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Source provenance of obsidian artifacts from the Early Stone Age (ESA) site of Melka Konture, Ethiopia

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Abstract

The source provenance of 10 Early Stone Age artifacts from the localities in Melka Konture has been determined by EDXRF. Results show that the early to mid-Pleistocene makers of the artifacts derived the raw material from a source located in their proximity, supporting the previously proposed short distance transport of raw material for the time period.

Keywords: Ethiopia; Early Stone Age; Obsidian; Geochemistry; XRF; Raw material transport

1. Introduction

In a previous paper we showed the near absence of obsidian provenancing investigations in Ethiopia in spite of the presence of obsidian artifacts in many archaeological sites in the country spanning from the Early Stone Age to the very recent past [12]. We have been actively pursuing a geochemical investigation of those artifacts and regional sources in an effort to assign them to their geological provenances. Here we present analysis of the Early Stone Age (ESA) artifacts from the site of Melka Konture and their geological provenance.

Melka Konture (Fig. 1) is located on the shoulder of the Ethiopian Plateau some 50 km west of Addis Ababa. The site proper is found on both sides of the Awash River extending for about 5 km. It was excavated in the 1960s and 1970s by Chavaillon and his colleagues, and represents a succession of localities the earliest of which is dated to 1.6 mya. Besides the ESA, Melka Konture also contains Middle Stone Age (MSA) and Later Stone Age (LSA) components. While the lithic artifacts of the latter two time periods are almost entirely made of obsidian those of the ESA also contain other raw materials [1,2,13].

The ESA localities in Melka Konture contain artifacts belonging to the Developed Oldowan (e.g. Garba IV and Gombore I) and continue through the Acheulean (e.g. Gombore II) [1,2]. All these localities contain obsidian artifacts although the highest proportion of obsidian is to be found at Garba IV. Here, obsidian amounts to twice as much as the other raw materials combined [13] and was obtained from small nodules as well as, less frequently, larger irregular blocks. Also, although it is generally partial and discontinuous, retouching seems to have been more frequent on the Garba IV obsidians.

We determined the source provenance of obsidian artifacts from Melka Konture because we wanted to test the hypotheses formulated by previous obsidian geochemical investigations in East Africa that indicated short distance raw material transport during the ESA [8,9]. Although Muir and Hivernel [11] characterized some artifacts from Melka Konture (see their table 2), these seem to have largely been obtained from the MSA and LSA components. We, therefore, undertook a survey of obsidian geological sources in the Ethiopian Rift Valley in order to identify the provenance of the ESA Melka Konture

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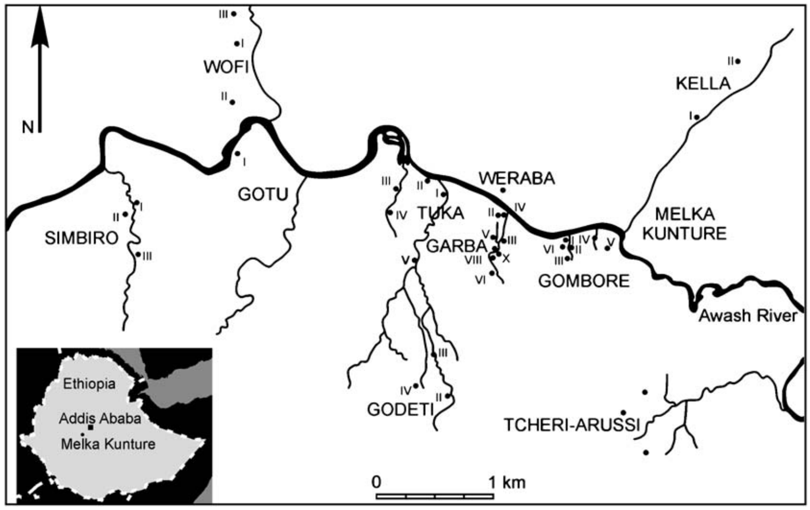

Fig. 1. Map showing the location of Melka Konture and its localities (after Chavaillon and Berthelet [1]).

artifacts. In this paper, we present geochemical composition of 10 ESA artifacts analyzed from the localities in Melka Konture of Garba IV ($n = 1$), Gombore II ($n = 4$), and Gombore I ($n = 5$). These artifacts were randomly selected from the excavated collections that are stored at the National Museum of Ethiopia.

