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Pastoral Neolithic studies in Northern Tanzania: An Interim Report on XRF and Stable Isotope Analyses in the Engaruka Area

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Introduction

This paper is an interim report on ongoing research on the Pastoral Neolithic (PN) period in northern Tanzania. We focus on presenting introductory results from natural scientific studies of material from Stone Age sites in the Engaruka area, especially materials excavated in 2004 from Engaruka Basin 6, a likely early Pastoral Neolithic site (Figures 1 and 2).

Research is part of a larger study investigating the chronology and nature of PN influences and the introduction of domesticates in the Rift Valley of northern Tanzania, and whether these phenomena are interrelated (e.g., Ambrose 1998; Bower 1991; Gifford-Gonzales 1998; Marshall *et al.* 2011). For instance, the subsistence base (e.g., Mutundu 2010), land-use patterns (e.g., Seitsonen 2009), and socio-cultural contact networks (e.g., Merrick *et al.* 1994), and their spatiotemporal change during the period of interest, will be intensively studied. Research questions will be approached based on the material collected by the University of Helsinki projects including the Cultural Ecology of the East African Savannah Environment in a Long-term Historical Perspective (2002-2004), The Long-term Ecology of the Savannah Environment: Archaeological, Ecological and Environmental Studies (since 2005), and the upcoming field research in the area by the project "Moving Frontier" of early herding in northern Tanzania (since 2012).

Analyses carried out include Accelerator Mass Spectrometry (AMS) radiocarbon dating, stable isotope analyses of ostrich eggshell for palaeoenvironmental data, and X-ray fluorescence (XRF) studies of obsidian artefact provenience. Stable isotope analyses of ostrich eggshell to obtain palaeoenvironmental proxy data have been rarely carried out in East African contexts, and were selected to be tested in the research area. Geochemical analyses of archaeological artefacts have also been sparse in Tanzania (see Merrick and Brown 1984; Schmid and Stern 1976), although in Kenyan archaeology XRF has been more widely applied, alongside electron microprobe analysis (e.g., Barut 1995; Langdon and Robertshaw 1985; Merrick *et al.* 1990; Nash *et al.* 2011; Ndiema *et al.* 2011). Since the results from the analyses were encouraging, especially from the XRF analyses, they will be extended in the near future.

Archaeological Studies in the Engaruka Basin

The first systematic archaeological studies in the Engaruka Basin were carried out in 2003-2004. This was a pilot study targeted at establishing the range of sites, and especially locating Stone Age remains, which were virtually unknown in the area. Research was instigated by the results

