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## Archaeological X-ray Fluorescence Reports

### Title

Source Provenance of Obsidian Artifacts from the Obsidian Figurine Feature within the Lower Tunnel, Bay 41, Pyramid of the Sun at Teotihuacán, Mexico

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**SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM THE OBSIDIAN  
FIGURINE FEATURE WITHIN THE LOWER TUNNEL, BAY 41, PYRAMID  
OF THE SUN AT TEOTIHUACÁN, MEXICO**



Effigy figure from the feature

by

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## INTRODUCTION

The analysis here of 40 obsidian artifacts from the obsidian feature in the lower tunnel at Teotihuacan, mostly blade-based small projectile points, debitage, and one effigy figure (above) indicates that they were all most likely produced from the Otumba source about 20 km east of Teotihuacán.

## LABORATORY SAMPLING, ANALYSIS AND INSTRUMENTATION

All archaeological samples are analyzed whole. The results presented here are quantitative in that they are derived from "filtered" intensity values ratioed to the appropriate x-ray continuum regions through a least squares fitting formula rather than plotting the proportions of the net intensities in a ternary system (McCarthy and Schamber 1981; Schamber 1977). Or more essentially, these data through the analysis of international rock standards, allow for inter-instrument comparison with a predictable degree of certainty (Hampel 1984; Shackley 2011).

All analyses for this study were conducted on a ThermoScientific *Quant'X* EDXRF spectrometer, located at the University of California, Berkeley. It is equipped with a thermoelectrically Peltier cooled solid-state Si(Li) X-ray detector, with a 50 kV, 50 W, ultra-high-flux end window bremsstrahlung, Rh target X-ray tube and a 76  $\mu\text{m}$  (3 mil) beryllium (Be) window (air cooled), that runs on a power supply operating 4-50 kV/0.02-1.0 mA at 0.02 increments. The spectrometer is equipped with a 200  $\text{l min}^{-1}$  Edwards vacuum pump, allowing for the analysis of lower-atomic-weight elements between sodium (Na) and titanium (Ti). Data acquisition is accomplished with a pulse processor and an analogue-to-digital converter. Elemental composition is identified with digital filter background removal, least squares empirical peak deconvolution, gross peak intensities and net peak intensities above background.

The analysis for mid Zb condition elements Ti-Nb, Pb, Th, the x-ray tube is operated at 30 kV, using a 0.05 mm (medium) Pd primary beam filter in an air path at 200 seconds livetime

to generate x-ray intensity Ka-line data for elements titanium (Ti), manganese (Mn), iron (as  $\text{Fe}_2\text{O}_3^T$ ), cobalt (Co), nickel (Ni), copper, (Cu), zinc, (Zn), gallium (Ga), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), niobium (Nb), lead (Pb), and thorium (Th). Not all these elements are reported since their values in many volcanic rocks are very low. Trace element intensities were converted to concentration estimates by employing a least-squares calibration line ratioed to the Compton scatter established for each element from the analysis of international rock standards certified by the National Institute of Standards and Technology (NIST), the US. Geological Survey (USGS), Canadian Centre for Mineral and Energy Technology, and the Centre de Recherches Pétrographiques et Géochimiques in France (Govindaraju 1994). Line fitting is linear (XML) for all elements. When barium (Ba) is analyzed in the High Zb condition, the Rh tube is operated at 50 kV and up to 1.0 mA, ratioed to the bremsstrahlung region (see Davis 2011; Shackley 2011). Further details concerning the petrological choice of these elements in Southwest obsidians is available in Shackley (1995, 2005, 2011; also Mahood and Stimac 1991; and Hughes and Smith 1993). Nineteen specific pressed powder standards are used for the best fit regression calibration for elements Ti-Nb, Pb, Th, and Ba, include G-2 (basalt), AGV-2 (andesite), GSP-2 (granodiorite), SY-2 (syenite), BHVO-2 (hawaiite), STM-1 (syenite), QLO-1 (quartz latite), RGM-1 (obsidian), W-2 (diabase), BIR-1 (basalt), SDC-1 (mica schist), TLM-1 (tonalite), SCO-1 (shale), NOD-A-1 and NOD-P-1 (manganese) all US Geological Survey standards, NIST-278 (obsidian), U.S. National Institute of Standards and Technology, BE-N (basalt) from the Centre de Recherches Pétrographiques et Géochimiques in France, and JR-1 and JR-2 (obsidian) from the Geological Survey of Japan (Govindaraju 1994).