We also present the elemental composition of 10 obsidian samples from the geological source of Balchit. The Balchit outcrop contains high artifact quality and easily knappable obsidians which have been K–Ar dated to 4.37 ± 0.07 mya [3]. Balchit is part of the Pliocene-Quaternary silicic volcanic zone in the Addis Ababa region Main Ethiopian Rift escarpment which has recently been termed as the Addis Ababa Rift Embayment. The Pliocene silicic volcanic centers of Wechecha, Furi, and Yerer are also located on the fringes of the Ethiopian Plateau in close proximity to Balchit. However, although we undertook surveys in these volcanic mountains no obsidian was located.

2. Method

Analytical details for obsidian characterization have been described previously [12,14], and consequently, the following description is necessarily brief. All archaeological samples were analyzed whole with their elemental analysis performed at the Archaeological XRF Laboratory, Department of Earth and Planetary Sciences, Berkeley, using a Spectrace/Thermo-Noran™ *QuanX* energy dispersive X-ray fluorescence spectrometer. The spectrometer is equipped with an air cooled Cu X-ray target with a 125 μm Be window, an X-ray generator that operates from 4 to 50 kV/0.02 to 2.0 mA at 0.02 increments, using an IBM PC based microprocessor and WinTrace™ reduction software. The data from the WinTrace software were transferred directly into Excel for Windows for manipulation and into SPSS for Windows for statistical analyses. In order to evaluate these quantitative determinations, machine data were compared to measurements of known standards during each run. RGM-1 is analyzed during each sample run for obsidian artifacts to check machine calibration, and is included in Table 1.

3. Results and discussion

Interesting results have been obtained from the geochemical characterization of the artifacts and geological sources. The geochemical composition of the archaeological artifacts and geological sources are presented in Table 1 with 10 elements expressed both as wt % (TiO_2, MnO, and total iron as $Fe_2O_3^T$) and as ppm (Zn, Ga, Rb, Sr, Y, Zr, and Nb).

Table 1 and Figs. 2 and 3 show EDXRF results of the elemental composition of the archaeological artifacts of Melka Konture and the source samples of Balchit. The archaeological artifacts range from the Oldowan (Garba IV and Gombore I) to the Middle Acheulean (Gombore II) while Balchit is an obsidian source outcrop located at 8°46′N and 38°37′E at an elevation of ca. 2140 m above sea level. The table and the figures clearly show a striking compositional similarity between the artifacts and the source of Balchit from which, we believe, the artifacts were made, or the raw materials brought. Balchit is found very close (approximately 10 km) from Melka Konture and thus the inhabitants of the site did not travel far in search of raw materials.

The geology of Balchit area is related to the Pliocene silicic activity in the Wechecha, Yerer and Furi volcanic centers in the Addis Ababa region (e.g. [6,7]). These centers produced predominantly trachytic lava with subordinate amount of other silicic and basaltic materials. They lie along the E–W trending Addis Ababa-Ambo-Nekemt lineament. The lineament is structurally related to the rift margin of the northern Main Ethiopian Rift and southern Afar [3,4,7]. K–Ar age determination also shows that the silicic/felsic rocks in Furi, Wechacha and Yerer are between 3 and 4.4 mya [3,10].

The main lithological unit in Balchit is a massive trachyte flow with intercalated rhyolite, pyroclastic and obsidian layers. The trachytes occur as massive flows of approximately over 50 m thick, and are exposed over a large area extending

