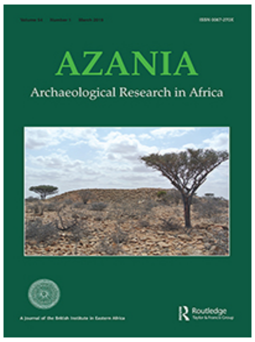

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The lithic assemblage from Sugenya, a Pastoral Neolithic site of the Elmenteitan tradition in southwestern Kenya

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ABSTRACT

The spread of mobile pastoralism throughout eastern Africa in the mid- to late Holocene fundamentally reshaped social and economic strategies and occurred against the backdrop of major climatic and demographic change. Early stone-tool-using herders in these regions faced new and unpredictable environments. Lithic technological strategies from this 'Pastoral Neolithic' (PN) period (*c.* 5000–1400 BP) reflect the social and economic solutions to the novel environmental challenges faced by food-producing communities. In southern Kenya, the 'Elmenteitan' technological tradition appears during the PN in association with a specialised herding economy and distinct ceramic styles and settlement patterns. The Elmenteitan is known mostly from rockshelter sites in the Central Rift Valley and few open-air Elmenteitan sites have been extensively excavated. Fewer still have benefitted from comprehensive lithic analyses. This paper presents typological and technological analyses of the Elmenteitan site of Sugenya located in the Lemek Valley of southwestern Kenya and excavated by Alison Simons in 2002. Technological patterns add resolution to Elmenteitan tool-use and production in the region and contribute new insights to the organisation of Elmenteitan obsidian exchange networks.

RESUMÉ

L'expansion du pastoralisme mobile à travers l'Afrique orientale dans la deuxième moitié de l'Holocène remodela profondément les stratégies sociales et économiques et s'effectua dans le contexte de changements climatiques et démographiques majeurs. Les premiers éleveurs utilisateurs d'outils en pierre de ces régions furent confrontés à des environnements nouveaux et imprévisibles. Les stratégies technologiques lithiques de cette période, dite 'Néolithique pastoral' (PN, *c.* 5000–1400 BP), reflètent les solutions sociales et économiques développées par les communautés productrices de nourriture, obligées de faire face à de nouveaux défis environnementaux. Dans le sud du Kenya, la tradition technologique 'Elmenteitan' apparaît au cours du PN associée à une économie d'élevage spécialisée et des styles de céramique et des schémas de peuplement distincts. L'Elmenteitan

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est surtout connu à travers des abris sous roche dans la vallée centrale du Rift; peu de sites à ciel ouvert appartenant à cette tradition ont fait l'objet de fouilles approfondies. Moins encore ont bénéficié d'analyses lithiques complètes. Cet article présente des analyses typologiques et technologiques du site Elmenteitan de Sugenya, situé dans la vallée de Lemek au sud-ouest du Kenya et mis au jour par Alison Simons en 2002. Les schémas technologiques améliorent notre compréhension de l'utilisation et de la production des outils Elmenteitan dans la région, et apportent de nouvelles informations relatives à l'organisation des réseaux d'échange d'obsidienne de cette tradition.

Introduction

Archaeological research shows that lifeways based on herding domesticated livestock likely spread throughout eastern Africa before those based on settled plant agriculture. Recent excavation projects have refined the chronology for the arrival and spread of herding. Mobile pastoralists appear to have arrived in the Lake Turkana Basin around 4800 BP (Hildebrand *et al.* in press), spread throughout southern Kenya after *c.* 3200 BP, and reached central Tanzania by 3000 BP (Grillo *et al.* 2018). It is now clear that the timing of the arrival of early food production in these regions corresponds to periods of dynamic climatic and demographic transitions (Gifford-Gonzalez 2016; Ashley *et al.* 2017; Skoglund *et al.* 2017; Marchant *et al.* 2018). This raises important questions over how early herders coped with novel challenges in eastern Africa's semi-arid environments where resources are heterogeneously distributed in space and time. Ultimately, the land-use strategies people developed during this Pastoral Neolithic (PN) period laid the foundation for the long-term persistence of herding economies in eastern — and later also southern — Africa.

Reconstructions of prehistoric herding practices have relied heavily on faunal analyses, which have helped elaborate aspects of herd management and identify the development of specialised pastoralism (Gifford *et al.* 1980; Marshall *et al.* 1984; Marshall 1990, 1991; Gifford-Gonzalez 2000; Simons 2004; Prendergast 2008, 2010; Prendergast and Mutundu 2009). More recently, isotopic and palaeoenvironmental studies are demonstrating regional diversity in herding strategy and mobility (Balasse and Ambrose 2005; Chritz *et al.* 2015; Janzen 2015; Githumbi *et al.* 2017). Material culture has played a less prominent role in these discussions, although in southern Kenya variation in lithic and ceramic styles has helped to identify discrete 'Elmenteitan' and 'Savanna Pastoral Neolithic' (SPN) traditions associated with early herding (Leakey and Leakey 1950; Ambrose 1980; Robertshaw 1990; Marshall *et al.* 2012). Typological differences between the Elmenteitan and the SPN may reflect fundamental economic divergences between the makers of these industries and thus require focused research.

Lithic technological analyses are especially important for detecting and interpreting economic differences, as strategies for producing and maintaining stone tools directly reflect the ways in which people interacted with their landscape (e.g. Parry and Kelly 1987; Nelson 1991; Andrefsky 1994, 2010; Ambrose 2002; Shea 2010). Investigations of PN lithic patterns have led to several hypotheses regarding the social and strategic organisation of stone-tool using pastoralists (Robertshaw 1988; Ambrose 2001; Goldstein 2014; Goldstein and Munyiri 2017). However, a paucity of well described lithic assemblages from extensively excavated and well-dated PN sites remains a major impediment to testing existing hypotheses and generating new ones.

The site of Sugenya (GuJf91A) in the Lemek Valley of southwestern Kenya is one of few excavated open-air PN occurrences outside the Central Rift Valley. Excavated by Allison Simons (2004) in 2002, Sugenya is a stratified and spatially differentiated site with material culture typical of the Elmenteitan group. Surveys of the broader Loita-Mara Plains have found evidence that the region was occupied by both SPN and Elmenteitan herders (Robertshaw 1990: 36–51), likely due to it experiencing local bimodal annual rainfall patterns that could support pastoral production (Marshall 1991). Analyses of subsistence practices at Sugenya contribute to a growing picture of specialised Elmenteitan economies focused on cattle, sheep and goats, with little evidence for wild resource use (Simons 2004; see also Marshall 1990). It is also possible that Elmenteitan herders practised some cultivation, but there has been too little recovery of botanical remains from Elmenteitan sites to address this issue adequately (Robertshaw and Collett 1983). In addition, data from Sugenya have been used in discussions of Elmenteitan social organisation (Simons 2004, 2005) and landscape management (Shahack-Gross *et al.* 2008). A description and analysis of the lithic assemblage from Sugenya are presented here for the first time with the goal of putting these discussions into a broader contextual framework and adding resolution to ongoing research on Elmenteitan strategies in the southwestern highlands of Kenya.

Background

The Pastoral Neolithic

African forms of pastoralism based on keeping and managing domesticated cattle originated in northeastern Africa by 7500 BP during a period of overall wetter early Holocene conditions. With the retreat of the Inter-Tropical Convergence Zone in subsequent centuries, increasing aridity and redesertification of the Sahara contributed to the movement of early food producers southward (Marshall and Hildebrand 2002; Kuper and Kröpelin 2006). Although the exact pathways remain unclear, economies with cattle and caprines of ultimately Near Eastern origin arrived in the Lake Turkana Basin of northern Kenya by 4800 BP (Marshall *et al.* 1984; Hildebrand and Grillo 2012). Pastoralist economies then-gave way to even more ephemeral — and more mixed — economies after 4000 BP during a period of extended and extreme aridity (Hildebrand and Grillo 2012; Wright *et al.* 2015). Small numbers of livestock begin appearing in hunter-gatherer contexts at sites like Enkapune Ya Muto in the Central Rift Valley and in the Lake Victoria Basin at this time, indicating some level of population mobility and interaction (Marean 1992; Ambrose 1998; Prendergast 2009; Dale and Ashley 2010; Wright 2011).

Evidence for economies structured around management of domesticated livestock does not appear until after *c.* 3200 BP in the Central Rift Valley. Specialised herding economies spread rapidly southward from this point, reaching at least as far as the site of Luxmanda in north-central Tanzania as early as 3000 BP (Grillo *et al.* 2018). Expansions westward were more protracted, as large herding sites in the Lemek Hills and Loita Plains appear only after 2700 BP (Robertshaw 1990). Small quantities of livestock are found at Kansyore fisher-forager sites around Lake Victoria, but specialised herding is not evident there until after *c.* 2000 BP (Robertshaw 1991; Lane 2004). Climatic amelioration, lake recharge and grassland recovery at this time certainly played a role in the sudden expansion southward, however the presence of local hunter-gatherers, new environments and especially new zoonotic disease risks also shaped the spread of early food production in eastern Africa (Gifford-Gonzalez 2000, 2017; Marshall *et al.* 2011). How early herding populations coped with these challenges is an ongoing question for Pastoral Neolithic research focused on the period *c.* 3200–1400 BP.

