

12. The Environmental Context of Oldowan Hominin Activities at Kanjera South, Kenya

Thomas W. Plummer*
Department of Anthropology
Queens College, CUNY and NYCEP
65-30 Kissena Blvd
Flushing, NY 11367
USA
thomas.plummer@qc.cuny.edu

Laura C. Bishop
Research Centre in Evolutionary Anthropology and Palaeoecology
School of Natural Sciences and Psychology
Liverpool John Moores University
Byrom Street, Liverpool, L3 3AF
United Kingdom
L.C.Bishop@ljmu.ac.uk

Peter W. Ditchfield
Research Laboratory for Archaeology, 6 Keble Road
Oxford, OX1 3QT
United Kingdom
peter.ditchfield@archaeology-research.oxford.ac.uk

Joseph V. Ferraro
Department of Anthropology
Baylor University
One Bear Place
Waco, TX, 76798
USA
joseph_ferraro@baylor.edu

John D. Kingston
Department of Anthropology, Emory University
1557 Pierce Drive
Atlanta, GA 30322
USA
jkingst@emory.edu

Fritz Hertel
Department of Biology
California State University Northridge
18111 Nordhoff Street

* Address for correspondence: thomas.plummer@qc.cuny.edu

Northridge, CA 91330-8303
USA
fritz.hertel@csun.edu

David R. Braun
NSF-IRFP, Department of Archaeology
University of Cape Town,
Rondebosch 7701
South Africa
dbraun@uct.ac.za

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Abstract

The earliest archaeological traces and two new hominin genera (*Homo* and *Paranthropus*) appear in the late Pliocene of Africa. These first appearances may reflect novel hominin adaptive responses to shifting resource bases over geological time and/or an increasingly seasonal distribution of food over the annual cycle. Whereas regional environmental change has been documented during the Plio-Pleistocene of East Africa, it is difficult to resolve relative proportions of specific habitats at a given place and time, how these may have changed over time, and the explicit nature of particular habitats. Detailed reconstructions of paleohabitats based on paleontological, geological and geochemical evidence are necessary in order to better understand the interplay between environmental change and hominin biological and behavioral evolution.

Reconstruction of the habitats in which archaeological sites were formed provides a window on habitat utilization by early *Homo*, independent of inferred hominin adaptations to specific environmental settings based on hominin morphology or the postmortem distribution of hominin fossils. Here we report on the paleoenvironmental setting of the ca. 2.0 Ma archaeological occurrences at Kanjera, southwestern Kenya. Sedimentological analysis indicates that the site was formed in an alluvial fan, probably near the margin of a lake. Isotopic analysis of pedogenic carbonates indicates that the site complex was formed in an open habitat. Bovid dietary category and taxonomic representation demonstrates that a preponderance of animals grazed and preferred open habitats. Site formation occurred in a grassland-dominated ecosystem, rather than an isolated patch of grassy vegetation within a more wooded setting.

12.1 Introduction

The late Pliocene (ca. 1.95–3.0 Ma) of Africa saw important developments in the evolutionary history of African environments. Environmental change driven by global cooling and drying (Vrba 1985, 1995; Prentice, Denton 1988; deMenocal 1995, 2004), increased global climatic variability (Potts 1998), as well as regional tectonic uplift (Partridge et al. 1995; Sepulchre et al. 2006) appear to have transformed the relatively wooded ecosystems found at many Late Miocene and Early Pliocene sites into complex mosaics incorporating larger amounts of C₄ grasses adapted to warm, dry conditions (WoldeGabriel et al. 1994; Leakey et al. 1995; Wesselman 1995; Reed 1997; Bobe and Behrensmeyer 2004; Bonnefille et al. 2004; Kingston and Harrison 2007). This increase in xerophytic vegetation is reflected in morphological changes across many African large mammal lineages related to the consumption of tougher and possibly more abrasive foods, as well

as the dispersal of the Eurasian grazer *Equus* across Africa around 2.3 Ma (Coppens and Howell 1976; Turner and Wood 1993; Wood 1995; Bobe and Behrensmeyer 2004).

Evolutionary change within the Hominini during the Late Pliocene is coincident with, and may be causally related to, these environmental changes (Vrba 1985). The last gracile australopithecines (*A. africanus* and *A. garhi*) disappeared between 2.4–2.5 Ma, and *Paranthropus* and *Homo* made their first appearances between 2.3 and 2.7 Ma (Walker et al. 1986; Hill et al. 1992; Wood 1992; Kimbel 1995; Kimbel et al. 1996; White 2002). Profound changes in hominin behavior, including the first manufacture of stone-tools, large mammal butchery, transport of toolstone and carcass parts, and the discard of lithic and faunal debris at locales now recognized as archaeological sites attributed to the Oldowan Industrial Complex began ca. 2.6 Ma (Isaac 1978; Rogers et al. 1994; Semaw et al. 1997; de Heinzelin et al. 1999; Roche et al. 1999; Plummer 2004; Dominguez-Rodrigo et al. 2005). The dental and gnathic specializations seen in *Paranthropus* and the appear-

ance of Oldowan sites may reflect novel hominin adaptive responses to both a changing resource base over geologic time as well as an increasingly seasonal distribution of food over the annual cycle (Foley 1987; Potts 1998; Plummer 2004).

