Settlement Dynamics of the Middle Paleolithic and Middle Stone Age

Edited by Nicholas J. Conard

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PREFACE

At the 1994 meeting of the Society for American Archaeology in Anaheim, California, Fred Wendorf and I developed the idea of starting a commission to study Middle Paleolithic and Middle Stone Age settlement. We recognized several deficits in the discourse in Middle Paleolithic research. Too much attention was being paid to sites in caves and rockshelters while more attention needed to be directed to the systematic study of open-air settings and the use of the landscape by late pre-modem people. Far too often the information available on the Middle Paleolithic and Middle Stone Age served the purpose of building "straw man" arguments by which to highlight or in some case deny these hominids the cultural and behavioral "revolution" that many colleagues believe characterized the rise of fully modem human behavior with the advent of the Upper Paleolithic. We both were of the opinion that the study of the Middle Paleolithic and Middle Stone Age must be directed toward broader goals than simply serving to contrast and help define what followed this period.

The Middle Paleolithic and Middle Stone Age, which lasted several hundred thousand years, must be worthy of study in its own right as a source of information on the course of human evolution and as a means of documenting and seeking to understand the diverse patterns of behavior in the period immediately preceding and during the rise of anatomically and culturally modem people. Researchers need a stronger focus on patterns of settlement to bring existing data on technology, subsistence, mobility, social organization and other areas into clearer view. During the early 1990s many publications on these and other topics appeared, but few studies were published that focused directly on settlement and other broader issues of Middle Paleolithic and Middle Stone Age behavior. Both Prof. Wendorf and I agreed that the study of early systems of settlement provided a difficult and important challenge and that an attempt to address this question on a local, regional and global scale would help to advance the discourse in Paleolithic archaeology and improve our understanding of the course of human evolution.

With these goals in mind we proposed the founding of Commission of the International Union of Prehistoric and Protohistoric Sciences (UISPP) to study Middle Paleolithic and Middle Stone Age Settlement at a meeting of the UISPP in Tulcea, Romania in 1995. This proposal met a favorable response, and the first meeting of the newly defined Commisson 27 took place at the XIII Congress of the UISPP in Forli, Italy in September 1996. Two years later twelve of the papers presented at the symposium appeared in the proceedings of the congress in Forli. In January 1999 the Department of Early Prehistory and Quaternary Ecology of the University of Tübingen, Germany hosted the second meeting of Commission 27 on Middle Paleolithic and Middle Stone Age Settlement Systems. Here researchers delivered 30 papers and engaged in lively debate and discussion on issues of settle-

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CHAPTER 2

MIDDLE AND LATER STONE AGE SETTLEMENT PATTERNS IN THE CENTRAL RIFT VALLEY, KENYA: COMPARISONS AND CONTRASTS

STANLEY H. AMBROSE

Abstract. In the central Rift Valley of Kenya, Middle Stone Age (MSA) sites with extremely high artifact densities are concentrated at an altitude of 2,100-2,200 m. Based on ethnographic analogy with local hunter-gatherers, Isaac proposed a model of MSA settlement preference for the forest/savanna ecotone. This ecotone is currently located at an elevation of 2,300-2,400 m. The ecotonal settlement preference model has also been applied to the Holocene Later Stone Age (LSA). Archaeological and paleosol (fossil soil) stable carbon isotope evidence shows that the ecotone and the focus of human settlement rose from 1,940 to at least 2,400 m between the early Holocene wet phase and the middle Holocene dry phase. LSA and MSA settlement patterns during the driestperiod of the Holocene and during the Last Glacial cannot yet be securely characterized. During these times of decreased resource density and predictability the ecotonal settlement preference may have been abandoned, mobility and home range size increased, and regional intergroup interaction and exchange intensified. This change in socioterritorial organization should be reflected by a greater diversity of settlement locations and greater amounts of stone tool raw materials from distant sources. The limited evidence available for the MSA and LSA is consistent with this scenario but more research on environmental reconstruction, geochronology, and lithic source use is needed.

Résumé. *Dans la zone centrale de la Vallée du Rift, au Kenya, les sites du Middle Stone Age (MSA) montrant une densité artefactuelle très forte sont concentres a une altitude de 2,100-2,200 m. Par analogie ethnographique avec les chasseurs-cueilleurs locaux, Isaac a propose pour le MSA un modèle d'établissement préférentiel dans les ecotones de forêt/savanne. Cet ecotone est généralement situé a une altitude de 2.300-2,400 m. Le modèle de preference d'établissement a été egalement applique au Later Stone Age (LSA) du Holocene. Les témoins archéologiques, d'une part, et les teneurs en isotopes stables du carbone des paléosols (sols jossiles), d'autre part, indiquent que l'écotone et la concentration des établissements humains se sont déplacés de 1,940 m a au moins 2,400 m entre la phase*

humide du Holocene ancien et la phase sèche du milieu du Holocene moyen. Les modes d'établissements LSA et MSA ne peuvent encore être caractérisés de façon certaine pour la période la plus sèche du Holocène et durant le glaciaire derniec Durant ces periodes de densité et de prédictabilité des ressources decroissant, la préférence d'établissement ne pourrait plus avoir été dictée par l'écotone, la mobilité et la taille du territoirepourrait avoir augmenté et les échanges et interactions intergroupes à I'ichelle régionale s'est intensifié. Ce changement dans l'organisation socio-territoriale devrait se traduirepar une plus grande diversiti des lieux d'établissements etpar une quantité plus importante d'outils lithiques de matière premiere de provenance lointaine. Les témoins, peu nombreux, disponibles sur les sites MSA et LSA confortent cette hypothèse, dont la confirmation nécessite néanmoins la poursuite des recherches dans les domaines de la reconstitution environnementale, de la géochronologie et de l'étude de l'approvisionnement lithique

INTRODUCTION

The objective of this paper is to review the existing evidence for settlement patterns during the Middle Stone Age (MSA) in the central Rift Valley of Kenya. Comparisons will be drawn with the better-documented settlement patterns of the Holocene Later Stone Age (LSA). One objective of this comparison will be to evaluate the degree to which MSA and LSA social and territorial systems differed in their adaptations to similar resource structures and their responses to climate change (Ambrose and Lorenz 1990), and the potential implications of differences for the evolution of modem human behaviors. Future directions for research to test models of settlement and social and territorial organization will be proposed.