At the centre of many discussions about variability in PN strategies is the identification of two discrete patterns of material culture that co-occur in space and time. The 'Savanna Pastoral Neolithic' (SPN) encompasses sites with a predominately domestic fauna associated with a wide range of ceramic styles including Narosura, Nderit, Ileret, Akira and Maringishu, a preference for grey-hued obsidians sourced to the Lake Naivasha Basin, particular lithic production techniques and tool styles, cairn burials and settlement in lowland savannas (Wandibba 1980; Bower 1991; Ambrose 2001, 2002, 2012; see also Bower and Nelson 1979; Gifford *et al.* 1980). In contrast, the highly uniform 'Elmenteitan' group of sites is identified by minimally decorated mica-tempered ceramics, large blade production, its own lithic tool styles, nearly exclusive use of green obsidian from Mt Eburru sources, cremation burials and settlement in highland areas (Ambrose 1980, 2001; Robertshaw 1988a, 1990; Goldstein 2017).

Elmenteitan groups also practised more intensive or specialised herding in the Loita-Mara region. Sites there have yielded faunal assemblages in which 95–99% of the identifiable specimens are domesticated cattle or caprines (Marshall 1990, 1994, 1998; Simons 2004). Lowland rockshelter sites are dominated by sheep and goats, possibly reflecting a pattern of seasonal herding of caprines in drier low-elevation areas of the Central Rift Valley (Gifford-Gonzalez 1985; Robertshaw 1988b: 64). More mixed economies seem to characterise Elmenteitan occurrences around Lake Victoria, reflecting either increased interaction with foragers (Chritz *et al.* 2015) or a situation in which pastoralists were experiencing some form of economic stress (Marshall and Pilgram 1986; Marshall 1994). Isotopic and historical linguistic evidence may suggest some dimension of cultivation, but no macrobotanical evidence for this has yet been recovered from Elmenteitan sites (Ambrose and DeNiro 1986: 323; see also Robershaw and Collett 1983).

Differences in lithic technological strategies between the SPN and the Elmenteitan are well documented. Industries belonging to the SPN are more variable, but feature larger microlithic elements, lower ratios of bipolar pieces, a use of more diverse raw materials and a greater prevalence of bidirectional core design (Robertshaw 1990; Ambrose 2001; Goldstein 2017). Elmenteitan lithic strategies, on the other hand, appear more uniform, centring around the production of large, broad and flat blades with a characteristic 'dorsal-proximal faceting' style of striking platform preparation (Ambrose 2001). Geometric microliths at Elmenteitan sites are smaller and there is generally also a greater representation of backed blades, segments and notched tools (Ambrose 2002). In addition, Elmenteitan assemblages demonstrate a typical core reduction sequence with specific unidirectional and naviform core morphologies (Goldstein 2018a). Elmenteitan lithic assemblages as far as 250 km from the Central Rift Valley demonstrate a strong preference for using obsidian, specifically from sources on Mt Eburru (Merrick and Brown 1984; Merrick *et al.* 1990; Ambrose 2012). Disparate Elmenteitan communities appear to have been linked by a form of obsidian distribution or exchange network in which SPN-producing groups did not participate (Robertshaw 1988; Ambrose 2012; Goldstein and Munyiri 2017).

Ideas about Elmenteitan obsidian exchange have driven most previous discussions about the social structures of this group. Robertshaw (1988, 1990) interpreted increasing proportions of bipolar pieces in assemblages with increasing distance from the Central Rift obsidian sources as evidence of increasing emphasis on raw material conservation as access to obsidian became more strained. Endscraper curation rates at PN sites are highly variable and may also reflect fluctuating levels of obsidian access across space and time (Goldstein 2014). Less attention has been paid to variability in technological strategies between Elmenteitan sites that may reflect regionally specific adaptations or spatial variability in tool use within individual sites. Testing existing hypotheses about PN strategies and opening newer lines of inquiry requires larger comparative datasets from more well documented ancient pastoralist sites.

Sugenya

The site of Sugenya (SASES:GuGf91A) is located just south of the town of Lemek in the foothills near the western end of the Lemek Valley in southwestern Kenya (01°06'49"S, 035°21'21"E, 1913 m a.s.l.). Several excavated Elmenteitan sites are known from this valley, including Ngamuriak and Sambo Ngige just 5 km to the east and the Oldorotua 1 and 5 localities around 10 km to the southwest (Robertshaw 1990) (Figure 1). Several SPN sites in the Lemek Valley have also been sampled and there are several dozen locations where Elmenteitan, SPN and Pastoral Iron Age materials are visible on the surface. It was during surface surveys that Peter Robertshaw first identified typically Elmenteitan material culture eroding from a roadcut at Sugenya (Robertshaw *et al.*

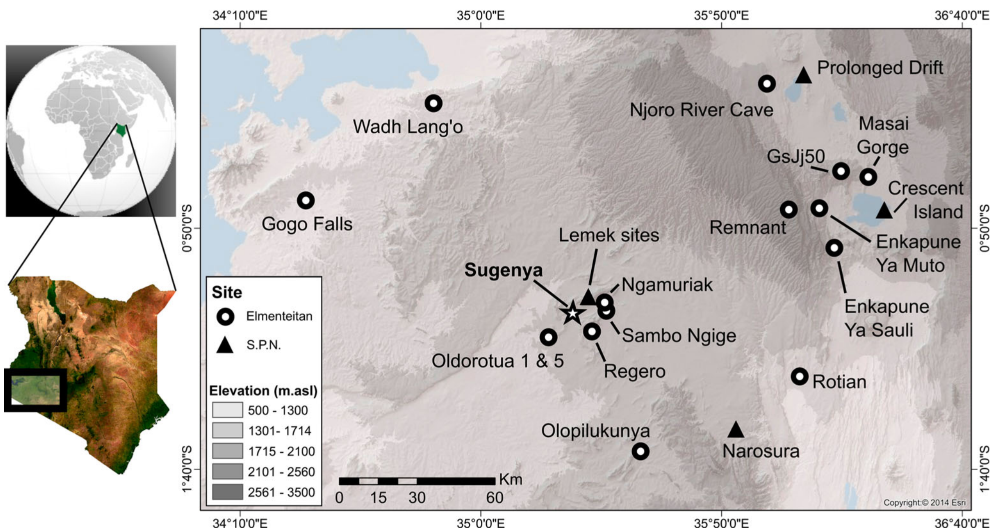

Figure 1. Map of southwestern Kenya showing the locations of Sugenya and other Elmenteitan and SPN sites mentioned in the text and/or referenced in comparative analyses.

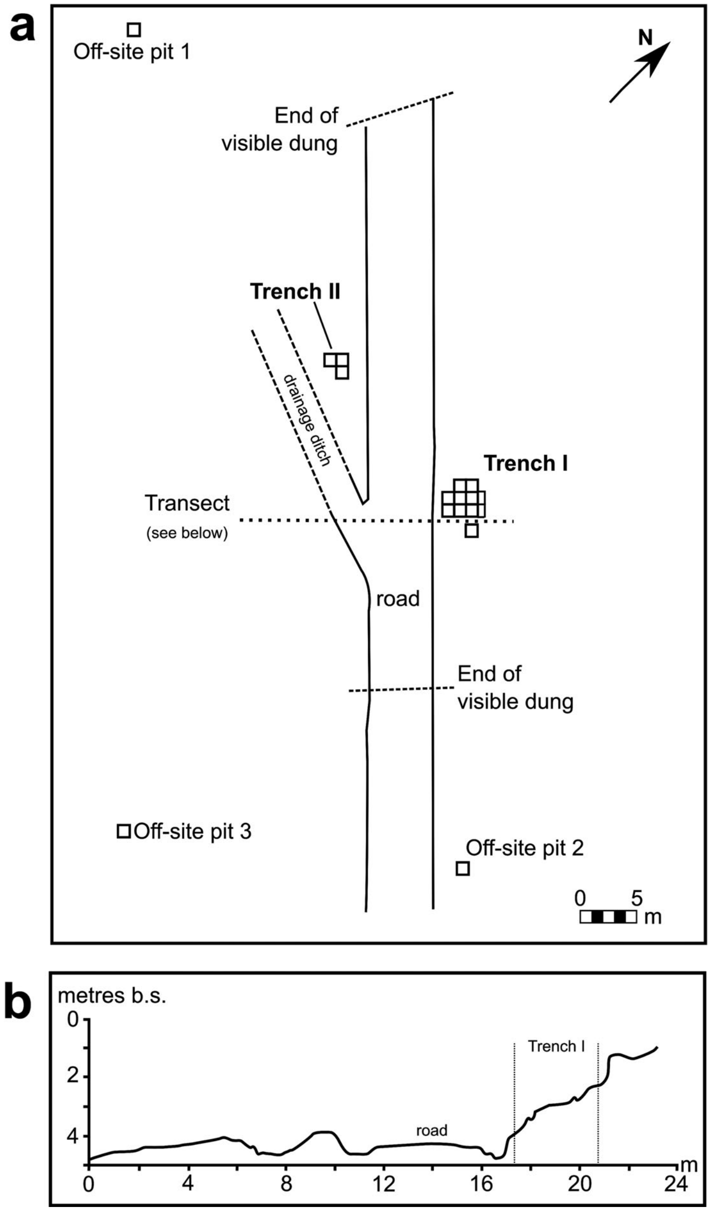

Figure 2. Sugenya: (a) site plan showing the locations of the excavation trenches; (b) section profile (after Simons 2004 Figures 4.3 and 4.5).

1990). Of particular note was a stratified layer of fine pale sediments believed to derive from accumulations of ancient animal dung. Formal excavations at Sugenya began in 2002 (Simons 2004; Figure 2).