The postcranial skeletons of the oldest hominin(s) attributable to the genus *Homo* (e.g. *H. habilis*) are poorly known (Wood 1992; Wood and Collard 1999; Dunsworth and Walker 2002). In contrast, the African hypodigm of *H. erectus* sensu lato includes several partial skeletons, and documents a tall, narrow body form proportioned similarly to modern humans living in hot, open, dry environments (Ruff 1991, 2000). Combined with an essentially modern nose configuration (Franciscus and Trinkaus 1988) and the ability to endurance run (Carrier 1984; Bramble and Lieberman 2004; Hilton and Meldrum 2004), it is likely that this taxon thermoregulated like humans, and was capable of prodigious sweating, insuring efficient cooling during bouts of high activity during the heat of the day (Foley 1987). The possibility that forms of *Homo* preceding *H. erectus* exhibited femoral elongation (Hausler and McHenry 2004), the ability to endurance run (Bramble and Lieberman 2004) and a modern nose configuration (Franciscus and Trinkaus 1988) may indicate that earlier members of the genus were also increasingly utilizing open, arid settings. Indeed, a number of researchers have suggested that the evolution of the genus *Homo* was climatically forced by African aridification (Vrba 1985; Stanley 1992; deMenocal 1995). Definitive evidence of Plio-Pleistocene hominin activities within such open settings has thus far eluded paleoanthropologists. The location of hominin fossils themselves may not provide a clear indication of habitat preference during life, as taphonomic factors unrelated to hominin behavior can affect the preservation and distribution of fossils (Behrensmeier, Hill 1978; Brain 1981; White 1988; Lyman 1994). Moreover, paleoenvironmental reconstructions at many localities frequently lack the resolution necessary to ascertain the habitat structure present during the time periods of interest. Undisturbed archaeological sites provide a record of hominin activity at a defined locale. By reconstructing the environmental context of an archaeological occurrence, a clear association between hominin activity and environmental context can be made. Here we present our reconstruction of the paleoenvironmental context of hominin activities at the Late Pliocene Oldowan site of Kanjera South, Kenya. Both *Homo* and *Paranthropus* are known from East Africa during this time. As discussed in detail in Plummer (2004), we feel it is unlikely that *Paranthropus* produced Oldowan tools and so ascribe the activities at Kanjera to an undetermined species of early *Homo*.

12.2 Physical Setting

The Late Pliocene Oldowan occurrences at Kanjera South (0°20'24" S, 34°32'16" E) are found on the northern margins of the Homa Mountain Carbonatite Complex, Homa Peninsula, southwestern Kenya (Figure 12.1). The history of paleoanthro-

pological research on the Peninsula is summarized in Pickford 1984; Behrensmeier et al. 1995; Plummer and Potts 1995; Ditchfield et al. 1999. Volcanic activity began with doming of the central portion of the edifice in the Late Miocene and shifted from the center to peripheral vents during the Pliocene and Pleistocene (Saggerson 1952; Le Bas 1977). Today, the heavily eroded edifice of Homa Mountain is 1754m high, approximately 600m above the level of Lake Victoria. The mountain's lower slopes are incised by a radial drainage system exposing Late Miocene through recent sediments (Kent 1942; Pickford 1984; Ditchfield et al. 1999). Evergreen woodland and bushes cover portions of the upper slopes undisturbed by human activity.

Fossiliferous deposits outcrop at Kanjera in three areas, termed the Northern, Middle and Southern Exposures (Behrensmeier et al. 1995) (Figure 12.1). The deposits in the North and South are members of the Kanjera Formation (Fm); the Middle Exposures deposits postdate the others and have not been formally described. The Oldowan archaeological occurrences are known from the Southern Member of the Kanjera Fm, discussed in more detail below.

12.3 The Chrono- and Litho-Stratigraphy of Kanjera South

The Southern Member of the Kanjera Formation has six Beds, from oldest to youngest KS-1 to KS-6 (Behrensmeier et al. 1995; Ditchfield et al. ms). The Oldowan archaeological occurrences are largely restricted to Beds KS-1 to KS-3. A combination of biostratigraphy (co-occurrence of *Equus* sp., the suid *Metridiochoerus andrewsi* and the proboscidean *Deinotherium* sp.) as well as magnetostratigraphy (the presence of the Olduvai subchron [1.77–1.95 Ma] in Beds KS-5 and KS-6) indicate that the archaeological occurrences must predate the base of the Olduvai Subchron at 1.95 Ma (Plummer et al. 1999; Ditchfield et al. ms). Here we only discuss Beds relevant to the Oldowan occurrences, KS-1 to KS-4 (Figure 12.1).

