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The Middle Stone Age of the northern Kenyan Rift: age and context of new archaeological sites from the Kapedo Tuffs

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ABSTRACT

Rift Valley sites in southern Ethiopia and northern Kenya preserve the oldest fossil remains attributed to *Homo sapiens* and the earliest archaeological sites attributed to the Middle Stone Age (MSA). New localities from the Kapedo Tuffs augment the sparse sample of MSA sites from the northern Kenya Rift. Tephrostratigraphic correlation with dated pyroclastic deposits from the adjacent volcano Silali suggests an age range of 135–123 ka for archaeological sites of the Kapedo Tuffs. Comparisons of the Kapedo Tuffs archaeological assemblages with those from the adjacent Turkana and Baringo basins show broad lithic technological similarity but reveal that stone raw material availability is a key factor in explaining typologically defined archaeological variability within this region. Spatially and temporally resolved comparisons such as this provide the best means to link the biological and behavioral variation manifest in the record of early *Homo sapiens*.

Introduction

Fossil and genetic data support an eastern African origin for *Homo sapiens* some time in the later part of the middle Pleistocene, ≥195 ka (White et al., 2003; McDougall et al., 2005; Gonder et al., 2007). Rather than focus on species-level distinctions or ‘‘modern/nonmodern’’ contrasts, a number of recent studies have emphasized the diversity among populations of middle and late Pleistocene hominins in Africa and elsewhere, particularly in the mosaic of primitive and derived features, life history traits, and complex mitochondrial and nuclear DNA signatures (e.g., Lahr and Foley, 1998; Howell, 1999; Forster, 2004; Eswaran et al., 2005; Trinkaus, 2005; Smith et al., 2007). In Africa, the archaeological record of this period is characterized by the replacement of the Acheulian by Middle Stone Age (MSA) sites that preserve the first evidence for subcontinental-scale regional variation (Clark, 1988; McBrearty and Brooks, 2000; McBrearty and Tryon, 2006), mirroring a broader phenomenon of post-Acheulian diversification of the archaeological record also seen in Europe and western Asia (e.g., Ronen and Weinstein-Evron, 2000; Soressi, 2004, 2005; Hovers and Kuhn, 2006; see also Gao and Norton, 2002). Exploring the relation between biological and behavioral variation among geographically diverse hominin populations within (and outside of) Africa requires an integration of genetic, fossil, archaeological, and paleoenvironmental data at fine temporal and spatial scales (e.g., Barham, 2001; Potts, 2002; Gamble et al., 2005; James and Petraglia, 2005; Banks et al., 2006; Vanhaeren and d’Errico, 2006).

We describe here one small step towards achieving our long term goal of understanding temporal and spatial variation among African middle and late Pleistocene hominin populations that included *Homo sapiens*, and report our recent discovery of five new MSA artifact localities from the Kapedo Tuffs. These sites are likely constrained to a narrow temporal window between 135 ka and 123 ka, and occur in the northern Kenya Rift Valley between the better studied Turkana and Baringo basins. The area between these basins is particularly important for understanding human biocultural evolution, but which until now has not been the subject of detailed paleoanthropological investigation. The Turkana Basin preserves the fossil remains of the earliest *Homo sapiens* (McDougall et al., 2005), and the Baringo Basin preserves some of the oldest known MSA sites (Deino and McBrearty, 2002; Tryon and McBrearty, 2002, 2006; McBrearty and Tryon, 2006). As the Kapedo Tuffs represent a new artifact-bearing area, we first describe their geological setting, estimated age determined through tephrostratigraphic correlation, and the composition of all recovered artifact assemblages. We then integrate these data from the Kapedo

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Tuffs into a comparison of archaeological data from neighboring depositional basins to initiate studies of geographic variation in hominin behavior among MSA sites in this area. Our comparisons of MSA artifacts from the Kapedo Tuffs, Turkana Basin, and Baringo Basin emphasize the role of stone raw material as an explanation for interassemblage differences among these areas, and serve to highlight environmental factors that affect a number of stone tool assemblage attributes that are frequently used to interpret population-specific behavioral variation at Pleistocene sites.

The Kapedo Tuffs and Silali

The Kapedo Tuffs (1°04′N, 36°05′E), described by Dunkley et al. (1993) and McCall (1999), consist of bedded pumiceous tuffs and intercalated fluvial conglomerates and sands. The Kapedo Tuffs are exposed west of Silali, the largest Quaternary volcano in the Kenyan portions of the Gregory Rift (Fig. 1), near Kapedo village. Kapedo marks the political boundary between the Baringo and Turkana districts and the informal divide between local Pokot and Turkana pastoralists. The region is semi-arid with typical daytime air temperatures of 35–40 °C. Rainfall peaks in April and August, with annual potential evaporation rates exceeding ~445 mm of rainfall per year. The area, at ~780 m elevation, is predominantly bushland or semi-desert with sparse grass, contrasting sharply with the relatively lush doum palm-ringed alkaline hot springs south of Kapedo and to the north at Lorusio (Dunkley et al., 1993; Renaut et al., 1999).

The Kapedo Tuffs appear discontinuously over an area of ~50 km^2, with exposures up to 20-m thick in sections along the Kapedo River to the west of Silali (Fig. 2a). Outcrops adjacent to the western margin of the rift are typically normally faulted and tilted eastward in a series of blocks that dip as much as 40°. Although thickly stratified pumice lapilli tuffs (≤3 cm clasts) likely represent proximal airfall deposits from Silali, much of the pyroclastic component of the Kapedo Tuffs is variably reworked, as indicated by the presence of cross-bedding, scouring, and channeling structures, as well as intercalated sands and conglomerates (Dunkley et al., 1993; McCall, 1999).

The geochemical evolution and chronology of volcanism on Silali has been the subject of prior detailed study (McCall and Hornung, 1972; Dunkley et al., 1993; Macdonald et al., 1995; Smith et al., 1995). Silali is composed of a bimodal suite of mafic rocks of mildly alkaline to peralkaline affinity and trachytes formed by fractional crystallization of basaltic magma. ^{40}Ar/^{39}Ar age estimates of one of the Quaternary lavas shown in Fig. 2b (the Lower Trachytes of Dunkley et al., 1993) suggest that the initial shield-building phase of Silali was completed by ~216 ka. This was followed by at least three major phases of explosive activity represented by the Lower Pyroclastic Deposits, the Upper Pyroclastic Deposits, and the Arzett Tuffs (Dunkley et al., 1993; Smith et al., 1995). The Lower Pyroclastic Deposits and the overlying Upper Pyroclastic Deposits are visible only in the caldera (Fig. 2a). Both consist of rubbly pyroclastic breccias with thin pumiceous layers, zones of intense welding, and trachyte lavas with a combined thickness of 140 m. An ^{40}Ar/^{39}Ar age of 135 ± 3 ka for the Upper Pyroclastic Deposits has been reported [sample SIL-4A of Smith et al. (1995: 301)], consistent with the 132 ± 3 ka estimate for sample SIL-6 from the Kapedo Tuffs. The equivalence of these ages lead Smith et al. (1995: 304) to propose the cross-section shown in Fig. 2b, correlating the Kapedo Tuffs with the Upper Pyroclastic Deposits. Finally, the Arzett Tuffs appear only on the western flanks of Silali (Fig. 2a–b) and include prominent pyroclastic cones that consist of up to 40 m of stratified pumice lapilli tuffs, breccias, and glassy welded air-fall units (Smith et al., 1995). Sample SIL-5 of Smith et al. (1995: 301) from one of these cones suggests an age of 123 ± 3 ka for the eruption and deposition of the Arzett Tuffs.