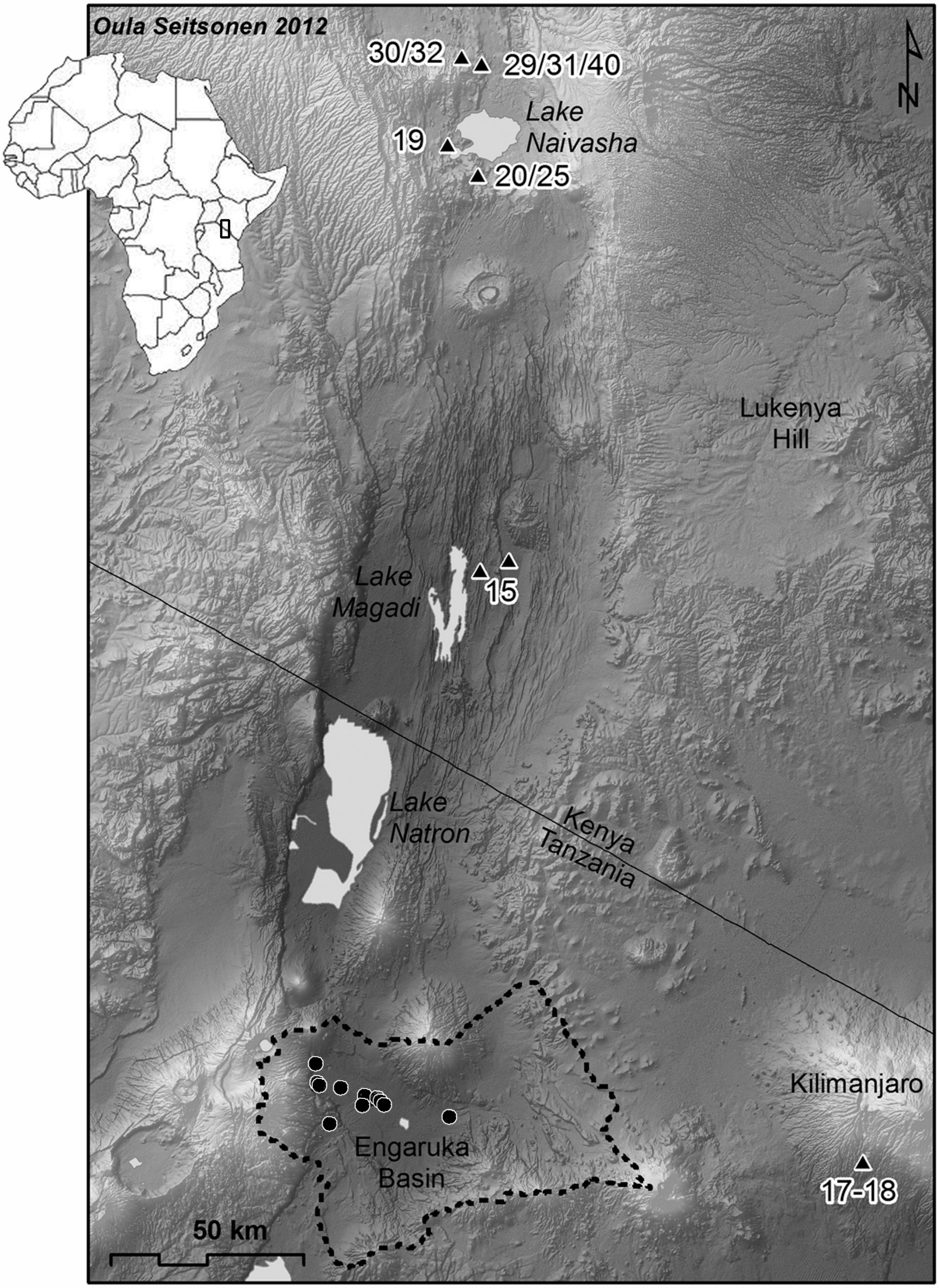

Figure 1: Stone Age sites in the Engaruka Basin (black dots), limits of the basin (dashed line), selected obsidian source localities (black triangles; numbering refers to petrographic groups in Merrick & Brown 1984 and Merrick et al. 1994), and other locations mentioned in the text (Digital Elevation Model based on Aster GDEM, a product of METI and NASA).