The base of KS-1 has not been seen, but the unit is at least 4m thick. Lower KS-1 is a thick, poorly bedded, poorly sorted agglomerate. Upper KS-1 exhibits evidence of alluvial reworking, beds up to 50 cm thick and weak to moderate pedogenic alteration of the pyroclastic parent material.

KS-2 has a poorly defined base that is often gradational from the upper part of KS-1. KS-2 is a moderately pedogenically altered, micaceous, fine sand to silt, with abundant granule to pebble grade clasts. At several horizons in Upper KS-2 there are thicker, laterally discontinuous pebble conglomerates (KS-2 CP) lacking channelization and showing very weakly erosive bases.

KS-3 is a clay-rich medium to fine grained sand with an often strongly bioturbated base, which, along with other soft sediment deformation, points to a wetter depositional environment than the underlying beds. It shows moderate to well-developed paleosols. Towards the northern part of

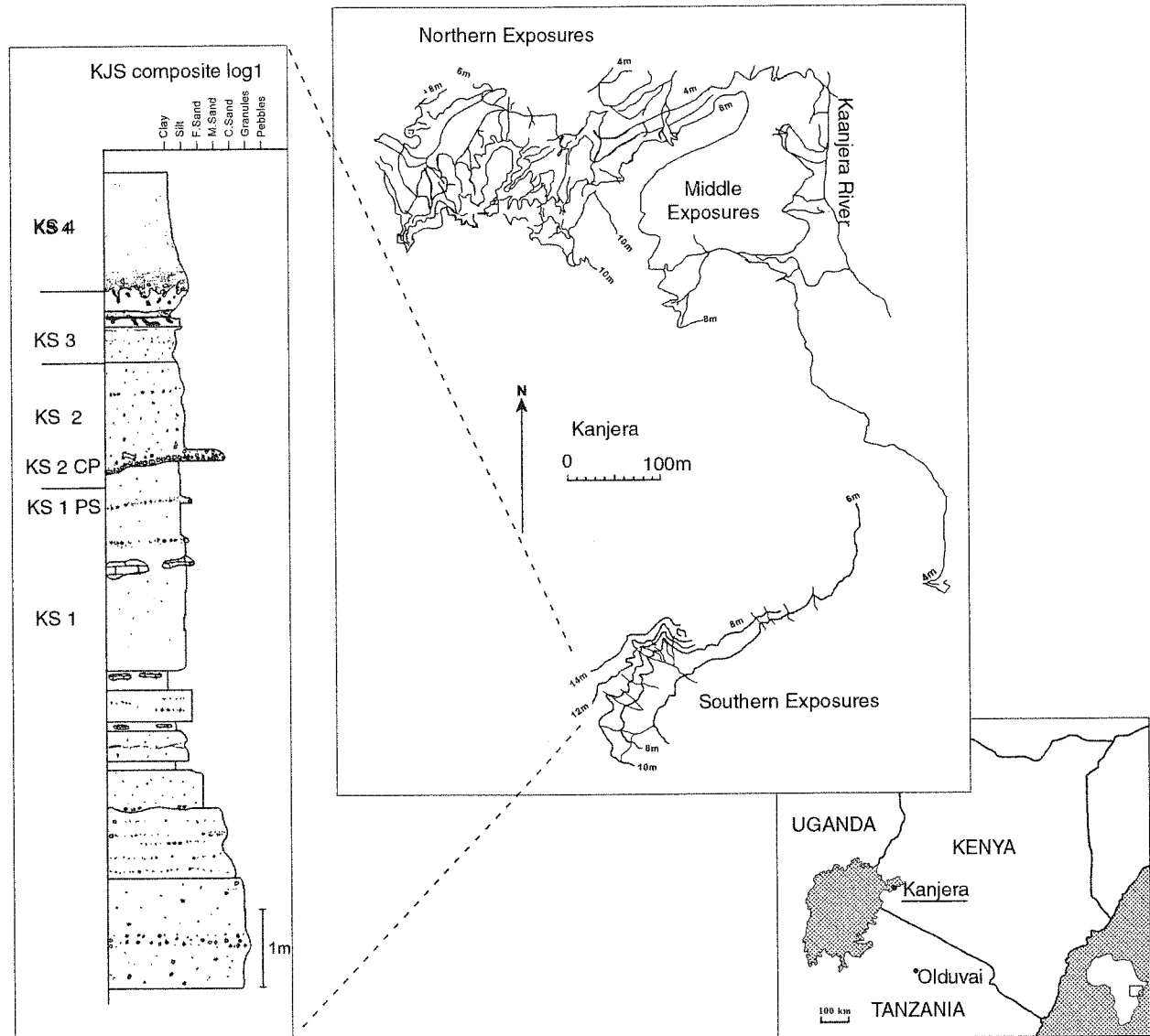


FIGURE 12.1. Placement map and stratigraphic diagram showing the location of Kanjera in southwestern Kenya and of the Southern Exposures at Kanjera. Oldowan artifacts and zooarchaeological fauna are found in beds KS-1 to KS-3.

the Southern Exposures a moderately sized (approximately 1m deep and 2m wide) KS-3 channel feature displaying clear crossbedding with flow directions to the North is present.

