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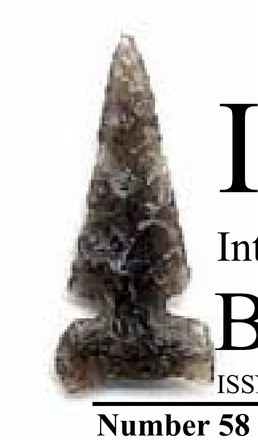

IAOS

International Association for Obsidian Studies

Bulletin

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NEWS AND INFORMATION

NEWS AND NOTES

Have news or announcements to share? Send them to IAOS.Editor@gmail.com for the next issue of the *IAOS Bulletin.*

CONSIDER PUBLISHING IN THE IAOS *BULLETIN*

The *Bulletin* is a twice-yearly publication that reaches a wide audience in the obsidian community. Please review your research notes and consider submitting an article, research update, news, or lab report for publication in the *IAOS Bulletin*. Articles and inquiries can be sent to IAOS.Editor@gmail.com Thank you for your help and support!

CONFERENCES

The annual IOAS business meeting will be held during the SAA conference in Washington, DC, on Friday, April 13, 2018. Please see your conference program for meeting location. All IAOS members are invited to attend.

Mark your calendars for the International Obsidian Conference to be held May 27-29, 2019 in Hungary. See details in this issue of the *IAOS Bulletin.*

NOTES FROM THE PRESIDENT

The year of 2017 has been productive for me, and I hope for all of you as well. After acquiring the Bruker Vi, I first conducted several hundred analyses of standards, with and without filters/vacuum and using different voltage, amperage and time settings, in order to calibrate the results obtained on archaeological objects and be able to compare values with those from my previous studies as well as those of others, whether by XRF or other methods. Just for the "regular" analysis of obsidian artifacts without a vacuum, the well-known set of 40 obsidian standards produced by the Archaeometry Laboratory at the University of Missouri were tested five times each (in three different months), for 60 seconds, showing excellent consistency. I was not happy with the EasyCal software provided by Bruker, and instead did linear regression using the given and raw values for each element in each set of analyses and entered the data into a beta-program created by Lee Drake and based on the statistical program "R". The regression lines were excellent for trace elements Rb, Sr, Y, Zr, Nb, and Th; very good for Ba and As; and good for La and Ga. They were great for major elements K, Ca, Ti, Mn and Fe. I am now comparing calibrated values I have done on geological obsidian source samples with those published by others.

Starting in the summer, I used this new model to conduct analyses on about 3500 artifacts, half of them obsidian from the central Mediterranean. As I have done the last

few summers, I have been traveling with colleague Andrea Vianello, currently a visiting scholar at my university, to a number of different museums and storage facilities in Italy and conducting non-destructive analyses. While many of these assemblages are from surveys and old excavations, and thus with

limited chronological control and contextual information, some are quite recent. Overall, the large amount of data does provide the ability to really compare different sites and regions. I have published in 2017 two articles that summarize what has been accomplished on obsidian sourcing in the central Mediterranean, especially by using a pXRF.

For the International Obsidian Conference held last year on Lipari, formal publication arrangements have been made for a Special Topics section of *Open*

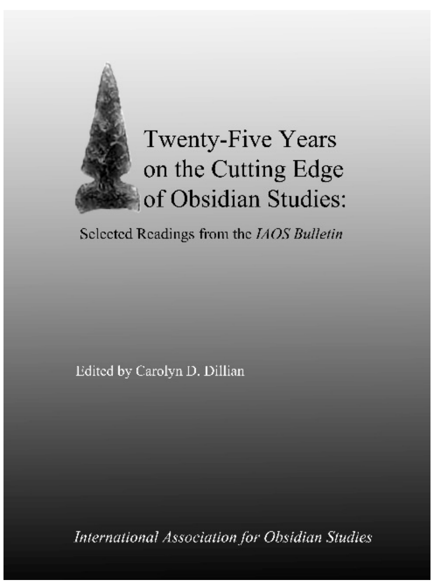
Archaeology, an open-access peer-reviewed journal with De Gruyter, with no limitations on length and number of tables and color illustrations, and edited by myself, Maria Clara Martinelli, and Andrea Vianello. Most of the articles should be fully published by the spring of 2018, while it's not too late to still submit.

I appreciate the efforts and contributions made by IAOS officers and members over the past two years, and I give my best wishes to the new President of IAOS, Kyle Freund.

Robert Tykot, IAOS President
Department of Anthropology
University of South Florida
rtykot@usf.edu

Tykot, R.H. (2017). A Decade of Portable (Hand-Held) X-Ray Fluorescence Spectrometer Analysis of Obsidian in the Mediterranean: Many Advantages and Few Limitations. *MRS Advances* 2(33-34): 1769-1784.

Tykot, R.H. (2017). Obsidian Studies in the Prehistoric Central Mediterranean: After 50 Years, What Have We Learned and What Still Needs to Be Done? *Open Archaeology* 3: 264-278.



Twenty-Five Years on the Cutting Edge of Obsidian Studies: Selected Readings from the IAOS Bulletin

Edited volume available for purchase online!

As part of our celebration of the 25th anniversary of the IAOS, we published an edited volume highlighting important contributions from the *IAOS Bulletin.* Articles were selected that trace the history of the IAOS, present new or innovative methods of analysis, and cover a range of geographic areas and topics. The volume is now available for sale on the IAOS website for $10 (plus $4 shipping to U.S. addresses).

http://members.peak.org/~obsidian/iaos_publications.html

International addresses, please contact us directly at IAOS.Editor@gmail.com for shipping information.

1st Circular – IOC 2019

International Obsidian Conference 2019

27–29 May 2019,
Budapest and Sárospatak (Hungary)
Venue: in Budapest: Hungarian National Museum and
in Sárospatak: Rákóczi Museum of the HNM

Dear Friends and Colleagues,
The Hungarian National Museum and Rákóczi Museum of the HNM, cordially invites you to participate in the International Obsidian Conference held in Budapest and Sárospatak (Hungary) between 27-29 May, 2019.
We aim to invite experts on all aspects of obsidian studies extending from natural sciences to anthropology.
Following the successful meeting in Lipari 2016, the conference is addressing a global scope on obsidian with a special interest in local (Carpathian) sources.

The suggested sessions for the Conference are the following:
· Formation and geology of obsidian
· Sources and their characterisation
· Analytical / methodological aspects of obsidian studies
· Archaeological obsidian by chronological periods
· Lithic technology and use wear
· Theoretical and cultural anthropological issues

Your ideas concerning other sessions are welcome! Sessions can be suggested for the Conference not later than 15th December 2017.
The subject areas and numbers of sessions will be finalised when the deadline for sending abstracts is due and all abstracts are considered.

Local Organising Committee

· Katalin T. Biró
· András Markó
· Zsolt Kasztovszky
· Tamás Weiszburg
· Piroska Csengeri
· Bálint Péterdi
· Gábor Papp
· Miklós Rajczy
· Edit Tamás
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· Centre for Energy Research, Hungarian Academy of Sciences, Budapest, Hungary
· Hungarian Geological and Geophysical Institute, Budapest, Hungary
· Hungarian Natural History Museum, Budapest, Hungary
· Herman Ottó Museum, Miskolc, Hungary
· State Geological Institute of Dionýz Štúr, Bratislava, Slovakia
· Institute of Archaeology, Slovak Academy of Sciences, Nitra, Slovakia
· Masaryk University, Brno, Czech Republic
· Taras Shevchenko National University, Kyiv, Ukraine
· Ferenc Rákóczi II. Transcarpathian Hungarian Institute, Beregovo, Ukraine

Contact persons:

- Katalin T. Biró, Hungarian National Museum, tbk@ace.hu
- András Markó, Hungarian National Museum, markoa@hnm.hu

Technical Information:

Duration and dates: 3 days, 27 – 29 May 2019.
Post-Conference excursion: 1 day, 30t May 2019.
Location: The conference will take place in the Hungarian National Museum, Budapest and the Rákóczi Museum of the HNM at Sárospatak, Hungary.

Oral contributions: Oral contributions will be 15 minutes, followed by 5 minutes discussion. Please prepare them in common presentation format (ppt, pps).
Internet video conference possibility will be provided for registered participants but we definitely prefer your personal presence!
Poster presentation: The posters should be planned as standing (portrait) orientation and their size must not exceed A0 (841 x 1189 mm)
Abstracts: Max. 300 words (including author’s details and institutional affiliation).
Language: The official language for the conference is English.

Deadline for submitting abstracts: end of May 2018.
Deadline for registration: TBA.
Registration fee:

full registration fee	100 EUR
distance participants	50 EUR
early bird registration (until 15.01.2019)	80 EUR
students and accompanying persons	50 EUR
early bird registration (until 15.01.2019)	40 EUR

Other costs:

conference dinner	40 EUR

Conference excursions: Within conference time and costs two excursions are planed to the sources of the Hungarian and Slovakian obsidian (Carpathian 1 and 2 types), respectively
A post-conference tour to Carpathian 3 sources (Ukraine) is anticipated depending on possibilities at extra costs (will be specified later).
Please keep in your mind that for the citizens of a number of countries visa is required to Ukraine.

Accommodation: Budapest is a metropolitan city with wide range of accommodations. The organisers will suggest conference hotels in the vicinity of the HNM. The hotel prices are in the range of 60 to 120 Euro / day, hostels can be obtained at cheaper prices (30 to 60 euro). Participants can also make their arrangements by internet services.
Sárospatak is a small town in NE Hungary. The chief hotel is currently available at the price 60 euro / day, we will try to achieve special prices for the conference participants. There are a number of hostels and pensions also available. We will offer possibilities on the conference homepage in due time.