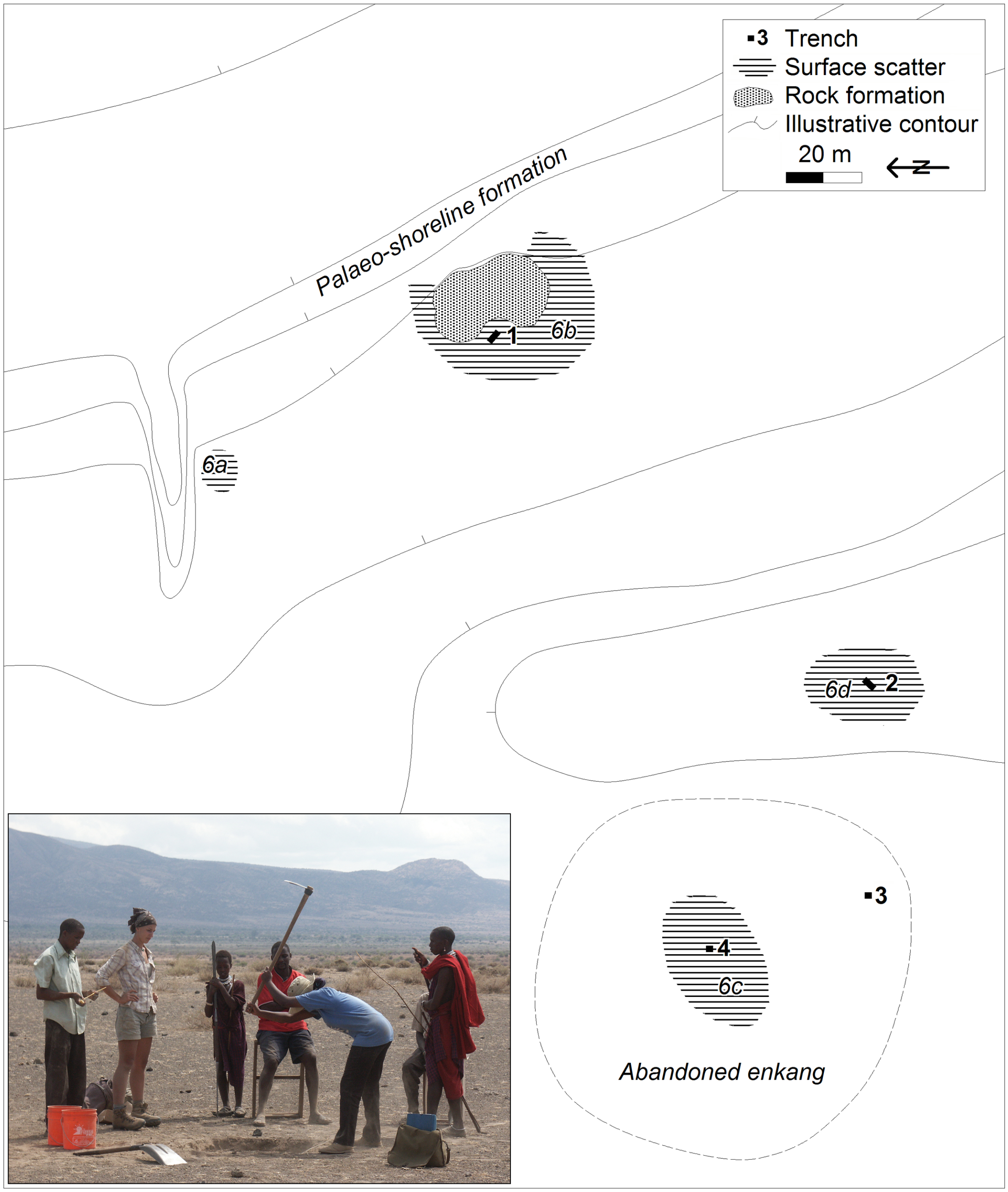

Figure 2: General map of the Engaruka Basin 6 site, 6a-d present distinct surface scatters; inset: trench 4 excavated by Norah Kavete, while Louise Iles and locals observe (map and photograph: O. Seitsonen 2004).

acquired in adjoining areas (e.g., Leakey 1966; Leakey *et al.* 1972; Mehlman 1989; Prendergast *et al.* 2007), and by a few remarks on Stone Age material made e.g., by Louis Leakey and by Charles Keller *et al.* (1975) during palaeontological and palaeoenvironmental research in the Engaruka and Lake Manyara areas; however, these archaeological observations were never published in detail.

Keller and his colleagues' research confirmed the presence of Early and Middle Holocene high lake levels in both Engaruka and Lake Manyara Basins (Keller *et al.* 1975). New palaeoenvironmental data has been collected in our surveys (Seitsonen 2005, 2006) and in the research of our Swedish colleagues (e.g., Muzuka *et al.* 2004; Ryner 2004; Ryner *et al.* 2008). Due to this, our pilot surveys were closely tied to palaeo-shoreline formations, such as terraces and raised beaches.