The data from the WinTrace<sup>TM</sup> software were translated directly into Excel for Windows software for manipulation and on into SPSS for Windows (ver. 21) for statistical analyses. In

order to evaluate these quantitative determinations, machine data were compared to measurements of known standards during each run. RGM-1 a USGS obsidian standard is analyzed during each sample run of 20 for obsidian artifacts to check machine calibration (Table 1).

Source assignments were made by reference to the few Mesoamerican source samples in the laboratory data base, Cobean et al. (1991), Glascock (2011), Glascock et al. (1990), and Nelson and Tingey (1997). Further information on the laboratory instrumentation can be found at: <http://www.swxrflab.net/>. Trace element data exhibited in Table 1 are reported in parts per million (ppm), a quantitative measure by weight (see also Figures 1 and 2).

## DISCUSSION

While source standards for Otumba were not available to this laboratory, reference to the above cited published standards indicates that these artifacts were most likely produced from this nearby source. An effort was made to refer to source standard data that were acquired with x-ray fluorescence spectrometry (XRF) since those acquired by neutron activation analysis (NAA) measure Sr, Zr, and Ba poorly, and Y and Nb not at all, and these are trace elements that are significantly discriminating silicic melt incompatible elements measured well by XRF (see Glascock 2011; Shackley 2005, 2011). Other elements, such as rare earth elements (REEs) are very useful discriminating elements, but given their low quantities in volcanics, especially rhyolites, are not measured well by XRF but extremely well by NAA (Glascock 2011).

Given this, the elements Rb, Sr, Zr, and Ba were plotted on three-dimensional and bivariate plots against the Central Mexican, and Guatemalan XRF source standard data from Glascock (2011), and Nelson and Tingey (1997; see Figures 1 and 2 here). While there are inter-instrument differences, no other published Mesoamerican source fits the data as well as Otumba. Additionally, given its proximity to Teotihuacán, and the large nodular character of the source, it

seems a reasonable assignment. It has been called "one of the most important sources of obsidian in Prehispanic central Mexico" exhibiting "cave-like mines" (Cobean et al. 1991:75). Cobbles of Otumba obsidian are available on the floor of the Teotihuacán Valley within a few kilometers.

One sample (number 33) is a rather unique piece of debitage in the assemblage that, while resembling the remaining pieces megascopically, is slightly higher in Sr than the other Otumba samples (see Table 1 and Figure 2). The only other published Mesoamerican source, analyzed by XRF, that comes close is Jalapa, a minor source in southern Guatemala well over 1000 km distant from Teotihuacán (Cobean et al. 1991). The data from the one sample analyzed by Nelson and Tingey's with WXRF are plotted in the figures here, but are not near the composition of that sample (Figures 1 and 2). The sample did have some dirty matrix and that may be responsible for the higher Sr. The other elements are within the splay of Otumba data in the plots (see Figures 1 and 2).

### REFERENCES CITED

- Cobean, R.H., J.R. Vogt, M.D. Glascock, and T.L. Stocker  
1991 High-Precision Trace-Element Characterization of Major Mesoamerican Obsidian Sources and Further Analyses of Artifacts from San Lorenzo Tenochtitlan, Mexico. *Latin American Antiquity* 2:69-91.
- Davis, M.K., T.L. Jackson, M.S. Shackley, T. Teague, and J. Hampel  
2011 Factors Affecting the Energy-Dispersive X-Ray Fluorescence (EDXRF) Analysis of Archaeological Obsidian. In *X-Ray Fluorescence Spectrometry (XRF) in Geoarchaeology*, edited by M.S. Shackley, pp. 45-64. Springer, New York.
- Glascock, M.D.  
2011 Comparison and Contrast Between XRF and NAA: Used for Characterization of Obsidian Sources in Central Mexico. In *X-Ray Fluorescence Spectrometry (XRF) in Geoarchaeology*, edited by M.S. Shackley, pp. 161-182. Springer, New York.
- Glascock, M.D., J.M. Elam, and K. Ayoama  
1990 Provenience Analysis of Obsidian Artifacts from the La Entrada Region, Honduras. In *Proceedings of the 1990 Archaeometry Symposium*, edited by E. Pernicka, and G.A. Wagner, pp. 395-404. Birkhäuser Verlag, Basel.
- Govindaraju, K.

1994 1994 Compilation of Working Values and Sample Description for 383  
Geostandards. *Geostandards Newsletter* 18 (special issue).

Hampel, Joachim H.

- 1984 Technical Considerations in X-ray Fluorescence Analysis of Obsidian. In *Obsidian Studies in the Great Basin*, edited by R.E. Hughes, pp. 21-25. Contributions of the University of California Archaeological Research Facility 45. Berkeley.