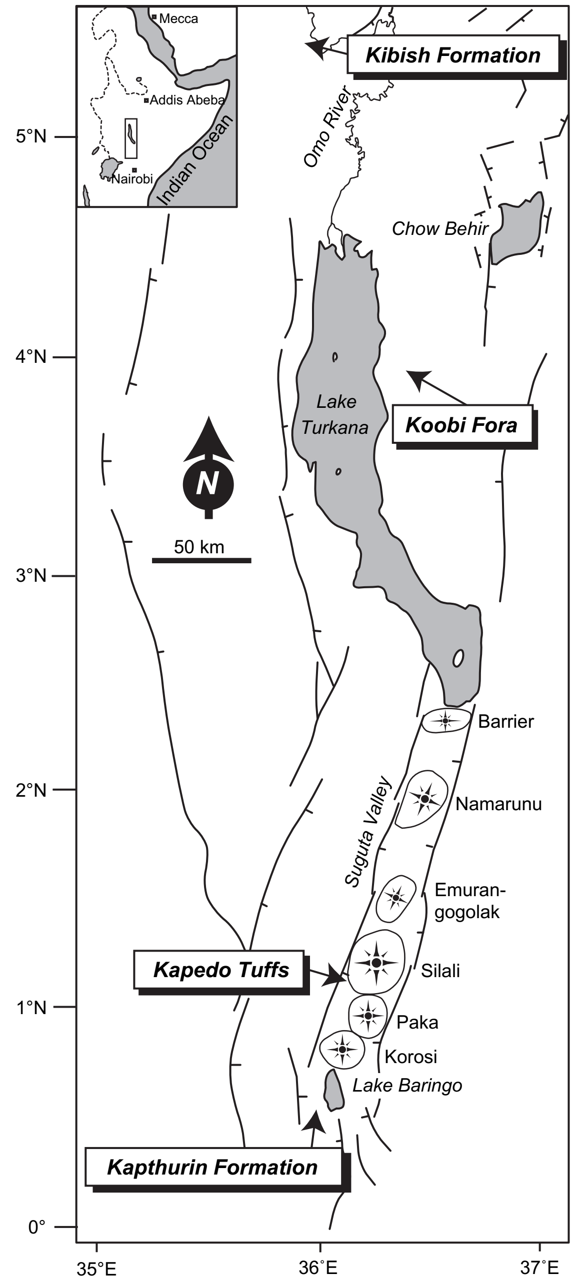

Fig. 1. Sketch map showing main boundary faults (tick on downthrown side) of the Gregory Rift, geographic features including named Quaternary volcanic edifices, and archaeological localities discussed in the text. Map after Butzer et al. (1969); Baker et al. (1972); Wolde-Gabriel and Aronson (1987); Dunkley et al. (1993) and McDougall et al. (2005).

Tephrostratigraphy and the age of the Kapedo Tuffs

Our goal is to augment the previous geochronological correlation of the Kapedo Tuffs with the Upper Pyroclastic Deposits using detailed comparisons of the chemical composition of tephra. This approach further constrains the age of the recovered artifacts from the Kapedo Tuffs. Although the Upper and Lower Pyroclastic Deposits and the Arzett Tuffs are distinct in the caldera and on the flanks of the volcano, they are difficult to distinguish on physical criteria alone in the more distal deposits represented by the Kapedo Tuffs (Dunkley et al., 1993: 47; McCall, 1999: 65).

We studied ten samples to assess stratigraphic equivalence between dated deposits and those from excavated archaeological

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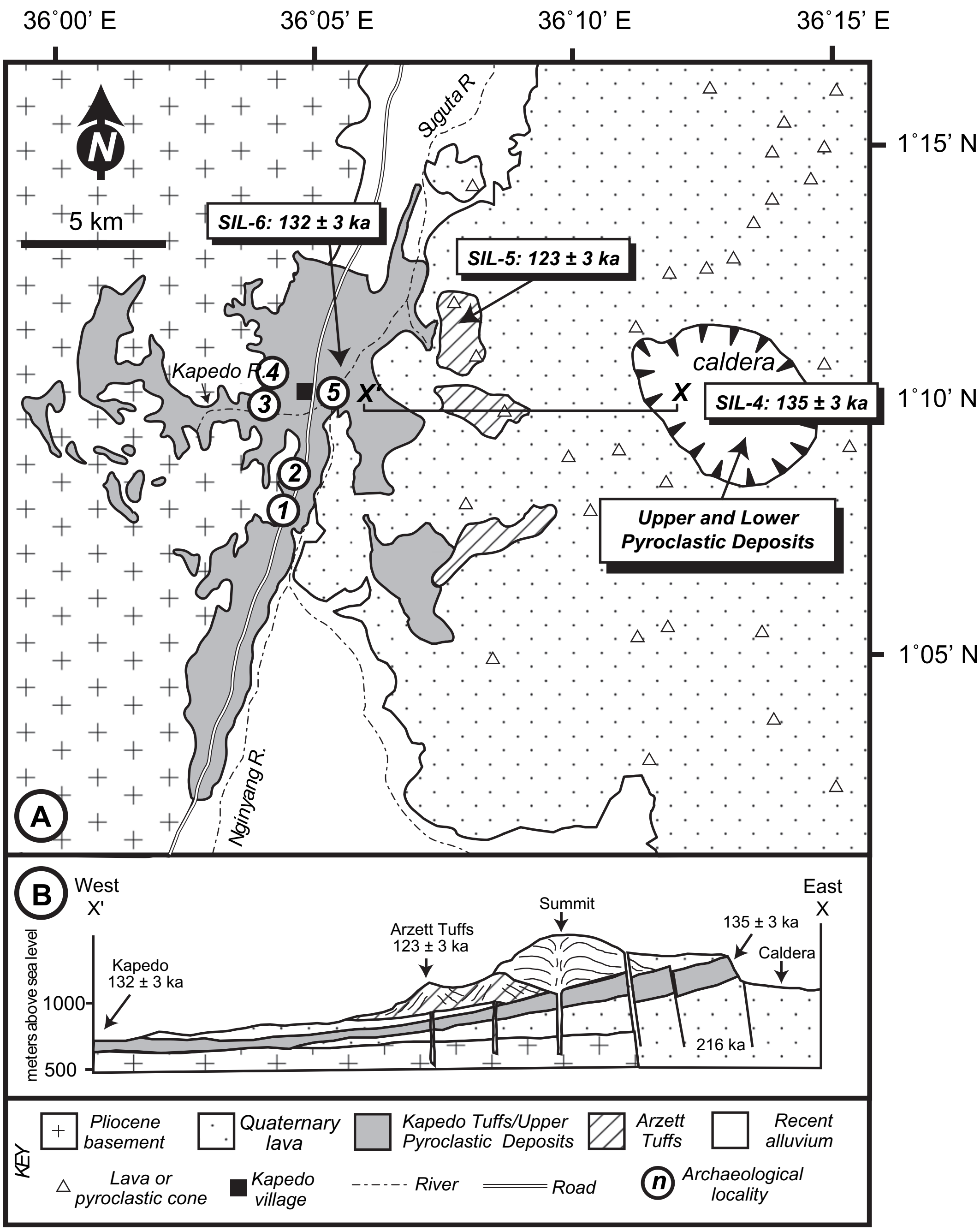

Fig. 2. Sketch map (A) and cross-section (B) of Silali, the Kapedo Tuffs, archaeological and tephra sampling localities, and available $^{40}Ar/^{39}Ar$ age estimates. After Dunkley et al. (1993); Smith et al. (1995); and McCall (1999). See text for discussion of cross-section and correlation/distribution of Kapedo Tuffs with Upper Pyroclastic Deposits on Silali.

sites in the Kapedo Tuffs. Fig. 2a shows the provenance of all collection areas and Fig. 3 provides summary stratigraphic sections of the excavated archaeological localities. Portions of the previously dated samples were provided by Dr. Alan Deino of the Berkeley Geochronology Center (designated by a "SIL-" prefix); tephra from archaeological localities 1 and 4 were collected by Tryon in 2006 (with a "CAT-" prefix).

Tephra studied here are poorly-to-moderately consolidated pumice lapilli tuffs except SIL-5A and SIL-5B, which are welded tuffs from the Arzett Cones. When viewed in thin section, individual pumice clasts have a vesiculated glass matrix with sparse ilmenite phenocrysts and alkali feldspar microlites. Fresh glass is rare in the Arzett Tuff samples (SIL-5A and SIL-5B) and absent from the dated Upper Pyroclastic Deposit sample (SIL-4A). These samples exhibit interwoven plagioclase laths with the variable presence of small areas of interstitial glass.

Analytical methods

Each sample was prepared as a polished thin section for geochemical compositional analysis of glass and phenocryst phases by electron microprobe. In the case of unconsolidated deposits, 3–4 pumice fragments were ultrasonically cleaned for 5–10 minutes in distilled water prior to mounting in epoxy on a single slide.