In 2004 seven survey transects were placed randomly running east-west, perpendicular to the palaeo-shoreline features recorded the previous year. During the few survey days, 13 Stone Age find locations were recorded on these transects, as well as a couple more during casual visits to the area (Seitsonen 2005). Based on the find assemblages, sites date from the Middle Stone Age to the Pastoral Neolithic (PN) period. One probable PN locality, Engaruka Basin 6, was also test excavated. Inspired by the introductory studies, larger-scale fieldwork is planned, aiming specifically at locating Pastoral Neolithic remains

Engaruka Basin 6

Engaruka Basin 6 site is situated on top of a palaeo-shoreline terrace in the western part of the basin (Figure 2). Four test trenches were dug at the site in 2004 to assess its research potential. Most of the site seems to have experienced notable erosion and disturbance by 20th century occupation(s), but trench 1 proved to be better preserved behind a rock formation. Finds were relatively sparse, but suggest that at least part of the material may be connected to the PN period; also preceramic Later Stone Age (LSA) and 20th century Maasai habitation seem apparent at the site, especially in trenches 3-4.

Initially the few located ceramic sherds were linked cautiously with the Nderit tradition (Seitsonen 2005). However, this association might be premature since we have very little knowledge of the ceramic sequence in the area: hopefully our upcoming field research will help to clarify this issue. Faunal remains have not been analysed yet, but based on the field observations they consist mostly of wild fauna (Israel ole Molel personal communication 28.09.2004), which is typical for the early PN occurrences (e.g., Bower 1991; Gifford-Gonzalez 1998). Also one fish jaw bone fragment was located (cf. Bower 1973), suggesting the presence of a lake of sufficient size for fish within the Engaruka Basin when the site was used. Whether this was during the proposed preceramic occupation or in the PN period cannot be answered at the moment.

Soil, charcoal, ostrich eggshell, and artefact samples were collected for laboratory analyses during the test excavations, and exported under a permit from the Tanzanian authorities to the University of Helsinki. AMS radiocarbon dating and stable isotope analyses were carried out in the University of Helsinki Dating laboratory, and XRF analyses of obsidian artefacts in the University of Helsinki Geochemical laboratory.

AMS analysis of a piece of charcoal of unidentified wood species, collected near the bottom of trench 1, gave a date of 1930–1690 cal BC (3554 ± 30 bp [Hela-2047]; all ^{14}C dates are calibrated with Oxcal 4.1.7 (Bronk Ramsey 2010), using SHCal04 southern hemisphere atmospheric curve (McCormic *et al.* 2004), 95.4 % probability). At the moment this is amongst the earliest radiometric dates from probable PN contexts this far south (e.g., Bower 1991).

Farther north, equivalent dates are connected to Nderit and Ileret ceramics (e.g., Bower 1991; Nelson 1995, 2002). Pottery resembling these traditions appears at the Enkapune ya Muto Rockshelter in the Central Rift of Kenya at 3720-3370 cal BC (4860 ± 70 bp [ISGS-1742]; Ambrose 1998), and at the Vaave Makongo site (GvJm4) at Lukenya Hill at 1890-1120 cal BC (3290 ± 145 bp [GX-5348]; ^{13}C corrected by Nelson (2002), original date 3285 ± 145 bp; see also Gifford-Gonzalez 2000). Wright (2005) also has a series of analogous OSL dates (4830 ± 390 bp [UIC-1071], 3870 ± 330 bp [UIC-1068], 3600 ± 320 bp [UIC-1070], 3450 ± 290 bp [UIC-921], 3120 ± 270 bp [UIC-1069], 3020 ± 270 bp [UIC-1392]), as well as one radiocarbon date (3423 ± 55 bp [AA-51444]), connected to the earliest appearance of *Bos taurus* and PN ceramics at the Galana River, southern Kenya (Wright 2007; Wright *et al.* 2007). Possible early dates for Nderit ceramics have also been suggested for the Serengeti Plains (Bower and Chadderdon 1986; Bower and Gogan-Porter 1981; Mehlman 1989: 45) and for the coast of Tanzania (Chami and Kwekason 2003). As new data accumulate, comparable dates for the appearance of ceramics and/or domesticates will most likely increase in northern Tanzania as well.