The degree to which MSA and Middle Paleolithic humans differed from behaviorally modem LSA and Upper Paleolithic humans in their ability to plan their use of the landscape and the effectiveness of resource exploitation remains an open question (Ambrose and Lorenz 1990; Ambrose 1998*a*; Bar-Yosef 1994; Binford 1989; Lieberman and Shea 1994; Marks and Freidel 1977; Roebrooks et al. 1988; Klein 1989, 1998). Strategic positioning of settlements to maximize efficiency of resource exploitation may have been perfected during or at the end of the MSA.

Settlement systems in the Middle Stone Age throughout East Africa are poorly understood for several simple reasons. Few systematic surveys have been conducted, few sites have been excavated, and most have not yet been reported. MSA site surveys and excavations in the central Rift Valley of Kenya have been conducted by Leakey (1931), Isaac (1972, Isaac et al 1972), Merrrck (1975), Anthony (1967, 1972, 1978), Bower et al (1977), and Ambrose (1984, 1986, 19986). In comparison to the LSA, MSA sites are rare The rarity of MSA sites may be due partly to their poor exposure and poor visibility The floor of the Rift has witnessed rapid alluvial and lacustrine sedimentation and has few deeply incised watercourses Many MSA sites may thus be deeply burled and others may have been destroyed through erosion

Behavioral and demographic factors may also account for the relative scarcity of MSA sites. First, a more restricted range of habitats may have been used during the MSA. MSA occurrences are clustered in a restricted range of elevations in the central Rift, suggesting a microhabitat preference for the ancient forest/savanna ecotone (Isaac 1972; Bower et al. 1977). Most known MSA sites are concentrated in areas that are highly susceptible to erosion, including the lower slopes of the escarpments bounding, and volcanic mountains within, the central Rift. Erosional bias does not, however, explain this apparent settlement preference because MSA sites are clustered within a very narrow range of this broad erosional zone (Isaac 1972). Moreover, LSA sites are concentrated within a different elevation range in this zone (Ambrose 1986). Second, in comparison to the LSA, MSA peoples may have had higher residential mobility, resulting in less intensive occupation of sites (Barut 1994) and lower site visibility. Third, population densities may have been lower during glacial periods (Butzer 1988; Klein 1998; Ambrose 1998*b*, 1998*c*), which would result in decreased densities of archaeological sites. All of these factors may have contributed to the relative scarcity of MSA occurrences.

The archaeological record of the central Rift appears to differ qualitatively from that of other regions: MSA occurrences are extremely common at elevations between 2,000 and 2,200 m (Isaac 1972; Bower et al. 1977). However, despite adequate exposure, few MSA sites occur below or above these altitudes (figs. 1 and 2). Isaac used ethnographic analogy with the Okiek (Dorobo) hunter-gatherers (Blackburn 1982) to propose a model of preference for settlement on the montane forest/savanna ecotone. A similar pattern of site distributions at 1,940-2,000 m in the central Rift was observed for the Holocene LSA (Ambrose 1984, 1986) and was also explained by ethnographic analogy with the Okiek. This ecotone is currently located at 2,300-2,400 m. If this ecotonal settlement preference was maintained throughout the Late Quaternary, then during dry periods this ecotone should have shifted to higher elevations, and during wetter periods it should have shifted to lower elevations.

The ecotonal settlement preference may have been abandoned during the most arid periods due to decreased resource density and predictability during the MSA and LSA. Mobility and home range size may have increased, and regional intergroup interaction and exchange intensified. This change in social and territorial organization should be reflected by a greater diversity of settlement locations and greater amounts of stone tool raw materials from distant sources. Detailed explanation of this model of change in social and territorial organization in response to environmental change and application of the model to the MSA of southern Africa has been presented by Ambrose and Lorenz (1990). This explanatory framework has also been used to examine changes in socioterritorial organization between the Pleistocene and early and middle Holocene in highland East Africa (Ambrose n.d.).

In this paper the ecotonal settlement preference model (Ambrose 1986; Isaac 1972) will be explored in more detail. New evidence for ecotonal settlement prefer-

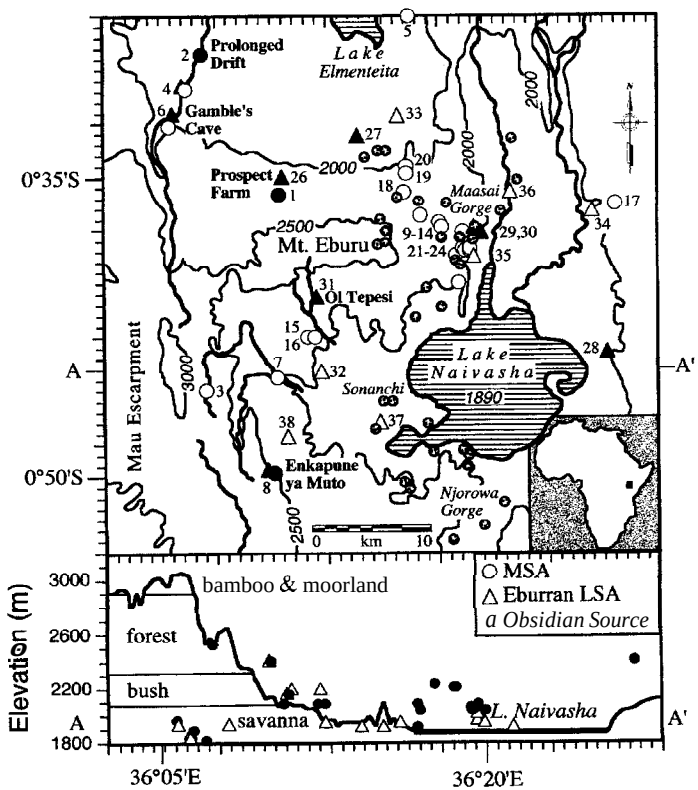

Fig. 1. Map of the central Rift Valley of Kenya, showing vegetation zones and the distribution of archaeological sites on an east-west elevation transect, locations of MSA and LSA sites, and locations of obsidian sources. Excavated archaeological sites are indicated by filled symbols. See tables 1a and 1b for the names of numbered sites.

ence during the Holocene LSA will be described. Archaeological evidence includes faunal habitat preferences, densities of bones and flaked stones within archaeological sequences and across the landscape, and presence of features such as hearths and bedding. Carbon and nitrogen isotope ratios of mammal bones and teeth provide

