oldowan or Acheulean (Leakey 1972). Hominins used relatively poor local raw materials, such as vesicular lavas, carbonatites and welded tuff to make a significant proportion of artefacts. They also used other raw materials that may have been sourced from local streams or been transported from further afield, as has been demonstrated for Kanjera South (Braun et al., 2008). The use of cobbles, which are otherwise absent in the Kanjera North sediments, as artifactual material is suggestive of transport of lithic raw materials by hominins, since these are not locally available (Plummer, 1992).

One excavation at the AC Site in Bed KN-4 yielded a nearly complete sub-adult hippopotamus skeleton (KNM-KJ 20653) in close spatial association with several cores, all of which were probably deposited in an ephemeral channel (Plummer and Potts, 1989; Plummer 1992). The bones are tightly clustered together, and they are relatively unweathered and unbroken, suggesting that they were not transported and were buried soon after death (Plummer 1992, Plummer and Potts 1989). Although there are numerous linear marks, pits, and abrasions on the bones, the most likely indication of interaction between hominins and the hippo carcass comes from probable cutmarks on the ilium; these are found in an area of muscle attachment that was unlikely to have been affected by trampling or sedimentary abrasion (Plummer and Potts, 1989; Plummer, 1992). Other indications of hominin faunal processing include a size 2 bovid distal humerus with cutmarks excavated from KN-3, and a medium mammal long bone shaft fragment with chop marks surface collected from KN-4. Other excavations from Kanjera North (e.g. GP site in KN-5) did not produce firm evidence of hominin/faunal interactions, although fossils and artefacts were spatially associated (Plummer and Potts, 1989; Plummer, 1992).

Discussion and Conclusions

The Homa Peninsula records evidence of hominin presence, both intermittent and more continuous, over nearly 6 million years of human evolution. The Homa Peninsula's location between the two branches of the Great Rift Valley makes it significant for studies of the evolution of East African landscapes because this area is otherwise poorly sampled. The region has significance in any examination of the evolution of hominin behaviour and hominin dispersals given that it supplies information about both in a unique ecological and geographical context.

Our record of the evolution of hominins and their behaviour is serendipitously preserved, and the archive presented by the sediments of the peninsula is no less compelling for its episodic nature. By the time hominins are making observable alterations in their environment with the advent of stone tool manufacture, the evidence of hominin occupation is less sporadic. Why were hominins either resident or frequent visitors to this region? The main attractor must have been the existence of both ephemeral and more permanent bodies of water and the diversity of habitats surrounding Homa Mountain. The sedimentation in many paleontological and archeological sites is associated with fluvial and lacustrine sources. However, the Kanjera sedimentological evidence points to the near constant presence of fresh, likely potable water in the vicinity of Homa Mountain. The combination of wooded slopes on the mountain as well as open expanses of grassland nearby would have provided hominins with an attractive setting and a diversity of resources.

At Kanjera South, where repeated hominin activities are evidenced, many of our analyses show that nearby fresh water may have been a local attraction. For example, use-wear on stone tools demonstrates that wood, tubers, and herbaceous plants such as sedges were processed. These plants are likely to be found near permanent or seasonal water sources. The presence of fresh water, particularly following seasonal rains, is also strongly indicated by the mortality profiles of antelopes, particularly the dominance of the juvenile small antelope, *Antidorcas recki* (Plummer et al, 2018). Modern springboks (*A marsupialis*) are seasonal breeders most likely to give birth during the rainy season, when ephemeral sources of water are more plentiful and permanent ones refreshed (Furstenburg, 2002). The low frequency of carnivore damage at Kanjera may suggest reduced risks of predation and fewer competitive interactions that also may have promoted recurrent occupation of the area.

The presence of water and of the concomitant food resources on the slopes and lowlands surrounding Homa Mountain would have made the region attractive to hominins. Moreover, tool use seems to have been adaptively significant, as hominins preferentially transported and used stones that were hard and, because of this, produced flakes that held a sharp edge for a long time. Hominins consumed foods including animal carcasses and USOs that would have required stone tool use to acquire and/or process, that were of high nutritional value, and in the case of whole gazelle carcasses and dense patches of tubers came in packets large enough to be shared. The fact that evidence of these activities is found through 3 meters of sediment indicates that these were not ephemeral behaviors, but were sustained activities by multiple generations of hominins in the vicinity of Kanjera South (Ditchfield et al., 1999, 2019; Ferraro et al., 2013). The behaviors evidenced at Kanjera, just prior to the first appearance of *H. erectus*, may be the archeological expression of this shift towards the tool-dependent foraging of high quality foods within a cooperative group context that provided the evolutionary milieu for the evolution of this taxon.