Wavelength dispersive quantitative analyses of major and minor element oxide abundance were conducted using a JEOL 8900R electron microprobe, housed in the Mineral Sciences Department of the Smithsonian Institution's National Museum of Natural History,

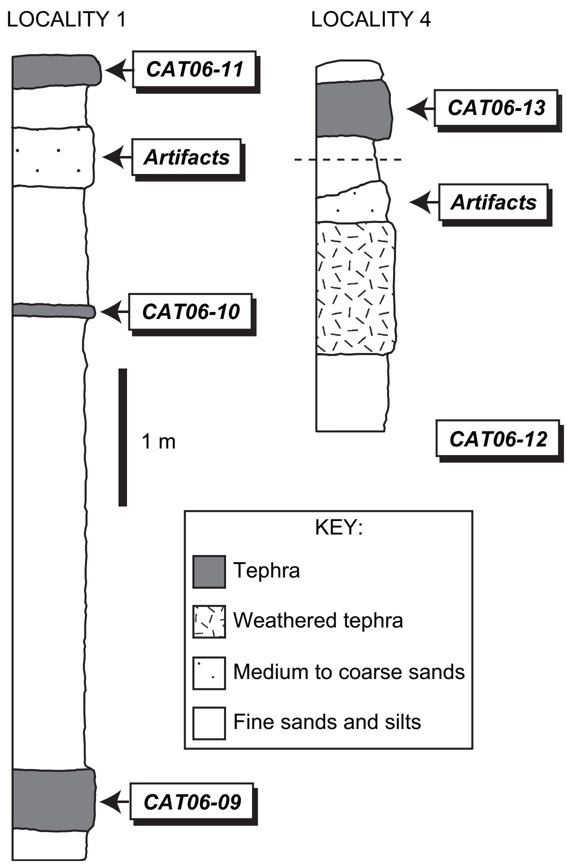

Fig. 3. Schematic stratigraphic sections of each of the two excavated Kapedo Tuffs archaeological localities. Shown are the location of analyzed tephra samples and in situ artifacts. The complete Locality 4 section is exposed 15 m west of the excavation, which preserves sediment below the dashed line only. All sediments at Locality 4 dip 10° to the east. Sample CAT06-12 is topographically below the measured section at Locality 4, but its stratigraphic relation could not be determined due to poor exposure.

with a 40° takeoff angle. Analytical conditions consisted of an accelerating voltage of 13 kV and a beam current of 8 nA, using a rasterized beam over an area of $\sim 6\ \mu m^2$. Counting times were 20 seconds on-peak and 10 seconds off-peak. Reference materials used for calibration include ilmenite (USNM 96189), anorthite (USNM 137041), bytownite (USNM R-2912), Kakanui hornblende (USNM 143065), microcline (USNM 143966) and glass VG-568 (USNM 7285), characterized by Jarosewich et al. (1980). Raw data were converted to concentrations using standard calculations with a PhiRhoZ matrix correction. These analytical procedures are the outcome of our extensive program of testing using USNM 7285, a rhyolitic glass from Yellowstone, to minimize sample damage and loss of volatile elements, particularly sodium. A volatile self-correction with a two-second interval was applied for Na, Si, and K using Probe for Windows software (Donovan, 2006). Rasterized area was limited by the small volume of unaltered glass in samples SIL-5A and SIL-5B.

Fresh glass for analysis in all samples was selected using backscattered electron images (Reed, 1996). We acquired on average 4–5 analyses per clast for ~16 analyses per sample. Only analyses with totals above an arbitrary 88% are included here, except for sample SIL-5B, where 85% was used as the minimum acceptable total to increase sample size. Analytical totals for glass analyses <100% are not normalized except where required for comparison with whole rock analyses. Normalizing data may mask analytical errors (Hunt and Hill, 1993) and makes unwarranted assumptions about the composition of the parent magma (e.g., Brown et al., 1992). The difference is largely due to water, not directly analyzed by the microprobe.

Comparative methods

Correlations between tephra deposits are best considered testable hypotheses, subject to continual revision with expanded datasets (e.g., Feibel, 1999a; Brown et al., 2006). This is in part due to the wide recognition of the many potential sources of within-sample compositional variation, which include instrumental error, postdepositional weathering and selective element leaching, heterogeneous batches of parent magma, the inclusion of older deposits during eruption and magma ascent, and reworking by fluvial or other processes (e.g., Hunt and Hill, 1993; Orton, 1996; Feibel, 1999a; Riehle et al., 2000; Donoghue et al., 2007). In general, the strongest correlations are those that show concordance between multiple independent datasets, including stratigraphic, fossil, chronological, and geochemical evidence. We complement prior correlations proposed on the basis of age equivalence by focusing on potential correlates suggested by geochemical variation within the volcanic glass phase of tephra deposits. Glass composition approximates the composition of the magma at eruption, and due to the complexity of the eruptive processes provides a potentially unique signature or 'fingerprint' (e.g., Feibel, 1999a; Turney and Lowe, 2001).

We test for correlations between deposits using a number of different approaches. As a first step, we use the mean value of analyzed element oxides from each sample to characterize the general structure of the data using cluster analysis (e.g., Campisano, 2007; Cortés et al., 2007) and the calculation of similarity coefficients (defined by Borchardt et al., 1972) for all possible sample pairs. Similarity coefficients (SC) are the mean of the ratios (<1) obtained by dividing pairs of sample means element by element, with SC > 0.92 considered indicative of a possible correlation (Froggatt, 1992; Kuehn and Foit, 2006). Our second step focuses on sample variance to more precisely examine the degree of compositional similarity among these tephra. Following the reasoning of Brown et al. (1992, 2006), we assume correlation between two deposits if there is overlap in the first standard deviations of the means of SiO_2, TiO_2, Al_2O_3, FeO, and CaO. We use the bootstrap (sampling with replacement 1,000 times) to test for pair-wise differences between the means of each sample because this method does not require assumptions about sample size or normality (Efron and Tibshirani, 1993; Manly, 1997). Bivariate plots of all analyses are used to seek petrologically meaningful patterns in the data. Although a strong case has been made for the use of discriminant function analysis for tephra correlation (Stokes and Lowe, 1988; Stokes et al., 1992; Pollard et al., 2006; cf. Kuehn and Foit, 2006), we do not employ this technique here because of an incomplete and insufficiently characterized reference set of eruptive events on Silali, as discussed below.

Results

Table 1 summarizes the results of 128 electron microprobe analyses of the glass phase of pyroclastic deposits from Silali and the Kapedo Tuffs. All examined tephra are trachytic/trachydacitic according to the compositional scheme proposed by Le Bas et al. (1986). Modal composition of all samples is quartz normative (saturated) except for SIL-6, which is nepheline normative (subsaturated). Electron microprobe analysis of feldspars ($n = 25$) showed minimal variation from an average composition of $An_{66}Ab_1Or_{33}$, rendering them unsuitable for correlation in this case (but see McHenry, 2005). Sample CAT06-10 is subdivided on the basis of individual clasts that show distinct compositional differences within Al_2O_3, TiO_2, and K_2O (Table 1).

Table 1
Summary results of electron microprobe analyses of glass from Silali area tephra, divided by sample locale. Element oxide results listed as weight percent mean and standard deviation. Locality 1 samples are listed in stratigraphic order. Sample CAT06-10 is a bimodal sample consisting of compositionally distinct clasts, here subdivided into CAT06-10a and CAT06-10b on the basis of variation within TiO_2, Al_2O_3, and K_2O. A tenth sample, SIL-4A, was examined but contained no fresh glass

Sample	*n*	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Total
Locality 1												
CAT06-11	22	58.33 ± 0.73	0.42 ± 0.04	13.24 ± 0.19	8.97 ± 0.39	0.34 ± 0.05	0.03 ± 0.01	0.74 ± 0.07	3.82 ± 0.87	3.38 ± 0.22	0.05 ± 0.02	89.33
CAT06-10a	11	59.53 ± 0.95	0.39 ± 0.06	13.60 ± 0.44	8.69 ± 0.69	0.32 ± 0.06	0.03 ± 0.01	0.76 ± 0.14	3.52 ± 1.12	2.96 ± 0.34	0.04 ± 0.01	89.83
CAT06-10b	9	58.56 ± 0.65	0.55 ± 0.03	14.47 ± 0.11	7.76 ± 0.34	0.31 ± 0.04	0.04 ± 0.01	1.01 ± 0.05	5.17 ± 0.70	3.41 ± 0.18	0.05 ± 0.02	91.34
CAT06-09	12	58.25 ± 1.12	0.46 ± 0.02	14.03 ± 0.23	8.42 ± 0.50	0.34 ± 0.06	0.03 ± 0.01	0.90 ± 0.08	4.30 ± 1.14	4.21 ± 0.26	0.05 ± 0.01	90.99
Locality 4												
CAT06-13	20	58.99 ± 0.74	0.51 ± 0.03	14.16 ± 0.17	8.28 ± 0.46	0.34 ± 0.06	0.05 ± 0.01	1.01 ± 0.09	4.40 ± 1.25	3.79 ± 0.46	0.06 ± 0.01	91.62
CAT06-12	18	59.74 ± 0.67	0.44 ± 0.04	13.28 ± 0.37	9.74 ± 0.66	0.33 ± 0.06	0.02 ± 0.01	0.82 ± 0.11	3.39 ± 0.91	3.88 ± 0.21	0.05 ± 0.02	91.69
Kapedo Tuffs												
SIL-6	18	59.77 ± 1.07	0.45 ± 0.03	15.26 ± 0.20	7.50 ± 0.31	0.32 ± 0.07	0.03 ± 0.01	1.08 ± 0.08	7.37 ± 0.67	4.60 ± 0.13	0.04 ± 0.01	96.77
Arzett Tuffs												
SIL-5A	10	59.82 ± 1.71	0.66 ± 0.07	14.61 ± 0.80	4.84 ± 0.70	0.10 ± 0.05	0.08 ± 0.04	1.26 ± 0.35	2.71 ± 0.91	4.90 ± 0.92	0.01 ± 0.04	88.99
SIL-5B	8	57.40 ± 1.51	0.48 ± 0.07	14.18 ± 0.94	3.94 ± 1.06	0.09 ± 0.09	0.09 ± 0.04	2.92 ± 0.30	5.29 ± 0.94	2.20 ± 0.37	0.01 ± 0.01	86.58
Total	128											