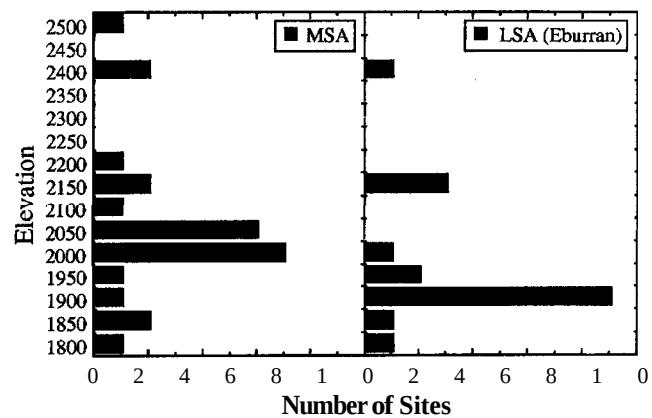

Fig. 2. Elevation frequency distributions of MSA and LSA sites in the central Rift Valley of Kenya.

direct evidence of microhabitats in which prey species lived (Ambrose and DeNiro 1989), and carbon isotope ratios of soil profiles provide direct evidence for the past position of forests and grasslands (Ambrose and Sikes 1991). Tests of the ecotonal settlement preference model for the MSA will be proposed using stable carbon isotope ratio analysis of paleosols to determine microhabitat contexts of sites (Cerling 1984; Cerling et al. 1989, 1991, 1997; Ambrose and Sikes 1991). Single Crystal Laser Fusion $^{40}Ar/^{39}Ar$ dating (SCLF) (Hu et al. 1994; Renne et al. 1997; Deino et al. 1998) of volcanic tephra interstratified with archaeological occurrences could be used to provide accurate dates of archaeological occurrences, permitting correlation with global paleoclimates. Lithic raw material source use patterns (Merrick et al. 1994) provide additional useful information for reconstructing social and territorial systems (Ambrose and Lorenz 1990).

MODERN ENVIRONMENTS AND LATE QUATERNARY CLIMATES IN THE CENTRAL RIFT VALLEY

The floor of the central Rift Valley contains two major closed lake basins with shallow lakes, separated by Mt. Eburu (fig. 1). This volcanically active region contains the majority of obsidian sources used during the Stone Age in Kenya and northern Tanzania (Merrick and Brown 1984). The current altitudes of the Naivasha and Nakuru-Elmenteita basins are 1,890 and 1,760 m, respectively. The western margin

Table 1a. *Holocene LSA (Eburran) archaeological sites in the central Rift Valley of Kenya shown in figure 1.*

Map Key	Eburran Site Name	Elevation (m)	Eburran phase
26	Prospect Farm Loc. 2	2150	2
4	Nderit Drift (GsJi2)	1840	1, 2 *
6	Gamble's Cave (GsJi1)	1934	3, 4
+	Hyrax Hill (GrJi25)	1860	5
+	Lion Hill Cave	1934	4
27	Ebum Station Cave (GsJi55)	1915	5
18	Naivasha Railway RS	1940	4, 5
29	Marula RS (GsJj24)	1940	3
30	Masai Gorge RS (GsJj25)	2010	2, 5
8	Enkapune ya Muto (GtJi12)	2400	4, 5 *
31	OL Tepesi RS (GsJi53)	2180	213, 5 *
32	Ngomut Ngai (GtJi31)	1950	213 *
33	GsJj14	1940	4
34	GsJj16	1940	4
35	GsJj29	1960	314
36	GsJj42	1915	3/4
37	GtJj6	1920	213
38	GtJi28	2190	2/3

(Key to symbols: * = sites with volcanic tephra; + = sites not shown in figure 1 because they are located outside of the map.

of the Rift, called the Mau Escarpment, rises to 3,100 m. Rainfall ranges from 600 mm on the Rift floor to over 900 mm on the top of the Mau Escarpment. Elevation-stratified floral zones grade from riparian acacia forests and woodlands around the lakes, to open and wooded savanna grassland on the plains. Above 2,200-2,300 m, denser bushland and woodland grade to montane forest above 2,400 m. Bamboo and montane moorland grasslands occur above 2,500 m.

This region witnessed dramatic environmental changes over relatively short periods of time in response to global climate change. High lake stands are widely reported prior to –22 ka and low lake levels and dry basins are recorded from 20 to 12 ka (Hamilton 1984; Butzer et al. 1972; Richardson 1972). High lake stands occurred several times prior to 40,000 BP, contemporary with the MSA. These lake stands have not been dated, but probably occurred during the Last Interglacial (Marine Oxygen Isotope Stage 5) and warm interstadials during the Last Glacial (Stage 3) (Isaac et al. 1972). During the early Holocene wet phase, Lake Naivasha reached overflow at 2,000 m, downcutting to a stable shoreline at 1,940 m. Lakes

Table 1b. *MSA archaeologrcal sites in the central Rift Valley of Kenva shown in figure 1*

Map key	MSA Site Name	Elevation	Comments
1	Prospect Farm Loc 1	2130	5 MSA horizons *
2	Prolonged Drift (GrJi11)	1805	1 in-situ MSA horizon *
3	Uruu East (GtJi32)	2540	Sparse surface scatter
4	Nderit Dnft (GsJi2)	1860	1 MSA horizon *
5	Kariandusi (GrJi21)	1895	Surface scatter
6	Gamble's Cave (GsJi32)	1936	Surface scatter
7	Marmonet Drift (GtJi15)	2080	5 MSA horizons *
8	Enkapune ya Muto (GtJi12)	2400	Sparse occupation *
9	Marula Valley 1 (GsJj53)	2180	2 MSA horizons *
10	Marula Valley 2 (GsJj54)	2070	3 MSA horizons *
11	Marula Valley 3 (GsJj79)	2020	MSA with handaxes *
12	Marula Valley 4 (GsJj81)	2180	MSA with handaxes *
13	GsJj2	2210	MSA with handaxes
14	Masai Gorge Camp (GsJj56)	2010	1 MSA horizon *
15	OL Tepesi Ridge (GsJi16)	2060	2 MSA horizons *
16	Kiteko Ridge	2060	2 MSA honzons *
17	Wetherall's site	2400	Surface rcatter *
17	GsJj5N	2075	Surface scatter
19	GsJj7	2020	Surtace scatter
20	GsJj21	2014	Surface scatter
21	GsJj22	2050	Surface scatter
22	GsJj28	2020	Surface scatter
23	GsJj38	2035	Surface scatter
24	GsJj39	2030	Surface scatter

* = sites with volcanic tephra, + = sites not shown in figure 1

Nakuru and Elmenteita also coalesced and overflowed at 1,940 m (Butzer et al. 1972). Montane forests undoubtedly expanded to lower elevations at this time (Maitima 1994). The habitat preferences of archaeological faunal species suggest the ecotone may have descended possibly as low as 1,940 m (Ambrose 1984, 1986). During the middle Holocene dry phase, lakes became smaller than at present, briefly drying by 3,000-3,400 BP (Richardson 1972). Soil carbon isotope analysis shows the savanna/forest ecotone rose to above 2,600 m (Ambrose and Sikes 1991). The modem climatic regime, with weakly bimodal seasonal rainfall, was established by 2,500 BP (Richardson 1972).