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Chapter 21 Bishop Table captions

Table captions

Table 1. Mammalian fauna currently assigned to the Kanam and Homa Formations based on fossils collected from the Kanam gullies, Homa Peninsula. X: taxon present. Body size class 2: 23-113 kg; class 3: 113-340 kg.

Table 2. Identified mammalian taxa collected from the Rawi, Abundu, Kasibos and Apoko formations.

Table 3. Fauna from the Kanjera South and Kanjera North formations.

Table 4. Carbon and oxygen stable carbon isotope values for mammalian enamel samples from Kanjera South, Kenya. After Plummer et al. 2009b.

Chapter 21 Bishop et al., Table 1

	Taxon	**Kanam Fm**	**Homa Fm**
Cercopithecidae			
	Parapapio ado		X
	Theropithecus darti		X
	Cercopithecidae indet.		X
Carnivora			
	Canis sp.		X
	Hyaenidae indet.		X
Suidae			
	Nyanzachoerus cf. *N. syrticus*	X	
	Nyanzachoerus kanamensis		X
	Notochoerus jaegeri		X
	Notochoerus cf. *N. scotti*		X
	Kolpochoerus heseloni		X
	cf. *Kolpochoerus* sp.	X	
	Metridiochoerus cf. *M. andrewsi*		X
Hippopotamidae			
	Hexaprotodon sp. (*H. imagunculus*)	X	X
	Hippopotamus sp.		X
Giraffidae			
	Sivatherium sp.		X
Bovidae			
	Tragelaphus cf. *T. kyaloae*		X
	Tragelaphini (size class 2)	X	X
	Tragelaphini (size class 3)	X	
	?Hippotragini sp.	X	
	Reduncini indet.	X	X
	Alcelaphini indet.	X	X
	Aepyceros sp.		X
	Antilopini indet.		X
	Neotragini indet.	X	
	Cephalophini indet.	X	
Rhinocerotidae			
	Ceratotherium sp.	X	
	Diceros bicornis		X
Equidae			
	cf. *Eurygnathohippus* sp.	X	
Proboscidea			
	Palaeoloxodon (*Elephas*) sp.	X	X
	Loxodonta adaurora		X
	Stegotetrabelodon orbis	X	
	Deinotherium bozasi	X	X
	Anancus kenyensis	X	
	Palaeoloxodon (Elephas) sp.	X	X
	Loxodonta adaurora		X
	Stegotetrabelodon orbis	X	
	Deinotherium bozasi	X	X

Chapter 21 Bishop et al; Table 2

	Taxon	**Rawi**	**Abundu**	**Kasibos**	**Apoko**
Hyracoidea					
	Heterohyrax sp.			X	
Cercopithecidae					
	Cercopithecoides kimeui	X			
	Cercopithecidae indet.	X		X	
Carnivora					
	Felidae	X		X	
	Dinofelis piveteaui			X	
	Hyaenidae		X		
Suidae					
	Notochoerus sp.	X			
	Metridiochoerus sp.	X			
	M. andrewsi	X			
	M. cf. *modestus*			X	
	Kolpochoerus sp.				X
	K. majus			X	
	Phacochoerus sp.				X
	Hylochoerus meinertzhageni				X
Hippopotamidae					
	Hippopotamidae, (cf *H. imagunculus*)	X			
	Hippopotamidae, large	X	X	X	X
	Hippopotamus cf. *gorgops*	X			
Giraffidae					
	Giraffa jumae	X			
Bovidae					
	Tragelaphini	X	X	X	X
	Bovini			X	X
	Syncerus sp.				X
	Pelorovis sp.				X
	Reduncini	X		X	
	Kobus sp.		X		
	Kobus kob	X			
	Neotragini			X	
	Alcelaphini		X	X	X
	Antilopini			X	
	Hippotragini				
Equidae					
	Equidae	X		X	X
	Equus sp.			X	X
Rhinocerotidae					
	Rhinocerotidae	X	X		
	Ceratotherium simum	X			
Proboscoidea					
	Elephantidae	X		X	
	Palaeoloxodon (*Elephas*) *recki*		X		