Hildreth, W.

- 1981 Gradients in Silicic Magma Chambers: Implications for Lithospheric Magmatism. *Journal of Geophysical Research* 86:10153-10192.

Hughes, Richard E., and Robert L. Smith

- 1993 Archaeology, Geology, and Geochemistry in Obsidian Provenance Studies. In *Scale on Archaeological and Geoscientific Perspectives*, edited by J.K. Stein and A.R. Linse, pp. 79-91. Geological Society of America Special Paper 283.

Mahood, Gail A., and James A. Stimac

- 1990 Trace-Element Partitioning in Pantellerites and Trachytes. *Geochemica et Cosmochimica Acta* 54:2257-2276.

McCarthy, J.J., and F.H. Schamber

- 1981 Least-Squares Fit with Digital Filter: A Status Report. In *Energy Dispersive X-ray Spectrometry*, edited by K.F.J. Heinrich, D.E. Newbury, R.L. Myklebust, and C.E. Fiori, pp. 273-296. National Bureau of Standards Special Publication 604, Washington, D.C.

Nelson, F.W., and D.G. Tingey

- 1997 X-ray Fluorescence Analysis of Obsidians in Western North America, Mexico, and Guatemala: Data Base for Source Identification. Manuscript in possession of author.

Schamber, F.H.

- 1977 A Modification of the Linear Least-Squares Fitting Method which Provides Continuum Suppression. In *X-ray Fluorescence Analysis of Environmental Samples*, edited by T.G. Dzubay, pp. 241-257. Ann Arbor Science Publishers.

Shackley, M. Steven

- 1995 Sources of Archaeological Obsidian in the Greater American Southwest: An Update and Quantitative Analysis. *American Antiquity* 60(3):531-551.

- 2005 *Obsidian: Geology and Archaeology in the North American Southwest*. University of Arizona Press, Tucson.

- 2011 An Introduction to X-Ray Fluorescence (XRF) Analysis in Archaeology. In *X-Ray Fluorescence Spectrometry (XRF) in Geoarchaeology*, edited by M.S. Shackley, pp. 7-44. Springer, New York.

Table 1. Elemental concentrations and source assignments for the archaeological specimens and USGS RGM-1 obsidian standard. All measurements in parts per million (ppm).

SAMPLE	Mn	Fe	Rb	Sr	Y	Zr	Nb	Ba	Pb	Th	Probable Source
1	396	1200 5	131	141	23	139	9	994	22	10	Otumba, Estado de Mexico
2	369	1173 2	127	142	21	144	12	985	19	5	Otumba, Estado de Mexico
3	432	1288 5	134	145	23	139	12	950	21	10	Otumba, Estado de Mexico
4	399	1261 5	137	148	21	140	11	927	24	12	Otumba, Estado de Mexico
5	361	1156 6	133	135	21	139	11	1015	22	17	Otumba, Estado de Mexico
6	507	1420 4	149	156	22	147	16	964	22	6	Otumba, Estado de Mexico
7	445	1322 5	147	151	21	146	14	863	23	14	Otumba, Estado de Mexico
8	419	1246 7	124	133	21	133	15	807	20	7	Otumba, Estado de Mexico
9	385	1174 8	128	140	22	145	13	954	20	17	Otumba, Estado de Mexico
10	401	1169 5	128	135	22	140	10	857	19	15	Otumba, Estado de Mexico
11	420	1150 2	116	132	22	133	8	704	19	11	Otumba, Estado de Mexico
12	392	1164 8	130	135	17	133	11	834	20	12	Otumba, Estado de Mexico
13	395	1195 5	125	138	21	135	14	928	21	16	Otumba, Estado de Mexico
14	426	1250 7	133	150	23	142	13	865	19	13	Otumba, Estado de Mexico
15	479	1345 5	144	152	20	144	12	870	23	16	Otumba, Estado de Mexico
16	412	1234 7	138	139	20	141	11	994	20	16	Otumba, Estado de Mexico
17	382	1182 6	123	140	23	143	11	947	19	16	Otumba, Estado de Mexico
18	378	1182 2	127	136	20	137	7	991	20	12	Otumba, Estado de Mexico
19	361	1121 6	124	135	20	141	12	1073	18	12	Otumba, Estado de Mexico
20	381	1206 7	130	145	22	140	13	958	21	12	Otumba, Estado de Mexico
21	436	1244 0	131	141	21	144	10	967	22	14	Otumba, Estado de Mexico
22	418	1256 4	138	148	21	146	15	997	22	22	Otumba, Estado de Mexico
23	509	1367 0	135	151	20	141	11	937	18	16	Otumba, Estado de Mexico
24	399	1254 8	132	147	21	138	10	956	22	11	Otumba, Estado de Mexico
25	493	1400 0	150	158	23	146	16	841	23	22	Otumba, Estado de Mexico
26	411	1192 2	130	141	24	144	14	1061	21	14	Otumba, Estado de Mexico
27	414	1290 3	139	150	23	149	16	980	19	13	Otumba, Estado de Mexico
28	442	1281 5	135	148	19	146	11	965	21	12	Otumba, Estado de Mexico