Excavations were concentrated on a 9 m^2 main trench near the apparent centre of the site. This trench contained a 10 cm-thick archaeological midden, as well as post-holes, possible hearths and dung deposits (Simons 2004: 97–98). A second trench measuring 3 m^2 was placed across the road, near an area where the suspected dung deposits were actively eroding on the surface. Simons (2004: 101) identified possible lenses of degraded animal dung, but not distinct features or middens in this trench. A third trench consisting of a single 1 x 1 metre square was added 3 m south of Trench 1 to determine if the midden there extended any further. These excavations produced a large assemblage of fauna, ceramics and stone artefacts. The pottery from Sugenya has not yet been specifically studied, but is typical of the Elmenteitan, including the characteristic use of mica temper, the presence of spouted vessels and a minimal employment of decoration. A radiocarbon date of 2340–2047 cal. BP (2230 ± 60 BP, Pta-9058) was obtained from the base of the midden layer in Trench 1 and a second date of 2919–2497 cal. BP (2680 ± 60 BP, Pta-9063) comes from the base of the underlying dung layer (Simons 2004). These dates likely reflect two distinct occupational episodes by Elmenteitan herders, rather than continuous occupation (Simons 2004: 115). This hypothesis is consistent with mobile herder lifeways and is supported by increasing evidence for the subsequent re-occupation of PN sites with large dung accumulations (Marshall *et al.* 2016).

Analysis of the site's fauna identified 97–98% of the assemblage as being domesticated cattle, sheep or goats. Livestock were found to have been in overall good health with very few dental hypoplasias. Age-at–death profiles are not consistent with premature culling that could be interpreted as a sign of population stress (Simons 2004). The faunal patterns at Sugenya are comparable to those at other Elmenteitan sites in the region, presenting a picture of stable and specialised pastoralist economies in the Lemek-Mara area between *c.* 2700 and 1900 BP (Marshall 1990; Robertshaw *et al.* 1990; Marshall *et al.* 2004). This domestic economy may have been supported by an increased emphasis on dairying (Marshall 1990) or may have been related to growing social and economic inequality (Robertshaw 1988). Simons (2004, 2005) has argued against the latter hypothesis based on faunal data. Sediment samples from Sugenya have also been instrumental in geoarchaeological research on methods for identifying ancient livestock dung and assessing its long-term ecological impacts (Shahack-Gross *et al.* 2008; Marshall *et al.* 2018).

The lithic assemblage from Sugenya has not been previously analysed. However, Simons (2004: 136–138) provides a description of several groundstone implements recovered from the excavations. A large grinding stone with possible ochre staining (Online Supplementary Information 1), a muller, a hammerstone and a smoothed 'pot burnisher' are included in the inventory of excavated material. A polished stone axe and several fragments of assorted ground stone implements were found on the surface during the original surveys (Robertshaw 1990: 169). In addition, excavations produced several fragments of non-local mica, which was commonly used as temper in Elmenteitan pottery (Online Supplementary Information 2). The excavated assemblage includes several bone tools and ornaments that have also been thoroughly described (Simons 2004: 139–151). Osseous tools primarily resemble awls manufactured on shaft fragments. Groundstone and bone tools occur in low frequencies at many PN sites and it is not yet clear if there are discernible differences in these technologies between the Elmenteitan and the SPN (see Langley *et al.* 2017).

Lithic analyses

The lithic material from Sugenya is now curated in the National Museums of Kenya, Nairobi. The assemblage is bagged by excavation unit and level. Material from each bag was sorted hierarchically, first by raw material and then separating formal tools, retouched pieces, cores and débitage. Formal and informal tools were measured and classified using established regional typologies (Nelson 1973; Robertshaw 1990). The only variation is that implements previously labeled *outils écaillés* and *batonnettes* are subsumed under the category of 'splintered pieces' when they exhibit bidirectional wedge-initiated flake scars, edge shattering and ventral compression rings consistent with bipolar reduction (after Andrefsky 2005; de le Peña 2015). These criteria were also used to identify bipolar débitage. Blades were identified as elongate flakes with multiple parallel flake scars indicative of hierarchical core reduction strategies (after Conard *et al.* 2004).

All other material fell under the category of 'flakes'. Measurements of length, width, thickness, striking platform type (after Ambrose 2002), striking platform width and thickness, plan-view symmetry, curvature (after Andrefsky 1986), flake scar direction, flake scar count and proportion of dorsal cortex were taken for each complete and proximal piece of débitage larger than 5 mm (after Goldstein 2018a). These attributes are relevant for reconstructing core reduction and management strategies, particularly for Elmenteitan assemblages. Other fragmentary debris was sorted by raw material, part and size and only counts and weights were recorded. All the raw data are available in Online Supplementary Information 3.

Analytical units

Division of Pastoral Neolithic assemblages into spatial or stratigraphic units presents several challenges. Few sites have well detailed stratigraphic sequences that have been well enough dated to differentiate discrete occupational episodes. Sites with multiple dates across long sequences often exhibit significant mixing between horizons (e.g. Robertshaw 1991; Lane *et al.* 2007). Moreover, PN assemblages tend to be small, while sub-dividing them by trench or stratum often leaves sample sizes that are too small for meaningful comparative analyses. Similar challenges are present at Sugenya, which has yielded only two dates from a single trench. This analysis follows the approach implemented by Simons (2004) in the original analysis of the fauna to provide comparative datasets. To assess potential variation in lithic technology at the site, the aggregate assemblages from both excavation areas are compared to one another, and the assemblages corresponding to the dated midden and occupational horizon contexts in Trench I are also compared. The aggregate assemblage from the site is then used for broader comparisons to other Elmenteitan occurrences following existing studies (Robertshaw 1988, 1990; Ambrose 2002; Goldstein 2017).

Results

Summary

The chipped stone assemblage from Sugenya totals 3811 pieces with a total weight of 7127.98 grams (see summary in Table 1). Obsidian makes up 85.68% of the assemblage by count, but only 31.64% by weight (obsidian makes up 83% of worked pieces and 76% of complete flakes). Quartz makes up only 11.04% of the assemblage, constituting 61.17% of the total assemblage weight due to the pieces being generally larger and heavier. Chert comprises 2.80% of pieces by count and 5.74% by weight. The remainder

Table 1. Sugenya: summary of the lithic assemblage.

	Obsidian	Quartz	Chert	Basalt
Cores				
Single platform	1	–	–	–
Opposed platforms	3	–	–	–
Rotated platform	2	–	–	–
Bipolar	7	–	–	–
Multiple platforms	1	–	1	–
Radial	2	–	–	–
Core-on-flake	6	–	1	–
Tools[a]				
Backed pieces	73	–	3	–
Scrapers	22	–	–	–
Borers	2	–	–	–
Burins	10	–	–	–
Other retouched	27	1	1	–
Débitage[b]				
Blades				
Complete	62	1	1	–
Proximal	106	–	3	–
Flakes				
Complete	64	49	18	1
Proximal	22	11	3	–
Platform rejuvenations	10	–	1	–

[a]See Table 2 for a more detailed inventory.
[b]Fragmentary debris is not included, see Table 3.

of the assemblage (N = 18) is made up of a mixture of coarse volcanics and quartzites. Most of the obsidian appears to be of the green-hued variety that derives from the upper slopes of Mt Eburru, however elemental testing of a sample of the obsidian pieces is still required to provide reliable proportions. Chert from the site resembles the pale waxy variety that occurs in small nodules around Lake Magadi to the southeast. All other raw materials are locally available on the Loita-Mara Plains.

Cores

The Sugenya assemblage includes few cores, but their overall proportion in the assemblage is consistent with that characterising other PN sites in the Lemek Valley (Robertshaw 1990). Management of core morphology at Sugenya can be divided into three raw material-dependent trajectories. Waxy beige-to-grey cherts from Lake Magadi typically occur in small tabular nodules. Many PN groups took advantage of this shape to produce short and thick bladelets by striking along the long axis of the nodule. Chert cores at Sugenya also reflect this strategy, with 1 to 3 platforms depending on the intensity of reduction. Quartz was used more expediently without hierarchical structure, resulting in multi-platform or radial core morphologies. Quartz cores were abandoned at much larger sizes and weights than those made of obsidian or chert, with no attempts to maximise raw material utility. This pattern of locally available quartz use is similar to that observed at Ngamuriak and Olopilukunya (Robertshaw 1990).

Obsidian is, not surprisingly, the most common material and it is also the most heavily curated. The abundance of typical Elmenteitan blades in the assemblage indicates that

Table 2. Sugenya: lithic tools and retouched pieces.

Tools	Count	
	Obsidian	Chert
Backed Pieces		
Crescent	22	1
Microdrill		1
Truncations		
Oblique truncation	16	–
Lateral truncation	2	–
Convergent truncation	1	–
Backed blades		
Curved backed blade	3	1
Straight backed blades	13	–
Other backed pieces		
Krukowski microburin	3	–
Partially backed flake	6	–
Fragments	7	–
Scrapers		
Endscraper	19	–
Double endscraper	1	–
Concave scraper	1	–
Fragments	1	–
Borers		
Awl	1	–
Perçoir	1	–
Burins		
Single burin	4	–
Burin plan	4	–
Dihedral burin	2	–
Burin spall	14	–
Notch		
Single notch	2	–
Double notch	1	–
Splintered pieces[a]		
Rectangular	33	–
Batonettes	10	–
Retouched pieces		
Retouched blade	5	–
Retouched flakes	11	1
Combination	3	–
Transforms	5	–

[a]While splintered pieces are presented here, they are considered to be primarily a class of bipolar core.

more formal core types were being reduced onsite. However, there is only one small obsidian core with adjacent flaking surfaces for bladelet removals. Rotating the core and adding a second blade reduction face on the side is a typical Elmenteitan strategy for maximising utility of cores once they become smaller than about 5–6 cm (Goldstein 2018a). Other obsidian cores are cores-on–flakes, bipolar cores or splintered pieces (following Goldstein and Munyiri 2017).