Transportation: Budapest is easily accessible by public transport with aeroplane, train, bus and it is also available by personal vehicles.
Sárospatak is about 250 kms from Budapest to the North-East, easily accessible by private car but not so easy by train or bus. Nearest international airports are found at Košice and Debrecen (70 and 120 km).
For the conference participants free (bus) transport will be organised from Budapest to Sárospatak at a given schedule.

Homepage: http://ioc-2019.ace.hu/

Please forward this circular to anybody who might be interested.
Looking forward to see you in Hungary!

Katalin and András

REGISTRATION FORM – 1st CIRCULAR
IOC 2019

International Obsidian Conference, at Budapest-Sárospatak (Hungary), 27–29 May 2019

PERSONAL INFORMATION

NAME		
First name		
Family name		
Title		
GENDER		**M / F**
AFFILIATION		
Institute		
Department		
ADDRESS		
City		
Country		
Postal code		
TEL.:	**FAX:**	**E-mail:**
I intend to present a lecture **YES/NO**		**I intend to present a poster** **YES/NO**
I am a student (confirmation needed)		**YES / NO**
I am an accompanying person		**YES / NO**
Any special request		

On-line registration will be open from January 2018 at the Conference web page
http://ioc-2019.ace.hu/
Your kind answer in email (or post) is appreciated by the Organisers.

FIRST HANDS-ON TESTS OF AN OLYMPUS VANTA PORTABLE XRF ANALYZER TO SOURCE ARMENIAN OBSIDIAN ARTIFACTS

Ellery Frahm
Yale Initiative for the Study of Ancient Pyrotechnology, Council on Archaeological Studies, Department of Anthropology, Yale University

Abstract
A few of the major portable X-ray fluorescence (pXRF) manufacturers have released new models in the past year or two. The technologies in these latest instruments have advanced so much that any performance appraisals more than a few years old are essentially obsolete. The X-ray detectors and associated electronics inside a new pXRF analyzer are more sensitive than those in many benchtop models just five or ten years ago. This report summarizes initial tests of the newest pXRF series – Vanta – from Olympus Scientific Solutions. The tests included sourcing 40 artifacts from two Early Bronze Age settlements in Armenia and analyzing a collection of geological specimens that had been measured using other techniques, including neutron activation analysis and energy-dispersive XRF at the University of Missouri Research Reactor as well as electron probe X-ray microanalysis at the University of Minnesota. This report is intended as documentation of the Vanta's high potential for non-destructive obsidian artifact sourcing that is fast, precise, and accurate.

Introduction

Before heading to Armenia this summer, I had an opportunity to evaluate a new Vanta pXRF instrument for several days, thanks to Olympus Scientific Solutions. Marcus Lake, Global Business Development Manager of Olympus' International Mining Group, was confident that I would be won over by the instrument, and in short, he was correct. I do not focus on my subjective impressions in this report, nor do I describe the user-experience side of conducting analyses – such discussions are best had with either an instrument or beer in hand (see Shackley, 2010). Instead, here I document some of the data collected during my tests of the Vanta. Ultimately, the evaluation was so successful that Yale purchased a Vanta to replace our aging pXRF instrument, so studies using more developed procedures will be forthcoming. For example, there was not enough time to devise an entirely new obsidian calibration in a few days just before the field season began. Thus, my report is intended as initial documentation of the Vanta's high potential for obsidian sourcing. The tests, as summarized here, included 40 artifacts from two Early Bronze Age (EBA) sites in Armenia as well as a series of obsidian specimens that had been previously analyzed using other techniques.

Methods and Materials I: Vanta Analyses

This section describes analyses of artifacts from two sites in Armenia: Gazanots along the Kasakh River and Sev Blur in the Ararat Depression. A total of 40 artifacts, preferentially chosen to reflect raw material variability, was analyzed from Gazanots (*n*=15) and Sev Blur (*n*=25). These artifacts reportedly originated from the sites' EBA layers, but precise provenience data are lacking. Figures 1 and 2 show the artifacts from Gazanots and Sev Blur, respectively.

The artifacts' compositions were not compared to published data in the literature. Instead, a collection of geo-referenced Southwest Asian obsidian specimens, which was used in earlier studies (e.g., Frahm and

Figure 1. Sourced obsidian artifacts from Gazanots.

Hauck, 2017), was analyzed using the same instrument. The geological specimens from the Southern Caucasus, in particular, were both collected in the field (in collaboration with the Institute of Archaeology and Ethnography and Institute of Geological Sciences, National Academy of Sciences, Republic of Armenia) and acquired from other collections (e.g., the collections of Robert L. Smith, M. James Blackman, and James Luhr, all housed at the Smithsonian Institute). A total of 105 geological obsidian specimens was newly analyzed using the Vanta instrument.

Figure 2. Sourced obsidian artifacts from Sev Blur.

Specifically, the tests involved an Olympus Vanta VMR handheld analyzer. This instrument has a Rh anode in a 4-W X-ray tube, which is capable of voltages up to 50 kV. When operated in the "GeoChem" mode, the X-ray tube's current and voltage vary in combination with two built-in beam filters to better fluoresce the heavier and lighter parts of the periodic table. In particular, the tube operated at 40 kV and ~70 μA to measure the heavier elements and at 10 kV and ~90 μA to measure the lighter elements. The characteristic X-rays are measured using a large-area (40 mm^2) Si drift detector and Olympus' new Axon technology, that is, ultra-low-noise signal-processing electronics that allow high count rates ($\gtrsim$ 100,000 counts/sec) with excellent spectrum resolution ($\lesssim$ 140 eV). High count rates correspond to better repeatability, lower uncertainties, and shorter measurement times. Thus, the total measurement time was only 20 seconds: 15 seconds for the heavier elements and 5 seconds for the lighter elements (see Figure 3 for a plot of measurement time vs. uncertainty). To minimize drift over time, a simulated X-ray photon is sent through the system, just microseconds before each measurement, to calibrate the energy scale. A built-in barometer automatically corrects for altitude and air density, which is particularly important when measuring light elements near sea level in New Haven or at an archaeological site on a mountainside in Armenia.

Measured X-rays must be corrected for a series of phenomena that occur in a specimen (e.g., absorption, attenuation, secondary and tertiary fluorescence) in order to convert these signals into fully quantitative elemental concentrations. There are several approaches to correction, including empirical methods (e.g., the Lucas-Tooth equation) and normalizing to a given spectral feature (e.g., Compton peak normalization). The Vanta's GeoChem mode utilizes fundamental parameters (FP), which uses a physics-based model to describe the relationship between X-ray emission intensities

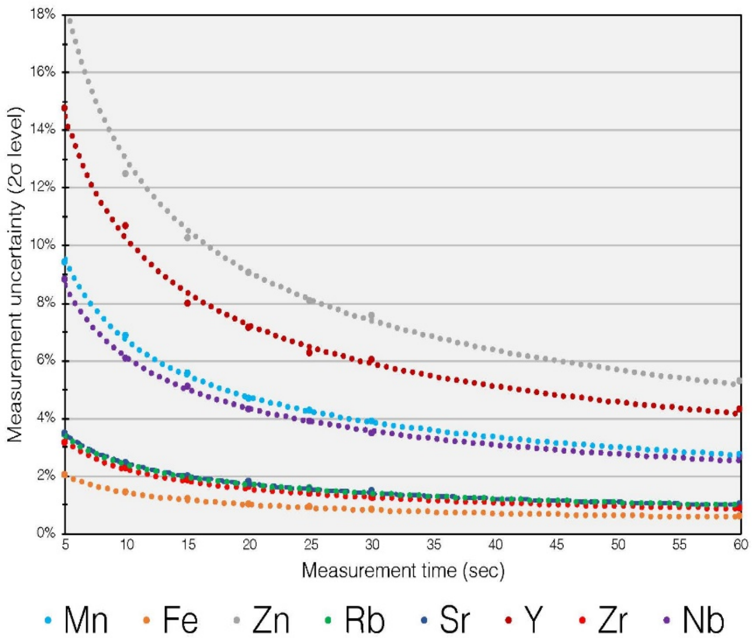

Figure 3. Plot of measurement time versus uncertainty for a specimen of Gutansar obsidian.

and elemental concentrations, accounting for a variety of parameters (e.g., attenuation coefficients for scattering and photoelectric absorption, fluorescent and absorption edge energies, Coster-Kronig transition probabilities, Rayleigh and Compton scattering cross sections). FP correction has been employed in select XRF applications for decades (de Boer and Brouwer, 1990), but it involves more intensive calculations than empirical methods, so adding powerful processors to pXRF instruments has permitted its implementation. The Vanta instruments, for example, have quad-core processors running Linux instead of a PDA. Based on inter-laboratory tests, Heginbotham et al. (2010) report that the best ranked XRF instruments used FP calibrated with standards, whereas instruments with empirical correction ranked lower. Specifically, they point out that "it is very clear that laboratories using fundamental parameters software calibrated with standards… performed consistently more accurately than laboratories using other methods" (Heginbotham et al. 2010:185).