Our comparisons augment and refine the basic observation apparent from Table 1: all samples from the Kapedo Tuffs, including dated sample SIL-6, differ markedly from the Arzett Tuffs (SIL-5A and SIL-5B) in the wt. % abundance of FeO, MnO, MgO, and CaO.

The dendrogram resulting from our cluster analyses (Fig. 4) shows the basic structure of our dataset and serves as a relatively straightforward graphic device to assist in our discussion of potentially correlative tephra deposits. The dendrogram (Fig. 4) shows not only the distinction between the Arzett Tuffs and the Kapedo Tuffs but further suggests that all Kapedo Tuffs samples from the archaeological localities are more like each other than any are to the dated sample SIL-6, particularly in the wt. % abundances of Al_2O_3, FeO, and CaO (Table 1). The similarity coefficients (SC) of all sample pairs are shown in Table 2. The results suggest compositional similarity among all samples from the Kapedo Tuffs, with values from archaeological Locality 1 suggesting correlation between deposits separated by ~1–2 m of alluvial sediment (Fig. 3).

Despite general similarity among the Kapedo Tuffs samples, comparisons that consider both the mean and variance of the elemental oxide abundance for each sample do not support any correlations between dated samples or archaeological localities, and serves to emphasize that the number of correlative beds varies by comparative method (e.g., Stokes et al., 1992; Kuehn and Foit, 2006; Pollard et al., 2006). The first standard deviations of the mean of the complete suite of five element oxides (SiO_2, TiO_2, Al_2O_3, FeO, and CaO) do not overlap for any sample pair. Further, at least two of the five element oxide means are significantly different ($p < 0.05$) for all bootstrapped pairwise comparisons.

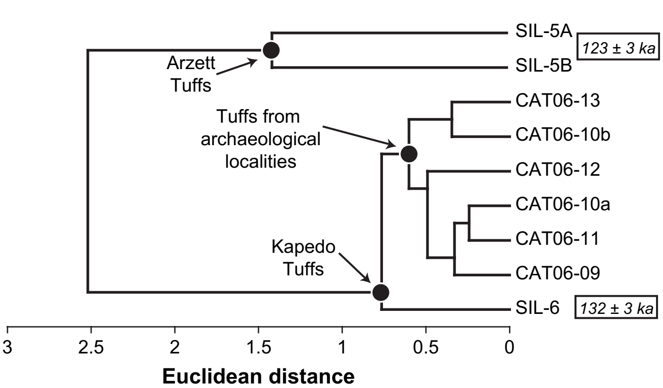

Fig. 4. Dendrogram of Silali area tephra samples using hierarchical cluster analysis. Degree of sample similarity determined by unweighted pair-group average linkage measured by Euclidean distance, calculated using Multivariate Statistical Package version 3.13 (Kovach Computing Services, 2008). Clustering is based on centered log-ratio transformed mean values of all available element oxides (the centered log-ratio is the natural log of the ratio of each oxide value to the geometric mean of all oxides in a particular sample). Data were transformed to avoid the unit sum constraint and to maintain variable independence required for cluster analysis (see discussions in Aitchison, 1986; Pollard et al., 2006; Cortés et al., 2007). Comparable results are obtained using raw data; adding or deleting elements has little effect on tree structure, with the Arzett Tuffs separated from other samples in each case and a lack of consistent clustering of SIL-6 with other samples.

The bivariate plot of Al_2O_3 and CaO in Fig. 5 shows the degree of within-sample compositional variation, and also suggests that while individual deposits within the Kapedo Tuffs samples cannot be reliably correlated, all may derive from a similar batch of magma or related eruptions. The covariation of Al_2O_3 and CaO among the Kapedo Tuffs samples (Fig. 5) suggests a general trend of different degrees of magma evolution due to fractional crystallization of feldspar (e.g., Wilson, 1993); Arzett Tuffs samples show no or different trends. The formation of crystals preferentially depletes the magma in particular elements (in the case of feldspar, Si, Al and, to a lesser extent, K, Na, and Ca). This process results in predictable changes in element relative abundance in the residual magma, which is reflected by the glass composition, and potentially provides a relative dating tool. The stratigraphic positions of sample CAT06-11 above CAT06-09 from Locality 1 (Fig. 3) support the hypothesis of increased feldspar crystallization with time. The evidence from sample CAT06-10a/b (Fig. 3) is equivocal, and it remains unclear whether the compositional variation within this sample is the result of heterogeneous magma at eruption or postdepositional reworking by fluvial or other processes. However, based on the compositional trend of covarying decreases in Al_2O_3 and CaO, the position of sample SIL-6 on this trend line (Fig. 5) and stratigraphic sequence at Locality 1, we infer that the Kapedo Tuffs samples from the archaeological localities represent related but later eruptions of more evolved magmas that are younger than sample SIL-6, which is dated to 132 ± 3 ka.

The results of our geochemical comparisons of volcanic glass from Silali and the Kapedo Tuffs indicate that the Arzett Tuffs are distinct from the Kapedo Tuffs, and that all samples of the Kapedo Tuffs are compositionally similar and follow an inferred trend suggesting that the archaeological localities are younger than sample SIL-6 at 132 ± 3 ka. Comparative methods including the use of similarity coefficients and comparisons of variances of element oxide abundance between samples produced different results, and as such support a general stratigraphic equivalence rather than precise correlations among the deposits studied here. We attribute the absence of confirmed correlations between Kapedo Tuffs deposits in part to the proximity of the source volcano, Silali. We

Table 2
Similarity coefficients (SC) for all Silali area tephra using SiO_2, TiO_2, Al_2O_3, FeO, and CaO. SC values are defined by Borchardt et al. (1972) as: $d(A,B) = \sum_{i=1}^{n} Ri/n$, where $d_{(A,B)}$ = SC for comparison between sample A and sample B, i = element number, n = number of elements, $R_i = X_iA/X_iB$ if $X_iB \geq X_iA$, otherwise X_iB/X_iA, X_iA = concentration of element i in sample A, and X_iB = concentration of element i in sample B. Sample pairs with SC ≥ 0.92 may be considered potential correlates (Froggatt, 1992) and are italicized, those with SC > 0.95, considered good evidence for correlation (Kuehn and Foit, 2006: 117), are shown in bold

Sample	Locality 1				Locality 4		Arzett Tuffs		
	CAT06-11	CAT06-10a	CAT06-10b	CAT06-09	CAT06-13	CAT06-12	SIL-6	SIL-5A	SIL-5B
CAT06-11	1								
CAT06-10a	***0.96***	1							
CAT06-10b	0.86	0.86	1						
CAT06-09	*0.92*	*0.92*	*0.95*	1					
CAT06-13	0.87	0.88	***0.96***	*0.94*	1				
CAT06-12	*0.95*	0.88	0.86	*0.93*	0.88	1			
SIL-6	0.87	0.87	*0.94*	*0.93*	*0.94*	*0.94*	1		
SIL-5A	0.73	0.73	0.84	0.78	0.83	0.74	0.82	1	
SIL-5B	0.70	0.69	0.74	0.74	0.75	0.70	0.74	0.78	1

infer a sedimentary archive that preserves a wider range of eruptive events of varying magnitudes than the rare, large-scale eruptions from distant sources typically used for correlation purposes in the Turkana Basin and elsewhere (e.g., Brown, 1972; Turney et al., 2006). A sample of the potential source areas on Silali (pyroclastic and lava cones) is shown in Fig. 2a. Our data support the hypothesis of Smith et al. (1995), based upon the age equivalence of SIL-6 (132 ± 3 ka) and SIL-4 (135 ± 3 ka), that the Kapedo Tuffs are the more distal equivalents of the eruptions that produced the Upper Pyroclastic Deposits, which are now exposed only in the caldera. The absence of pyroclastic deposits of the Arzett Tuffs from the uppermost deposits of archaeological localities 1 and 4 suggest that the artifact-bearing strata predate their eruption at 123 ± 3 ka. This implies an age range of 135–123 ka for hominin occupation of the area.