Splintered pieces are blade fragments with evidence of bifacial bipolar damage. These are sometimes considered to be 'wedge' tools (Nelson 1980), but appear to exist within

Table 3. Sugenya: summary of lithic débitage by raw material, classification, part and size-class for excavation Trenches I and II.

				Trench I		Trench II		*Total*	
Raw material	Type	Part	Size (cm)	Count	Mass (g)	Count	Mass (g)	*Count*	*Mass (g)*
Obsidian	Bipolar	Complete	1–3	67	65.2	21	21.4	*88*	*86.6*
		Complete	3–5	14	25.0	3	11.7	*17*	*36.7*
		Fragment	1–3	20	23.4	18	10.4	*38*	*33.8*
		Fragment	3–5	4	15.4	8	11.5	*12*	*26.9*
	Blades	Complete	1–3	16	13.7	9	10.6	*25*	*24.3*
			3–5	21	50.6	6	14.4	*27*	*65.0*
			5–10	5	25.2	3	24.3	*8*	*49.5*
			>10	0	0	1	34.0	*1*	*34.0*
		Proximal	1–3	55	68.9	36	47.9	*91*	*116.8*
			3–5	12	37.0	8	39.5	*20*	*76.5*
			5–7	0	0	1	7.3	*1*	*7.3*
		Fragment	1–3	32	30.2	25	15.8	*57*	*46.0*
		Fragment	3–5	9	18.4	4	22.7	*13*	*41.1*
	Flakes	Complete	<1	68	9.6	77	10.9	*145*	*20.5*
		Complete	1–3	117	162.8	107	54.4	*224*	*217.2*
		Complete	3–5	30	413.9	75	90.7	*105*	*504.6*
		Complete	5–10	4	330.7	0	0	*4*	*330.7*
		Proximal	<1	43	8.3	15	2.3	*58*	*10.6*
		Proximal	1–3	74	103.4	68	43.4	*142*	*146.8*
		Proximal	3–5	5	69.9	3	25.1	*8*	*95.0*
		Fragment	<1	656	78.3	790	106.3	*1446*	*184.6*
		Fragment	1–3	362	221.6	268	241.7	*630*	*463.3*
		Fragment	3–5	34	87.7	36	68.6	*70*	*156.3*
	Platform removals		all	9	78.6	2	2.1	*11*	*80.7*
Quartz	Flakes	Complete	<1	0	0	1	0.5	*1*	*0.5*
			1–3	2	1.4	0	0	*2*	*1.4*
		Proximal	1–3	1	2.8	0	0	*1*	*2.8*
			3–5	1	6.3	2	27.0	*3*	*33.3*
		Fragment	<1	31	15.7	46	17.7	*77*	*33.4*
			1–3	124	272	27	69.8	*151*	*341.8*
			3-5	54	728.1	7	72.3	*61*	*800.4*
Chert	Flakes	Complete	1–3	0	0	1	0.2	*1*	*0.2*
		Fragment	<1	3	1.2	8	1.9	*11*	*3.1*
			1–3	29	44.2	17	23.4	*46*	*67.6*
			3–5	2	14.5	2	31.3	*4*	*45.8*
Basalt	Flakes	Fragment	1–3 cm	5	12.1	0	0	*5*	*12.1*
			3–5 cm	9	39.4	0	0	*9*	*39.4*

a continuum of bipolar reduction beginning with large blade segments down to very small angular fragments, and so may be better considered cores (after Shott 1987). This is supported by Robertshaw's (1990, 1991) observation that the proportion of *outils écaillés* in lithic assemblages increases with distance from the obsidian source, reflecting a strategy of maximising raw material utility as obsidian becomes increasingly scarce. Adding the data from Sugenya and the recently excavated GsJj50 quarry site to this model (and removing the SPN assemblages which reflect different patterns of raw material use) reinforces the linear correlation between distance and production of bipolar segments. Splintered pieces at Sugenya are also slightly smaller than those at Ngamuriak (Figure 3). Differences in the distributions of splintered piece mass for the two sites are not significant (Mann-Whitney U: 450, $z=-1.39$, $p=0.17$). Splintered pieces at Sugenya

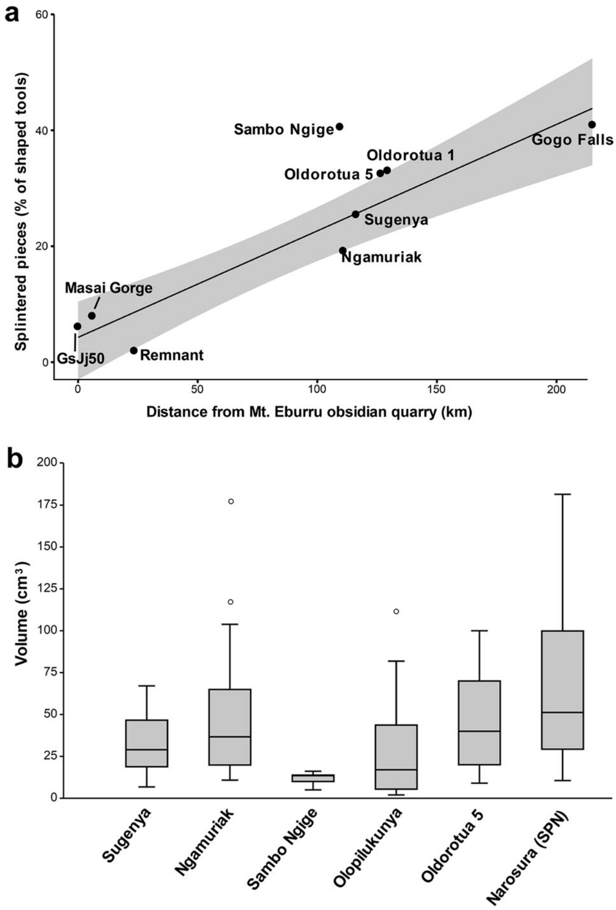

Figure 3. Splintered pieces: (a) percentage of worked artefacts that classify as splintered pieces with respect to distance from the Elmenteitan Obsidian Quarry (GsJj50) on top of Mt Eburru for Elmenteitan sites; (b) volume of splintered pieces from Elmenteitan sites with available data and the SPN site of Narosura.

were abandoned with the same amount of remaining potential or utility as at Ngamuriak, and likely also other Elmenteitan sites, regardless of distance from the obsidian sources.

Tools and worked pieces

Backed pieces

There are 76 backed pieces in the Sugenya assemblage, including 'microlithic' elements. Geometric crescents are the most common type of backed piece (28.95%) (Table 2) (Figure 4: a–k). Crescents at Elmenteitan sites in the Loita-Mara typically average around 1.6 cm in length, however those at Sugenya appear somewhat longer, with an average length of 1.95 ± 0.37 cm. That variation is nevertheless minor and Sugenya crescents follow the general Elmenteitan trend of being both smaller and more consistent in size than those at SPN sites. The crescents at Sugenya exhibit very little damage indicative of use, except for two pieces that have multiple features consistent with diagnostic impact

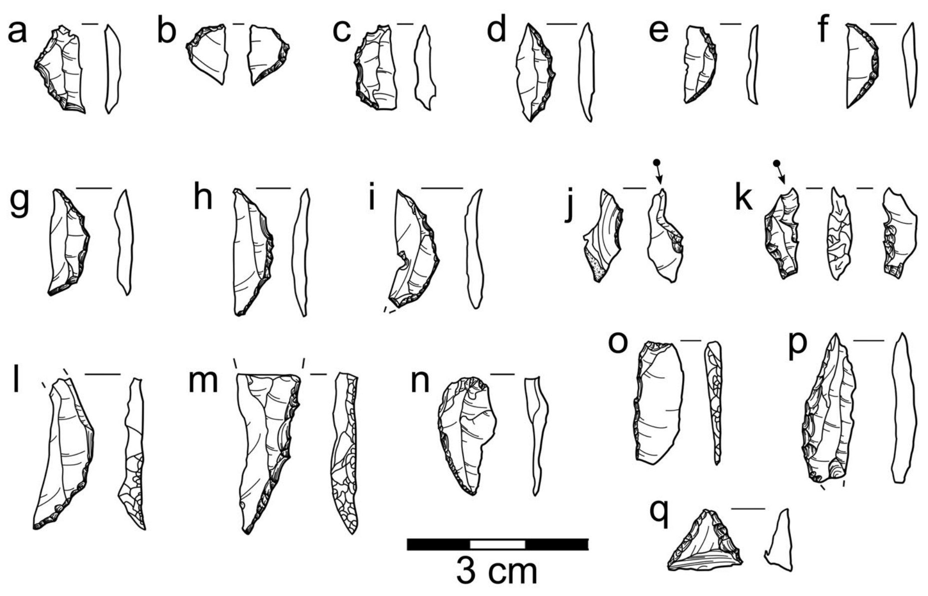

Figure 4. Obsidian backed pieces from Sugenya: (a–k) crescentic microliths; (l–n) oblique truncations; (o–p) backed blades; (q) convergent truncation.

fractures for obliquely oriented points or barbs in arrow shafts (Figure 4: j, k) (Yaroshevich *et al.* 2007; Goldstein and Shaffer 2017). That pattern would differ from Ngamuriak, where crescents displayed macroscopic damage that mostly reflected use as transverse arrow tips. Interpreting macro-fracture patterns on obsidian pieces is, however, problematic, with much larger assemblages needed to further investigate the possibility of variation in Elmenteitan microlith or projectile use (Goldstein and Schaffer 2017).