Calibration was accomplished and assessed using a set of 30 geological obsidian specimens from Armenia and Georgia. Matched specimens had been previously analyzed at the Archaeometry Lab at the University of Missouri Research Reactor (MURR) using neutron activation analysis (NAA) and energy-dispersive XRF (EDXRF) and at the University of Minnesota using electron microprobe analysis (EMPA), a type of microbeam X-ray spectrometry. MURR's NAA and EDXRF procedures for analyzing obsidian specimens are reported by Glascock and Giesso (2012). NAA of the specimens consisted of two irradiations in the reactor and three measurements of the emitted gamma rays, the last of which occurred about four weeks after the second irradiation. EDXRF of the specimens was conducted with a benchtop ElvaX instrument (30 mm^2 PN-diode detector with a resolution of ~180 eV at a rate of 1000 counts/second and a W X-ray tube operated at 35 kV and 45 µA for 400-second measurements). Of particular note is that the instrument was empirically corrected and calibrated, rather than using FP, specifically for obsidian (see Speakman and Shackley, 2013:1437). EMPA was conducted using a JEOL 8900 SuperProbe in two rounds: one for major elements (15 kV, 50 nA, 30-µm beam) and a second for trace elements (15 kV, 600 nA, 30-µm beam). The data were corrected using the ZAF scheme and calibrated using certified reference materials (CRMs). As documented in Frahm (2012), accuracy of the calibration was assessed with an obsidian CRM: VG-568 Yellowstone National Park rhyolitic obsidian, a common Smithsonian microbeam standard.

Half of the obsidian specimens (*n*=15) were randomly chosen as primary standards to "fine-tune" the instrument's factory calibration, which is based on a broad range of CRMs and is intended to be useful for a wide variety of mining and geological applications. Therefore, minor adjustments can be required

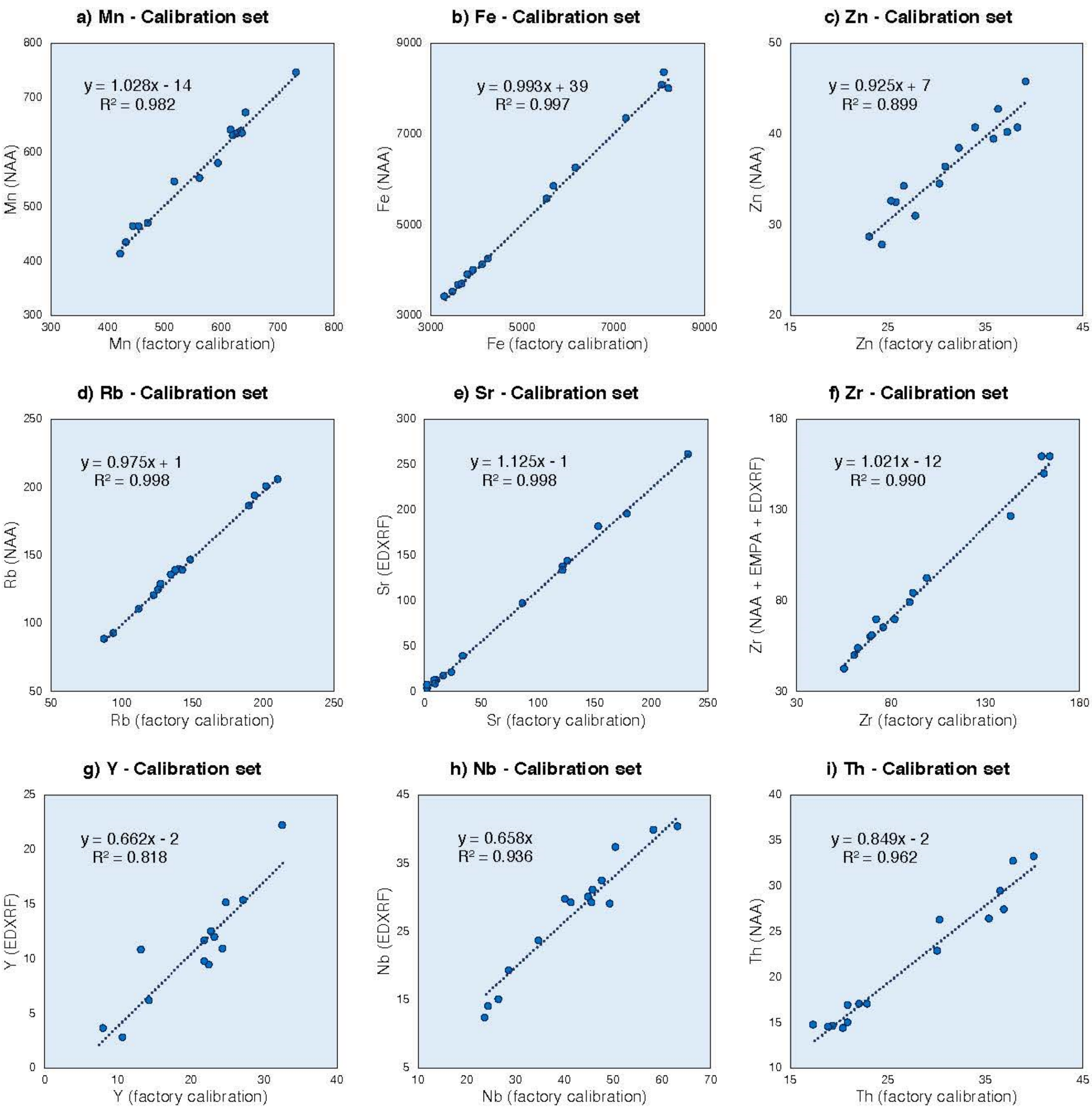

Figure 4. Elemental scatterplots of factory-calibrated Vanta pXRF data versus previous datasets.

to maximize reproducibility for the relatively narrow composition range of rhyolitic obsidians. Figs. 4a–i are scatterplots of the factory-calibrated Vanta pXRF values versus the earlier analytical datasets, preferably NAA data (when possible or sensible) due to decades of experience at MURR involving obsidian characterization using this technique. Six of these elements – Mn, Fe, Zn, Rb, Sr, and Zr (Figs. 4a–f) – exhibit both high reproducibility ($R^2 \geq 0.9$) and slopes nearly equal to 1 (m = 0.93–1.13). Two elements – Nb and Th – have high reproducibility ($R^2 = 0.94–0.96$) but lower slopes (m = 0.66–0.85), requiring greater adjustments. Y exhibits lower reproducibility ($R^2 = 0.82$), but this is due, in part, to its low

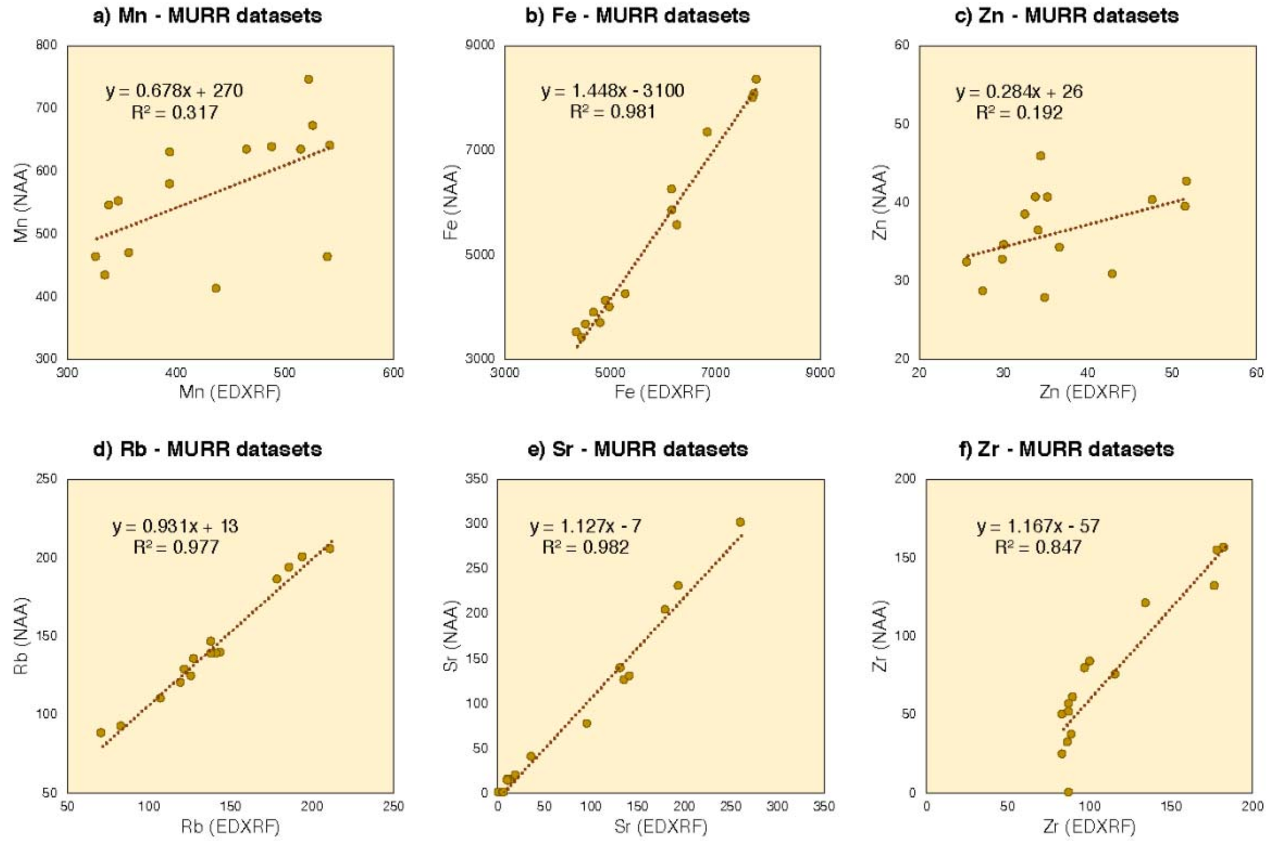

Figure 5. Elemental scatterplots of MURR NAA and EDXRF datasets.

concentrations (≲ 30 ppm) in these obsidian specimens – Horwitz et al. (1980) document how, for any analytical technique, uncertainties increase as concentrations decrease. These regression equations can be saved by the Vanta software as a set of custom "User Factors" that can bring slopes of the best-fit lines closer to the ideal value of 1.