29	439	1244 6	130	144	18	139	11	1055	20	10	Otumba, Estado de Mexico
30	421	1300 8	139	150	20	141	11	1000	22	13	Otumba, Estado de Mexico
31	514	1437 2	145	161	24	150	15	844	23	22	Otumba, Estado de Mexico
32	463	1309 0	137	148	26	150	13	1106	23	14	Otumba, Estado de Mexico
33	486	1236 3	132	174	23	141	11	955	22	12	Otumba, Estado de Mexico?
34	427	1229 8	128	146	21	140	9	1060	19	13	Otumba, Estado de Mexico
35	458	1309 0	140	152	21	146	11	933	25	13	Otumba, Estado de Mexico
36	533	1396 2	153	146	22	133	12	776	28	20	Otumba, Estado de Mexico
37	389	1247 8	132	148	22	137	14	881	22	11	Otumba, Estado de Mexico
38	450	1358 6	144	147	25	146	11	810	22	14	Otumba, Estado de Mexico
40	431	1327 6	145	155	19	145	15	942	24	13	Otumba, Estado de Mexico
41	350	1075 5	119	133	18	135	9	1096	18	16	Otumba, Estado de Mexico
RGM1-S4	281	1330 7	148	109	23	217	8	860	21	9	standard
RGM1-S4	284	1329 8	146	107	25	212	8	869	21	19	standard

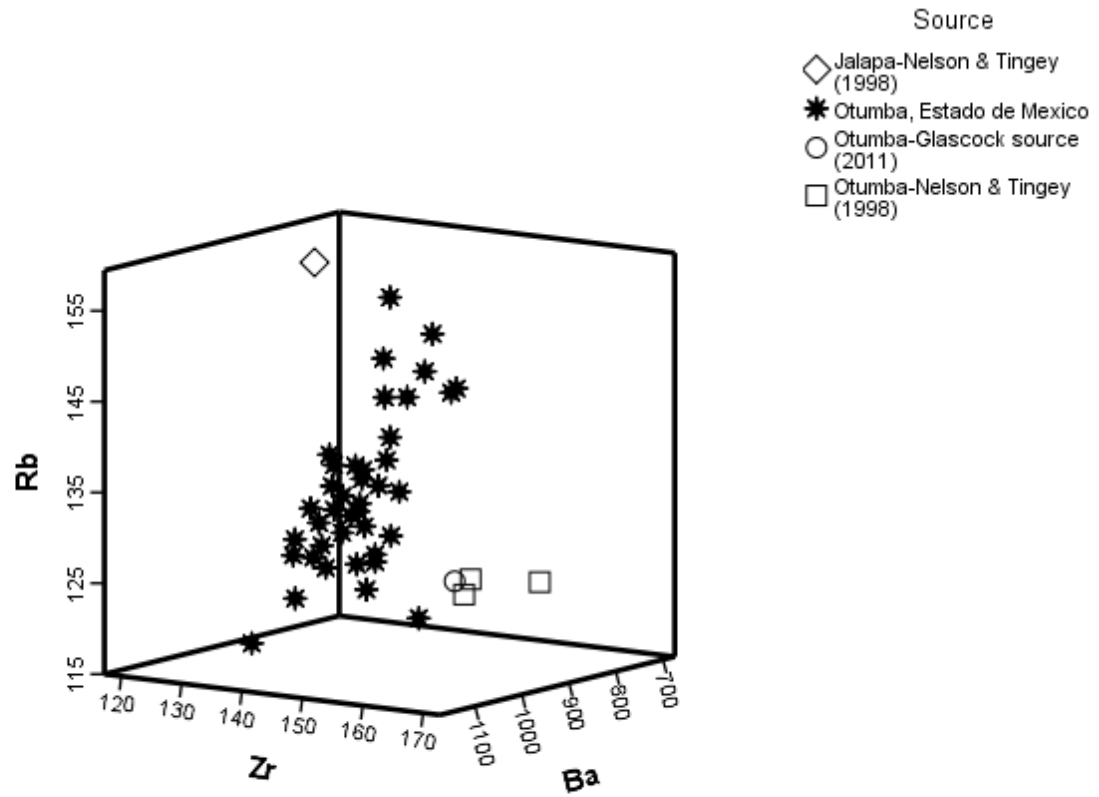


Figure 1. Zr, Rb, Ba three-dimensional plot of the elemental concentrations for all archaeological specimens.