Archaeology of the Kapedo Tuffs

Stone artifacts were recovered from five localities (Fig. 2a) in the Kapedo Tuffs, found during the 2006 walkover survey of all visible exposures within the Baringo District (the limits defined by our research permit). Results are summarized in Table 3 with representative artifacts illustrated in Fig. 6; fossils were sparse and limited to an equid tooth and a giraffe tooth, both from surface contexts with no clear relation to lithic artifacts. As shown in Table 3, surface and excavated artifact density within the Kapedo Tuffs as a whole and at individual locales is very low. The surface collected sample (from localities 1–5) is augmented by in situ artifacts recovered from excavations at localities 1 and 4. Each locality preserved a single artifact-bearing stratum identified through one-meter-wide excavated trenches that were subsequently laterally expanded to obtain the largest possible artifact sample. All sediment was removed following natural and arbitrary (10 cm) strata using hand tools and sieved through 6.4 mm wire mesh. All finds were piece-plotted relative to a site datum. Summary stratigraphic sections of these localities are shown in Fig. 3. At localities 1 and 4, artifacts were recovered from medium sands. Sediment grain-size and the absence of pieces <3 cm in maximum dimension suggest winnowing by water of both assemblages (e.g., Schick, 1986), although two sets each of three refitted flakes from locality 4 (including surface and excavated pieces) suggests preservation of some degree of spatial integrity.

The sample of cores and core fragments ($n = 12$) is dominated by bifacial centripetally flaked pieces with variable cross-sectional geometries (Fig. 6b–f). Most ($n = 7$) are asymmetrical in cross section, with a relatively flat upper surface with numerous flake scars and a thicker cortical base with fewer removals, conforming to existing definitions of Levallois cores (Boëda, 1994; Inizan et al., 1999). On the basis of flake scar patterns, these cores reflect both the preferential and recurrent Levallois methods for producing a single or multiple Levallois flake(s) per prepared surface, respectively. The extent to which this variability among the Levallois cores is due to size reduction at discard or other factors cannot be determined from the present sample (for discussion, see Baumler, 1988; Texier and Francisco-Ortego, 1995; Sandgathe, 2004). Dorsal scar patterns and cross-section symmetry suggest that three of the five recovered Levallois flakes conform to the traditional definition of Levallois flakes produced by the preferential method (Fig. 6g). A platform core (using the terminology of Conard et al., 2004) from Locality 3 (Fig. 6h) shows multiple parallel

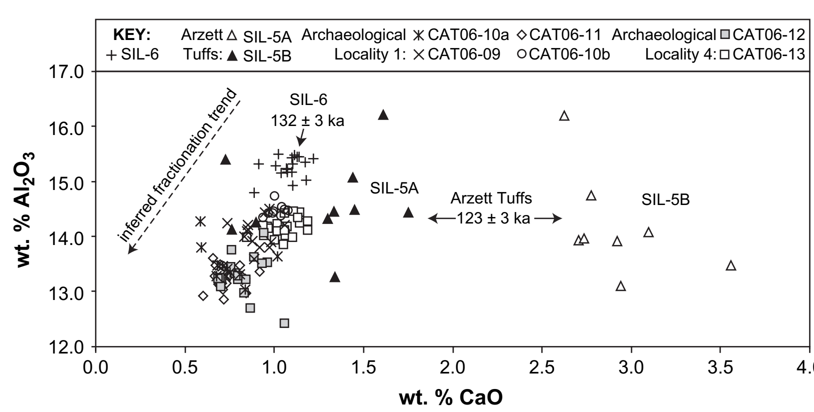

Fig. 5. Bivariate plot of weight percent CaO and Al_2O_3 for all Silali area tephra samples. Covariance of these two element oxides among the samples from archaeological localities 1 and 4 is consistent with fractional crystallization of observed feldspar phenocrysts. The sequence of deposits at Locality 1 supports this hypothesis, with stratigraphically lower deposits (CAT06-09) having a less evolved composition than CAT06-11 higher in the sequence.

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Table 3
Summary composition of Kapedo Tuffs archaeological localities, showing area collected and excavated. Artifact counts are listed as surface/excavated totals. Localities 2 and 5 represent isolated surface finds

Locality	Surface collection area (m^2)	Excavated area (m^2)	Cores (n)	Flakes (*n*)	Flake fragments/debris (*n*)	Retouched/shaped pieces (*n*)	Row total
Locality 1	325	18	3/0	7/5	7/0	1/0	18/5
Locality 2	NA	0	0/0	1/0	0/0	0/0	1/0
Locality 3	2310	0	7/0	16/0	62/0	3/0	88/0
Locality 4	300	9	1/0	4/16	10/18	0/0	15/34
Locality 5	NA	0	1/0	0/0	0/0	0/0	1/0
Column total			12	49	97	4	162

elongated removals from the long axis of the piece from steeply angled opposed striking platforms, suggesting blade production. Formal tools are rare ($n = 4$), and include casually flaked scrapers and a single pick with minimal bifacial flaking (Fig. 6a) made on an elongated cobble. The predominance of Levallois technology and absence of handaxes or other large cutting tools are consistent with a Middle Stone Age (MSA) attribution for the Kapedo Tuffs lithic assemblages.

Cortical surfaces (present on 46% of the combined artifact sample) suggest an exclusive use of stream cobbles for artifact production. Exposures of massive ~20-m-thick clast-supported conglomerates are intercalated with and cut into the Kapedo Tuffs where the Kapedo River is crossed by the Lomelo-Nginyang Road (Fig. 2; Dunkley et al., 1993: 47; McCall, 1999). These represent the only observed exposures with cobbles of sufficient size for the production of the artifacts from sediments penecontemporaneous with the archaeological sites. We collected and classified a random sample of 100 in situ cobbles (cf. Shelley, 1993; Stout et al., 2005; Texier et al., 2006). Of these, one was chert and the remainder lava, the latter likely derived from Pliocene volcano Ribkwo (described in Key, 1987). Of the lava cobbles, only 10 are lithologically and texturally similar in hand-specimen to the various trachytes and phonolites used in artifact production. This indicates the degree of raw material selection practiced by local hominin groups. Straight line distance of this presumed source (the only area with greater than pebble-sized clasts) and the artifact localities suggests occasional transport of heavy (~1 kg) artifacts (Fig. 6a–b) distances up to 5 km.

The sparse archaeological record of the Kapedo Tuffs may reflect ephemeral occupations of the immediate area by hominins, low population density, or minimal use of stone tool-related tasks in the area. Evidence from the Kapedo Tuffs sediments, including intercalated conglomerates, suggests torrential, seasonal reworking by fluvial processes (McCall, 1999) with no observed evidence for a permanent water source in Kapedo Tuffs sediments. Water shortage may have imposed limitations on occupation of the area west of Silali. However, the extent to which the archaeological record of the Kapedo Tuffs reflects hominin dispersals into more poorly watered areas during the presumed climatic amelioration at the onset of the last interglacial (~130 ka; Ambrose, 1998; Lahr and