KS-4 is a grey to brown, plastic, fine-grained, silty clay with occasional pedogenically altered horizons. It contains few terrestrial fossils and artifacts; however otoliths, fish teeth and fresh water gastropods are relatively common. The pedogenically altered layers become more common in the upper portion of the bed. The entire KS-1 to KS-4 sequence has yielded pedogenic carbonate nodules suitable for isotopic analysis.

12.4 Interpretation of the KS-1 to KS-4 Depositional Environment

Basal KS-1 was probably deposited in one or more relatively large flows of remobilized pyroclastic material possibly as lahars (volcanic debris flows) from the Homa Mountain complex in the South towards a depositional center in the North. These show little internal stratification and no pedogenic development, thus it is likely that they represent rapid, possibly catastrophic deposition across a preexisting landscape. By contrast the well bedded, better sorted and pedogenically modified upper parts of KS-1 yielding artifacts and fossils

represent slow reworking of the pyroclastic flow deposits by ephemeral streams running across the fan of the original pyroclastic flows. KS-2 represents a further development of this mode of deposition with more widespread and better developed pedogenesis. Stream flow through the area was restricted to poorly channelized shallow streams that were only weakly erosive into the interchannel deposits. This indicates the area probably had a low depositional slope and represents deposition in a low angle distal fan/lake flat setting. KS-3 documents a wetter depositional environment, reflected both in the style of pedogenic alteration and the increased hippopotamid representation in the fossil assemblage (Table 12.1). The channel feature seen in KS-3 is the first noted in the stratigraphic sequence. KS-4 represents a continuation of this wetter trend as lake deposits transgressed from North to South over the area, sealing the archaeological occurrences. This lake system was periodically dry enough for minor palaeosol development to take place at multiple horizons. These horizons become more common in the upper part of the KS-4 sequence, likely documenting a shallowing/drying trend.

12.5 The Oldowan Excavations

Since 1995 the Homa Peninsula Paleoanthropological Project has undertaken a number of excavations across the gently sloping outcrops of Kanjera South (Excavations 1, 2 and 5; 169m², 15m² and 4m² in size, respectively). Excavation 1 samples KS-1 through KS-3, whereas the other excavations only sample KS-3. Fossil and artifact-bearing horizons were dug with awls and dental picks in 5 cm spits. A Topcon laser theodolite was used for the precise determination of specimen 3D coordinates and in contour mapping. Item dip and orientation was measured with Brunton compasses, and sediments were dry sieved through a 1 mm mesh. To date, thousands of lithic and fossil specimens have been recovered (Table 12.1). Taphonomic and zooarchaeological analyses indicate that the site assemblages

formed predominantly through hominin activity (Plummer et al. 1999; Ferraro 2007; Ditchfield et al. ms.).

12.6 Paleoenvironmental Indicators

The stable isotopic analyses of paleosol carbonates and analysis of the archaeological fauna can be used to investigate the paleoenvironmental context of hominin activities at Kanjera. Stable isotopic analysis of pedogenic carbonates at archaeological sites provides an indication of vegetation structure at points on the landscape where archaeological accumulations formed (Sikes 1994; Sikes et al. 1999). Results of stable isotopic analysis of pedogenic carbonates from the archaeological horizons are indicative of habitats with a significant (>75%) proportion of C₄ plant biomass (Plummer et al. 1999; Plummer et al. ms). These values are consistent with dwarf shrub grassland, wooded grassland or open grassland habitats (Sikes 1994). The only other Oldowan site with published stable isotopic data of pedogenic carbonates is FLK I Level 22 (FLK Zinj), from Bed I Olduvai Gorge, Tanzania (Cerling and Hay 1986; Sikes 1994). The stable isotopic composition of carbonates from the Zinj archaeological horizon is indicative of a wooded (riparian woodland or grassy woodland) setting. Thus, isotopic data from these two sites suggest that Oldowan hominins were discarding archaeological debris in both relatively open as well as wooded contexts.

