APPENDIX: THE GEOLOGICAL SOURCE OF AN OBSIDIAN EAR (04.1941) FROM THE MUSEUM OF FINE ARTS, BOSTON

The small fragmentary obsidian sample removed by Richard Newman from an Egyptian sculpted ear at the Museum of Fine Arts, Boston (MFA 04.1941) is quite glassy and somewhat translucent, with a slight greenish tint to its otherwise black color. It has been noted that a green color is characteristic (but not necessarily so) of obsidian from Pantelleria, Lake Van, Abyssinia, and Arabia, although these obsidians are rarely translucent[1]. The sample was quantitatively analyzed for 11 elements using an electron microprobe equipped with wavelength dispersive X-ray spectrometers, following a procedure already established for the analysis of Mediterranean-region obsidians[2]. This inexpensive method is also minimally destructive in that only a millimeter-sized specimen must be removed from an artifact, and provides quantitative major and minor element data which may be compared to results from other analytical methods.

Three points were separately analyzed as a check against sample heterogeneity; the results were normalized to 100% and averaged (Table 1). The obsidian is clearly of rhyolitic type, with a slightly sodic hyperalkaline composition. Its high barium concentration is also notable, while no magnesium was detected.

Table 1. Analysis of an Egyptian Obsidian Ear (MFA 04.1941).

SiO_2	Al_2O_3	TiO_2	Fe_2O_3	MgO	CaO	Na_2O	K_2O	P_2O_5	MnO	BaO	Total
74.04	12.49	0.18	2.87	0.00	0.57	4.89	4.71	0.02	0.09	0.14	100.00

The composition of the MFA sample was then compared to existing data for obsidian sources in the Mediterranean, Europe, the Near East, the Red Sea region, Northeast and East Africa[3]. Sources in Europe, the Mediterranean and the Near East are reasonably well-known and chemically well-

[1] J.R. Cann and C. Renfrew, 'The characterization of obsidian and its application to the Mediterranean region', *Proceedings of the Prehistoric Society* 30 (1964), p. 111-133.

[2] R.H. Tykot. *Prehistoric Trade in the Western Mediterranean: The Sources and Distribution of Sardinian Obsidian* (Ann Arbor: University Microfilms, 1995); 'Characterization of the Monte Arci (Sardinia) obsidian sources', *Journal of Archaeological Science* 24 (1977); 'The provenance of obsidian found at the aceramic neolithic site of Kholetria *Ortos* (Cyprus)', A. Simmons (ed.), *Excavations at Kholetria Ortos (Cyprus)*, forthcoming.

[3] T.K. Bíró, I. Pozsgai, and A. Vlader, 'Electron beam microanalyses of obsidian samples from geological and archaeological sites', *Acta Archaeologica Academiae Scientiarum Hungaricae* 38 (1986), p. 257-278; V.M. Francaviglia. 'Characterization of Mediterranean obsidian sources by classical petrochemical methods', *Preistoria Alpina* 20 (1984), p. 311-332; 'Les gisements d'obsidienne hyperalcaline dans l'ancien monde: étude comparative', *Revue d'Archéometrie* 14 (1990), p. 43-64; 'Obsidian sources in ancient Yemen', A. de Maigret, *The Bronze Age Culture of Hawlan at-Tiyal and al-Hada (Republic of Yemen). A First General Report* (Rome: IsMeo, 1990), p. 129-136; J. Keller and C. Seifried, 'The present status of obsidian source identification in Anatolia and the Near East', C. Albore Livadie and F. Widemann (eds.), *Volcanologie et Archéologie. Proceedings of the European Workshop of Ravello, November 19-27, 1987 and March 30-31, 1989*, PACT 25(4) 1990, p. 57-87; H.V. Merrick, and F.H. Brown, 'Rapid chemical characterization of obsidian artifacts by electron microprobe analysis', *Archaeometry* 26 (1984), p. 230-236; 'Obsidian sources and patterns of source utilization in Kenya and northern Tanzania: some initial findings', *African Archaeological Review* 2 (1984), p. 129-152; Tykot 1995 and 1997, *op. cit.*

characterized; unfortunately, these are the least likely sources of obsidian objects found in Egypt[4]. No obsidian artifacts have been found at Neolithic sites in Egypt or the Sinaï; in the Chalcolithic and Bronze Ages, Anatolian obsidian did make it as far south as southern Israel, but not to the southern Negev or Sinaï[5]. It is not surprising then that the Ear, which has been stylistically dated to the New Kingdom, clearly does not match in its composition any known source in Europe, the western Mediterranean, the Aegean islands, central or eastern Anatolia (including Armenia and Soviet Georgia).