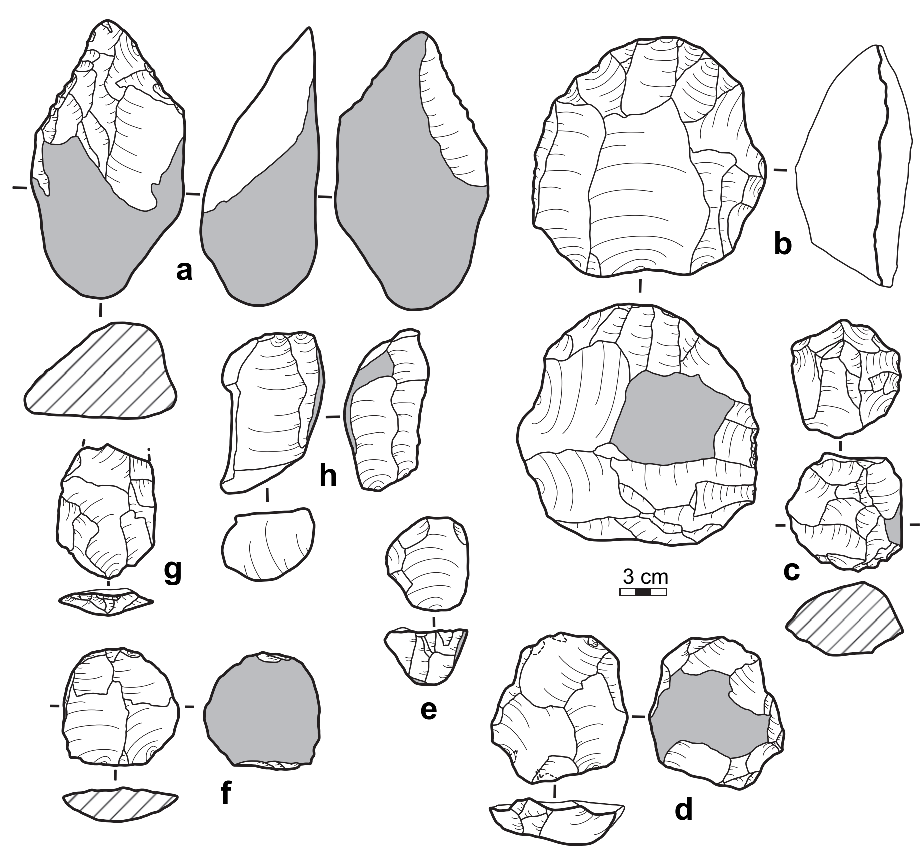

Fig. 6. Artifacts from the Kapedo Tuffs: a, pick, surface, Locality 1; b, Levallois core, surface, Locality 5; c, discoidal core, surface, Locality 4; d and e, Levallois core, surface, Locality 1; f, Levallois core, surface, Locality 3; g, Levallois flake, in situ, Locality 1; h, opposed platform blade core, surface, Locality 3. All artifacts made on lava.

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Foley, 1998; Rose, 2005) or near-abandonment during an interval of extreme aridity (~135–127 ka; Cohen et al., 2007; Scholz et al., 2007) cannot be resolved with the present data.

Regional comparisons

Our discoveries from the Kapedo Tuffs enlarge the presently modest sample of well-dated middle and late Pleistocene African archaeological sites, but more importantly, they facilitate comparisons with adjacent areas to begin to test for the geographic variation considered the hallmark of MSA sites, patterning that may signal the origins of regional identity (Clark, 1988; McBrearty and Brooks, 2000; Barham, 2001). We compare data from the Kapedo Tuffs with other Rift Valley MSA localities in southern Ethiopia and northern Kenya to explore the nature of archaeological variation, drawing upon sites from the adjacent Turkana and Baringo basins, north and south of the Kapedo Tuffs, respectively (Fig. 1). Feibel (1999b) and Potts et al. (1999: 783) have stressed that comparisons between basins (rather than site-specific studies) are at the appropriate spatial scale to examine hominin behavioral variability as they account for variation beyond that of a single site and its immediate environs.

We compare assemblages from Baringo Basin, Kapedo Tuffs, and Turkana Basin using typological and technological criteria at the coarse degree of resolution that others have used to examine subcontinental-scale regional variants among African MSA lithic assemblages (e.g., Clark, 1988; McBrearty and Brooks, 2000; Wurz, 2002). Our goal is not to establish the precise degree of similarity or dissimilarity among lithic assemblages in northern Kenya and southern Ethiopia, nor is it to erect formal industrial or industrial complex names for assemblages from the Kapedo Tuffs or elsewhere (cf. Clark et al., 1966). Detailed lithic technological studies that establish the presence of geographically and temporally restricted patterns of hominin behavior remain an important goal in analyses of MSA or other archaeological assemblages (e.g., Tostevin, 2003a,b; Wurz et al., 2005; Soriano et al., 2007). However, as a prelude to such a study, we explore geological processes that might also explain interassemblage patterning in an attempt to first reject the null hypothesis of non behavioral explanations for the observed archaeological differences (e.g., Clark, 1980; Rolland and Dibble, 1990; Inizan et al., 1999; White, 1998; Chase, 2006: 131–144; Dibble et al., 2006).

In doing so, it is important to emphasize that, whether the outcome of a short, intermittent research history or an accurate reflection of past hominin population density, the MSA archaeological record is sparse in the rift valleys of northern Kenya and southern Ethiopia. Because of the limitations of our artifact sample from the Kapedo Tuffs and elsewhere, our initial exploratory comparisons serve to initiate discussion and to generate a series of propositions that we hope will provide the impetus for further evaluation through continued fieldwork.

Comparative sample

Turkana Basin MSA sites are from the Kibish Formation in southern Ethiopia and from east of Lake Turkana in the vicinity of Koobi Fora, Kenya. Kibish Formation in situ and surface lithic assemblages are from the Member 1 sites of KHS and AHS with an estimated age of ~195 ka, based on underlying $^{40}Ar/^{39}Ar$-dated tephra, and site BNS from Member 3, with an estimated age of ~104 ka (McDougall et al., 2005; Shea, in press). The East Turkana material includes excavated and surface-collected sites of presumed late or middle Pleistocene age from near the edge of the present lake (FxJi-1, FwJi-2, FwJi-3) and closer to the basin margin (FxJj-61, FxJj-66, GaJj-17; Kelly and Harris, 1992; Kelly, 1996a,b; Bräuer et al., 1997). The Baringo Basin MSA sites are from the Kapthurin Formation and comprise artifacts from excavations at Koimilot Locus 1 and Locus 2 (Tryon, 2006) and from surface collections at Nyogonyek (Farrand et al., 1976; Tryon, 2003). Koimilot occurs within the Bedded Tuff Member and is dated to ~250–200 ka on the basis of tephrostratigraphic correlation with dated deposits elsewhere in the Kapthurin Formation (Tryon and McBrearty, 2006); the material from Nyogonyek is of uncertain age and stratigraphic placement but is likely ≥200 ka, the estimated minimum age for Kapthurin Formation sediments.

General similarities and differences

Rare unifacial and bifacial picks made on elongated lava cobbles as well as diverse Levallois flakes and cores are the typological and technological features that unify the lithic assemblages of the Kapedo Tuffs, Baringo Basin, and Turkana Basin. Examples of picks are found in the Kapedo Tuffs at Locality 1 (Fig. 6a), in Baringo Basin at Koimilot Locus 1 (Tryon, 2006), and in Turkana Basin at FxJj-61 near Koobi Fora (Kelly, 1996a: 159) and in Omo Kibish (Shea, in press). In isolation, such tool forms are poor temporal or industrial markers, although when found in abundance in eastern Africa have been attributed to the Sangoan industry or industrial complex (McBrearty, 1988; Clark, 2001). Levallois flakes and cores are present at all sites considered here, including examples suggesting use of both the preferential and recurrent methods (see Fig. 6b–f; Kelly, 1996a; Tryon, 2006; Shea, in press). Cores suggesting blade production occur only in the Kapthurin Formation and Kapedo Tuffs samples (Fig. 6h; Tryon, 2006), but their rarity severely limits their utility as regional markers.

Despite broad similarities in large tool and core forms, the Turkana Basin material differs from assemblages further to the south in: (1) the more frequent use of chert and other cryptocrystalline siliceous rocks as raw material, (2) generally smaller artifact size, and (3) more abundant retouched tools including points. Points, presumably hafted as hunting implements, are particularly important in this context, as they are considered the diagnostic implement of the MSA and a key signal of geographic differentiation (Clark, 1993; McBrearty and Brooks, 2000; Lombard, 2005; Brooks et al., 2006; Shea, 2006; Villa and Lenoir, 2006). The results of our investigation suggest that all of these differences among Rift Valley MSA sites in northern Kenya and southern Ethiopia can be explained by the geological abundance of cryptocrystalline siliceous rocks as a potential raw material source, providing a series of hypotheses for further testing and an important initial demonstration of the challenges facing identification of regional variation in hominin behavior.