Figs. 5a–f show the same elements as Figs. 4a–f but instead plot the MURR EDXRF and NAA datasets. For each of the elements, the ElvaX EDXRF data have lower R^2 values (i.e., reproducibility) and worse slopes (i.e., accuracy) with respect to the MURR NAA dataset than the factory-calibrated Vanta pXRF data in Figs. 4a–f. Mn and Zn exhibit particularly low reproducibility in the ElvaX data ($R^2 = 0.20$–0.32), and the Fe slope exhibits a considerable offset ($m = 1.45$). This occurs despite the ElvaX being empirically corrected and calibrated specifically for rhyolitic obsidians (Speakman and Shackley, 2013) and amid claims in the literature than empirical approaches are preferable and/or superior to FP with standards (e.g., Shackley 2011; Conrey et al., 2014; Drake, 2016).

The other half of the obsidian specimens were used as secondary standards to test the new calibration, as shown in Figs. 6a–i. In these plots, the linear regression equations in Figs. 4a–i were applied to these data. Seven of the elements exhibit high reproducibility ($R^2 \gtrsim 0.93$), and all nine of them have slopes nearly equal to 1 ($m = 0.98$–1.02). Two elements with lower reproducibility – Y and Nb ($R^2 = 0.86$ and 0.81, respectively) – not only occur at low concentrations but also are plotted against the empirically calibrated EDXRF data because these elements were not measured by NAA, meaning that the ElvaX instrument might be to

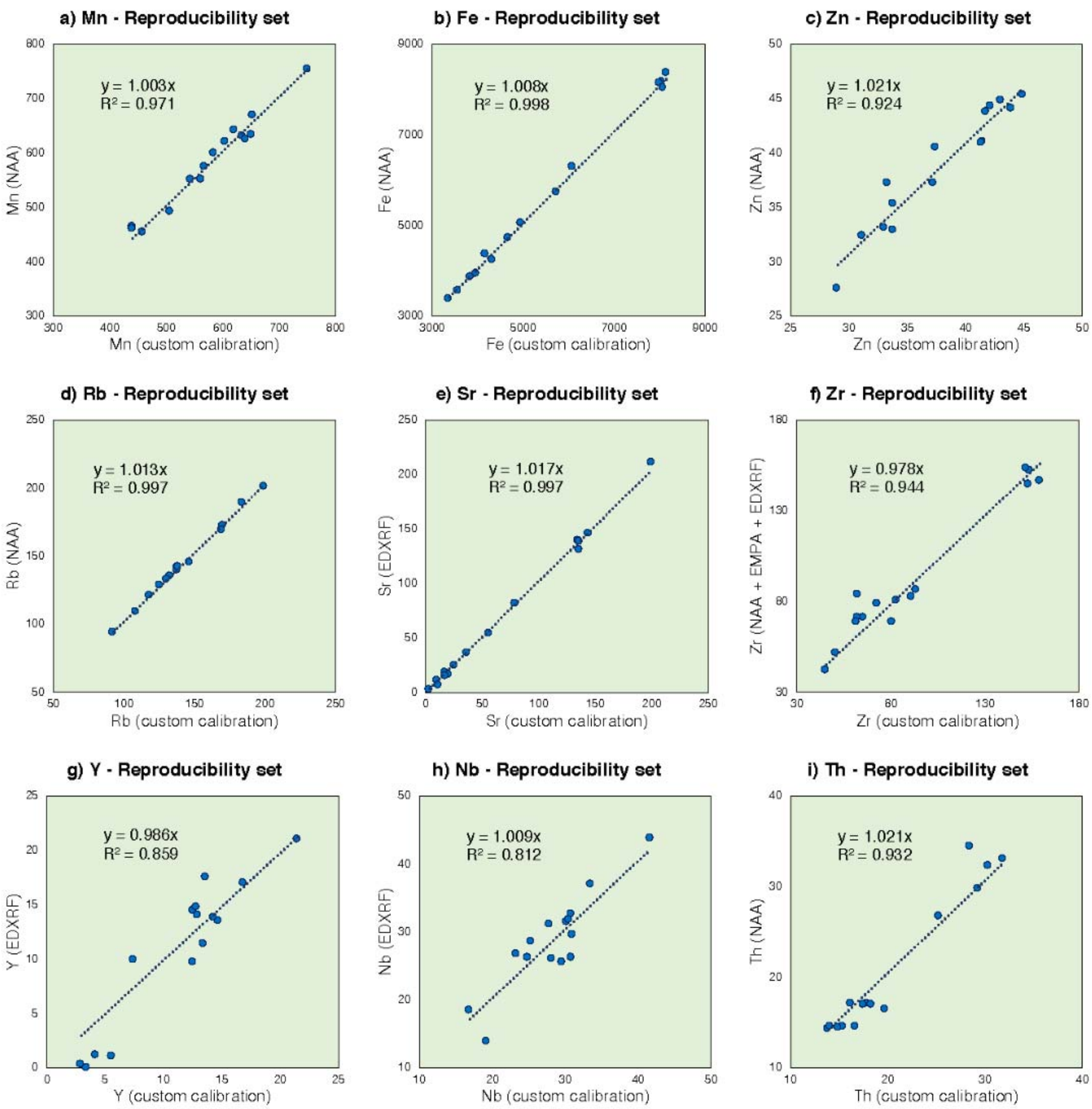

Figure 6. Elemental scatterplots of the custom-calibrated pXRF data versus previous datasets.

blame for these low correlations.

In addition, accuracy can be checked by analyzing a CRM and comparing the measurements to its certified elemental concentrations. Almost all obsidian CRMs, however, are finely powdered, and, as noted by Shackley et al. (2016), "a number of scholars have questioned the validity of using pressed powder pellets of international standards for empirical calibration and data checking" (64). Hence, the choice was made to analyze a solid obsidian specimen as a check, even if the specimen is not a CRM. In this instance, the specimen was a small block of Little Glass Buttes obsidian (Oregon, United States) obtained from MURR. This obsidian has been routinely used as a means to calibrate analytical instruments for archaeological applications (e.g., Carballo et al., 2007; Arnold et al., 2007, 2012; Pitblado et al., 2008, 2013), and it has been measured using several techniques in a variety of labs. Table 1 shows a series of Little

Lab/Group	Reference	Technique	Mn	Fe	Zn	Rb	Sr	Y	Zr	Nb	Th
NAA techniques											
MURR	Glascock 1999	INAA	327 ± 6	6200 ± 100	31 ± 7	95 ± 1	78 ± 20		118 ± 7		8 ± 1
MURR	Glascock & Ferguson 2012	INAA	328	6179	28	94	69		115		9
CNRS Orléans	Glascock 1999	FNAA	297 ± 30	6500 ± 300	90 ± 3	110 ± 1		23 ± 1	99 ± 10	12 ± 1	
XRF techniques											
Rome	Glascock 1999	WDXRF	387	7900		97	71	28	105	8	
Ashe Analytics	Glascock 1999	EDXRF	298 ± 13	5730 ± 150	24 ± 3	96 ± 2	69 ± 3	26 ± 2	96 ± 3	7 ± 1	
NWOSL	Glascock 1999	EDXRF	349 ± 47	6600 ± 800	41 ± 7	101 ± 3	73 ± 9	29 ± 9	109 ± 8	8 ± 2	
NWOSL	Skinner & Thatcher 2003	EDXRF	302 ± 29	5665 ± 684		105 ± 4	74 ± 3	27 ± 2	109 ± 3	8 ± 1	
Field Museum	Millhauser et al. 2011	pXRF	277 ± 12	5408 ± 87	32 ± 4	101 ± 4	73 ± 3		91 ± 3	6 ± 2	
Field Museum	Millhauser et al. 2015	pXRF	272 ± 12	5713 ± 93	26 ± 4	100 ± 4	73 ± 3		93 ± 3		
UGA CAIS	Speakman 2012	pXRF	323	6200	37	96	63	25	104	8	6
UMN IRM	Frahm & Feinberg 2015	pXRF		5940 ± 140		94 ± 3	78 ± 1		85 ± 1		
Particle beam techniques											
CNRS Grenoble	Glascock 1999	PIXE	291 ± 11	6070 ± 110	27 ± 2	105 ± 6	73 ± 5		105 ± 8		
ANSTO	Glascock 1999	PIXE/PIGME	357 ± 9	7020 ± 230	36 ± 1	109 ± 6	81 ± 6		107 ± 3		
ICP techniques											
CNRS Orléans	Glascock 1999	LA-ICP-MS	269 ± 5	6840 ± 280	27 ± 1	97 ± 1	52 ± 1	18 ± 2	83 ± 7	9 ± 1	8 ± 1
CNRS Grenoble	Glascock 1999	ICP-AES/MS	333 ± 10	6500 ± 360		94 ± 1	67 ± 1	26 ± 1	106 ± 2	8 ± 1	8 ± 1
Rio de Janiero	Glascock 1999	ICP-AES/MS	303	6100	29	95	66	23	106	8	10
Rio de Janiero	de B. Pereira et al. 2001	LA-ICP-MS	282 ± 1		29 ± 4		65 ± 2		93 ± 3	8 ± 1	9 ± 1
IIRMES	Scharlotta 2010	LA-TOF-ICP-MS	299 ± 36	5353 ± 631	27 ± 26	79 ± 13	45 ± 13	13 ± 2	64 ± 9		6 ± 1
MURR	Glascock & Ferguson 2012	MD-ICP-MS	304	5738	24	82	55	17	96	7	7
MURR	Glascock & Ferguson 2012	LA-ICP-MS	294	5400	27	92	44	18	83	9	8
		Mean ± St Dev	310 ± 31	6161 ± 638	33 ± 16	97 ± 8	67 ± 11	23 ± 5	98 ± 13	8 ± 1	8 ± 1
		This study	369 ± 7	6330 ± 23	28 ± 1	98 ± 1	76 ± 1	15 ± 1	86 ± 1	4 ± 1	11 ± 1

Table 1. Little Glass Buttes obsidian analyses and the calibrated data from this study.