Chapter 21 Bishop et al; Table 3

	Taxon	**Kanjera South**	**Kanjera North**
Cercopithecidae			
	Cercopithicinae indet.	X	
	Cercopithecus sp.		X
	Theropithecus indet	X	
	Theropithecus oswaldi		X
Carnivora			
	Carnivora, size 2	X	
	Canidae indet	X	
	Felidae indet.		X
	Felidae, size 3	X	
	Hyaenidae indet.		X
	Crocuta sp.	X	
	cf *Civetta viverina*	X	
Suidae			
	Metridiochoerus andrewsi	X	
	Metridiochoerus modestus	X	
	Metridiochoerus compactus		X
	Metridiochoerus hopwoodi		X
	Kolpochoerus heseloni		X
	Kolpochoerus sp.	X	
	Phacochoerus sp.		X
Giraffidae			
	Giraffidae indet.	X	
Hippopotamidae			
	Hippopotamidae, size 3		X
	Hippopotamus, size 6	X	X
	Hippopotamus cf. *gorgops*		X
Bovidae			
	Tragelaphini		X
	Tragelaphini, size 3	X	
	Tragelaphus, size 2	X	
	Bovini	X	
	Pelorovis		X
	Pelorovis cf *oldowayensis*		X
	Syncerus acoelotus		X
	Reduncini, size 1–3	X	X
	Kobus sp.	X	X
	Cephalophini indet.		X
	Alcelaphini, size 2 and 3	X	
	Parmalarius altidens	X	
	Parmularius agusticornis		X
	Connochaetes sp.	X	
	Megalotragus sp		X
	Antilopini, size 1 and 2	X	X

	Antidorcas recki	X	
	Gazella sp.		X
	Hippotragini indet.		X
Equidae			
	Equus sp.	X	X
	Eurygnathohippus sp.	X	X
Rhinocerotidae			
	Rhinocerotidae indet.	X	
	Diceros bicornis		X
	Ceratotherium simum		X
Proboscoidea			
	Elephantidae, indet.	X	
	Loxodonta africana		X
	Paleoloxodon recki		X
	Deinotherium sp.	X	
Lagomorpha			
	cf. *Lepus*	X	
Manidae			
	Phataginus giganteus		X
Rodentia			
	Thryonomyidae	X	
Aves			
	Accipitridae *Gyps*	X	
	Phalacrocoracidae		
	Phasianidae		
	Struthionidae		
Gastropoda		X	X