Raw material types and abundance

More frequent use of chert distinguishes the Turkana Basin MSA lithic assemblages from those of the Baringo Basin. Integration of the Kapedo Tuffs artifacts suggests a geographic gradient in the frequency of chert (here defined as all cryptocrystalline siliceous rocks precipitated from an aqueous solution of lacustrine or hydrothermal origin) and related rocks at Rift Valley MSA sites in northern Kenya and southern Ethiopia, increasing northwards from the equator (Fig. 7). Although of variable quality, available data suggest an identical trend in the geological abundance of chert (Fig. 7). The high frequency of chert at archaeological sites relative to its geological abundance is consistent with the preferential selection of this material by hominins. Such a hypothesis is also consistent with a wider trend seen at MSA sites of the increased use of fine-grained cryptocrystalline rocks (e.g., Merrick et al., 1994; Raynal et al., 2001; but see Negash et al., 2006), and made more apparent through comparison of the lava- or quartz-dominated Early Stone Age sites from the same region, particularly Turkana

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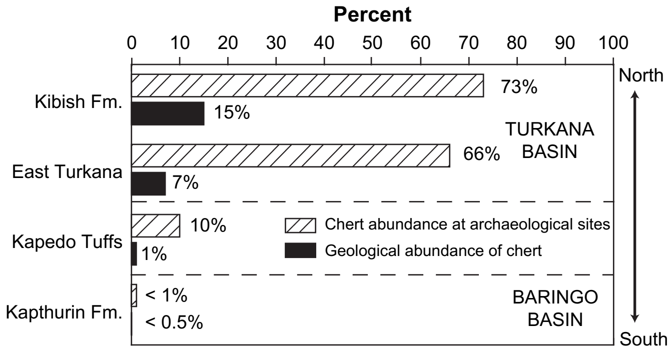

Fig. 7. Histogram comparing relative archaeological and geological abundances of chert from Rift Valley sites in northern Kenya and southern Ethiopia. Geological abundance of chert is estimated from outcrops penecontemporaneous with archaeological sites from the Kapthurin Formation (800 clasts from eight locations; Tryon and McBrearty, unpublished data), the Kapedo Tuffs (this paper), and Member 1 of the Kibish Formation (175 clasts; Shea, in press). Available data from East Turkana are from older deposits (Frostick and Reid, 1980: 436; Lepre, 2001), have poorly defined provenance (Kelly, 1996a: 189–190), or are qualitative estimates of chert abundance (Barthelme, 1985). We use a value of 7% (Toth, 1982: 118, from a sample of 28 cobbles) as a likely average for estimates that range between 0% and "abundant quantities" (Barthelme, 1985: 277).

Basin (e.g., Isaac et al., 1997; de la Torre, 2004). However, the concomitant northward increase of geological and archaeological chert abundance among the sites studied here suggests that differences between basins in use of this material at MSA sites are most simply explained by its natural availability.

Artifact size

The nature of a lithic assemblage is determined in part by stone raw material abundance and form (e.g., Kuhn, 1995; Roth and Dibble, 1998; Dibble et al., 2005; Moore and Brumm, 2007), and the small average size of the Turkana Basin material may be largely dictated by diminutive chert clasts available for use. Following Toth (1985), Fig. 8 plots core size against distance to the Rift Valley margin for chert and lava cores. Maximum core size is used as a proxy for average artifact size because cores are sufficiently large

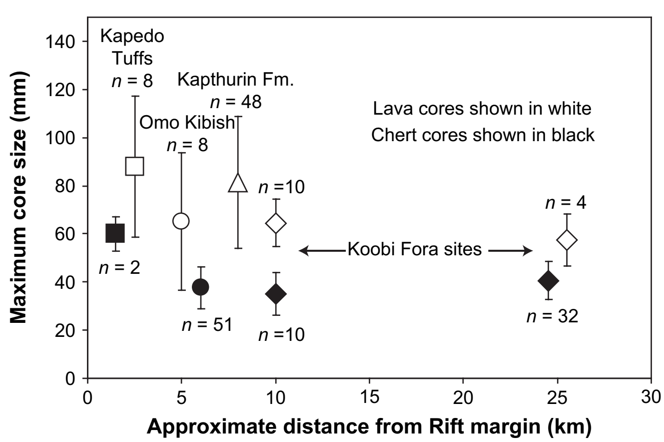

Fig. 8. Relation between core size and site distance from basin margin, as a rough approximation of fluvial clast transport distance. Core size is measured as the maximum linear dimension of Andrefsky (1998: 139) shown here as the mean and first standard deviation. Sample size (*n*) indicated for each comparative group. Distance for the Kapthurin Formation sites is measured from the Saimo Fault that defines the eastern margin of the Tugen Hills (Chapman et al., 1978); the main border faults of the western margin of the Gregory Rift are used for the Kapedo Tuffs (McCall, 1999). The East Turkana Basin margin distance estimate uses the Karari Escarpment or the Suregai Plateau (Isaac and Behrensmeyer, 1997), with the Nkalabong horst used for sites from the Kibish Formation (Moore and Davidson, 1978; Wolde-Gabriel and Aronson, 1987).

to be unaffected by the minor stream flow processes that winnow sites or by the collection bias towards larger pieces inherent in the surface collected samples used here. Estimated distance of each site from the Rift Valley margin (Fig. 1) serves as a rough measure for clast transport distance, as this topographic break divides the volcanic highlands where source rocks are eroded and the lower lying areas where most stream deposits and archaeological sites occur.

Core size diminishes with increased distance from the Rift Valley margin, with chert cores consistently smaller than those of lava (Fig. 8). Core size is unlikely to reflect intensive reduction due to raw material conservation during transport in these cases, as local sources were used for even the smallest sized assemblages from the Kibish Formation (Shea, in press). Instead, the pattern appears to reflect downstream reduction of fluvial clast size with increased transport distance. This process is widely documented (e.g., Pettijohn, 1975), and occurs due to progressive size sorting with decreased channel gradient and, to a lesser extent, clast abrasion (cf., Jones and Humphrey, 1997; Rice, 1999; Lewin and Brewer, 2002). Although other factors such as particle shape or material density provide complicating factors (Frostick and Reid, 1980), the consistently smaller size of chert cores regardless of Rift Valley margin distance points to smaller initial clast sizes. Although initial size cannot be estimated with precision, most chert deposits in the rift valley formed in shallow lakes or as hydrothermal precipitates infilling voids and cavities in lava and typically occur as thin beds or nodules (10^{-1}–10^{0}-m-thick), whereas Rift Valley lava flows show a greater size range (10^{0}–10^{2}-m-thick; e.g., Hay, 1968; Eugster, 1969; Chapman et al., 1978; Davidson, 1983; Key, 1987; Hackman, 1988; Key and Watkins, 1988; Renaut and Owen, 1988; Haileb et al., 2004). From this perspective, geological rather than behavioral factors likely explain most of the interassemblage variation related to artifact size due to the dimensions of available raw material 'packages,' and the proximity of Rift Valley-margin sources may in part explain the presence of large (>10 cm) lava Levallois cores from the Kapedo Tuffs (Fig. 6b) and the Kapthurin Formation (Tryon et al., 2005).

Retouched artifact frequency

Points and other retouched pieces are relatively abundant in the Turkana Basin sample; they are rare or absent in those from the Kapedo Tuffs and Baringo Basin. Comparisons of retouched piece frequency to total artifact count show stark contrasts among chert and lava raw material types (Fig. 9). As shown in Fig. 9b, log-transformed sample size and retouched artifact count among chert artifacts show a strong statistically significant correlation ($r^2 = 0.893$, $p < 0.000$), a result not observed for artifacts made of lava ($r^2 = 0.166$, $p = 0.093$). The difference in the slopes of the two regressions is statistically significant ($p < 0.000$; Zar, 1999: 360–364), showing that amongst this sample, lava retouched artifacts are always rare relative to those of chert. Our sample combines both surface and excavated assemblages, the typological composition of which may differ due to a number of postdepositional processes (see Rogers, 1997). In Fig. 9b, chert artifact abundance is plotted for both the surface and excavated portions of the FxJj-61 assemblage. The results are comparable although, as expected, the relative abundance of retouched artifacts is higher for the surface-collected sample. This further emphasizes the differences between artifacts of the two raw material types, as lava retouched artifacts are rare even from large surface collections from the Kapthurin Formation (e.g., Nyogonyek) and elsewhere.