Glass Buttes obsidian analyses and the calibrated data from this pilot study, exhibiting good agreement within the range of reported values.

Methods and Materials II: Niton Analyses

For comparison, I also analyzed 60 obsidian artifacts – principally bladelets and cores – from the Epipalaeolithic/Early Neolithic (EP/EN) cave site of Apnagyugh-8 (also known as Kmlo-2), near Gazanots, using different pXRF instruments. This site and its lithics are described by Arimura et al. (2009) and Chataigner et al. (2012). In a previous obsidian sourcing study (Chataigner and Gratuze, 2014), a set of 20 "Kmlo" tools was analyzed using laser-ablation inductively coupled plasma mass spectrometry (LA-ICP-MS). The most common sources reflected in their set were Gutansar (*n*=10), the Tsaghkunyats sources (4), and the Arteni complex (3), and the rest were single finds from Hatis, Geghasar, and Sarıkamış. Like the Gazanots and Sev Blur artifacts, Apnagyugh-8 artifacts were not compared to literature values. Instead, these artifacts were compared to my database of Southwest Asian obsidian analyses with pXRF (e.g., Frahm and Hauck, 2017; Kandel et al., 2017).

These artifacts were analyzed with a Thermo Scientific Niton XL2 instrument. It is outfitted with a 2-W, Ag-anode tube to create the X-ray beam. The voltage and current change in combination with different built-in X-ray filters to fluoresce elements in different parts of the periodic table. The elements of primary interest were measured for 60 seconds using the "main" X-ray filter with a tube voltage of 45 kV and a current of ≤ 44 µA. This model measures the characteristic X-rays using a 7-mm^2 Si P-N diode detector that has a resolution ≤ 180 eV. The geological specimens were analyzed using a Thermo Scientific Niton XL3t GOLDD instrument. It, too, is equipped with a 2-W, Ag-anode tube. The elements of interest were measured for 30–40 seconds using the "main" X-ray filter with a tube voltage of 40 kV and a current of ≤ 50 µA. This model has a 25-mm^2 Si drift detector with a resolution ≤ 165 eV. Both instruments used FP correction, and the details regarding their means of the calibration are documented in Frahm (2014) and Frahm and Feinberg (2015).

Source	Geological/Artifacts		Mn (ppm)	Fe (ppm)	Zn (ppm)	Rb (ppm)	Sr (ppm)	Y (ppm)	Zr (ppm)	Nb (ppm)	Sr/Rb	Zr/Rb
Tsaghkunyats 1 (Arqayasar/Kamakar)	geological	mean	424	7366	34	88	263	3	135	16	3.00	1.54
		st dev	16	79	2	1	2	1	1	1	0.04	0.03
	artifact	Gazanots-11	424	7362	32	86	260	3	132	14	3.02	1.53
Tsaghkunyats 2 (Ttvakar)	geological	mean	460	6232	29	94	202	3	89	19	2.15	0.95
		st dev	12	111	2	1	3	1	2	1	0.04	0.01
	artifacts	Gazanots-2	440	6140	29	92	199	3	88	19	2.16	0.96
		Gazanots-5	458	6234	27	95	202	3	91	20	2.13	0.96
		Gazanots-12	443	5926	26	91	197	3	85	15	2.16	0.93
		Gazanots-13	459	6526	28	94	198	3	87	21	2.11	0.93
Tsaghkunyats 3 (Damlik)	geological	mean	434	5716	32	111	173	5	81	18	1.56	0.73
		st dev	17	138	2	3	2	1	3	1	0.03	0.03
	artifacts	Gazanots-1	417	5463	31	110	172	4	79	18	1.56	0.72
		Gazanots-7	424	5708	32	112	171	5	83	19	1.53	0.74
		Gazanots-14	453	5761	31	114	173	4	81	17	1.52	0.71
		Sev Blur-16	418	5734	31	109	173	5	79	18	1.59	0.72
Gutansar	geological	mean	637	8073	42	138	138	13	154	31	1.00	1.11
		st dev	18	129	2	2	4	1	3	1	0.03	0.03
	artifacts	Gazanots-3	637	8000	39	138	139	14	152	30	1.01	1.10
		Gazanots-4	627	8070	41	136	143	12	156	30	1.05	1.15
		Gazanots-8	630	7934	42	138	135	14	149	30	0.98	1.08
		Gazanots-10	631	7934	39	136	136	14	151	31	1.00	1.11
		Gazanots-15	651	8493	44	141	140	13	155	30	0.99	1.10
		Sev Blur-13	614	7972	40	136	142	13	156	30	1.04	1.15
Hatis	geological	mean	503	6427	34	110	122	9	77	20	1.10	0.69
		st dev	17	431	2	2	3	1	1	1	0.02	0.02
	artifact	Sev Blur-21	489	6120	28	109	121	7	76	18	1.11	0.70
Kars-Digor 2	geological	mean				121	56		113	16	0.47	0.94
		st dev				5	3		5	2	0.02	0.03
	artifact	Sev Blur-15	352	6944	32	123	52	9	111	12	0.42	0.90
Pokr Arteni	geological	mean	577	4136	36	124	32	14	65	25	0.26	0.52
		st dev	30	203	2	6	7	1	3	2	0.07	0.05
	artifacts	Gazanots-6	525	4271	34	114	36	15	66	24	0.32	0.58
		Gazanots-9	510	4360	33	119	41	13	70	23	0.34	0.59
		Sev Blur-1	578	5009	38	121	41	14	67	23	0.34	0.55
		Sev Blur-2	537	4104	33	117	36	13	64	23	0.31	0.55
		Sev Blur-3	547	4263	37	121	36	13	65	22	0.30	0.54
		Sev Blur-4	551	4243	37	119	37	13	66	23	0.31	0.55
		Sev Blur-5	663	3735	45	142	16	17	64	33	0.11	0.45
		Sev Blur-6	579	3945	34	126	28	13	63	24	0.22	0.50
		Sev Blur-7	541	4217	34	117	35	13	64	22	0.30	0.55
		Sev Blur-8	552	4121	34	118	36	14	65	22	0.31	0.55
		Sev Blur-9	547	4225	34	122	35	14	68	24	0.29	0.56
		Sev Blur-10	576	4275	38	122	35	13	66	24	0.29	0.54
		Sev Blur-11	569	4178	36	122	37	13	67	22	0.30	0.55
		Sev Blur-12	584	4203	35	120	37	13	64	22	0.31	0.53
		Sev Blur-14	553	4338	38	122	37	14	66	22	0.30	0.54
		Sev Blur-17	571	4334	32	122	38	12	67	24	0.31	0.55
		Sev Blur-18	578	4467	37	121	32	15	63	27	0.26	0.52
		Sev Blur-19	557	4308	36	123	37	14	67	26	0.30	0.54
		Sev Blur-20	528	4286	36	121	36	14	67	24	0.30	0.55
		Sev Blur-22	528	4164	34	119	37	14	66	24	0.31	0.55
		Sev Blur-23	589	4326	38	131	27	15	64	25	0.21	0.49
		Sev Blur-24	613	4447	38	123	37	14	67	24	0.30	0.54
		Sev Blur-25	543	4330	34	121	36	14	67	22	0.30	0.55

Table 2. Elemental data for the Gazanots and Sev Blur artifacts and for the corresponding geological obsidian specimens.

Test Data and Results

Figure 7 and Table 2 show source identification data for the Sev Blur and Gazanots obsidian artifacts, and Figure 8 and Table 3 provide the same data for Apnagyugh-8. The distribution of the identified obsidian sources (and those not identified at these sites) across the region are illustrated in Figure 9. None of the obsidian sources near Lake Van were identified at these sites, neither were sources in southwestern and northern Armenia nor the one source in Georgia. Each of the

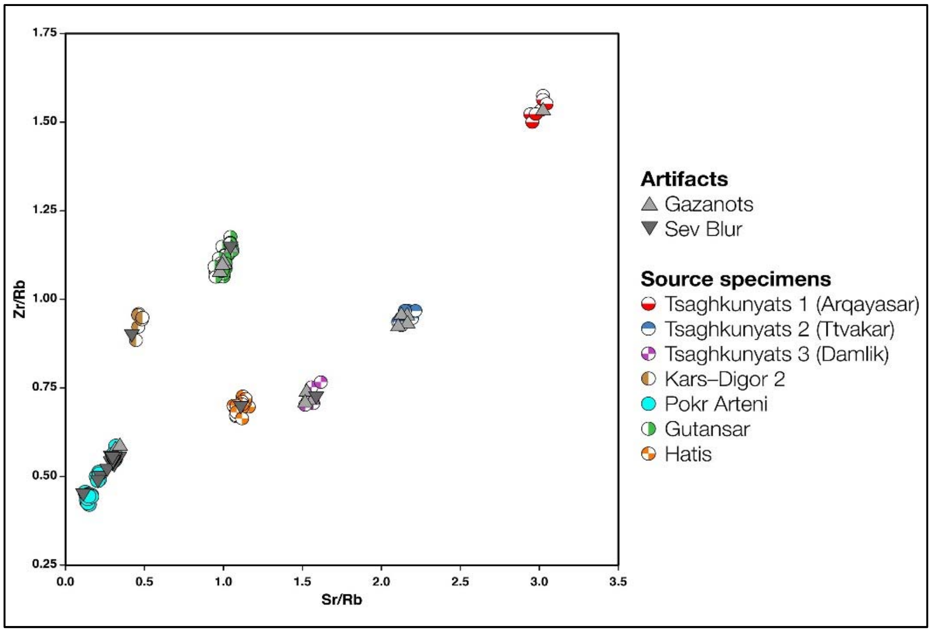

Figure 7. Source identification of the analyzed Gazanots and Sev Blur obsidian artifacts.

sources reported at Apnagyugh-8 by Chataigner and Gratuze (2014) is also present in my dataset (albeit in somewhat different proportions), plus an additional source – Kars-Arpaçay 2 – is represented by 5% of the artifacts. Taken together, Gutansar, the Tsaghkunyats sources, and the Arteni complex reflect 85% of artifacts analyzed by Chataigner and Gratuze (2014) and 87% in this study.