Table 1
Elemental composition of Melka Konture artifacts and the Balchit source

Sample #	Location	Source/artifact	TiO_2	MnO	$Fe_2O_3^T$	Zn	Ga	Rb	Sr	Y	Zr	Nb
GOMII-1	Gombore II	Artifact/Middle Acheulean	0.20	0.04	1.37	43	16	175	71	28	191	50
GOMII-2	Gombore II	Artifact/Middle Acheulean	0.22	0.04	1.29	42	21	171	66	24	191	56
GOMII-A	Gombore II	Artifact/Middle Acheulean	0.21	0.04	1.35	45	20	181	78	31	188	51
GOMII-B	Gombore II	Artifact/Middle Acheulean	0.23	0.04	1.43	51	21	192	83	31	207	48
GARIV-1	Garba IV	Artifact/Oldowan	0.19	0.04	1.27	40	24	170	69	33	189	50
GOMIB-A	Gombore I	Artifact/Oldowan	0.23	0.05	1.41	45	21	191	84	31	214	55
GOMIB-B	Gombore I	Artifact/Oldowan	0.19	0.04	1.14	27	19	159	68	28	186	56
GOMIB-1	Gombore I	Artifact/Oldowan	0.21	0.04	1.27	43	21	169	74	25	192	50
GOMIB-2	Gombore I	Artifact/Oldowan	0.23	0.04	1.43	47	18	191	85	26	200	52
GOMIB-3	Gombore I	Artifact/Oldowan	0.22	0.05	1.42	44	21	192	80	27	199	56
42-1	Balchit	Source	0.20	0.05	1.43	42	20	182	78	31	201	65
MA-2	Balchit	Source	0.24	0.04	1.53	50	22	191	84	32	206	47
MA-3	Balchit	Source	0.25	0.04	1.53	51	20	188	73	24	195	50
MA-4	Balchit	Source	0.25	0.04	1.51	47	21	191	83	24	204	51
42-5	Balchit	Source	0.23	0.04	1.44	45	24	183	77	27	202	65
42-6	Balchit	Source	0.20	0.04	1.42	42	22	184	76	28	199	57
42-W	Balchit	Source	0.21	0.04	1.38	40	20	178	76	27	198	61
42-X	Balchit	Source	0.22	0.04	1.32	38	20	182	72	23	194	54
42-Y	Balchit	Source	0.22	0.05	1.41	44	21	193	82	27	210	64
42-Z	Balchit	Source	0.22	0.04	1.41	37	20	181	74	27	201	57
RGM1-H1			0.27 ± 0.02	0.04 ± 0.00	1.8 ± 0.05	37 ± 2	20 ± 2	151 ± 6	113 ± 2	25 ± 3	222 ± 4	9 ± 5

from the Furi volcanic center towards the Balchit-Melka Konture area. They are grey, slightly altered, and have porphyritic texture with phenocrysts of predominantly feldspar (both plagioclase and alkali feldspars, >25%), and subordinate amount of quartz, pyroxene and altered brownish grains of probably Fe–Ti oxides and other mafic phases. They have also a micro- to cryptocrystalline groundmass.

The rhyolites occur mostly as a thin layer (<1 m) intercalated within the trachyte flow, but more frequently found at the base of the flow where they are mainly interlayered with obsidian and other felsic materials. They are light grey, have fine-grained texture, and contain characteristic thin lamination (often less than a cm) of lava flow. In some places, moderately dipping thin layers of dark grey, fine-grained felsic rocks sometimes slightly vesicular, with or without visible laminar flow not readily recognized as rhyolite are also observed. Also locally, pockets of fragmented as well as vesicular felsic rocks probably of pyroclastic origin are associated with the rhyolite unit. These rocks appear to show a spatter agglutinate structure characteristic of explosive activity.

The obsidian boulders and fragments commonly occurring in Balchit are associated with rhyolitic/felsic layers. Though intact obsidian flow layer is not well exposed, obsidian cobbles and boulders are found abundantly in several horizons (approximately 2–3 m thick) over a large area. These cobbles/boulders are most probably the result of strongly weathered and fragmented obsidian flow layer that has been intercalated with the rhyolite. The obsidian fragments are black, vitreous, largely contain thin lamination, and most exhibit typical conchoidal fracture pattern. Some obsidian samples also contain large but rare vesicles that are filled with secondary silicic materials.

As stated above, these Balchit obsidians have been K–Ar dated to 4.37 ± 0.07 mya [3]. Other comparable dates are to be found in Assebot, a Mio-Pliocene volcanic center aligned along the southern margin of the Afar rift with its obsidians K–Ar dated to 5.6 mya [4,5] and 5.23 mya [15]. However, our characterization of Balchit obsidians shows an altogether different geochemical composition and it can be excluded from being a potential source. Also comparable in age, but spatially closer to Melka Konture is Entoto, another silicic center with its obsidians having a distinctly different chemical composition from the artifacts of Melka Konture (Fig. 3).