Analysis of archaeological fauna provides an additional method of assessing the paleoenvironmental context of hominin activities (Tables 12.1 and Tables 12.2). In contrast to the locus specific signal from stable isotopic analysis of pedogenic carbonates, macromammalian taxa range broadly during life (Estes 1991; Kingdon 1997) and so provide information on the variety of habitats within a region. The relatively small faunal sample from KS-1 is composed primarily of grazing or mixed feeding ungulates probably (based on modern analogues) favoring relatively open settings, particularly the alcelaphine

TABLE 12.1. Summary of excavated materials from Kanjera South

Bed	Total NISP*	Macromammal NISP	Macromammal MNI	Principal fauna (%NISP, %MNI)	Lithics
KS-1	982	975 (525)	25	Bovid (92.4, 72.0), Equid (4.4, 8.0), Suid (1.5, 8.0), Hippo (0.2, 4.0)	179
KS-2	2190	2153 (886)	40	Bovid (82.6, 67.5), Equid (11.6, 10.0), Suid (0.9, 5.0), Hippo (1.0, 2.5)	2533
KS-3	491	470 (172)	16	Bovid (77.9, 68.8), Equid (4.7, 6.3), Suid (0.6, 6.3), Hippo (14.0, 12.5)	171

*NISP refers to the number of identifiable specimens (Lyman 1994). Here "Total NISP" reflects the sum of specimens recovered with coordinate data. Tens of thousands of non-identifiable bone fragments <2cm are not included in the present study. MNI refers to the minimum number of individual animals necessary to account for the bones in the assemblage. Fossil from conglomeratic facies (CP levels of Plummer et al. 1999) are poorly preserved and are likewise excluded from these counts. Macromammals weigh > 5 kg. Macromammal NISP values are total sums of specimens identified to Linnean class and, in parentheses, the sum of specimens identified beyond class. %NISP and %MNI include macromammals only. Faunal data from Ferraro (2007). Lithic data from Braun (2006), also excluding artifacts from the CP levels.

TABLE 12.2. Macromammalian fauna from Excavation 1, by bed. Several important surface collected taxa noted as well

Taxonomic group	KS-1	KS-2	KS-3	KS-1 and KS-2 Surface
Cercopithecidae				
Cercopithecine indet.		X		
<i>Cercopithecus sp.</i>		X		
<i>Theropithecus sp.</i>		X		
Carnivora				
Felidae, size 3				X
Felidae, size 2		X		
Hyaenidae		X		
<i>Crocuta cf. dietrichi</i>	X			
Suidae				
Suidae, size 2	X		X	
Suidae, size 3a	X			
<i>Metridiochoerus andrewsi</i>				X
<i>Metridiochoerus modestus</i>		X		
Hippopotamidae	X	X	X	
Giraffidae		X		
Bovidae				
Tragelaphini, size 3a		X		
Reduncini, size 1		X		
Reduncini, size 2		X	X	
<i>Kobus sp.</i>		X	X	
Hippotragus sp. size 3		X		
Alcelaphini cf. <i>Parmularius altidens</i>	X	X	X	
Alcelaphini, size 3b	X	X	X	
<i>Antidorcas recki</i>	X	X	X	
Equidae			X	
<i>Equus sp.</i>	X	X		
<i>Eurygnathohippus sp.</i>	X	X		
Rhinocerotidae		X		
Proboscidea				
Elephantidae			X	
<i>Deinotherium sp.</i>				X

Parmularius cf. altidens, the antelope *Antidorcas recki* and the equid genera *Equus* and *Eurygnathohippus*. The recovered remains of *Struthio* (ostrich) and a lagomorph (cf. *Lepus*) also suggest grassland habitats.

The largest and most diverse faunal sample is known from KS-2. Monkeys attributable to the genera *Theropithe-*

cus and *Cercopithecus* reflect the presence of C₄ vegetation as well as C₃ food and shelter, respectively. The giraffid and tragelaphine bovid fossils indicate the proximity of woodland, as perhaps does the suid *Metridiochoerus modestus* (Bishop 1999). The bovid *Hippotragus* may reflect the ecotone between C₃-rich and C₄-rich habitats, whereas the

reduncine bovids are suggestive of seasonally waterlogged (edaphic) grassland. The presence of standing water is consistent with the recovery of fish, crocodile and hippopotamus remains.

The limited KS-3 sample also exhibits a preponderance of grassland indicators as well as evidence of rising lake levels noted in the discussion of the depositional environment. In addition to antilopines, alcelaphines, and equids presumably signaling secondary grasslands, two different reduncine bovids suggest the presence of edaphic grass. Hippopotamid fossils are more common in KS-3 than underlying Beds, which corresponds with the increasing dominance of the lake in the landscape during KS-3 times.