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Field Number	Taxon	δ^{13}C VPDB	δ^{18}O VPDB
2218	Cercopithecidae	0.763	-1.215
10501	*Cercopithecus* sp.	-1.384	0.468
859	*Theropithecus*	0.572	-0.817
2066	Hyaenidae- Crocuta-sized	0.801	-1.621
63	Suidae	1.105	-2.012
3775	Suidae	-0.885	-0.596
5386	Suidae	-0.932	-1.016
4718	Suidae	-1.72	-2.677
14363	Suidae, cf. *Metridiochoerus* size 2/3a	-0.007	-0.745
5888	*Metridiochoerus* sp	1.246	-0.452
KJ95-17	*Metridiochoerus andrewsi*	1.741	-1.385
5162	*Metridiochoerus modestus,* size 2	0.549	-0.997
2	*Hippopotamus* sp.	-3.351	-2.984
8	*Hippopotamus* sp.	0.092	-2.153
25	*Hippopotamus* sp.	-1.001	-2.112
49	*Hippopotamus* sp.	0.851	-0.459
365	*Hippopotamus* sp.	0.666	-1.935
792	*Hippopotamus* sp.	2.051	-1.626
2039	*Hippopotamus* sp.	-1.219	-2.216
5004	*Hippopotamus* sp.	0.12	-1.174
7211	*Hippopotamus* sp.	2.041	0.238
7900	*Hippopotamus* sp.	-0.328	-1.708
8898	*Hippopotamus* sp.	1.683	-0.317
10188	*Hippopotamus* sp.	0.386	-2.829
17990	*Hippopotamus* sp.	2.661	-1.178
586	Alcelaphini, size 2/3a	2.544	-0.781
632	Alcelaphini, size 2/3a	1.967	-0.527
755	Alcelaphini, size 2/3a	2.063	-0.485
922	Alcelaphini, size 2/3a	2.134	-0.09
4280	Alcelaphini, size 2/3a	2.275	0.83
4549	Alcelaphini, size 2/3a	1.141	-1.549
6428	Alcelaphini, size 2/3a	2.718	0.818
4564	Alcelaphini, size 3a	1.914	0.475
4714	Alcelaphini, size 3a	1.987	0.324
4807	Alcelaphini, size 3a	1.592	0.999
5233	Alcelaphini, size 3a	2.505	-0.582
5475	Alcelaphini, size 3a	2.947	-0.959
6318	Alcelaphini, size 3a	0.212	0.855
6351	Alcelaphini, size 3a	2.675	-0.532
6436	Alcelaphini, size 3a	4.565	1.954
6510	Alcelaphini, size 3a	2.037	0.059
6511	Alcelaphini, size 3a	2.338	0.316
7309	Alcelaphini, size 3a	2.385	-0.213
8191	Alcelaphini, size 3a	2.091	-1.003
15868	Alcelaphini, size 3a	2.019	-0.205
22830	Alcelaphini, size 3a	2.417	-1.126
4003	Alcelaphini, size 3b	2.441	0.825
4300	Alcelaphini, size 3b	2.899	-0.607
4511	Alcelaphini, size 3b	2.971	-0.313
4801	Alcelaphini, size 3b	2.521	1.112
5991	Alcelaphini, size 3b	2.541	-0.507
6541	Alcelaphini, size 3b	1.829	1.016
9770	Alcelaphini, size 3b	2.104	-1.159
10941	Alcelaphini, size 3b	2.433	0.229
10949	Alcelaphini, size 3b	2.448	-0.046
17469	Alcelaphini, size 3b	3.318	-1.283
166	Antilopini, size 1	1.231	1.595
4172	Antilopini, size 1	0.916	-0.335
4313	Antilopini, size 1	2.773	-1.114
4320	Antilopini, size 1	1.248	1.635
5165	Antilopini, size 1	1.567	1.406
5579	Antilopini, size 1	1.176	-0.756
5631	Antilopini, size 1	1.644	-0.018
6360	Antilopini, size 1	0.668	0.917
6417	Antilopini, size 1	1.358	0.459