Concluding Remarks

The Vanta VMR is very fast and can acquire precise and accurate data for obsidian. It is still common to see pXRF measurement times of 3 to 5 minutes in the literature (e.g., Escola et al. 2016; Lynch et al. 2016; McCoy and Robles, 2016; Mialanes et al. 2016; Panich, 2016; Perreault et al. 2016; Pintar et al. 2016; Skelly et al. 2016; Kocer and Ferguson, 2017; Liebmann, 2017; Millhauser et al., 2017;

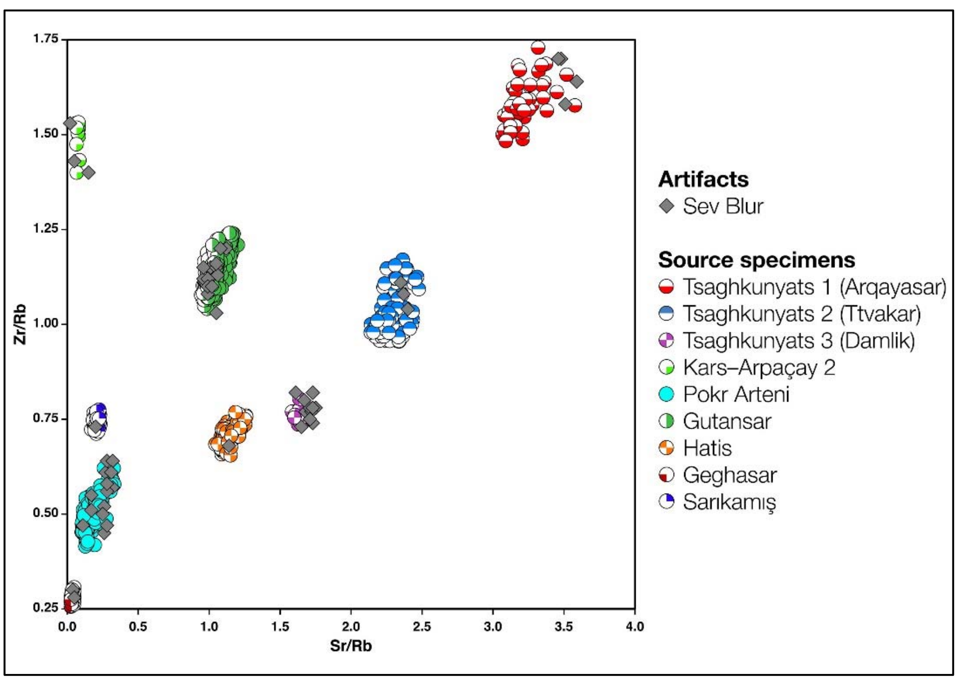

Figure 8. Source identification of the analyzed Apnagyugh-8 obsidian artifacts.

Source	Geological/Artifacts		Mn (ppm)	Fe (ppm)	Zn (ppm)	Rb (ppm)	Sr (ppm)	Zr (ppm)	Nb (ppm)	Sr/Rb	Zr/Rb
Geghasar	geological	mean	561	3836	44	199	7	55	40	0.04	0.28
		std dev	31	63	3	4	1	2	5	0.01	0.01
	artifacts (n=3)	mean	564	3736	47	179	8	51	30	0.05	0.29
		std dev	49	116	0	24	2	5	5	0.01	0.01
Gutansar	geological	mean	530	7427	52	137	142	156	31	1.03	1.14
		st dev	48	312	4	4	6	5	2	0.04	0.03
	artifacts (n=17)	mean	517	7204	50	137	140	155	23	1.02	1.13
		st dev	25	446	4	9	8	12	9	0.04	0.04
Hatis	geological	mean	437	5980	46	108	123	77	20	1.14	0.71
		st dev	27	257	3	3	4	2	1	0.04	0.02
	artifact (n=1)		370	5117	47	90	103	61	28	1.14	0.68
Kars-Arpaçay 2	geological	mean	–	–	–	136	10	203	28	0.07	1.49
		st dev	–	–	–	6	1	13	2	0.01	0.04
	artifact (n=3)	mean	458	5719	101	124	9	181	16	0.07	1.45
		st dev	59	653	14	5	8	15	13	0.07	0.07
Pokr Arteni	geological	mean	505	4153	48	127	23	65	27	0.18	0.51
		st dev	31	136	3	6	5	4	2	0.05	0.04
	artifacts (n=15)	mean	472	4194	51	118	30	65	17	0.26	0.55
		st dev	51	222	13	11	7	9	8	0.06	0.07
Sarıkamış	geological	mean	398	4729	47	124	27	87	14	0.22	0.69
		std dev	18	31	3	4	2	2	1	0.01	0.02
	artifact (n=1)		377	5122	47	117	23	85	30	0.20	0.73
Tsaghkunyats 1 (Arqayasar/Kamakar)	geological	mean	397	6773	46	86	276	135	16	3.22	1.58
		st dev	26	105	2	3	5	4	3	0.12	0.06
	artifacts (n=4)	mean	364	6583	52	78	272	128	9	3.51	1.66
		st dev	28	290	11	3	13	4	7	0.06	0.06
Tsaghkunyats 2 (Ttvakar)	geological	mean	419	5849	44	92	210	94	20	2.29	1.03
		st dev	23	100	4	3	6	5	3	0.07	0.06
	artifacts (n=3)	mean	392	5803	47	88	209	95	16	2.37	1.08
		st dev	20	35	0	4	9	5	4	0.03	0.04
Tsaghkunyats 3 (Damlik)	geological	mean	388	5444	45	108	175	82	18	1.63	0.76
		st dev	27	94	2	3	3	3	1	0.03	0.02
	artifacts (n=13)	mean	404	5435	47	104	176	81	16	1.69	0.77
		st dev	26	265	0	5	8	6	8	0.05	0.03

Table 3. Elemental data for the Apnagyugh-8 artifacts and for the corresponding geological obsidian specimens.

Goebel et al. 2018). In contrast, the Vanta's measurements for this test were just 20 seconds each – a decrease of 89–93%, making it an order of magnitude faster. Given that time is commonly associated with analytical quality, such speed is likely to be met with a degree of skepticism. Neff et al. (1996) even began a paper with the aphorism "Good, fast, cheap; pick any two," and it reoccurs in their discussions of analytical technique selection (Neff, 2005; Bishop, 2012). There are, however, clear reasons for the Vanta's considerable speed. For example, a 40-mm^2 X-ray detector is 5.7 times larger than a 7-mm^2 one, and the Vanta's signal-processing electronics adapt to the incoming X-ray count rate in order to attain the optimum throughput at high resolution.

Even the Vanta's factory-set GeoChem calibration was able to reproduce NAA measurements better than the empirically calibrated benchtop EDXRF system, which was used to analyze obsidian in peer-reviewed publications (e.g., Blomster and Glascock, 2011; Giesso et al. 2011; Glascock et al. 2011; Knight et al. 2011; Millhauser et al. 2011; Hirth et al. 2013; Parry and Glascock, 2013; Cortegoso et al. 2016; Escola et al. 2016; Durán et al. 2017). Of particular note is that the benchtop instrument was empirically calibrated specifically for obsidian, even serving as the starting point for one pXRF manufacturer's obsidian calibration (Speakman and Shackley, 2013:1437). Using obsidian-specific "User Factors" based on well-characterized obsidian specimens, the Vanta data are even better. For