Similar environmental changes probably occurred during each glacial and interglacial period. The savanna/forest ecotone was probably lower during marine oxygen isotope stages 7 (penultimate interglacial), 5A, 5C, 5E (warm substages of the Last Interglacial) and 1 (early Holocene), and generally higher than at present during stages 6 (penultimate glacial), 5B, 5D (cold periods in the Last Interglacial), and 2-4 (Last Glacial). The millennium scale fluctuations in forest elevation and lake levels described above for the Holocene may have occurred during the Late Pleistocene and may be related to global climatic variations known as Dansgaard-Oeschger events (Dansgaard et al. 1993). These quasi-cyclic rapid shifts between glacial and near-interglacial temperatures, which have an average duration of 1,500-3,000 years, are now known to persist with lower amplitude through the Holocene (Bond et al. 1997). High climatic variance at the millennium scale places limitations on our ability to generalize about the environment within an isotope stage or substage. This also raises questions about our ability to correlate accurately human occupations with environmental regimes based upon assignment to a marine oxygen isotope stage. When dating is based on less accurate and precise techniques such as U-series, ESR and TL, for which standard deviations are much larger than the duration of Dansgaard-Oeschger events, then errors in correlation with paleoenvironments can occur.

MODERN AND LATE QUATERNARY SETTLEMENT SYSTEMS IN THE CENTRAL RIFT VALLEY

MODERN HUNTER-GATHERER SETTLEMENT PATTERNS

The Okiek are semi-sedentary hunter-gatherers who maintain defended territories in montane forests on the Mau Escarpment and other montane forest areas of central and western Kenya. Their territories comprise a series of long parallel ridges bounded by streams rising from the forestisavanna ecotone to the top of the Mau Escarpment. They maintain traps and beehives, hunt large and small mammals in the montane forest, and collect wild honey and hunt large mammals in the savanna. The forest is divided into named, defended territories for the purpose of maintaining exclusive access to hives and traps, but not for hunting. Their diet is predominantly meat and honey, with insignificant amounts of wild plant foods and small amounts of domestic grains obtained by trade with surrounding farmers. A broader plant-based subsistence prior to food production seems unlikely because (1) plant processing tools (grindstones) are extremely rare in Holocene LSA sites, and (2) archaeological horizons with abundant uncarbonized and carbonized plants contain no plant foods (Ambrose 1986; Slikkerveer and Lange 1991).

The Okiek are effectively sedentary, largely due to the stability of their resource base. They now prefer to settle in the lower montane forest near the savanna ecotone. This settlement location permits easy access to both forest and savanna environments, is warmer and drier than the high montane forests, and keeps them out of conflict with the politically superior herder and farmer populations (Maasai, Kalenjin, Kikuyu, Kisii). They establish temporary camps at high altitudes when mass flowenng of nettles occurs. Temporary beehives and traplines are set, but the cold, wet environment is uncomfortable and beehives and traps rot quickly. Archaeological evidence discussed below suggests that before the advent of food production they may have preferred the savanna side of the forestlsavanna ecotone (Ambrose 1986, 1998*b*)

LATER STONE AGE SETTLEMENT PATTERNS

Elevation distributions of MSA and Holocene LSA sites are shown in figures 1 and 2, and tables 1a and 1b provide a list of site names, the key to sites plotted in figure 1, elevations and other information about the archaeological sites. Figure 1 also shows obsidian source locations.

The archaeological record of the Late Pleistocene LSA in the central Rift is known from only five sites. Four different stone tool industries are represented, but only two industries may be represented at more than one site. Some industries may be up to 50,000 years old (Ambrose 1998*b*); no occurrences are demonstrably synchronous. Lithic raw material source use patterns are poorly known. Hypotheses about LSA subsistence and settlement patterns between 50,000 and 12,000 BP cannot be tested with such scant evidence.

The Holocene record is better documented. From 12,000 to ~ 3,000 BP, all sites can be assigned to the Eburran (Kenya Capsian) lithic industry (Ambrose et al. 1980). Phases 1-3 of the Eburran, dated to between 12,000 and 7,000 BP, are distinguished by large backed blades (mean length 50 to 35 mm). Phases 4-5 have smaller backed tools (mean length approximately 21-25 mm); phase 5 occurrences are defined by the presence of ceramics, which first appear by 4,900 BP, and/or domestic stock, which first appears by 4,000 BP (Ambrose 1984, 1998*b*).

Sites of phases 1-3 and early phase 4 of the Eburran Industry are found predominantly at elevations of 1,940-2,000 m around the perimeters of the Naivasha and Nakuru basins (Ambrose 1986). The most important sites are Gamble's Cave and Lion Hill Cave (Leakey 1931), Naivasha Railway, Marula and Maasai Gorge rockshelters (Ambrose 1984, 1985, 1986; Gifford-Gonzalez 1985; Onyango-Abuje 1977). They all have extremely high densities of fauna and artifacts, suggesting high intensity occupations. Although they are located close to the paleo-shorelines of the expanded early Holocene lakes, their locations do not appear to be linked to, or restricted by them. The faunal assemblages contain either predominantly forest and bush-dwelling mammals, or an extremely diverse mix of species with forest, bush and savanna habitat preferences, and they have virtually no fish hones (Ambrose 1984, 1986; Gifford-Gonzalez 1985; Onyango-Abuje 1977).