These preliminary results suggest that in many instances, the presence or abundance of retouched pieces such as points at MSA sites, is related not just to sample size (e.g., Grayson and Cole, 1998) but also to the abundance of siliceous stone raw material, a result mirrored at Early Stone Age sites from Olduvai Gorge, Tanzania

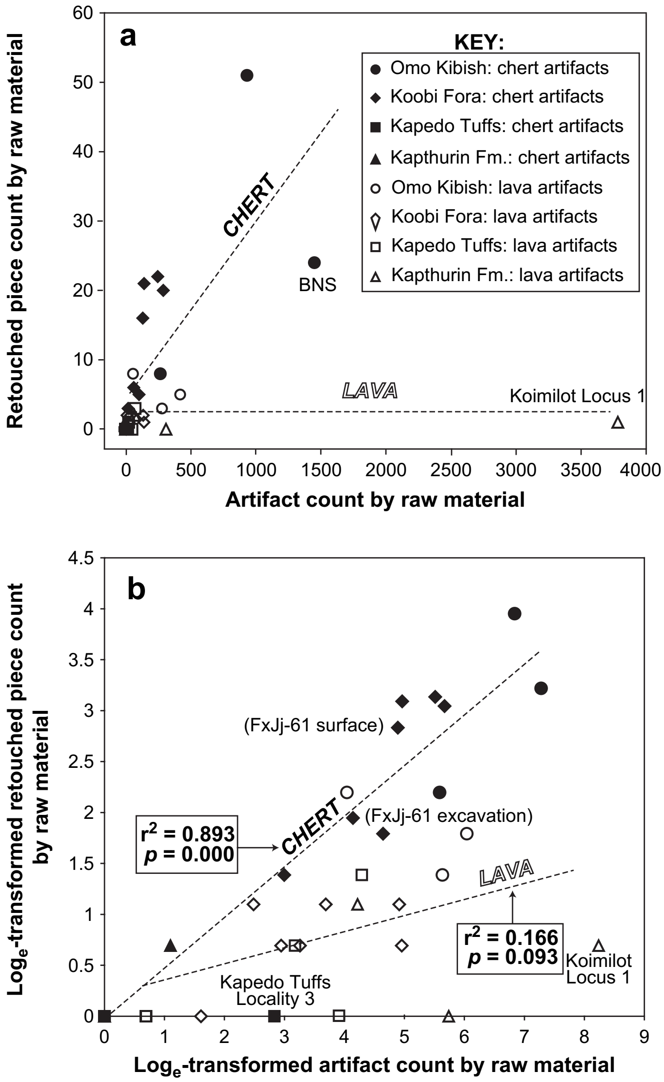

Fig. 9. Effect of stone raw material type (chert vs. lava) on relative abundances of retouched artifact counts for Rift Valley assemblages in northern Kenya and southern Ethiopia. A least-squares regression of (a) untransformed and (b) transformed data suggest a strong positive relationship between sample size and retouched artifact count among chert artifacts and a weak one among lava artifacts. Data were $\log_e$-transformed following a Box-Cox procedure using SAS 9.1 software (SAS Institute Inc., 2002–2003) to identify the appropriate transformation to normalize the distribution of the error terms in the linear regression of the raw data (Neter et al., 1996). A constant value (1) was uniformly applied prior to transformation, since the logarithm of zero is undefined. Key is the same for both (a) and (b). Outliers are labeled; data points in parentheses are surface and excavated portions of the same site.

(Kimura, 2002). Although this general finding may relate to hominin preference for this rock type, it may also result from differences in raw material mechanical properties. That is, while some retouch reflects deliberate flake removals designed to shape a piece, other instances of flake removals are the result of the rejuvenation of worn edges or even accidental postdepositional breakage by trampling or other processes (e.g., McBrearty et al., 1998). Importantly, relative to those of lava, chert retouched pieces have edges that dull faster, fracture more readily, and leave more abundant macro- and microscopic traces of resharpening (e.g., Kamminga, 1982; Jones, 1994). Whatever the interpretation of the cause of retouched piece frequency, the influence on assemblage typology is the same. Retouched tools such as points continue to play a key role in our understanding of MSA variability at sites throughout the Africa (e.g., McBrearty and Brooks, 2000; Garcea, 2004; Villa et al., 2005; but see also Wurz, 2002), but their presence or abundance may be strongly dictated by the available stone raw material.

Discussion and conclusions

The Kapedo Tuffs archaeological record is sparse and consists of lithic artifacts recovered from five localities over a $\sim$50 km^2 area of discontinuously exposed outcrops of tuffaceous sediments. The artifacts are typologically Middle Stone Age (MSA), characterized by the reduction of locally available lava cobbles using various Levallois and other flake production methods. Rare retouched artifacts include casually flaked scrapers and a pick. More than 128 electron microprobe analyses of ten tephra samples from the Kapedo Tuffs and the adjacent Quaternary volcano Silali provide the basis for stratigraphic correlation between ^{40}Ar/^{39}Ar-dated deposits and those found at archaeological sites. Correlation of the Kapedo Tuffs with the Upper Pyroclastic Deposits of Silali (Smith et al., 1995) and the absence of overlying deposits from the Arzett Tuffs indicate an age range of 135–123 ka for the archaeological sites. This age estimate implies that sediments of the Kapedo Tuffs were deposited rapidly, represent a narrow interval of time, and preserve an archaeological record with a high degree of temporal resolution relative to many other Pleistocene localities. Furthermore, this age estimate suggests the presence of hominins in the Rift Valley in eastern Africa between 1°–2° N latitude, during or slightly before the onset of the last interglacial, and are thus relevant to address proposed hominin population expansions during this climatic interval (e.g., Ambrose, 1998; Lahr and Foley, 1998; but see also Cohen et al., 2007; Scholz et al., 2007).

The Kapedo Tuffs are geographically intermediate between the Turkana and Baringo basins. Data from the Kapedo Tuffs thus serve as important points of comparison for understanding the nature of regional archaeological variation between these better-studied areas, reducing the spatial gaps that serve to exaggerate differences and mask clinal variation. We present here the first attempt at a regional synthesis of Rift Valley MSA sites of northern Kenya and southern Ethiopia. As sites and artifacts are sparse and research history is short, our initial comparisons await fuller evaluation through additional fieldwork. Comparison of MSA sites from these three areas suggests general technological parity in the rare production of heavy-duty tools (sensu Clark, 2001) and the use of diverse Levallois methods of flake production. Given the present limitations of our dataset, the nature of the comparison and the degree of observed similarity are insufficient to erect formal industrial names or to infer shared behavioral traditions. However, the explanations of the observed differences among these lithic assemblages are instructive for future attempts to do so, which remain an essential step in the analysis of African Pleistocene hominin behavioral variability. Among the MSA sites of the Kapedo Tuffs, Kapthurin Formation, East Turkana, and the Omo Kibish, our data fail to reject the null hypothesis that the observed archaeological differences are due to nonbehavioral explanations, in this case the geological abundance of chert or similar cryptocrystalline rocks. That is, among the sample studied here, hominin use of chert is positively correlated with its availability, and chert abundance has a pronounced impact on average artifact size (a morphological difference that could be attributed to cultural preference) and the abundance of retouched pieces (important in many typological comparisons).

Finally, our discovery of sites in the Kapedo Tuffs demonstrates the still largely untapped potential of the northern Kenya Rift. Basic geological mapping of this portion of the Rift Valley has already been accomplished, accompanied by suites of precise ^{40}Ar/^{39}Ar dates on eruptive deposits from all Quaternary volcanic edifices in the region (e.g, Key, 1987; Dunkley et al., 1993). This provides the framework for additional archaeological reconnaissance and relatively rapid age approximation using established stratigraphic frameworks, augmented in our case by tephra correlation. MSA artifacts are sparse from western Turkana (e.g., Whitworth, 1965), and much of the Rift Valley between Lake Baringo and Lake Turkana remains to be archaeologically surveyed; potentially promising are the late Pleistocene and younger deposits of paleo-Lake Suguta north of Silali (Truckle, 1976; Casanova et al., 1988; Dunkley et al., 1993; Sturchio et al., 1993; Trauth et al., 2005), where only sparse Holocene-aged material with poor provenience has thus far been reported (Sutton, 1990) due to minimal investigation.

Defining the nature, scale, and chronology of regional differences among Middle Stone Age sites is a critical task still confronting archaeologists. This forms an essential step towards examining fine-scale geographic variation in the behavior and morphology of Pleistocene African hominin populations that included early representatives of *Homo sapiens* (cf. Clark, 2002; Foley and Lahr, 2003). Accomplishing this goal requires data at finely resolved spatial and temporal scales and an understanding of the causes, behavioral or otherwise, that define archaeological variation. Our work in the Kapedo Tuffs points the way towards how this may be achieved, reveals some of the limitations confronted when doing so, and indicates important areas for future research.

Acknowledgements

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