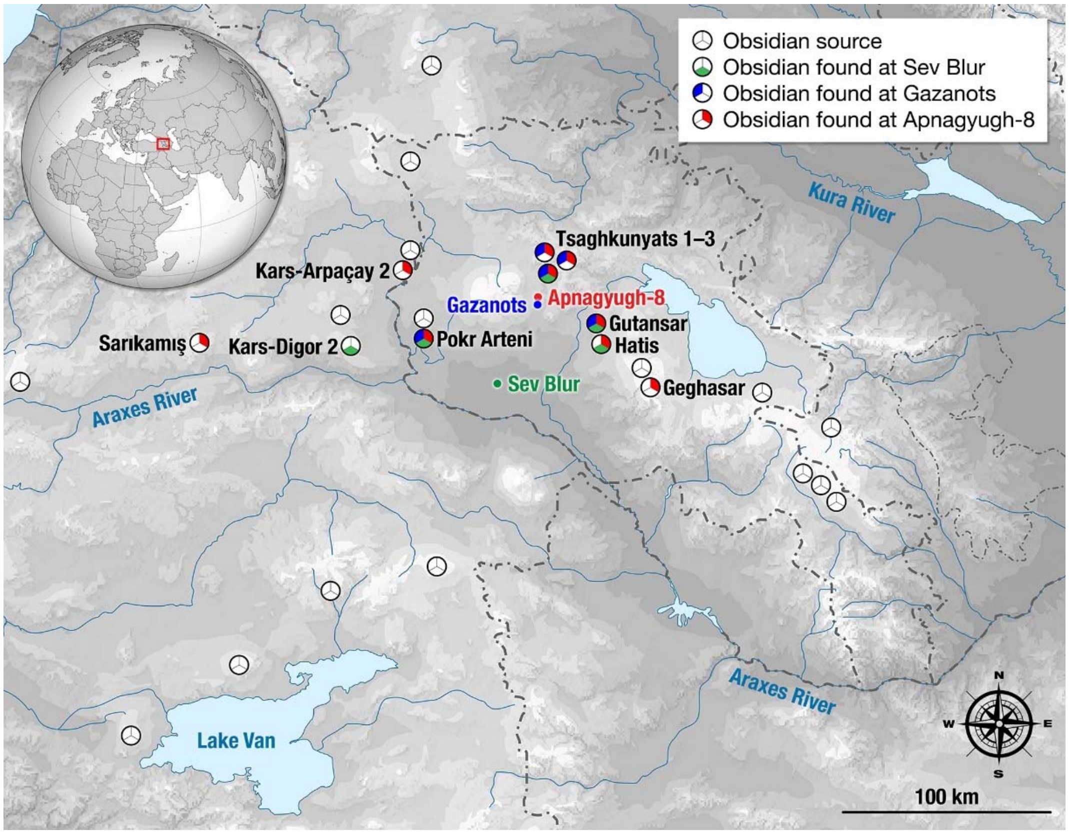

Figure 9. Geographic distribution of the sites and the identified and unidentified obsidian sources.

this test, such specimens only originated from Southern Caucasus sources.

The Vanta's precision is attested by the tighter clusters in Figure 7 than Figure 8 – the Vanta data exhibit less spread than the Niton data. I interpret there to be two major reasons for this high precision. First is the high count rate, which reduces the measurement uncertainty with great speed (Figure 3). Second is the instrument's ultra-low-noise signal-processing electronics – there is very little instrument drift as a result. Therefore, at least for the Vanta, the key to high-precision data is not fiddling with X-ray tube or detector settings – it has powerful algorithms.

Almost five years ago, a colleague and I maintained that "the potential for [pXRF] to bring about change in the routine analysis of diverse archaeological materials… will not be realized simply as the result of technological innovations in hardware and software. Rather these instruments may initiate changes in the *practice* of archaeological science" (Frahm and Doonan, 2013:1432; emphasis added). This brief report focuses more on the former issues than the latter, but considerable speed, for instance, is one feature that could facilitate such changes in practice. So too are ease-of-use and ruggedness. It was not until computers became small, durable, and easy to use in the form of iPads and other tablets that they proliferated in archaeological field applications. I have yet to see anyone state that iPads are too easy for non-experts to use. Rather, iPads have been highlighted as one way to "cultivate an environment of accessibility to archaeology" (Thum and Troche, 2016) and change – even upend – workflow in the field (e.g., Fee et al. 2013; Uildriks, 2016). Olympus has a rather iPad-like philosophy with the Vanta: the instrument's power remains largely automated and behind-the-scenes to a user, perhaps leading to the mistaken impression that it is unsophisticated, but as shown here, such innovation allows one to focus on research design and data collection, rather than X-ray tube and detector settings, and still acquire precise, accurate measurements.

Conflict of Interest Statement

I have no financial interest in Olympus Scientific Solutions. I have not provided paid services to OSS. OSS neither requested nor approved this paper. Instead, I maintain a professional working relationship with OSS, just as I have with various manufacturers whose analytical instruments I have used over the years.

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INVENTORY AND ANALYSIS OF SOME OBSIDIAN ARTIFACTS IN THE JAMES M. COLLINS COLLECTION

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Abstract
An inventory and analysis of four lots of Native American artifacts within the James M. Collins Collection curated at Southern Methodist University reveals the research value of archaeological materials with less than perfect provenience information. All that is known about the origins of these artifacts is that they appear to have come from Oregon. Elemental analysis by energy-dispersive X-ray fluorescence identifies the most likely geochemical source for all of the obsidian artifacts in these lots. Source profiles identified from the 75 artifacts represent major sources located in southwestern Idaho. Similarly, the morphology of the artifacts is consistent with material from the northern Great Basin. Based on artifact morphology and the obsidian sources represented in the collection, we suspect these artifacts originally derive from far southeastern Oregon.

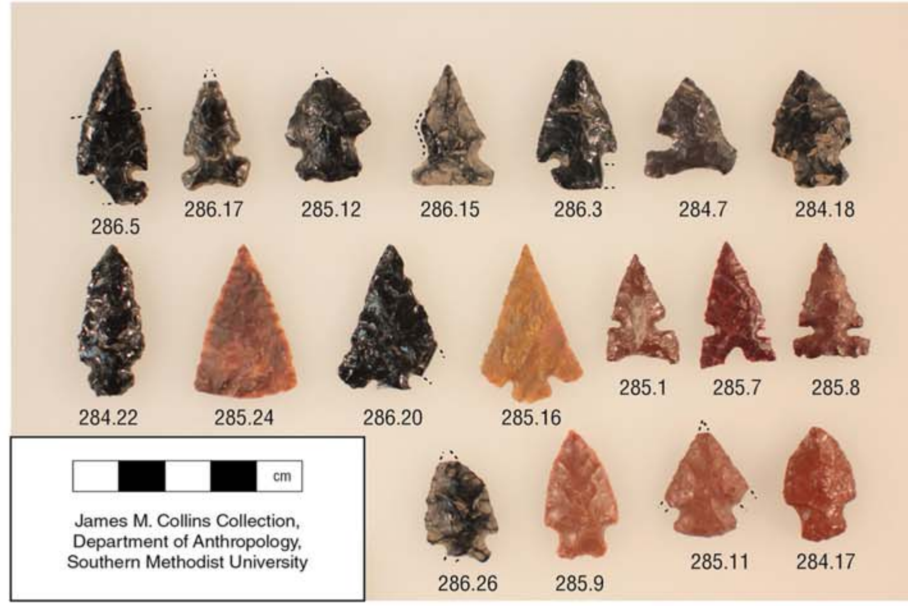
Introduction

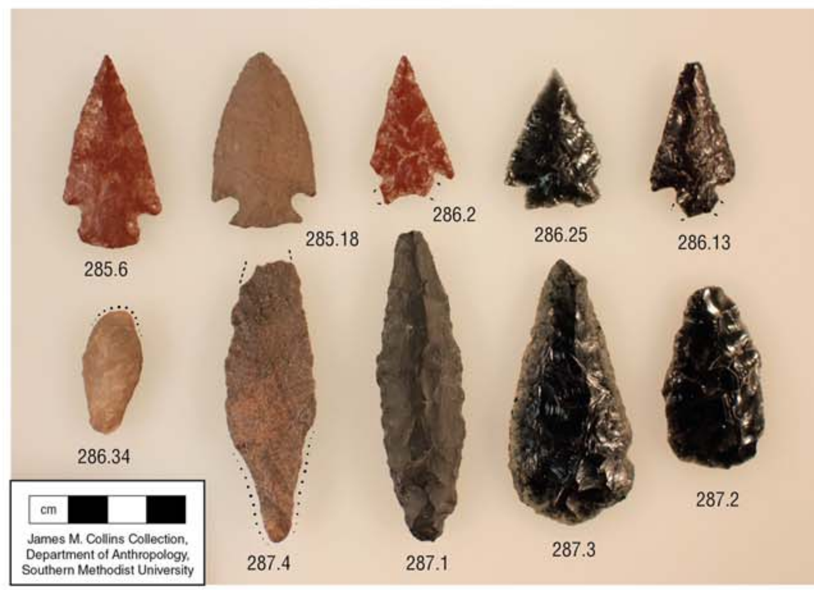
Universities and museums are often the recipients of collections of artifacts, donated or gifted by well-meaning individuals who have expended considerable effort to accumulate their collections. In some instances, the artifact collector was an amateur archaeologist who retained reliable and specific information about the original find context of these artifacts. Too often, though, there is minimal information about how and where the collector obtained portions of the materials. This leaves the receiving institution with a collection of artifacts of relatively dubious utility from a research perspective. As a result, such collections typically receive little attention from research-oriented archaeologists, and very frequently languish in relative obscurity in storage (Brody 2002; Fürst 1991; Hilton 2009; Russell 1978).

Such collections potentially could be useful for educational opportunities—providing students firsthand experience working with material culture, or as examples of specific types of tools representative of various culture-historical phases and Native American culture areas. The James M. Collins Collection is one such artifact collection that could be used for educational opportunities. The collection has never been thoroughly catalogued or inventoried. We present an inventory and analysis of a portion of the collection as part of ongoing efforts to integrate collections-based research into undergraduate curricula.