Only one archaeological site at higher elevations is known to contain an early Holocene wet phase Eburran occupation. 01 Tepesi Rockshelter, located at 2,180 m within the montane forest on Mt. Eburu, contains an occurrence of phase 2 or 3 of

the Eburran dated to 9760 ± 100 BP (ISGS 2317). Only 252 flaked stone artifacts were recovered (less than 1 per 0.01 m^3). Neither identifiable faunal remains nor hearths were encountered in this ephemeral occupation. The overlying Eburran phase 5 and underlying Pleistocene LSA occurrences have much higher flaked stone artifact densities (40-137 and 196-302 artifacts per 0.01 m^3, respectively), reflecting high intensity occupations.

Prospect Farm Locality 2, on the north slopes of Mt. Eburu at 2,150 m, is the only known high elevation early Eburran site with very high artifact densities (Anthony 1967, 1972). It appears to be a significant exception to the pattern of ephemeral use of high altitudes during the early Holocene. However, it is dated to 10,560 ± 1650 BP, which places it within the Younger Dryas, when a drier climate prevailed and the forest/savanna ecotone may have been higher.

During the middle Holocene, gradual drying began after 7000 BP, and the focus of settlement appears to have shifted gradually to higher altitudes. At Gamble's Cave (GrJi1), artifact and faunal densities begin to decline in phase 4 of the Eburran, and faunal habitat preferences reflect more bush and grassland species. Bushbuck (Tragelaphus scriptus) predominated in phase 3 but reedbuck (*Redunca cf. fulvorofula*) predominated in phase 4 (Ambrose 1984, 1986).

No sites on the Rift floor below 1,940 m are known to have Eburran occupations that date to between 6000 and 3500 BP. All have sterile horizons or erosional unconformities (Ambrose 1984, 1986). However, two sites at higher elevations have occurrences dating to the middle Holocene dry phase.

Enkapune Ya Muto Rockshelter (GtJi12), located at 2,400 m on the Mau Escarpment, contains a long stratified sequence of deposits that clearly documents changes in the past position of the ecotone and the focus of human settlement (Ambrose 1984, 1986). The earliest Eburran occupation levels date to 6350 BP (Ambrose 1998*b*). Low densities of artifacts and high frequencies of less fragmentary faunal remains suggest low intensity occupation (5-22 flaked stone artifacts and 9-41 g of bone per 0.01 m3). The micro- and macrofaunal species habitat preferences (Ambrose 1984; Marean 1992; Marean et al. 1994) indicate the site was surrounded by montane forest at this time. Stable carbon and nitrogen isotope analysis of collagen from the teeth of the herbivores (Ambrose and DeNiro 1989) shows that some prey had lived in deeper forests than exist at present anywhere in the central Rift, further indicating close proximity of the montane forest to the site at 6350 BP. In younger Eburran phase 4 and early phase 5 horizons, dated between 6000 and 4000 BP, the extremely rich and diverse faunal assemblages include increasing proportions of bush and open habitat species. Densities of faunal remains, lithic artifacts, and hearths increase dramatically (59-100 flaked stone artifacts and 17-116 g of bone per 0.01 m^3). Peak occupation intensities occur at around 5000 BP, associated with large hearths surrounded by uncarbonized and partly carbonized grass bedding. The latest Eburran occupations show predominantly bush, woodland, and grassland species. Artifact and faunal densities decline dramatically by 4000 BP (11.6 artifacts

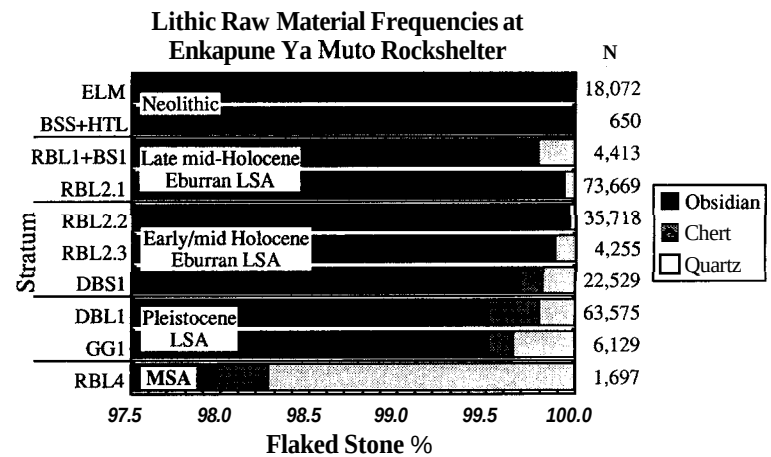

***Fig.* 3.** Percentages of flaked obsidian, chert and quartz in *Holocene* and Pleistocene LSA and MSA archaeological occurrences at Enkapune Ya *Muto Rockshelter.* See Ambrose *(1998b)* for a description of this stratigraphic sequence.

and 12.7 g of bone per 0.01 m^3) and proportions of non-local lithics (chert and quartz) increase (fig. 3). Aeolian sandy silts of these beds suggest open arid conditions predominated between 3900 and 2800 BP when the site was peripheral to the Eburran settlement system (Ambrose 1986, 19983).

0 1 Tepesi Rockshelter (GsJi53) provides additional evidence for intensive occupation of higher altitudes during the middle Holocene dry phase. It contains intensive Eburran phase 5 occupations dating to between 4560 ± 80 and 3120 ± 70 BP (ISGS 2318 and 2389). The mix of forest and grassland species (Ambrose and Mbae n.d.) associated with high artifact and faunal densities, large hearths and ash beds. suggests an ecotonal context during peak occupation.

During the peak of the middle Holocene dry phase (3000-3500 BP) the focus of Eburran settlement may have moved to even higher altitudes, but no sites above 2,400 m have been found to contain early and middle Holocene occurrences. Enkapune ya Sauli Rockshelter (GtJi10), located in montane forest and bamboo at 2,540 m was regularly occupied by recent Dorobo (Okiek) hunter-gatherers. The shallow deposits contained only Elmenteitan Neolithic, Iron Age, and protohistoric occupations (Ambrose 1984).

Horizons dating to the peak of the dry phase at lower altitude sites all have either erosional unconformities, sterile aeolian silts and sands, or extremely low artifact and faunal densities (Ambrose 1986). Eburu Station Lava Tube Cave (GsJi55), located at 1,910 m in the Nakuru Basin (Ambrose and Mbae n.d.), contains a very ephemeral phase 5 Eburran occupation dated to between 3570 ± 70 and 3000 It 70 BP (ISGS 2967 and 2322). Flaked stone artifact densities are relatively low compared to the overlying Elmenteitan Neolithic (14 versus 23 artifacts per 0.01 m^3) and bone densities are extremely low (2.12 versus 223-1,405 g per 0.01 m^3).