Obsidian sources in the Red Sea region have not been fully investigated. Zarins[6] considers 11 reported Arabian sources and 21 from Africa which potentially could have supplied obsidian to Egypt; only 10 have been chemically analyzed, and few sources have sufficient numbers of specimens analyzed to define their compositional range. Geological samples from several sources in Yemen and Ethiopia have been collected and analyzed[7] but others have been inaccessible for political reasons. The MFA Ear clearly does not come from the sources near Mt. Fantalé, at Canõn de l'Aouache, or at Balchit in the Afar region of Ethiopia; nor does it come from Djabal Isbīl or Djabal al-Līsī in the Dhamar-Reda field of highland Yemen; nor does it match the few samples that have been analyzed from the Tibesti sources in northern Chad[8].

The TKY-5 sector of the Aden Trap Series in the Wasitah area of Dhamar-Reda in Yemen[9] provides only a partial match with the MFA Ear for several important elements. Although Francaviglia reports that this particular obsidian apparently has poor mechanical features, thus making it unlikely to have been used for tools, several archaeological specimens from the Dahlak and Farasan Islands and from Hureidha in Yemen may be of Trap Series obsidian. A small blade from a predynastic tomb at Gerzeh, analyzed by Cann and Renfrew, cannot come from TKY-5 as it has a very low barium content[10]. Likewise, some obsidian beads from Nagada and a blade from Abydos, also analyzed by Cann and Renfrew, do not match the TKY-5 source. These artifacts most likely come from two different sources in the Red Sea region.

A single geological specimen reported from Arafali on the Buri peninsula of Ethiopia[11] does have a high barium content, so that this presumed source plots closely with that of TKY-5 on simple barium-zirconium diagrams, and this has led to some mistaken interpretations in the literature[12]. Fortu-

[4] A. Lucas, 'Obsidian', *ASAE* 41 (1942), p. 275; 'Obsidian', *ASAE* 47 (1948), p. 122-123; J. Zarins, 'Ancient Egypt and the Red Sea trade; the case for obsidian in the predynastic and archaic period', A. Leonard. Jr. and B.B. Williams (eds.), *Essays in Ancient Civilization Presented to Helene J. Kantor*, Studies in Ancient Oriental Civilization 47 (Chicago: The Oriental Institute, 1989), p. 343.

[5] I. Perlman and J. Yellin, 'The provenience of obsidian from Neolithic sites in Israel', *Israel Exploration Journal* 30 (1980), p. 83-88.

[6] J. Zarins, *op. cit.*; 'Obsidian and the Red Sea trade. Prehistoric aspects', M. Taddei and P. Callieri (eds.), *South Asian Archaeology 1987, Proceedings of the Ninth International Conference of the Association of South Asian Archaeologists in Western Europe, held in the Fondazione Giorgio Cini, Island of San Giorgio Maggiore, Venice* (Rome: Istituto Italiano per il Medio ed Estremo Oriente, 1990), p. 507-541.

[7] Cann and Renfrew, *op. cit.*, p. 133, table II, nos 31-32, 66-67, 96-97; Francaviglia, *op. cit.*, p. 55-60, tables 1-12; p. 135, table 1. No tables of data are included in the publications by Zarins.

[8] Cann and Renfrew, *op. cit.*, p. 133, table II, nos 33, 53; Francaviglia, *op. cit.*, p. 64, table 18, nos 4-6.

[9] Francaviglia, *op. cit.*, p. 135, table 1.

[10] Cann and Renfrew, *op. cit.*, p. 133, table II, no 75. This interpretation is contra Zarins, *op. cit.*, p. 366-367.

[11] Cann and Renfrew, *op. cit.*, p. 130, table I, no 67; p. 133, table II, no 67.

[12] Zarins, *op. cit.*, p. 366-367.

nately, however, these two sources on opposite sides of the Red Sea differ in the composition of their other trace elements. The Arafali source specimen does group with a fragment of an unprovenanced New Kingdom statue from the Petrie Collection[13]. Whether archaeological samples from the Dahlak and Farasan Islands, coastal Arabia, upland Saudi Arabia, and the Hadhramaut also belong to this group[14] cannot be assessed without full publication of the analytical data, and so it cannot be concluded at this time that there was trade in obsidian across the Red Sea.

Finally, one other archaeological example comes from New Kingdom Egypt. An 18th dynasty statuette fragment attributed to the Amarna period, analyzed for both major and trace elements by Francaviglia[15] closely matches the presumed Arafali source. The MFA Ear matches the major/minor element composition of this statuette very closely, and it appears likely that both come from the same geological source, presumably Arafali. Nevertheless, some caution is warranted since this source is represented by only a single geological specimen, and the match depends on comparing analyses done in three separate laboratories.

We may conclude that the Egyptians probably utilized obsidian sources in Ethiopia and possibly Yemen, accessible by coastal routes along the Red Sea, beginning in the Predynastic period and continuing through at least the New Kingdom.

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[13] Cann and Renfrew, *op. cit.*, p. 130, table I, n° 71; p. 133, table II, n° 71.
[14] Zarins, *op. cit.*, p. 367.
[15] Francaviglia, *op. cit.*, p. 64, table 18, n° 7.