Stable Isotope Analyses

Stable isotope analyses of ostrich eggshell (OES) carbonate can offer a useful proxy for palaeoenvironmental conditions in arid areas (e.g., Johnson *et al.* 1997, 1998). For this purpose OES fragments were collected for analyses during the excavations of archaeological deposits. Tested carbon and oxygen isotope values give information on the carbon isotope composition of plants and on the oxygen isotope composition of water used by the plants in the diet of ostriches (e.g., Johnson *et al.* 1998; Sonninen 1999). Analytical methods followed generally the steps described in Sonninen (1999) excluding the heating in vacuum to outgas volatile components and using on-line technique for isotope measurement, with each sample analysed twice. At the moment only half of the analysed OES derive from radiocarbon dated archaeological contexts: the results of stable isotope analyses from the dated contexts are presented in Table 1.

Compared with the values from the Early Holocene context at Misfortune Hill site, situated in the northern end of Lake Manyara (see Seitsonen 2006), samples from Engaruka Basin 6 show both higher $\delta^{13}C$ and $\delta^{18}O$ values. This is suggestive of a higher percentage of C_4 plants in the diet of ostriches as well as increased evaporation, proposing increased aridity compared to the Early Holocene period. On the other hand, the Iron Age samples, which derive from excavations connected to the Engaruka Complex in the 17th to 18th centuries (e.g., Stump 2006; Sutton 2000; Westerberg *et al.* 2010), show comparable values to the Engaruka Basin 6 samples. These observations are generally in line with other palaeoenvironmental proxies, *e.g.,* with the lake coring studies carried out at the Empakai Crater on the Crater Highlands (Muzuka *et al.* 2004; Ryner *et al.* 2006, 2007, 2008). When fully dated, the OES isotope series will provide one more proxy for examining past environmental changes in the area.

Site	OES sample nr.	$\delta^{13}C$ ‰ vs V-PDB	$\delta^{18}O$ ‰ vs V-PDB	^{14}C age lab.nr.	BP	s.d.	Cal. (95,4 %)	^{14}C sample type
Misfortune Hill	21 23	-8.54 -7.78	1.25 0.45	Hela-1013	9280	± 60	8610 - 8290 BC	charcoal
Engaruka Basin 6	16 20 18	-2.13 -3.35 -0.37	3.48 5.33 3.83	Hela-2047	3554	± 30	1930 - 1690 BC	charcoal
Kitete 1	19	-2.80	5.52	Hela-1008 Hela-1009	1015 1085	± 30 ± 30	900 - 1030 AD (R Combine)	charcoal charcoal
Engaruka, South Village 2	17	-1.81	2.16	Hela-719 Hela-720	175 140	± 40 ± 40	1660 - 1960 AD (R Combine)	charcoal charcoal
Engaruka, South Village 1	12	-2.63	4.49	Hela-718	185	± 40	1640 - 1960 AD	charcoal

Table 1: Results of the stable isotope analyses of ostrich eggshell from the currently dated contexts.

X-ray Fluorescence Analyses of Obsidian Artefacts

XRF analyses of archaeological materials had not been previously carried out at the University of Helsinki, and we decided to test the methodology by examining the provenience of four obsidian artefacts from Engaruka Basin 6. Analysis acted as an opening phase for larger-scale, archaeologically focused XRF studies in the laboratory. Three obsidian flake fragments from trench 1 (Tz-1, Tz-3–4), and one fragment of a retouched artefact from the surface next to this trench (Tz-2) were analysed. We also wanted to test the correlation between obsidian colour and source geochemical groups by selecting two pieces with an opaque greenish tinge (Tz-1–2) and two translucent greyish ones (Tz-3–4). Based on these samples, there is a loose association between the colour and geochemistry, but this correlation cannot be used for provenience studies (cf. Ndiema *et al.* 2011).