SOIL CARBON ISOTOPE EVIDENCE FOR THE HOLOCENE ECOTONE SHIFT

Stable carbon isotope analysis of soils has become a useful tool for environmental reconstruction in tropical environments. Soils, by definition, reflect the environment of the immediate location in which they are formed, unlike macrofaunal and pollen assemblages, which may reflect environmental conditions over larger catchment areas. The stable carbon isotope ratios ($^{13}C/^{12}C$) of tropical plants are bimodal: tropical grasses with the C4 mode of photosynthesis have high $\partial^{13}C$ values (-12 ± 2‰), and trees shrubs and most other broad-leaved plants (C3 plants) have low values (-26 ± 3‰) (Ambrose and Sikes 1991). Soil organic carbon is derived from the plants that grow and decompose on them. Its stable carbon isotope ratio accurately reflects the proportions of trees to grass in tropical environments (Cerling 1984; Cerling et al. 1991, 1997; Ambrose and Sikes 1991).

The utility of this technique can be illustrated with our research in the central Rift Valley. Natural soil profiles were sampled along an altitude transect from the floor of the Rift to the top of the Mau Escarpment and their carbon isotope ratios analyzed at depths of 0-5, 10-15, 30-35, and 50-55 cm below the surface. The surface soils accurately reflect the proportions of trees to grass in the modern environment. Soil profiles in open habitats at lower elevations showed small and non-systematic changes with depth below surface. However, four sites that are presently located in montane forests below 2,700 m had carbon isotope compositions at depths of 30-55 cm that demonstrate up to 75-80% C4 (grass) biomass grew on these sites during the peak of the middle Holocene dry phase. Only one site, located at 2,990 m at the top of the Mau Escarpment, did not show a change to grassland. The evidence from this transect suggests that the forestkavanna ecotone rose to above 2,600 m but did not reach 3,000 m during the middle Holocene dry phase.

CHANCES IN HOLOCENE LSA SETTLEMENT AND SOCIOTERRITORIAL ORGANIZATION

The combined evidence from nine rockshelters located at different altitudes in the central Rift indicates peak occupation intensities were associated with the forest/savanna ecotone and that this ecotone rose from below 1,940 m during the early Holocene wet phase to at least 2,400 m during the middle Holocene dry phase. Isotopic evidence presented above suggests the ecotone rose to above 2,600 m during the peak of this dry phase. Persistence of the ecotonal settlement preference during the peak of the middle Holocene dry phase cannot yet be discounted because no deeply stratified sites that contain Eburran occupation horizons of this age have been found above 2,400 m. High altitude sites of this era must still be excavated to test this hypothesis. However, territory size probably expanded as resource density declined to its lowest levels during the peak of the dry phase. Compared to the average size of tropical hunter-gatherer territories (Kelly 1995) the land area above 2,600 m in the central Rift is relatively small (fig. I) and may have supported only a few small band territories. The absence of intensive occupation of all sites at lower elevations during the peak of the dry phase suggests population size declined, the ecotonal settlement preference was abandoned, and settlement mobility increased due to decreasing abundance and predictability of food resources. Regional evidence for change in socioterritorial organization during the Holocene supports this hypothesis. The frequency of non-local lithic raw materials in artifact assemblages increased during the middle Holocene dry phase at Enkapune Ya Muto (fig. 3) and throughout highland Kenya and Tanzania, indicating higher mobility, more open territorial boundaries, and greater intergroup information exchange (Ambrose n.d.).

MIDDLE STONE AGE SETTLEMENT PATTERNS

MSA sites in the central Rift Valley are predominantly located at 2,000-2,200 m (fig. 2, table Ib). Uruu East (GtJi32), located at 2,540 m in montane forest on the Mau Escarpment, is the highest known MSA site. It is a very low density surface scatter of artifacts. Open sites have virtually no preserved faunal remains and none have been dated, so habitat reconstructions must be based on other lines of evidence. Glynn Isaac (1972; Isaac et al. 1972) conducted a systematic survey of artifact densities in surface exposures along an altitude transect from the floor of the Nakuru Basin to the north slopes of Mt. Eburu. Median artifact densities on four ridge crests on Mt. Eburu reached a peak of 44 per m^2 at 2,140 ± 60 m. Artifact densities on the Rift floor were never more than 10% of this value and much lower on the exposed slopes of Mt. Eburu up to 2,400 m (Isaac 1972). This restricted distribution led Isaac to propose the ecotone settlement preference model.

Multiple occupation horizons with interstratified volcanics are common around 2,100 m but are unknown at higher elevations (table 1b). Prospect Farm Locality 1, which lies within the zone of highest artifact densities in Isaac's survey, exemplifies this kind of site (Anthony 1967, 1972, 1978; Merrick 1975). Four high density MSA occurrences were encountered in a 15 m deep excavation. Several volcanic pumice and ash horizons are interstratified in this sequence. The youngest MSA horizon has been dated by obsidian hydration (Michels et al. 1983) to approximately 50,000 BP and the earlier ones to the Last Interglacial.

Prolonged Drift (GrJi11), located on the floor of the southern Nakuru Basin, is the only known low altitude excavated MSA occurrence in the central Rift (Merrick 1975). A volcanic ash dated to approximately 30,000 BP (the Makalia Ash) discon-

fonnably overlies an *in situ* MSA occurrence in a weakly developed paleosol capping a series of sands and silts of an aggrading stream channel (Merrick 1975). This occurrence is considered to be late MSA, older than 40,000 BP. The occurrence comprises patches of flaked stone artifacts associated with well-preserved bone. No faunal analysis has been published. In comparison to the Prospect Farm Locality 1 MSA occurrences, artifact densities are considered by the excavator to be relatively low (less than 50 flaked artifacts per 0.01 m^3). Merrick (1975; Merrick et al. 1994) suggests the site may be a specialized short-term hunting and butchery site.

In the Naivasha Basin, one late MSA occurrence was found at the base of the sequence at Enkapune Ya Muto Rockshelter (Ambrose 19986). The absence of an unconformity with the overlying early LSA, as well as the presence of a few small backed microliths, suggests it is close to the MSA/LSA transition. This horizon probably dates to early Stage 3, between 50,000 and 59,000 BP. Artifact and faunal densities (5.92 flaked stone artifacts and 3.24 g of bone per 0.01 m^3) are significantly lower than those of the Eburran in this sequence (as noted above), suggesting very low occupation intensities and infrequent use of this high elevation rockshelter during the late MSA. The small faunal assemblage contains both forest and grassland species, including one equid, one tragelaphine, and one cercopithecine monkey (Marean 1992). This faunal assemblage is too small for reliable environmental reconstruction.