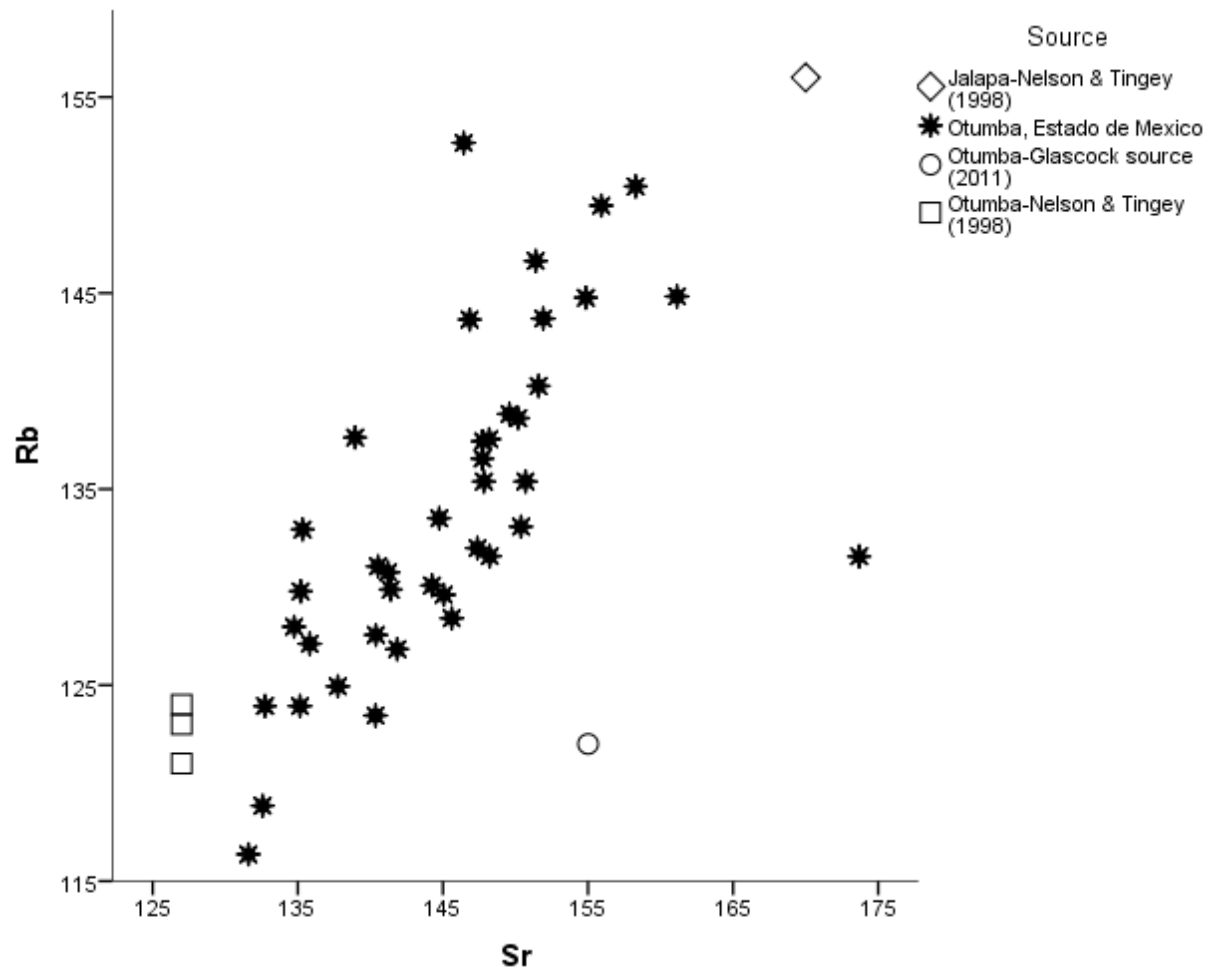


Figure 2. Sr versus Rb bivariate plot of the archaeological samples and published source standard data.