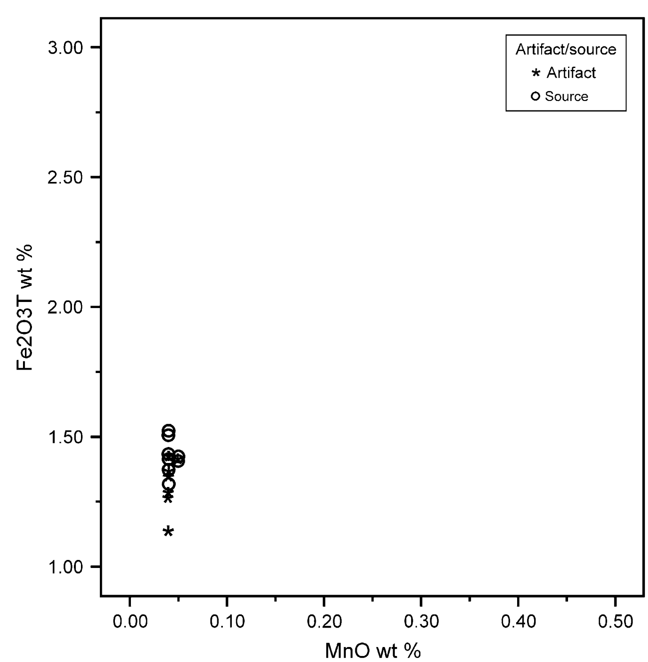

Fig. 2. $Fe_2O_3^T$ and MnO two-dimensional plot for the Melka Konture artifacts and Balchit source.

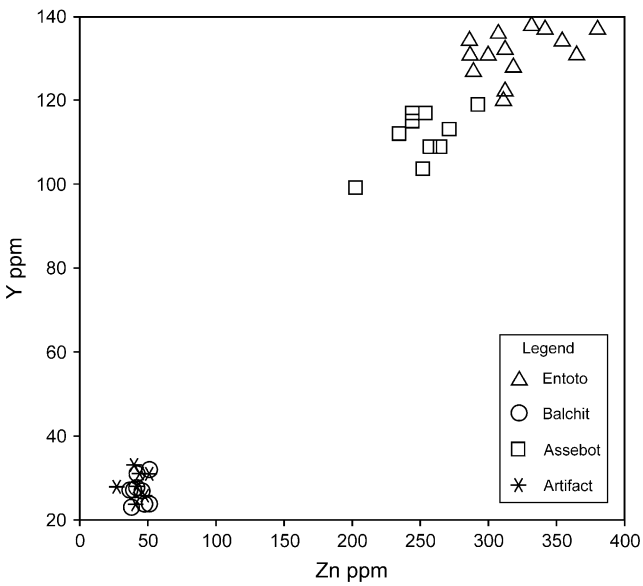

Fig. 3. Y and Zn two-dimensional plot for the Melka Konture artifacts and the obsidian geological sources of Balchit, Assebot, and Entoto.

A single obsidian geochemical analysis of the source of Balchit by Chernet [3] fits well with our analysis as those of Muir and Hivernel [11]. While Chernet [3] used a Direct Current Argon Plasma (DCP) Spectrometer, Muir and Hivernel [11] employed wet chemistry (for majors) and optical spectrography (for traces) when analyzing their specimens. Using EDXRF, and WDXRF to characterize three of the source specimens, all the instrumental results were comparable.

4. Conclusions

The literature is replete with obsidian characterization studies. However, such studies, with rare exceptions, are focused on recent time periods. Here we have shown that such studies can also be applied to the very remote past. Melka Konture contains some of the earliest, if not the earliest, obsidian artifacts on earth. Our characterization of the Balchit source and the determination that Melka Konture's early to mid-Pleistocene ESA knappers used this source only 10 km distant, suggests that they did not travel far in search of raw materials, further suggesting that they had a small home range. Our results, combined with those of the conclusions of Muir and Hivernel [11] who showed that the sources of the MSA and LSA components of Melka Konture are from Balchit, demonstrate that the successive inhabitants of Melka Konture utilized an obsidian source located in their proximity. The short distance to source also supports the results of previous investigations in East Africa which demonstrated the relative proximity of raw material sources for ESA sites [8,9].

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