Although there are macromammal indicators of multiple habitats in each faunal assemblage, the representation of taxa preferring grassland settings is most salient. In the rest of our paleoecological discussion we will focus on bovids, which provide the bulk of the macromammal sample by Bed (78–92%; Table 12.1). Zooarchaeological analysis indicates that the bovids were predominantly collected by hominins (Ferraro 2007). The extent to which hominin foraging practices would have biased paleoenvironmental reconstructions from these samples, however, is unclear. Certainly, issues of processing decisions, transport dynamics, etc., may result in discordance between initially-acquired and subsequently-deposited faunal assemblages. Subsequent biotic and abiotic taphonomic biases may further modify assemblage compositions. Lastly, and perhaps most importantly, the extent to which Early Stone Age hominin prey preferences track local faunal abundances remain wholly unknown. On the other hand, analysis of death assemblages from a range of modern African predators demonstrates that relatively accurate habitat reconstructions can be made from them — specifically when dealing with the presence/absence of taxa (Reed 1997). The wide array of taxa from Oldowan sites (Potts 1988; Plummer 2004) suggests that Oldowan hominins had a broad search image, and that their carcass collecting behavior may provide an accurate paleoenvironmental signal.

The frequency of the tribes Alcelaphini and Antilopini within a bovid sample is often used as a grassland indicator termed the alcelaphine plus antilopine criterion, or AAC (Vrba 1980). Comparison with modern analogues suggests that sites with AAC values of greater than 60% are open (frequently grassland-dominated) settings, whereas those with AAC values less than 30% have considerable bush or tree cover (Vrba 1980; Kappelman 1984; Potts 1988). Whether calculated using NISP or MNI, alcelaphines and antilopines at Kanjera South greatly outnumber members of the other bovid tribes, suggesting that the local ecosystem was grassland-dominated.

Shipman and Harris (1988) elaborated on the AAC, proposing a method of habitat reconstruction utilizing the frequency of alcelaphines and antilopines (AA) as well as the summed frequencies of reduncines and bovines (RB) and tragelaphines and aepycerotines (TA). They demonstrated a good correspondence between bovid tribal representation and regional habitat representation in modern wildlife areas

and extended this relationship to the fossil record. Wildlife areas with high AA frequencies tend to be arid and often have a relatively large proportion of open habitats (Figure 12.2). Parks with high TA frequencies generally also have low rainfall but were dominated by a variety of woodland/bushland habitats. Parks with high RB frequencies tend to have high rainfall and generally include riparian grassland and woodland. Figure 12.2a presents the ternary diagram for the modern wildlife areas discussed by Shipman and Harris (1988). Figure 12.2b presents a plot of the Kanjera tribal values, by Bed, compared with relevant modern and fossil samples. The Kanjera samples sort with several modern open or grassland-dominated ecosystems (e.g., Serengeti, Tanzania), consistent with the large proportion of grazers. Also grouped with them are the Olduvai site samples from the driest portion of the Bed I sequence (FLK NI L/4–6) (Potts 1988; Fernandez-Jalvo et al. 1998). A number of analyses have suggested that the FLK NN I levels from Bed I Olduvai were deposited under moist conditions (Potts 1988; Plummer and Bishop 1994) and here they plot out with well wooded areas having high frequencies of reduncines (e.g. Lake Nakuru, Kenya; Arli, Burkina Faso). FLK I Zinj (L/22), the only Bed I Olduvai archaeological site assemblage universally viewed as having been predominantly formed through hominin activity, is plotting with Fina, Mali and reasonably close to Kainji, Nigeria, both wet, well-wooded areas with reasonably high AA and RB frequencies. As noted with the analysis of pedogenic carbonates, the depositional context at Kanjera seems to have been in a more open setting than that documented for FLK Zinj. The Lake Turkana Basin provides additional paleontological and archaeological samples from multiple localities. Some of the largest paleontological samples as well as several Oldowan occurrences have been found in the Late Pliocene deposits of the Shungura Fm, Ethiopia (Howell et al. 1987; Bobe and Eck 2001; de la Torre 2004). Members E through G span the interval from roughly 1.9 to 2.4 Ma and *Homo* as well as *Paranthropus* appear to be present through much of this sequence (Suwa et al. 1996). Oldowan archaeological sites in Member F are approximately 2.3 Ma, and seem to be near ecotones between riparian woodland and forest and more open savanna (Howell et al. 1987; de la Torre 2004). Although the surface collected Shungura Fm faunas, deposited in sediments from a large, meandering river system, may not be directly comparable to the archaeological faunal assemblages from Kanjera, they do suggest paleoenvironmental settings considerably different than those present during KS-1 through KS-3 deposition (Figure 12.2b). The low frequencies of alcelaphines and antilopines are in stark contrast to what has been recovered at Kanjera South. The Member E and F faunas have very high TA frequencies, suggesting a considerable amount of dry bushland or woodland. Lower Member G appears a bit wetter with a higher frequency of reduncines. Upper Member G, roughly coeval with the Kanjera occurrences, is dominated by reduncines, and still has a reasonably high TA frequency. This is suggestive of a near-water setting with extensive riparian grass-