The artefacts were ground to fine powder using a wolfram carbine ball mill, and fused to glass beads applying a sample to lithium borate flux ratio of 1:10 according to the Geochemical laboratory method of Heikkilä *et al.* (2009). Analyses were performed in five runs on Philips PW1480

		Tz-1		Tz-2		Tz-3		Tz-4	
SiO_2	%	70.80		69.58		74.58	>S by 1.75 %	73.04	>S by 0.21 %
TiO_2	%	0.29		0.31		0.12		0.17	
Al_2O_3	%	8.23		8.55		12.14		10.34	
Fe_2O_3	%	7.80		8.28		1.92		3.73	
MnO	%	0.21		0.24		0.04		0.06	
MgO	%	<0,01	<LLD-2	<0,01	<LLD-2	<0,01	<LLD-2	<0,01	<LLD-2
CaO	%	0.26		0.40		0.37		0.16	
Na_2O	%	6.85	>S by 1.01 %	6.78	>S by 0.94 %	4.43		5.39	
K_2O	%	4.36		4.36		4.68		4.31	
P_2O_5	%	0.01		0.02		0.01		0.01	
Ba	ppm	39		101		<21	<LLD-2	<21	<LLD-2
Ce	ppm	888	>S by 478 ppm	511	>S by 101 ppm	172		368	
Co	ppm	96		231		312		892	
Cr	ppm	13		13		10		10	
Cu	ppm	<33	<LLD-2	64		71		214	
Ga	ppm	30	>S by 3 ppm	35	>S by 8 ppm	25		31	>S by 4 ppm
La	ppm	427	>S by 247 ppm	228	>S by 48 ppm	67		123	
Nb	ppm	461	>S by 288 ppm	292	>S by 119 ppm	147		267	>S by 94 ppm
Ni	ppm	20		12		<4	<LLD-2	18	
Rb	ppm	454		224		280		374	
Sr	ppm	<6	<LLD-2	7		<6	<LLD-2	<6	<LLD-2
U	ppm	28		13		16		28	
V	ppm	<7	<LLD-2	9		15		26	
Y	ppm	353	>S by 223 ppm	227	>S by 97 ppm	85		179	>S by 49 ppm
Zn	ppm	554		389		89		223	
Zr	ppm	3214	>S by 2664 ppm	1548	>S by 998 ppm	408		1403	>S by 853 ppm
Total	%	100.00		100.00		100.00		100.00	
Original	%	99.45		98.88		98.43		97.50	
Petrological group		30/32		29/31/40		19		20/25	
Distance (km)		270		265		250		240	

Notes:
Results have been normalised to 100 percent
>S = content is higher than the highest content of used standards
<LLD-2 = content is smaller than the "Lower Limit of Detection", as calculated with 2 s.d.
Petrological groups:
30/32 = GsJj52 / Masai Gorge
29/31/40 = Upper Eburru / W Naivasha #1 / Masai Gorge Box Canyon
19 = Sonanchi Crater / Mundui
20/25 = Njorowa Gorge / Naivasha Lake Edge S

Table 2: Elemental composition of the analysed obsidian artefacts from Engaruka Basin 6, their probable petrological group association (based on Merrick et al 1994), and the Euclidean distance to the source locality (rounded to nearest five kilometres).

wavelength dispersive (WD) x-ray spectrometer, calibrated for 26 major, minor and trace elements (Table 2). Calibration standards include 19 fused bead, natural rock certified reference materials and one pure flux sample as blank. Analysis results were matrix and line overlap corrected using SuperQ 3.0 program by Philips Analytical B.V.

Based on their elemental composition, the analysed obsidian artefacts all derive from sources situated around Lake Naivasha, *ca.* 250km north (Figure 1) (Merrick and Brown 1984; Merrick *et al.* 1994). This is an analogous distance to those observed for obsidian artefacts in the Mt. Kilimanjaro region, at Lake Eyasi, and in Serengeti (Merrick and

Brown 1984; Merrick *et al.* 1994; Mturi 1986). The nearest known obsidian sources to Engaruka are found at Mt. Kilimanjaro (Figure 1:17-18) and at Ol Doinyo Nyegi, Lake Magadi (Figure 1:15), both more than a hundred kilometres away (Merrick and Brown 1984), but their chemical compositions differ notably from the analysed specimens (Figure 3).