At Marmonet Drift (GtJi15), located in the northwest comer of the Naivasha Basin at an elevation of about 2,040 m, an approximately 30-m deep exposed section contains five MSA occurrences and eleven interstratified volcanic layers. The nearby site of Ngomut Ngai (GtJi31), a fault-controlled sinkhole located at about 1.960 m, has a 21 m vertical exposure with multiple paleosols, tephra, and diatomite layers. It contains one early .Holocene Eburran occurrence, but no MSA horizons. The abundance of MSA horizons at Marmonet Drift provides a dramatic contrast with the complete absence of MSA artifacts at Ngomut Ngai. However. this difference is consistent with the apparent focus of MSA activities at higher altitudes.

EVIDENCE OF LITHIC RAW MATERIAL SOURCE USE FOR MSA SETTLEMENT SYSTEMS

The lithic raw material distribution at Enkapune ya Muto Rockshelter differs significantly from that of the LSA (fig. 3). Quartz and chert are more abundant in the MSA than in the LSA. The closest source of quartz is approximately 65 km; chert sources are unknown but may be equally distant.

Merrick and Brown (1984; Merrick et al. 1994) have made important contributions to our understanding of lithic raw material source use patterns in East African prehistory through their program of chemical analysis of obsidian sources. As noted above, most major sources of obsidian are located within the central Rift Valley (fig. 1). During the Acheulian, obsidian is rarely found more than 30 km from its source, probably within the range of direct procurement (Memck and Brown 1984).

During the MSA small numbers of obsidian artifacts occur up to 305 km from their sources, far beyond the range of direct procurement, so intergroup exchange seems likely. Site-to-source distances also increase from earlier to later horizons at two sites in Kenya (Prospect Farm and GvJm16 at Lukenya Hill). This increase in use of distant sources may reflect differences in home range size, mobility, and inter-group exchange networks between stable interglacial and unstable glacial environments.

Obsidian source use patterns in three MSA horizons at Prospect Farm Locality 1 and the main occupation horizon at Prolonged Drift may provide important insights into settlement systems (fig. 4). At Prospect Farm, obsidian from 75 km away comprises less than 2% of the artifacts in each assemblage. In the earliest horizon, 91% of the artifacts from known sources are from within 10-15 km of the site. In the second horizon, 57% of the assemblage comes from sources 10-15 km away, and 19% comes from a source 40 km away in the southern Naivasha Basin (Njorowa Gorge). In the youngest MSA horizon, 37% comes from sources 10-15 km from the site, one source 30 km away in the west Naivasha Basin (Sonanchi) comprises 60%, but the southern Naivasha source, only 40 km away, comprises only 1% of the analyzed sample.

At Prolonged Drift, over 95% of the obsidian identifiable to its source comes from Sonanchi (46%) and 0 1 Njorowa (50%) in the Naivasha Basin, located 40 and 50 km, respectively, from this site (fig. 1). The remaining 4% comes from Masai Gorge, 30 km away (fig. 4). Strong preference for these comparatively distant sources is remarkable because the closer high quality sources of Mt. Eburu and Masai Gorge, which were intensively used before and after this time, lie between Prolonged Drift and the Naivasha Basin sources (Merrick et al. 1994).

Unlike western Europe (Geneste 1988, 1989), lithic reduction sequences do not seem to differ for tools made on near versus far sources, and proportions of shaped tools and intensity of reduction do not appear to differ significantly between close and more distant sources at Prolonged Drift and Prospect Farm (Merrick et al. 1994). Only one possible MSA quarry site has been identified, but it has not been excavated. Differences in reduction sequences and patterns of lithic source use economy in different site types in this region are not yet apparent, but more research is definitely needed.

DIVERSITY AND CHANGE IN MSA SETTLEMENT AND SOCIOTERRITORIAL ORGANIZATION

Does Prolonged Drift represent a specialized activity location associated with potential base camps at the hypothesized forest/savanna ecotone, or could it represent a component of a more mobile settlement system? Patterns of lithic raw material source use, combined with the scant evidence for its age, may help evaluate these alternatives. Prolonged Drift was probably occupied during the Last Glacial period (Stage 3 or 4), when resource density and predictability would have been comparatively low. High mobility, large territories with undefended boundaries, opportunis-

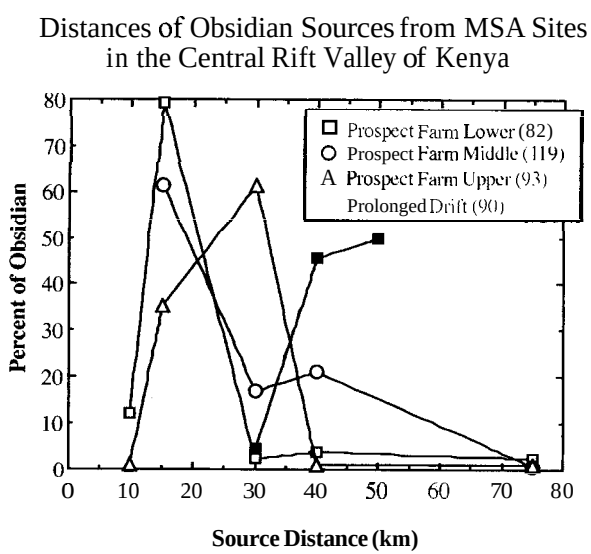

Fig. 4. Percentage of obsidian from sources at different distances from MSA sites in the central Riji Valley of Kenya. Data are from Merrick et al. 1994: table 2. Assetnblage size is indicated in parentheses in the figure legend. Specimens from unknown sources have been excludedfrom these sums andpercentages.

tic and frequent site relocation and high frequencies of lithic raw materials from distant sources are expected (Ambrose and Lorenz 1990; Ambrose n.d.). Prolonged Drift has a lithic raw material source composition completely unlike that of Prospect Farm, located only 10 km away, and is thus unlikely to be a component of that presumably ecotone-focused stable territorial system. It may reflect an opportunistic settlement system in risky ice age environments.