Truncations are all made from obsidian and make up 25% of the total number of backed pieces. They are mostly oblique truncations, again consistent with the pattern found on most other PN sites (Figure 4: l–n). More specific to the Elmenteitan is the high proportion of non-microlithic backed blades (21% counting only complete pieces, 38% including fragments and partially backed pieces) (Figure 4: o–p). Backed blades at Sugenya do not have the intensive utilisation and edge damage typical of this tool class at Elmenteitan sites. Distributions of lengths and widths for truncations, straight backed blades and curved backed blades from Sugenya are given in Figure 5 in relation to published size ranges for these tools at the Elmenteitan sites of Ngamuriak and Olopilukunya. This figure demonstrates the complex variation in backed piece metrics between sites, with the straight backed pieces from Sugenya clustering with the range for those at Ngamuriak, both of which skew shorter for this tool class relative to Olopilukunya. Conversely, curved backed and truncated pieces from Sugenya and Olopilukunya are much longer and wider than their counterparts from Ngamuriak. Differences in thickness of backed pieces are less clear. Overall, this variation might indicate that patterns of design, use, retouch and disposal could differ between different classes of microlithic tools at Pastoral Neolithic sites.

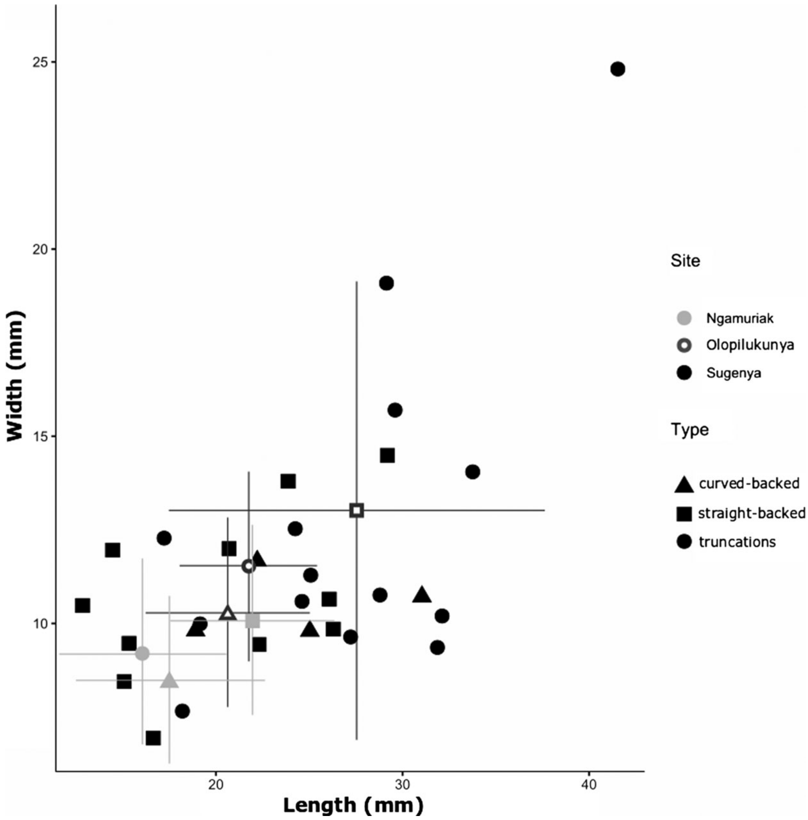

Figure 5. Metric variation in non-geometric backed pieces at Sugenya in comparison to average values from Ngamuriak and Olopilukunya. Lines represent one standard deviation in metric variation from the means, as reported by Robertshaw (1990).

The remaining backed piece types are Krukowski microburins (N = 3, 3.9%) that result from microlith production accidents plus a single example of a chert microdrill (Figure 6). The latter is backed on three sides with a generally triangular shape ending in a tip that is rounded from circular abrasion. Over a hundred nearly identical chert drills were excavated at the nearby SPN site of Lemek NW and were labelled as 'miscellaneous microliths' by Robertshaw (1990). Similar tools are elsewhere associated with bead manufacture (e.g. Yerkes 1983), although they may also be a form of awl or *perçoir*.

Other tools

Excavations at Sugenya produced 22 scrapers (Table 2). Almost all are single concave endscrapers made on blades (Figure 7 a–g). Endscrapers in this assemblage are made on thinner blade blanks than those at most other Elmenteitan sites, although this may be driven again by efforts to increase raw material utility by producing thinner blades. It is possible to quantify the intensity of endscraper curation using thickness to estimate the original length of the blade and then calculating an index value to represent the proportion of the blade that has been 'lost' due to utilisation and retouch (following Goldstein 2014). When applied to the Sugenya endscraper assemblage, the average scraper reduction index

Figure 6. Sugenya: chert micro-drill.

value is 0.41, which is nearly identical to the average value for Ngamuriak. (Mann-Whitney U: 185, z=-0.59, p=.55) (see also Supplemental Information 2).

Sugenya also has a high proportion of burins (N=10), as is typical for PN sites. Single, *plân* and dihedral variations are present (Figure 7j–k). There are numerous burin spalls (N=14), many of which show evidence of serial burin removals from the same edge (Figure 7l–m). Lacking evidence of wear or damage to the spalls themselves, it is more likely that these were not tool blanks, but rather efforts to refresh the working edges of true burins. Burins and scrapers are proportionally represented to each other relative to other Elmenteitan sites. Other types of tools, like notches, common in other Elmenteitan collections are rare at Sugenya (Figure 7h). Likewise, there are only two boring tools. No other formal tool types are definitively present. The Sugenya assemblage does include several transformed and multi-tools, many of which include burin edges or ended their use-life as burins. Examples include an oblique truncation transformed into a dihedral burin, a splintered piece that was later notched and burinated, a backed flake that was burinated down one margin and then subjected to bipolar damage and a burinated backed blade.

Retouched flakes outnumber retouched blades three-to-one and are highly variable in size and type and location of retouch. There is no sign of preferential form of retouch in terms of abrupt versus flat or ventral versus dorsal and some pieces even present bifacial edge retouch. Raw material also seems to have no influence on the form, location or

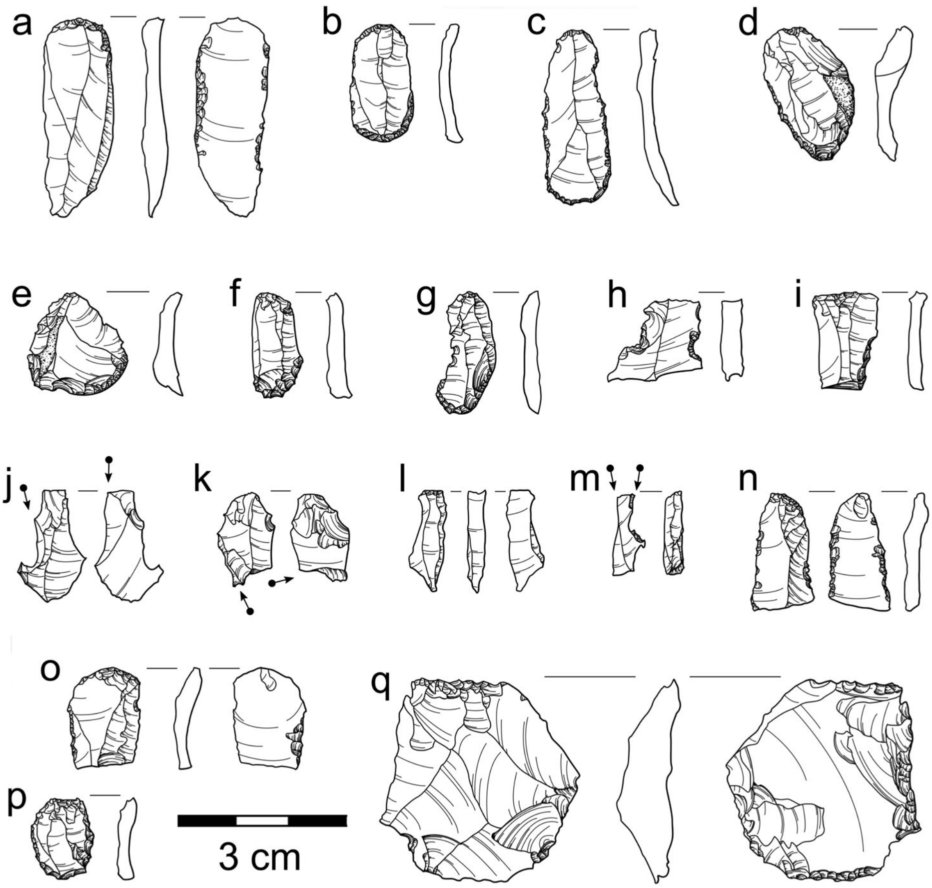

Figure 7. Sugenya: non-backed obsidian tools: (a–d, f–g) endscrapers; (e) concave scraper; (h) double notch on blade; (i) possible notch or backed blade; (j–k) burins; (l–m) burin spalls; (n–o) utilised blade segments; (p) retouched flake; (q) retouched core-on-flake.

intensity of retouch. A lack of patterning in casually retouched pieces has also been observed in the Elmenteitan assemblages at Ngamuriak (Robertshaw 1990) and GsJj50 (Goldstein and Munyiri 2017). One common feature of the Elmenteitan absent from Sugenya is the heavily utilised blade/blade segment. Several small retouched pieces show intensive retouch and utilisation on several flake margins, leading to the possibility that the lack of large knife-tools is due to more intensive curation within even the 'informal' tool-kit.