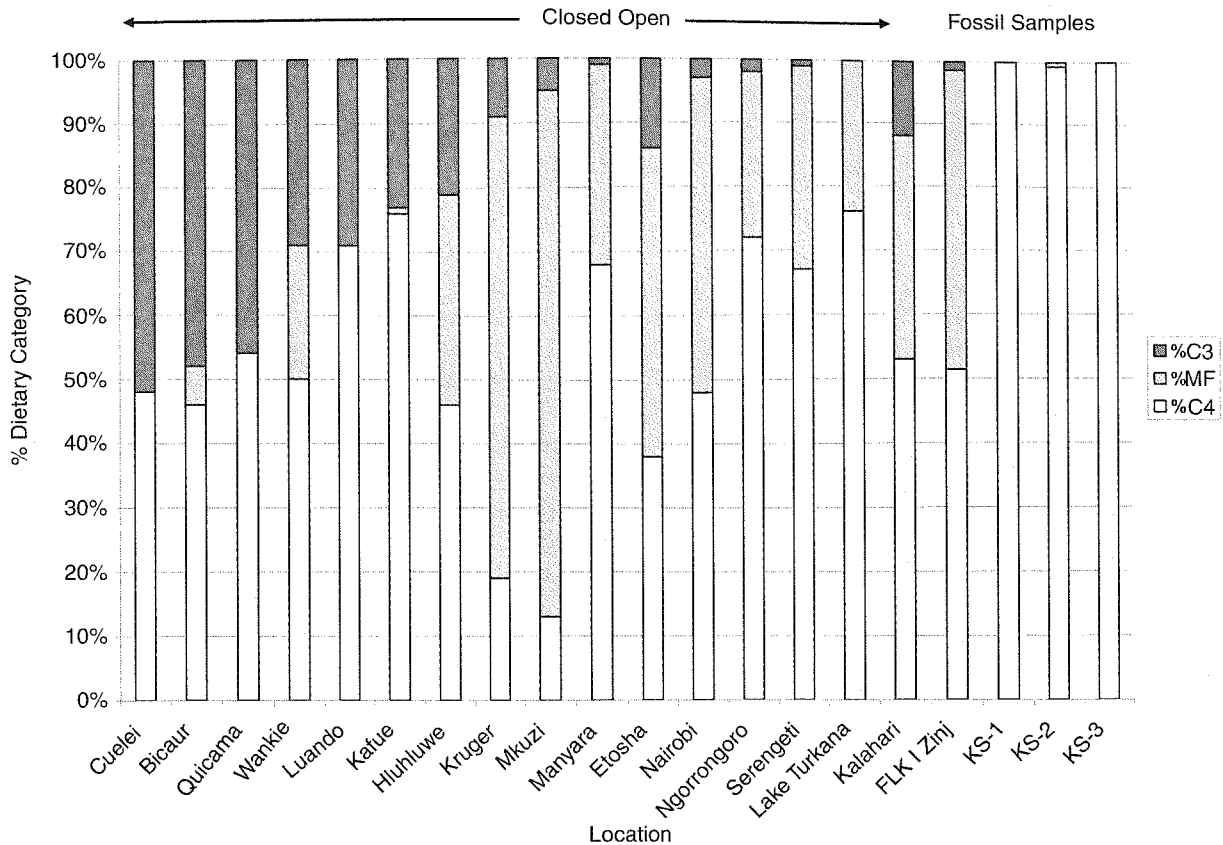


FIGURE 12.3. Stacked bar charts showing the frequency of different bovid dietary categories for parks with low frequencies of Alcelaphini and Antilopini and a high proportion of C_3 vegetation (closed) and parks with high frequencies of Alcelaphini and Antilopini and a low proportion of C_3 vegetation (open). Dietary category frequencies for four fossil assemblages (FLK I Zinj and Kanjera bovid assemblages by bed) are shown on the right side of the plot. The Kanjera assemblages are dominated by grazing bovids, whereas the FLK I Zinj assemblage exhibits a higher frequency of bovids with a mixed browse and graze diet. Modern data from Sponheimer and Lee-Thorpe (2003), FLK I Zinj NISP data from Bunn and Kroll (1986) and Kanjera NISP data are from Ferraro (2007).

lands and some woodland, with drier bushland/woodland found away from the main axis of the river. Comparisons between Kanjera South, Bed I Olduvai and the Omo Shungura Fm illustrate the diversity of environments inhabited by early *Homo* in the Late Pliocene.

Carbon stable isotope data from tooth enamel provides an additional method of paleoenvironmental reconstruction complementing analyses discussed above. Sponheimer and Lee-Thorpe (2003) defined three dietary classes (C_3 consumers, C_4 consumers, mixed feeders) using isotopic data and a literature review of bovid diets and habitat preferences. In their scheme, C_3 consumers eat 80% or more C_3 vegetation, C_4 consumers eat 80% or more C_4 vegetation, and bovids with diets intermediate between these extremes are mixed feeders (Figure 12.3). These isotopically-defined dietary boundaries were then used to categorize the diets of modern African bovid tribes (e.g. Alcelaphini are C_4 consumers, Aepycerotini are mixed feeders and Tragelaphini are C_3

consumers). The relative frequency of bovid tribes from a particular wildlife refuge are transformed into frequencies of different consumer types, with percentages of C_3 consumers being used to distinguish parks with a high percentage of open versus closed habitat. They found that relatively "open" wildlife areas had a bovid fauna with less than 15% C_3 consumers, whereas parks with a substantial amount of woodland or bushland habitat always had more than 20% C_3 consuming bovids.