To what extent do the three occurrences at Prospect Farm represent an ecotonal settlement location preference? The two oldest occurrences may date to the Last Interglacial (Michels et al. 1983), when resource density and predictability were probably high. In terms of the relationship between resource structure and socio-territorial organization (Ambrose and Lorenz 1990; Ambrose n.d.) this resource structure may have favored infrequent and scheduled residential mobility, small closed

territories, and little intergroup interaction. Low frequencies of lithic materials from distant sources are expected. These occurrences are thus likely to reflect an ecotone-based settlement system. The latest MSA occurrence appears to date to the Last Interglacial, when resource density and predictability may have been lower. The presence of higher frequencies of comparatively more distant sources from the Naivasha Basin suggests a larger home range, higher residential mobility, and possibly more frequent regional exchange and interaction between bands. However, its lithic source use pattern is more similar to earlier horizons at Prospect Farm than to Prolonged Drift, so it may still represent an ecotonal settlement preference.

FUTURE TESTS OF MSA ECOTONAL SETTLEMENT PREFERENCES

This review of the scant evidence for MSA settlement systems and socioterritorial organization demonstrates that far more research is needed. Many MSA and early LSA sites in the Naivasha and Nakuru basins have multiple archaeological occurrences and interstratified volcanic tephra (tables la, lb). Advances in technology of SCLF $^{40}Ar/^{39}Ar$ dating (Hu et al. 1994; Chen et al. 1996; Renne et al. 1997; Deino et al. 1998) now make it possible to date sites as young as 2000 calendar years with precision equal to and accuracy greater than radiocarbon dating. With an accurate chronology it should be possible to make refined correlations with paleoclimates documented in deep sea and ice cores, and thus to infer the probable environmental contexts of MSA sites. We could then begin to test adequately the hypothesis that MSA sites were located on a paleoecotone and that their locations shifted elevation in response to climatic change. Sites located at higher altitudes should date to cooler, drier stadial periods or drier parts of interstadials, and sites at lower altitudes should date to warm, humid phases of interglacial and interstadial periods, when the ecotone shifted to lower altitudes than at present.

The rarity of significant faunal assemblages and the poor prospects for recovering pollen present significant challenges for environmental reconstruction. Stable carbon isotope analysis of paleosols seems to provide the most direct evidence for the past position of the forest/savanna ecotone. Volcanic tephra that can be traced across the landscape provides isochronous markers for paleosols that contain MSA occurrences. Paleosols occurring at altitudes above an archaeological occurrence should have the lowest $\partial^{13}C$ values, reflecting more closed habitats, those in the vicinity of the occurrences should have intermediate ones, and those at lower elevations should have the highest $\partial^{13}C$ values, reflecting open grassland habitats.

Other lines of evidence may indicate changes in settlement systems and adaptations during drier and wetter periods (Ambrose and Lorenz 1990; Ambrose n.d.). When the ecotonal settlement pattern was in place, contemporary occurrences above and below the ecotone should have been small, reflecting short-term, specialized, task-specific, seasonal occupations. Lithic raw material source use should resemble that at the main ecotonal sites. When resources were abundant and predictable, during warm, humid interglacial and interstadial periods, lower frequencies of non-local

lithics should be found and sites should be larger. Conversely, during drier periods, when the ecotone was higher, mobility should have been greater and territories larger in response to decreased abundance and predictability of food resources. Such sites should be smaller and should contain a greater diversity of non-local lithic raw materials. As discussed above, the central Rift Valley contains many well-documented, chemically characterized obsidian sources (Merrick and Brown 1984; Merrick et al. 1994), so this hypothesis can also be tested. It should then be possible to compare the responses of MSA and LSA hominids in similar ecological conditions and evaluate whether there are significant differences in settlement systems, resource exploitation, and social and territorial organization.

The Acheulian/MSA transition may date to as early as 250,000 BP in the Kenya Rift Valley (McBrearty et al. 1996). Some central Rift MSA sites may thus span the penultimate interglacial-glacial cycle (isotope stages 7 and 6), including those with significant numbers of handaxes in Marula Valley (table Ib). It should be possible to use obsidian source use patterns at such sites to determine if there are significant behavioral evolutionary changes in settlement systems in similar environments through time (eg., interglacial stages 7 versus 5, and glacial stages 6 versus 3/4).

DISCUSSION AND CONCLUSIONS

MSA occurrences in the central Rift Valley that probably date to the Last Interglacial, exemplified by the early horizons at Prospect Farm, appear to reflect an ecotonal settlement pattern with low residential mobility, small territories, and little regional interaction. MSA occurrences that probably date to the early Last Glacial at Prospect Farm, Prolonged Drift and Enkapune ya Muto seem to reflect socioterritorial systems with higher residential mobility, larger territories, and/or greater regional interaction and exchange. Prolonged Drift and Enkapune ya Muto do not seem to be part of an ecotone-based settlement system. This pattern of ecotonal settlement preference during the Last Interglacial versus increased dispersion in response to environmental change during the Last Glacial appears to be similar to that observed between the early Holocene wet phase and the middle Holocene dry phase in the central Rift Valley in the Eburran (Ambrose 1986), as well as throughout highland Kenya and northern Tanzania (Ambrose n.d.).

We have previously argued that adaptive responses to changes in resource structure in southern Africa and elsewhere during the MSA. as reflected by lithic source use patterns and faunal exploitation patterns, were less pronounced because resource exploitation and information exchange systems were less effective than in the LSA (Ambrose 1998*b*; Ambrose and Lorenz 1990; Klein 1989). Barut (1994) noted non-local raw materials were more common in MSA than in LSA occurrences in northern Tanzania excavated by Mehlman (1989). Non-local lithics were interpreted as evidence for high residential mobility due to ineffective exploitation of local food resources. This model may account for high frequencies of non-local lithics in the

MSA at Enkapune ya Muto during the Last Glacial. However, his model cannot be fully evaluated without accurate reconstruction of resource structures.

Data for existing lithic source use in the central Rift provide evidence for differences in social and territorial organization between climatic regimes within the MSA and within the LSA. However, obsidian source use patterns during the LSA in the central Rift Valley have not yet been systematically analyzed in the same way as the MSA (Merrick et al. 1994), so they cannot yet be directly compared. Much more research on MSA site structure, function, environmental context, and lithic and faunal resource exploitation is needed to determine if differences in capacity for adaptive responses to changes in resource structure existed between the MSA and LSA in this region.

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