Débitage

Débitage is here considered to comprise all flake debris or angular pieces, complete or fragmentary, that are not retouched. In total, débitage accounts for 93% of the lithic assemblage from Sugenya (Table 3). Obsidian is the dominant raw material (89.7%), followed by quartz (8.2%), chert (1.7%) and lavas (<1%). Most of it comprises flakes that are not diagnostically blades or bipolar debris, which account for 87.7% of the assemblage by

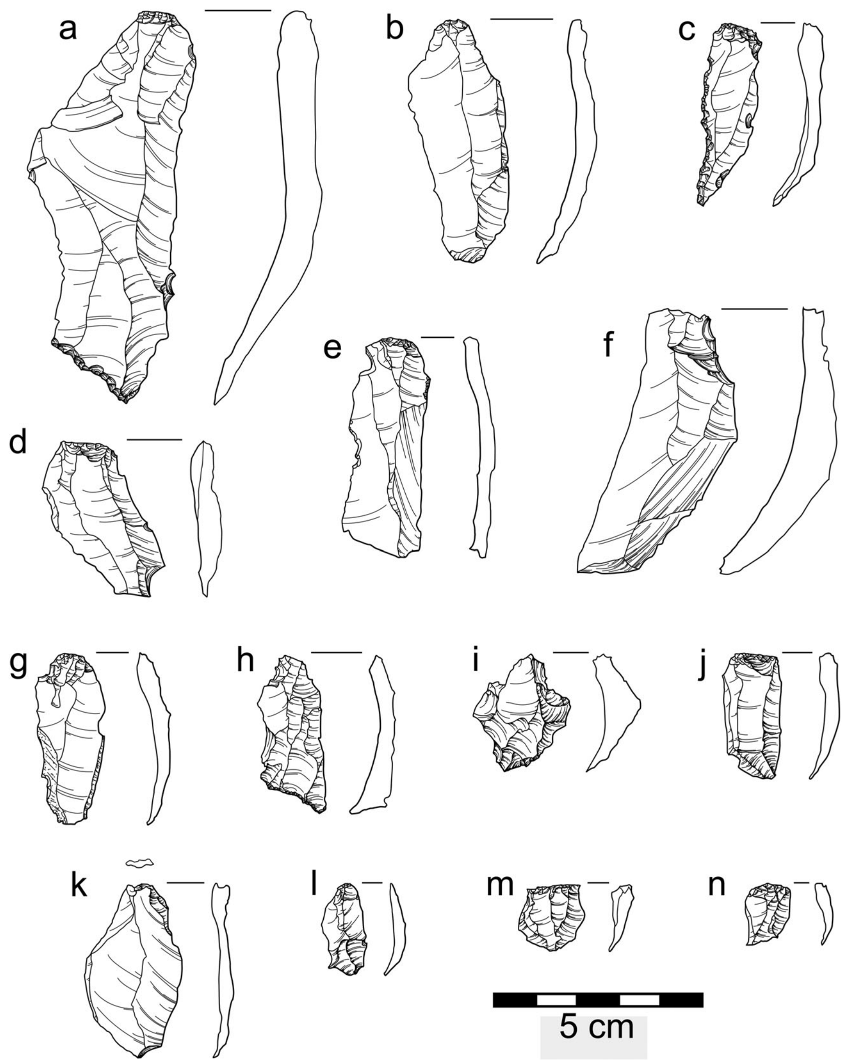

Figure 8. Sugenya: representative obsidian débitage: (a, h–j, l) blades with bidirectional scars; (b–e, g, k) blades with unidirectional scars; (f) distal blade with perpendicular scars; (m–n) over-removals from late stage pyramidal bladelet cores. Dorsal-proximal faceting is visible on pieces a–e, g, j and l. All pieces are oriented proximal end up.

count and 76.7% by weight. Blades and blade fragments make up 7.5% of all the débitage by count, but 16.6% by weight, reflecting the larger size of blade fragments in the site relative to flakes. In addition, a small component of the assemblage comprises bipolar debris (4.8% by count and 6.7% by weight). These proportions are about the same when counting only complete and proximal pieces, an approach that provides a more accurate count for number of individual flakes. Most of the obsidian and chert non-blade debris is smaller than 3 cm in maximum dimension, reflecting a combination of retouch, platform shatter and preparation flakes, as well as late-stage reduction of small nearly expended cores. Complete obsidian blades are generally larger, mostly falling into the 3–5 cm

Table 4. Sugenya: obsidian blade attribute summary table.

	Scar directionality							
	<45 mm		*45–55 mm*		*55–70 mm*		*>70 mm*	
Orientation	N	%	N	%	N	%	N	%
Parallel	45	91.8	9	90.0	4	80.0	-	-
Bidirectional	3	6.1	1	10.0	1	20.0	1	50.0
Alternated	–	–	–	–	–	–	1	50.0
Radial	1	2.0	–	–	–	–	–	–
Total	49	99.9	10	100.0	5	100.0	2	100.0
	Scar count							
	<45 mm		*45–55 mm*		*55–70 mm*		*>70 mm*	
Scar count	N	%	N	%	N	%	N	%
1	1	2.0	–	–	–	–	–	–
2	22	44.9	1	10.0	–	–	–	–
3	19	38.8	4	40.0	4	80.0	1	50.0
4	7	14.3	5	50.0	1	20.0	1	50.0
Total	49	100.0	10	100.0	5	100.0	2	100.0
Average curvature (degrees)	7		12		7		11	
Average dorsal cortex	1%		2%		5%		0%	

range with several being over 5 cm long (Figure 8). This follows the core assemblage in providing further evidence for intensive reduction of obsidian.

The length of complete blades provides a useful proxy for estimating the length of obsidian cores brought to the site. The longest blade from Sugenya is 10.1 cm in length, but there is a large gap between this and the next largest blade of 7.2 cm and then a continuous distribution of blade sizes down to 1–2 cm. Larger blades were preferentially used for many Elmenteitan tools. It is therefore possible that people at Sugenya had access to cores as large as 10 cm andthat many of the larger blades are not being recovered as complete pieces. Core size also decreases more quickly earlier in the reduction sequence,

Table 5. Sugenya: striking platform types and sizes for obsidian blades and flakes.

	Platform type	N	%	Average platform width (mm)	Average platform thickness (mm)	Average platform area (mm^2)
Blades	Plain	10	6.06	7.69 ± 2.90	3.15 ± 1.47	26.8
	Abraded with dorsal-proximal faceting	91	55.16	6.16 ± 22.27	2.15 ± 0.90	14.4
	Abraded only	23	13.93	6.65 ± 1.73	2.63 ± 0.61	17.0
	Microfaceted	4	2.42	10.34 ± 4.35	4.79 ± 1.88	54.7
	Cortical	0	0.00			
	Point	37	22.43			
	Total	155				
Flakes	Plain	70	39.11	15.55 ± 8.35	7.30 ± 4.23	141.3
	Abraded with dorsal-proximal faceting	39	21.79	8.48 ± 5.20	2.55 ± 1.21	25.7
	Abraded only	3	1.68	7.91 ± 3.40	3.63 ± 1.36	30.0
	Microfaceted	8	4.47	21.06 ± 9.65	7.19 ± 3.10	176.5
	Cortical	3	1.68	15.27 ± 4.95	7.66 ± 2.00	122.4
	Point	56	31.28			
	Total	109				

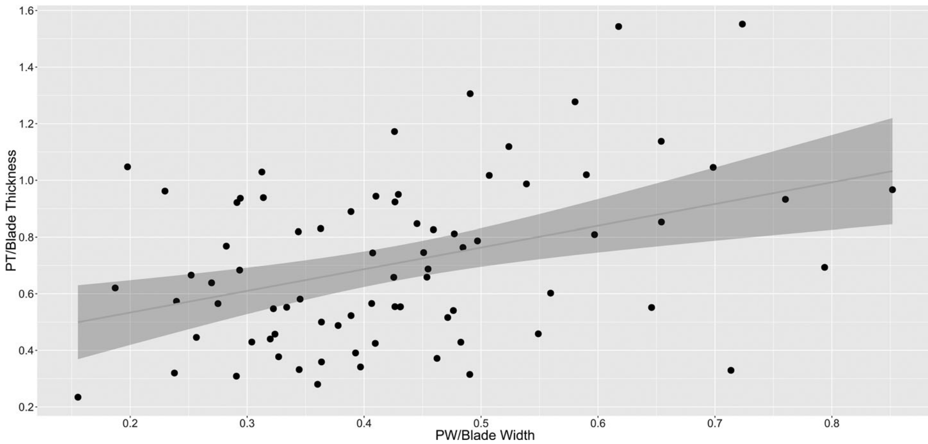

Figure 9. Sugenya: relationship between striking platform and cross-sectional area of obsidian blades.

possibly explaining why the limited excavations did not recover blades between 7 and 10 cm long. There is little cortex on any of the obsidian débitage, with cortex being slightly more frequent on larger blades (Table 4). Blade curvatures are generally less than 10°, which is considered effectively flat. Flat blade production is typical of the Elmenteitan.