Total iron (as Fe_2O_3), calcium (as CaO), and titanium (as TiO_2) compositions of the analysed artefacts and selected sources are shown in Figure 3 (Merrick *et al.* 1990; Merrick *et al.* 1994). Merrick

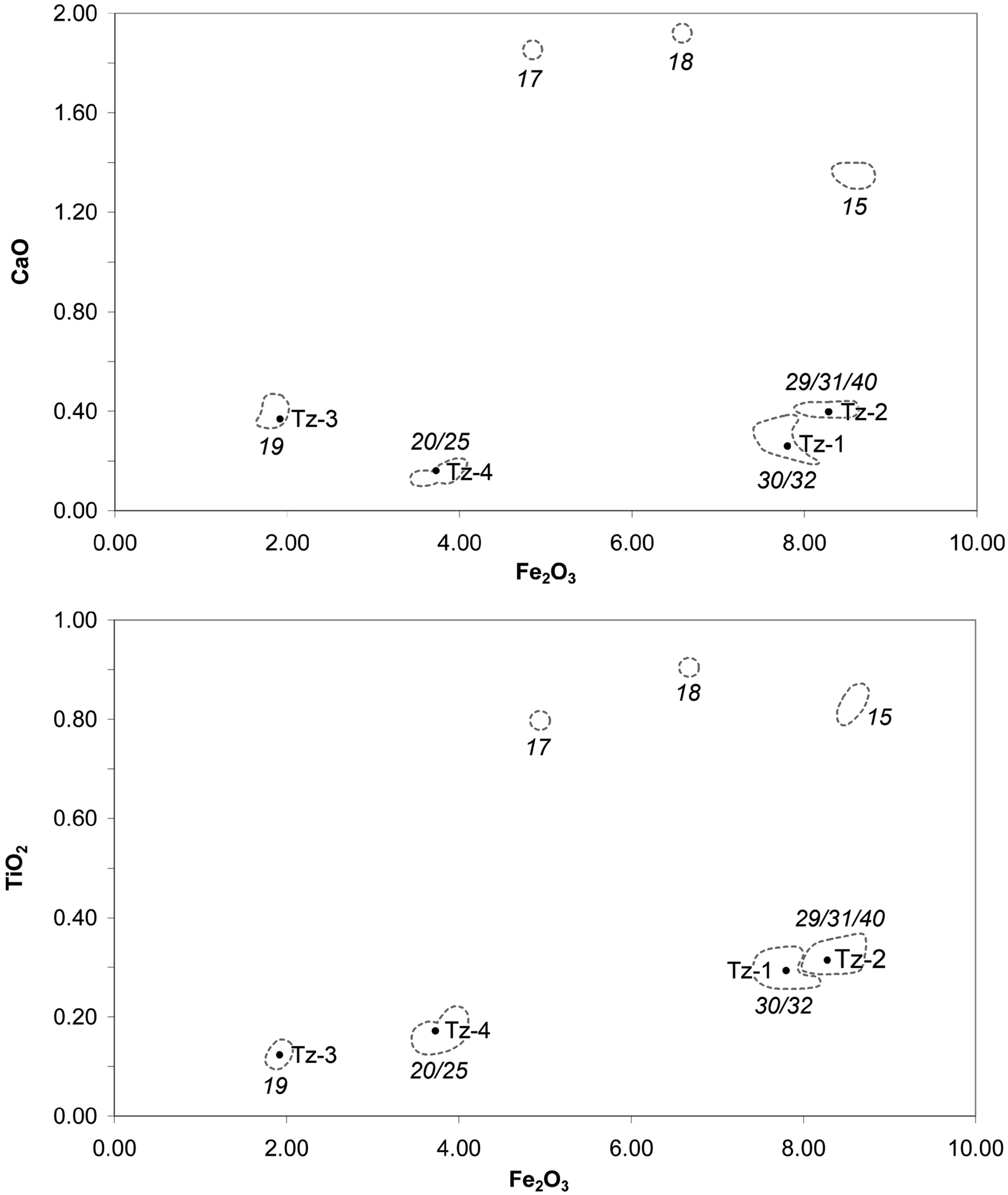

Figure 3: Scatter-plots of: Top) the total iron (as Fe2O3) vs. calcium (CaO) values; and Bottom) the total iron (as Fe2O3) vs. titanium (as TiO2) values for the analysed obsidian artefacts; dashed lines show the source petrological groups (based on Merrick & Brown 1984; Merrick et al. 1990).