Carbon stable isotopic data have been obtained from the teeth of the full spectrum of taxa from Kanjera (Plummer et al. ms.) allowing us to place our data into Sponheimer and Lee-Thorpe's (2003) framework. The Kanjera bovid sample is composed almost entirely of C_4 consumers, consistent with other indications of open habitat for the locality. This strong "grass" dietary signal is not simply the result of hominin selectivity for several taxa of grazing bovids. Taxa that frequently are mixed feeding at other localities (e.g. *A. recki*) are grazing at Kanjera,

and taxa that tend to browse elsewhere (e.g. the tragelaphines) are mixed feeding with a strong grass component. Using the relationship between tribe and diet to convert the FLK I Zinj bovid assemblage into dietary categories suggests that the Zinj bovid assemblage was also not drawn from a densely wooded area, but that the relatively high frequency of mixed feeders signals a greater availability of C_3 vegetation than was found in the region around Kanjera during KS-1 to KS-3 deposition.

12.7 Summary and Discussion

Multiple lines of evidence indicate that Late Pliocene Kanjera was a lightly-wooded to open grassland habitat, with a lake to the North and presumably bushes and woods lining nearby hills and perhaps some drainages. Wash from the foothills of Homa Mountain drained toward the lake, burying faunal and lithic materials on a generally low-energy alluvial plain during KS-1 through KS-3 deposition. The lake transgressed from North to South through time, completely covering the locality during KS-4 deposition (Behrensmeyer et al. 1995; Ditchfield et al. ms).

Paleoenvironmental information is playing an increasingly important role in interpreting the pattern of hominin biological and behavioral evolution. Faunal, isotopic and pollen data suggest that Plio-Pleistocene ecosystems were more heterogeneous and frequently contained more C_4 vegetation than those of the early Pliocene ecosystems (Reed 1997; Bobe and Behrensmeyer 2004; Kingston and Harrison 2007). Prominent hypotheses for how global climatic change impacted biotic evolution in Africa emphasize shifts in the relative proportion of C_4 plants (particularly grasses) versus C_3 woody vegetation in floral communities (deMenocal 1995; Behrensmeyer 2006). The morphology of fossils of the genus *Homo* from at least the beginning of the early Pleistocene shows morphological adaptations to open, arid environments. Yet definitive evidence of grassland dominated settings, and of hominin activities within open habitats has remained elusive.

Our limited review of several Plio-Pleistocene faunal assemblages and more extensive reviews elsewhere (e.g. Reed 1997; Bobe and Behrensmeyer 2004) illustrate a high degree of environmental variability across East Africa during the Plio-Pleistocene. The paleoenvironmental significance of research at Kanjera South is that it provides the first clear documentation of recurrent hominin activities in an open habitat within a grassland-dominated ecosystem, confirmed by the isotopic geochemistry of paleosols and stable isotope analysis reconstruction of faunal diet. This complements work at Olduvai, where sites such as FLK Zinj appear to have formed in a woodland, and the Plio-Pleistocene settings during Shungura Fm deposition, where archaeological occurrences have been found near woodland/savanna ecotones and where the presence of edaphic grassland and/or woodland was more salient than secondary grassland. Several important things are suggested by these

data. First, there seems to be a great deal of unevenness in the distribution of secondary grassland, which is likely to have been a regionally variable phenomenon. Variability in habitat representation over geologic time, rather than a unidirectional increase in C_4 vegetation, may have been an important factor shaping hominin evolution (Potts 1998). Second, if these Late Pliocene archaeological sites reflect the range of settings occupied by one species of tool-using hominin, it would suggest that tool use buffered the effects of environmental variability by allowing hominins to expand the range of foods being acquired or acquire certain types of food more efficiently.

Finally, reconstructing the overall environmental context of Plio-Pleistocene ecosystems and the specific settings of archaeological site formation are important, because our understanding of Oldowan hominin habitat utilization impacts our consideration of hominin group size and cohesion, diet, degree of competition with carnivores on site, the place of hominins within the carnivore competitive hierarchy and the potential selective pressures important in transforming an early form of *Homo* into *Homo erectus* by 1.8 Ma (Foley 1987; Plummer 2004). The evidence from Kanjera South suggests that at least one species of the genus *Homo* was repeatedly utilizing an open setting, prior to the earliest evidence for the emergence of *H. erectus*.

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