All blade attributes relevant to core reduction strategy fit within the known patterns for Elmenteitan sites (Table 3). Striking platforms are predominately prepared by abrasion against the platform down the dorsal core surface, resulting in the pattern of 'dorsal-proximal faceting' that is diagnostic of the Elmenteitan industry (Ambrose 2002). Blades with this form of faceting account for 55.16% of the total complete and proximal blades, however another 22.43% of blades exhibit 'point' platforms prepared in the same way, but are too small to measure. The proportions of platform types are identical to those at other Elmenteitan sites, but the Sugenya pattern is especially similar to that from nearby Ngamuriak (Table 5). Average striking platform area is also comparable to Ngamuriak at 2.82 cm^2 and both are slightly above the more typical Elmenteitan average of around 2 cm^2. At least for Sugenya this may be driven by a few larger faceted blade platforms. Discounting these drops the average platform area to 1.94 cm^2. Unidirectional flake scars on over 90% of the blades reflect a preference for single platform cores, especially early on in the reduction sequence. Smaller blades have a higher proportion of bidirectional flake scars, indicating the addition of platforms to remove bladelets more effectively from nearly expended cores. Again, this reflects a raw material management strategy that has been documented for other Elmenteitan lithic economies (Goldstein 2018a).

Unlike other Elmenteitan sites, relationships between obsidian blade dimensions are weak in the Sugenya assemblage. Striking platform and blade width and thickness correlate strongly in blades from the Elmenteitan Obsidian Quarry (GsJj50) (Goldstein 2018a); however, the relationship between these variables at Sugenya is weak (Figure 9). There is also no strong correlation between blade length and either width or thickness, something that conflicts with existing data that show that blade thickness is a strong predictor of maximum blade length at many PN sites in southwestern Kenya (Goldstein 2014). At

Table 6. Sugenya: representation of tool and core types in the midden and dung horizons of Trench I.

	Midden	Dung
Backed pieces		
Crescent	11	3
Truncation	7	3
Backed blades	14	6
Scrapers	11	5
Burins	7	-
Splintered pieces	15	8
Retouched pieces	11	2
Other	4	2
Cores		
1 platform	1	-
2 platform	4	-
Bipolar	5	-
Expedient	7	2
Total	*17*	*2*

Sugenya, that relationship presents a linear R^2 of only 0.52, far lower than observed at Elmenteitan sites such as Ngamuriak.

Intra-site comparisons

Comparison of the lithic artefacts from the two major excavation trenches provides a rough indicator for possible lateral variation in activity patterns at Sugenya (following Simons 2004). Controlling for total excavation volume, both trenches have about equal representations of blades and blade debris. Nevertheless, Trench I has numerous bipolar flakes, while Trench II has a much higher density of non-bipolar flakes and flake debris per cubic metre (Table 3). Except for two pieces, all flakes reflecting core modification of platform rejuvenation come from Trench I. These differences in flake type representation are statistically significant even when counting only complete and proximal pieces (χ^2 = 15.45, df = 3, p = 0.001).

Blades in Trench II are slightly longer on average than those in Trench I and although this difference is statistically significant (Mann-Whitney U: 80, z = -3.56, p =<0.05) it is probably too slight to reflect a practical technological difference in core size or shaping strategy between units. Differences in reduction stages should be detectable in the distributions of blade proximal-distal curvatures (after Goldstein 2018a) and there is no difference in blade curvature between Trenches I and II at Sugenya (Mann-Whitney U: 182, z = 1.514, p = 0.13). All tool types are equally represented in terms of both count per cubic metre and relative proportion in both trenches (χ^2 = 3.81, df = 7, p = 0.82). Only splintered pieces appear slightly more frequently in Trench II. Finally, local raw materials like quartz and basalt are much more frequent in Trench I compared to Trench II. This difference is especially pronounced in total weight, with Trench I yielding 190.06 g/m^3 of quartz relative to Trench II's 69.37 g/m^3.

Simons (2004) also explored the horizontal variation in fauna between the lower animal dung horizon and the overlaying midden horizon within Trench I at Sugenya. Not surprisingly, the density of lithic debris of all types is more frequent in the midden horizon. The same was observed for the fauna from these layers (Simons 2004: 230–234). Débitage assemblages from these horizons demonstrate no other differences in raw material representation, flake type or blade attributes. Some tool and core types do occur in unequal proportion between layers (Table 6). Controlling now for overall lithic density, the dung layer has proportionately higher frequencies of microlithic and non-microlithic backed pieces and splintered pieces, whereas hierarchical cores, scrapers, burins and burin spalls are nearly absent from the dung horizon.

Discussion

Overview of the Sugenya lithic assemblage

The lithic assemblage from Sugenya displays blade production techniques and a general operational sequence consistent with what has been reported from other Elmenteitan sites. Obsidian is the dominant raw material and was used for the production of long and flat blades, whereas more local raw materials were used only expediently. Most of the obsidian appears to be of the green variety usually sourced to Mt Eburru, but this awaits formal geochemical testing. While few obsidian cores were recovered, blade attributes suggest the predominance of parallel cores with a single platform early in the reduction sequence, followed by a shift to bidirectional and rotated platform hierarchical cores at smaller sizes. Nearly expended cores and blade segments were subjected to bipolar reduction along the long axis, often producing rectangular splintered pieces. Throughout the reduction sequence striking platforms were intensively prepared through dorsal-proximal grinding, producing the characteristic faceting patterns of Elmenteitan blades (Ambrose 2001). Finer blades were preferentially selected as blanks for knives and concave endscrapers. Smaller bladelets were backed in a variety of ways, with an emphasis on crescents and truncations.

In terms of tool form, Sugenya resembles other Elmenteitan sites in southern Kenya, but with lower than typical proportions of some diagnostic forms. Backed geometrics and other shaped pieces are especially similar to the nearby large open-air habitation of Ngamuriak and the smaller sites of Oldorotua 5 and Sambo Ngige (Robertshaw 1990). All these sites have nearly identical distributions of microlithic crescent lengths, which are both within the smaller range characteristic of the Elmenteitan, but with mean lengths slightly higher than Elmenteitan sites from the Central Rift (see Ambrose 2002). There is a preference for single-ended concave endscrapers on blades as is expected for the Elmenteitan, in contrast to the more common appearance of double-ended scrapers from SPN sites in southwestern Kenya. A high frequency of burins and burin spalls is also shared with the assemblage from Ngamuriak.

Following the tool ratios used by Robertshaw (1988, 1990) to compare PN sites in the southwestern highlands of Kenya, Sugenya fits near the centre of the overall Elmenteitan distributions when graphed (Figure 10). This is especially true when considering the overall Sugenya assemblage and the material from discrete stratigraphic dung and midden horizons. Sugenya therefore appears to be a typical Elmenteitan site in terms of the representation of major tool forms. These data also add to the observation of apparently higher rates of bipolar core production in Elmenteitan sites when compared to their SPN counterparts in the same region.

When considering the rest of the tool assemblage, Sugenya demonstrates a few atypical features. In particular, retouched and heavily utilised blades and notched blades are

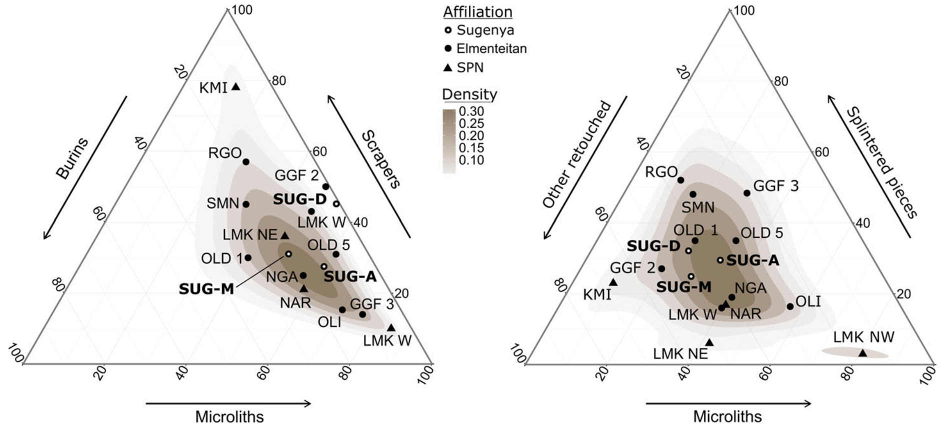

Figure 10. Ternary plots of ratios between scrapers, microliths and burins (left) and splintered pieces, microliths and all other retouched pieces (right), demonstrating the relationship between Sugenya and other PN sites in southwestern Kenya. Elmenteitan site names are abbreviated thus: Gogo Falls Trench 2 (GGF2); Gogo Falls Trench 3 (GGF3); Lemek West (LMK W); Ngamuriak (NGA); Oldorotua 1 (OLD1); Oldorotua 5 (OLD5); Olopilukunya (OLI); Regero (RGO); Sambo Ngige (SMN). Sugenya total assemblage (SUG-A); Sugenya dung layer (SUG-D); Sugenya midden (SUG-M). SPN site names are abbreviated thus: Kimani (KIM); Lemek North-East (LMK NE), Lemek North-West (LMK NW); Narosura (NAR). Density gradients represent the strength of statistical clusters. The Sugenya dung and midden points (SUG-D and SUG-M) were not used in density calculations. Figures after Robertshaw (1988).

conspicuously rare. Several blade segments do feature bifacial damage consistent with utilisation, but none of these demonstrates the invasive ventral retouch and intensive edge wear that is present on blades at other Elmenteitan sites (Ambrose 1980; Nelson 1980). There are several smaller blade fragments with substantial utilisation and wear that might be considered more curated examples. However, greater curation pressure does not explain why so many of the larger informal blade tools would be abandoned with so little utilisation.