and his colleagues (1990, 1994) have noted that these elements can be used for describing the general provenience of obsidian, but also, that information on more elements will be needed before precise separation between exact sources can be made. Coleman *et al.* (2008) have showed that rubidium (Rb) is another good element for separating between sources, giving in fact a more clear-cut separation with our samples than calcium and titanium; however, rubidium values are not available for all source locations. Chlorine (Cl) and manganese (Mn) also have been analyzed by Barut (1995) for the Lukenya Hill obsidian samples (also Merrick *et al.* 1994). Ndiema *et al.* (2011) used yttrium (Y) and zirconium (Zr) in their studies (also Merrick *et al.* 1994); however, the Y and Zr values of Engaruka artefacts are mostly beyond our current calibration standards. In the upcoming studies we hope to achieve clearer separation between sources based on the numerous elements we analyse for each sample (cf. Coleman *et al.* 2008).

Based on their visual characteristics, i.e., the greyish colour, the rest of our Engaruka Basin 6 obsidian samples might derive from the southern Lake Naivasha sources (19, 20/25); this will be tested with additional XRF analyses. The reliance on southern Naivasha sources has been described as typical for sites connected to the Narosura ceramics, and use of the Mount Eburru sources situated northwest of Lake Naivasha for the Elmenteitan sites, whereas wide-ranging use of obsidian sources seems typical for preceramic LSA sites and rock-shelter sites contemporaneous with the PN period (e.g., Merrick and Brown 1984; Merrick *et al.* 1990; Robertshaw 1990). However, to our knowledge no other obsidian provenience analyses have been carried out at early PN (Nderit) sites south of the Lake Turkana area (Nash *et al.* 2011; Ndiema *et al.* 2011), and thus we currently have no comparative material for the Engaruka Basin 6 analyses.

In the Lake Turkana area obsidian use in the Nderit (–Ileret) period relied heavily on the local sources (Nash *et al.* 2011; Ndiema *et al.* 2011). This is in clear contrast with the later PN period obsidian use in central Kenya and northern Tanzania, where obsidian acquisition depended largely on the long-distance movement of raw materials from the Kenyan Central Rift sources (e.g., Merrick and Brown 1984; Robertshaw *et al.* 1983). Engaruka Basin 6 apparently dates to the earliest phases of the spread of ceramic technology to northern Tanzania. If this happened from a northerly direction, as has been suggested (e.g., Bower 1991; Nelson 1995, 2002), the existence of socio-cultural contact networks running north-south along the Rift Valley might be anticipated, i.e., for the exchange of lithic raw materials.

Conclusion

In this paper we present a note on the ongoing natural scientific analyses connected to the study of Pastoral Neolithic period in Northern Tanzania. Although the PN period has been rigorously investigated in Kenya, on the Tanzanian side of the border its study is still largely in a formative phase (e.g., Bower 1991; Lane 2004). Ongoing studies and the upcoming large-scale fieldwork will hopefully start filling the gaps in current archaeological knowledge.

The Engaruka Basin 6 site appears to date to the early appearance of PN influences in northern Tanzania, a "trickle" of new technologies and innovations in what appears to be the entry of small, mobile groups of pastoralists apparently from a northerly direction, and the possible adoption of ceramic production by local hunter-gatherers (cf. Bower 1991). This seems to predate the "splash" of food-producing economies in the evolved stage of PN (Bower 1991). This scenario will be evaluated in the light of new archaeological data to be collected in our forthcoming field research.

The ongoing natural scientific analyses will provide us one more proxy for examining the palaeo-environments of the area when all the OES isotope samples have been dated, and provide new evidence of the socio-cultural contact networks of the inhabitants once the additional XRF analyses of obsidian and ceramic provenience are finished. The upcoming large-scale fieldwork will offer material for these and other types of analyses, e.g., for detailed faunal, ceramic, and lithic studies. Together these will provide a new base of data for the explorations of the origins, extent, and nature of the PN occurrences in northern Tanzania.

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