6432	Antilopini, size 1	0.256	1.137
11317	Antilopini, size 1	1.26	1.29
14416	Antilopini, size 1	0.537	0.514
14452	Antilopini, size 1	1.009	-0.799
14655	Antilopini, size 1	0.881	0.327
15580	Antilopini, size 1	1.946	0.704
20515	Antilopini, size 1	1.033	1.435
21420	Antilopini, size 1	-0.419	0.417
732	Antilopini, size 1	0.834	-0.392
6512	Antilopini, size 2	-1.148	-0.378
12522	Antilopini, size 2	0.59	0.046
17737	Antilopini, size 2	2.369	-0.08
18386	Antilopini, size 2	1.953	-0.066
21053	Antilopini, size 2	1.934	0.272
203	Bovidae, size 3	-8.238	-2.054
14525	Bovidae, size 3b	2.808	0.251
16443/c	Bovidae, size 3x	2.071	1.306
299	Bovini size 5	1.948	-0.621
3654	Bovini, size 5	1.76	-0.743
286	Reduncini, size 2	1.979	-2.936
6296	Reduncini, size 2	1.318	-1.122
12043	Reduncini, size 2	-0.256	-1.034
13837	Reduncini, size 2	1.794	1.622
9	Reduncini, size 3a	2.578	-0.794
438	Reduncini, size 3a	1.806	0.037
2168	Reduncini, size 3a	0.328	0.881
12045	Reduncini, size 3a	2.424	-0.562
23316	Reduncini, size 3a	0.677	-3.399
408	Reduncini, size 3x	2.251	-0.85
3333	Tragelaphini, size 3a	-1.655	0.057
13490	Tragelaphini, size 3a	-2.473	-0.374
21035	Equidae, size 3b	1.376	-0.776
68	Equidae, size 3x	1.556	-0.981
76	Equidae, size 3x	1.201	1.252
408	Equidae, size 3x	1.332	-1.297
638	Equidae, size 3x	1.455	-0.018
1352	Equidae, size 3x	1.351	0.366
1764	Equidae, size 3x	2.05	-0.985
2840	Equidae, size 3x	1.528	0.414
3673	Equidae, size 3x	1.258	-0.128
4942	Equidae, size 3x	0.721	0.574
5117	Equidae, size 3x	1.553	-1.024
5256	Equidae, size 3x	1.621	0.869
6104	Equidae, size 3x	1.76	-1.483
6891	Equidae, size 3x	1.552	-1.08
7463	Equidae, size 3x	1.765	0.525
10746	Equidae, size 3x	1.135	-0.05
15507	Equidae, size 3x	1.405	-0.171
160	*Equus* , size 3x	1.67	0.812
700	*Equus* , size 3x	1.617	0.615
720	*Equus* , size 3x	1.368	-1.612
3388	*Equus* , size 3x	1.283	-1.521
3934	*Equus* , size 3x	1.602	-0.678
66	*Eurygnathohippus, size 3x*	1.344	-0.635
102	*Eurygnathohippus, size 3x*	1.185	0.62
865	*Eurygnathohippus, size 3x*	1.997	-1.364
2871	*Eurygnathohippus, size 3x*	1.476	-1.855
3664	*Eurygnathohippus, size 3x*	1.171	-0.942
3905	*Eurygnathohippus, size 3x*	0.908	-0.66
5762	*Eurygnathohippus, size 3x*	1.236	-1.936
19677	*Eurygnathohippus, size 3x*	1.295	-2.312
6369a	*Eurygnathohippus, size 3x*	-0.019	-2.657
6369b	*Eurygnathohippus, size 3x*	1.555	-2.762
6291	Rhinocerotidae, cf *Ceratotherium*	2.224	-0.58
5873	Elephantidae	1.611	-2.485
8512	Elephantidae	1.973	-2.481
KJ-95	*Deinotherium* sp	-10.616	-2.37
KNM KJ 189	*Deinotherium* sp.	-7.556	-2.292