Notched blades are another tool type that occurs in low frequencies at Sugenya relative to other Elmenteitan sites. One of the most common multi-tools/transforms for the Elmenteitan is the addition of a large heavily utilised notch to a lateral margin of an end-scraper (see Goldstein 2014). This specific transform does not occur at all in the Sugenya sample. Instead, most tool transformations seem to involve burinations. While the overall ratio of burin tools is not particularly high in the assemblage, there is more evidence for repeated burinations from the same flake margin and flakes with burin removals tend to have multiple margins with burin or burinoid removals. With most of the tool assemblage demonstrating formal affinities with the Elmenteitan and none with the SPN, it is safe to assert that the Sugenya material reflects variability within Elmenteitan lithic economies.

Intra-site variation

Spatial and stratigraphic units recorded in the excavations at Sugenya provide rare, and quite useful, perspectives on intra-site variation in lithic production. Insofar as they can be reconstructed, strategies of blade production within the site appear to have been uniform and are typical of the Elmenteitan. The proportions and densities of different classes of tools, cores and débitage do nevertheless demonstrate some spatial patterning. In terms of vertical differences, Trench I yielded a higher proportion of formal cores and core preparation debris, but also displayed more diversity in raw material relative to Trench II where non-blade flake debris was much more common. However, any straightforward distinction between a core reduction area and a tool use/repair area is complicated by the contradiction that while bipolar cores are far more common in Trench II it is Trench I that yielded a higher proportion of bipolar flakes. Nearly all the débitage and cores come from the midden layers of Trench I, which likely represents secondary deposition events wherein signatures from different activities could become mixed. Despite this taphonomic complication, the Sugenya pattern offers promising clues that discrete activity areas may be detectable at other PN sites (see also Robertshaw *et al.* 1990; Grillo *et al.* 2018).

Differences between the depositional episodes represented by the dung and midden horizons in Unit I are more pronounced in terms of lithic tools than they are in proportions of débitage. Tools associated with 'domestic activities' such as scrapers and burins are more common in the midden levels, but are rare in the dung-derived deposits. Non-microlithic backed tools occur at slightly greater density in the dung level. Whether or not the apparent spatial patterning of lithic artefact deposition corresponds in some way to different activity areas requires further investigation with larger sample sizes, however these differences do provide a warning about interpretations of PN assemblages based solely on tool ratios. When plotted, the tool ratios for the dung horizon, midden horizon and total assemblage separate out, reflecting the aforementioned horizontal variation. Differences are not great and all fall within what appears to cluster broadly with other Elmenteitan sites. Even so, this exercise demonstrates that the spatially limited excavations typical of PN archaeology may be producing datasets that are not representative of the whole site. If spatial patterning in stone artefact distributions does reflect behavioural variation, then it is not clear if comparing site averages is at all useful.

Sugenya in a regional context

Heavily reduced cores, comparatively shorter blades and high proportions of bipolar tools and debris are all lines of evidence that support the hypothesis that the inhabitants of Sugenya were attempting to maximise their supply of lithic raw material. In this respect Sugenya looks less like nearby Ngamuriak than it does the site of Olopilukunya in the Loita Hills (Robertshaw *et al.* 1990). Patterns at both smaller sites suggest a limited number of cores were brought to the location with reduction sequences reflecting efforts to conserve that supply by extending raw material utility.

Several features at Sugenya demonstrate that this strategy reflects planning for future raw material scarcity, which did not necessarily come to pass. The production of more splintered pieces with distance reflects an expectation that intensive reduction will become necessary. Splintered pieces at Sugenya were minimally reduced compared to the much smaller specimens from other Elmenteitan sites where conditions of raw material scarcity may have been more acutely felt. In addition, blade segments and formal tools like scrapers are just as, if not less, curated than those from other Elmenteitan sites. Smaller blades do indicate fewer small cores being brought to the site.

Occupational episodes at Sugenya may have been too brief for obsidian stockpiles to be expended and a more curated signature might thus be present at subsequently occupied sites. Conflicting curation patterns might also be a product of complexity within the structures of Elmenteitan obsidian acquisition.

For the Elmenteitan, differences in access to obsidian must be interpreted with consideration to the model of organised regional Elmenteitan distribution or exchange systems (Robertshaw 1988; Ambrose 2001; Goldstein and Munyiri 2017). Provisioning Elmenteitan-producing communities with obsidian from specific quarries on Mt Eburru in the Central Rift Valley did not necessarily involve a hierarchical organisation. Even at sites with evidence for constrained access to such networks, they were reliable enough that Elmenteitan producers could safely avoid alternative raw materials in lithic production.

The lithic assemblages from Sugenya add a new degree of resolution as to how Elmenteitan obsidian distribution was organised on a regional level. It has been proposed that obsidian acquisition was carried out by special purpose groups travelling to the quarry rather than by local communities, but it is not at all clear how the system operated beyond that point (Goldstein and Munyiri 2017). Patterns appear to be more complex than simple down-the-line exchange. Excavations at Ngamuriak, an Elmenteitan site only a few kilometres closer to the obsidian sources than Sugenya, produced a large assemblage with about 20,000 pieces of imported obsidian. Ngamuriak's assemblage had much larger blades and more cores deposited at larger sizes, suggesting not only much greater supply or access to obsidian, but also less pressure to curate that supply intensively. Sugenya and Ngamuriak lay only 5 km apart in the same valley and the differences in lithic strategies between them are too great to be explained by distance alone.

Consideration of the Sugenya dataset presents three possibilities for explaining the emerging pattern of Elmenteitan obsidian acquisition. First, the consistency and frequency of obsidian exchange may have fluctuated over time, possibly even on yearly or decadal scales that are difficult to measure archaeologically. Alternatively, inhabitants at some sites may simply have had better primary access at certain times and those sites may have acted as distribution centres on a more localised scale. If sites like Ngamuriak represent 'richer' habitation sites of this kind, this might support Robertshaw's (1990) model for some form of social inequalities in the Elmenteitan, at least in the form of more-or less expansive social networks.

Finally, the differences may reflect variation in Elmenteitan settlement strategies. This may have resembled a fission-fusion organisation similar to that of many ethnohistorically known herders in the region (e.g. Western and Dunne 1979; McCabe 2004), where accumulations of obsidian present at larger sites like Ngamuriak were divided among the constituent families during seasonal dispersals, who would in turn have curated their obsidian supply such that it would last until the next aggregation or re-supply event. Sites like Sugenya, Oldorotua 5, Olopilukunya and the other smaller Elmenteitan sites in the Lemek Valley may reflect shorter-term habitations of dispersed family units. Different microenvironments may have been exploited in different ways, resulting in the variation in which tool forms are emphasised at different sites. These scenarios are not mutually exclusive, but all would feature some reduction in 'supply' as obsidian was moved further across the landscape. Testing between these, or alternative, possibilities requires more excavations of Pastoral Neolithic sites and reanalysis of existing lithic assemblages.

Conclusions

Interpretations of Elmenteitan lithic technological organisation outside the Central Rift Valley have been based on only a handful of larger sites like Ngamuriak (Robertshaw 1990), Gogo Falls (Robertshaw 1991) and Wadh Lang'o (Lane *et al.* 2004). Several smaller scale excavations have added valuable insights into regional diversity, but produced small lithic assemblages with limited comparative potential (see Robertshaw 1990: 123–170, 267–270; Siiriäinen 1990; Marshall *et al.* 2016). Assemblages from recent and more extensively sampled sites like Sugenya provide important datasets for regional comparative analyses of technological variation that test hypotheses on social and economic organisation of early herders in southern Kenya. The Sugenya assemblage strengthens the identification of the Elmenteitan lithic tradition as a consistent suite of technological strategies that indicate a different approach to pastoralism than that which is evident from the SPN. At the same time, analysis of the Sugenya material has helped identify axes of intra-Elmenteitan variation in how that technology was deployed. Perhaps more importantly, these analyses add resolution to emerging models concerning the social organisation of early herders in Africa in terms of regional exchange and interaction systems.

Trajectories for the spread of herding in eastern Africa were shaped by the decisions that early pastoralist communities made in the diverse and unpredictable environments that they encountered. Over subsequent centuries, pastoralists developed social and economic strategies that helped ensure the long-term persistence of lifeways centred on livestock management. Herder strategies had lasting effects on the environment (Shahack-Gross *et al.* 2008) and influenced the continued evolution of food-production practices in eastern Africa. Renewed interest in the PN is improving our understanding of this critical time period in terms of tool technology (Langley *et al.* 2017; Goldstein 2018a, 2018b), ceramics (Prendergast *et al.* 2012; Ashley and Grillo 2015) and herding practices (Chritz *et al.* 2015; Janzen 2015; Grillo *et al.* 2018). Many opportunities for further work remain, both in terms of new excavations and of existing lithic, ceramic, and faunal assemblages that are in need of (re-)analysis. Such work will contribute to ongoing discussion on one of the most transformative processes in the recent African past (e.g. Ambrose 2001; Lane 2004; Gifford-Gonzalez 2005, 2017; Smith 2008; Marshall *et al.* 2012; Jerardino *et al.* 2014; Sadr 2015).

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