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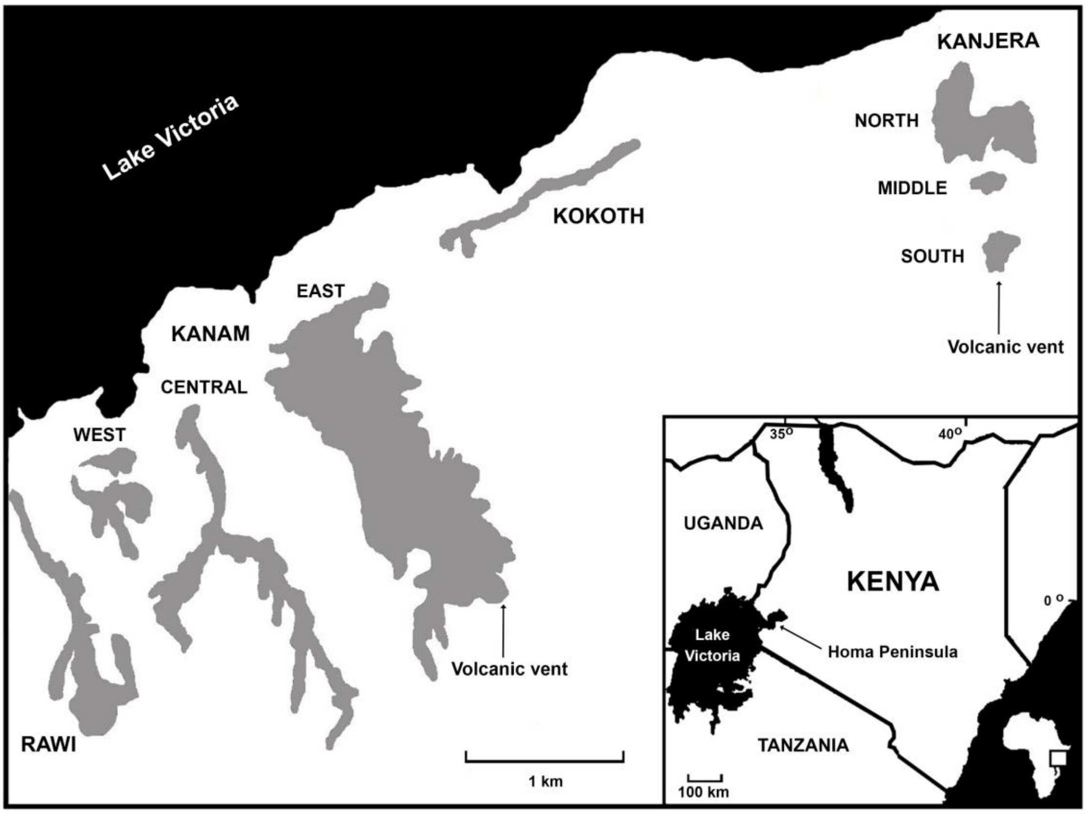
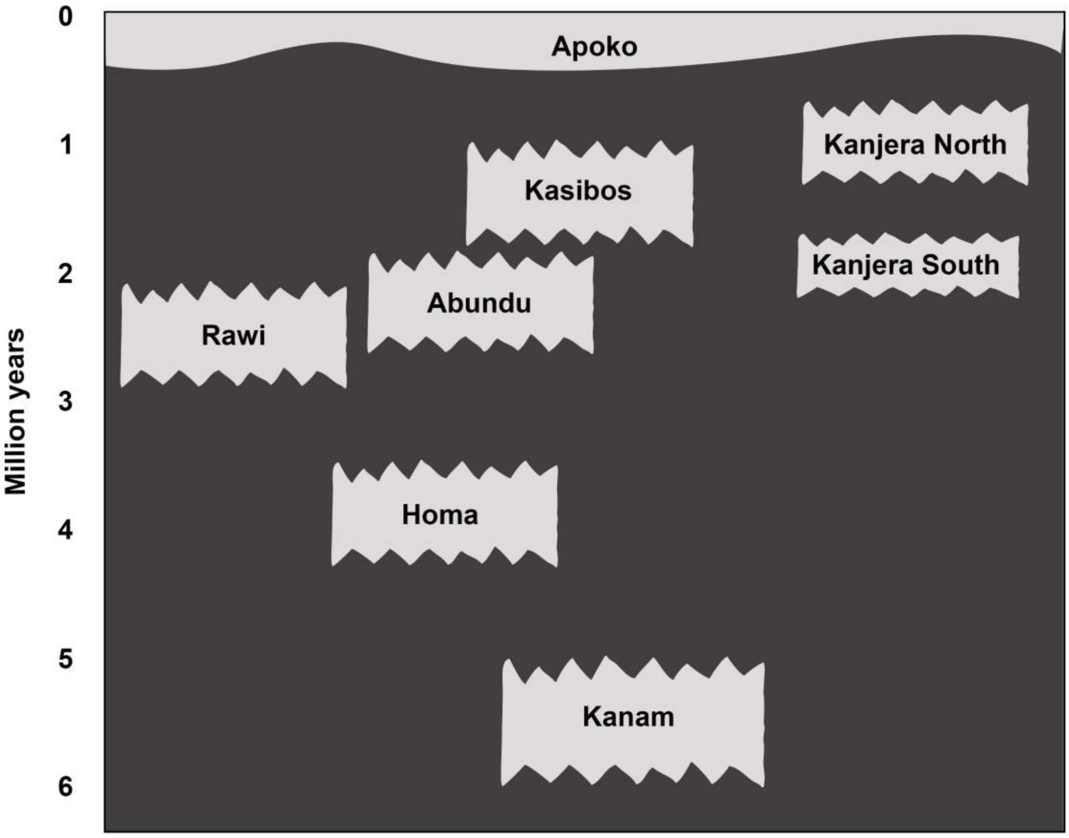
Figure Captions

Figure 1. Map showing the Homa Peninsula localities discussed in the text (after Pickford, 1984).

Figure 2. Schematic composite stratigraphy of sedimentary formations discussed in the text. The numerical scale on the right shows the approximate age of units in millions of years (before present).


Lake Victoria
KANJERA
NORTH
MIDDLE
SOUTH
Volcanic vent
KOKOTH
EAST
KANAM
CENTRAL
WEST
RAWI
Volcanic vent
1 km
35°
40°
UGANDA
KENYA
0°
Lake Victoria
Homa Peninsula
TANZANIA
100 km


0
1
2
3
4
5
6
Million years
Apoko
Kanjera North
Kasibos
Kanjera South
Abundu
Rawi
Homa
Kanam