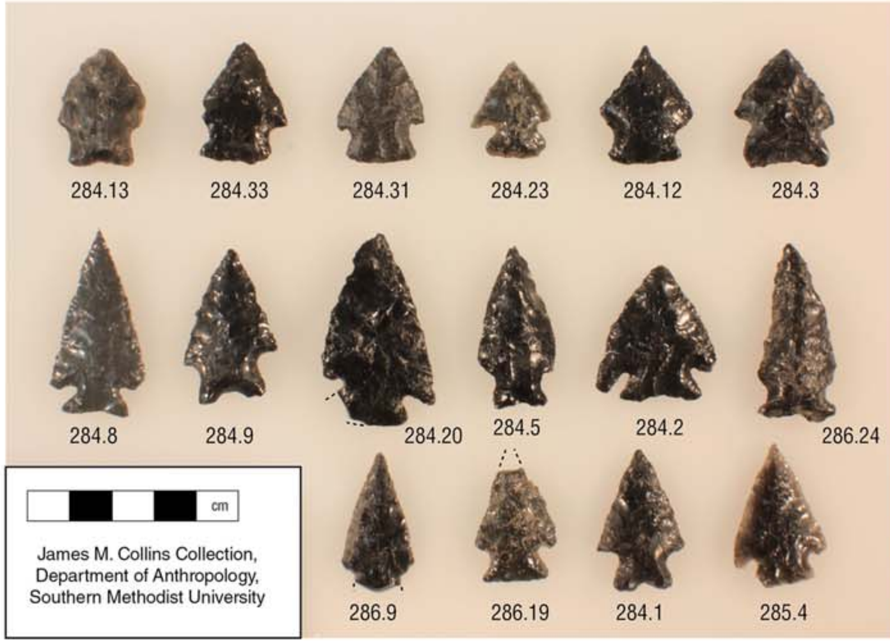
James M. Collins (b. 1916, d. 1989) is perhaps best known as a U.S. Representative of the Third Congressional District of Texas between 1968 and 1983. Collins was a graduate of Southern Methodist University (SMU), and an avid collector of Native American artifacts throughout his life. Collins traded for, or purchased, the majority of materials in his collection, often taking out advertisements in magazines such as *Popular Mechanics* and *Field and Stream* that announced Collins' interest in buying artifact collections. Based on limited paperwork and notes that Collins retained with the collection, most of the materials were acquired from individual artifact collectors from across the United States.

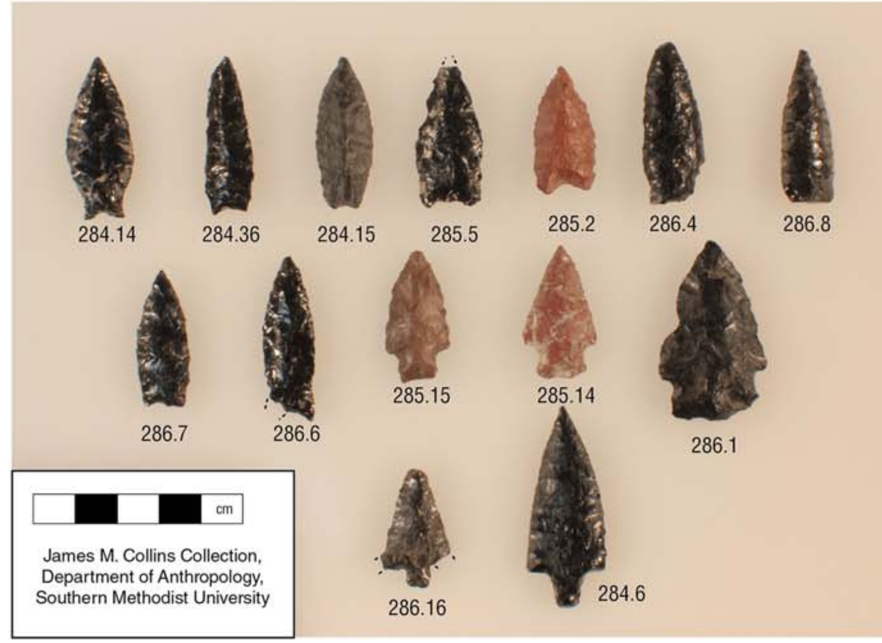
After his death, Collins' family gifted his collection to the Department of Anthropology at SMU. As part of the gifting process, the Collins family retained Gregory Perino to

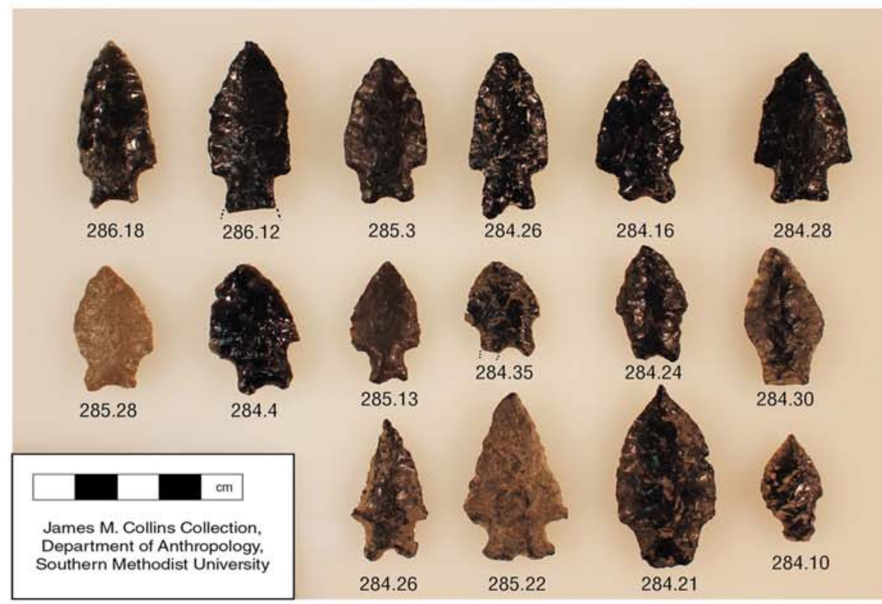




Figures 1-4. Clockwise from upper left, Figures 1, 2, 3, 4. Selection of projectile points from the James M. Collins Collection curated at SMU.







Figures 5-7. Clockwise from upper left, Figures 5, 6, 7. Selection of projectile points from the James M. Collins Collection curated at SMU.

appraise the collection, and as part of that process Perino assigned numbers to various lots (boxes, bags, and coffee cans) of artifacts. Most of these lots appear to represent how the artifacts were acquired and stored by Collins. In some instances, the original correspondence between Collins and the individuals who sold the artifacts to him is included in the box, making it possible to identify the original provenience to a toponym, a general geographic locality, or the county level. Perino's appraisal contains brief descriptions and counts of artifacts in each lot.

After acquiring the collection in early 1992 SMU began the arduous task of inventorying and assigning unique catalog numbers to each piece within the collection. This process was never completed, resulting in many, but not all, of the artifacts being assigned unique catalog numbers.

Here, we draw attention to four closed wooden frames in the collection that contain roughly 130 artifacts, most of which are obsidian knives and projectile points. These frames bear stickers indicating they are lot numbers 284, 285, 286, and 287. However, the contents of these frames do not agree with the brief descriptions of lots 284—287 as given in Perino's appraisal:

- 284: Oregon (Box of 234 dart/knife points good to common)
- 285: Unnamed state (group of 2 mauls, 1 pestle, 3 mortars and 1 oval mano)
- 286: Unnamed state (5 large mauls, 1 stone bowl)
- 287: Unnamed state (11 stone mauls)

None of the frames contains groundstone implements, and lot 284 contains only 39 artifacts—not 234. An undated SMU curation document listing storage locations and brief descriptions of each lot in the collection does not contain entries for any lot numbers above 280. However, this catalog *does* describe lot 269 as a "Box with 4 wooden frames [and] 3 large black frames." This is the only entry in the document that mentions four wooden frames, and no other groups of four identical wooden frames (to which this description might refer) have been located within the collection.

Perino's appraisal describes lot 269 as "217 dart/knife points" from Oregon. The box stored at SMU that is labeled as containing 269 contains only three large black frames labeled as having come from Oregon and holding approximately 200 flaked-stone artifacts. It thus appears that at some point between Perino's appraisal and the creation of the undated curational document at SMU, some artifact lots were renumbered and combined into boxes, likely for ease of storage. Though we cannot demonstrate it, we strongly suspect that the four frames currently labeled lots 284–287 were, at the time of Perino's appraisal, inventoried as a single lot (Perino's 284) along with other as-yet unidentified materials. When small stickers with lot numbers were affixed to the frames, each frame was accidently assigned its own lot number, beginning with Perino's originally assigned number 284. At some point the four frames were then added to a cardboard box containing other materials from Oregon (labeled as lot 269). When the SMU curation document was produced, whomever inventoried this cardboard box simply assumed that all of the artifacts it contained belonged to a single artifact lot.

A final clue to the provenance of lots 284–287 may come from the frames themselves. The frames appear to be handmade and are more or less identical to each other. The backing of each frame consists of scrap pieces of plywood wood paneling, and though none of the frames has any writing on them indicating how and where the artifacts come from, one of the frames is stamped "Hearin Products." We suspect that this is a stamp of the Hearin Products Company, a supplier of plywood-paneling that operated

ANID	K %	Ti	Mn	Fe %	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb
92-1.284.01	4.245	1487	223	1.449	63	19	25.7	192	40	64	412	49.9
92-1.284.02	3.526	1037	228	1.510	58	20	24.8	189	33	58	420	47.0
92-1.284.03	4.084	1338	297	1.340	61	19	28.5	181	41	55	396	46.7
92-1.284.04	3.857	2318	375	2.366	227	24	41.7	321	bdl	90	1117	110.7
92-1.284.05	3.781	1271	295	1.646	66	17	22.7	170	44	55	472	52.5
92-1.284.06	3.486	1176	355	1.641	76	21	27.3	195	42	54	448	45.0
92-1.284.07	3.455	1035	198	1.338	50	21	23.5	183	33	57	407	50.8
92-1.284.08	3.727	1114	191	1.374	61	17	23.3	189	37	51	406	39.9
92-1.284.09	3.712	866	499	2.448	245	31	44.1	350	bdl	108	1156	109.8
92-1.284.10	3.687	bdl	584	0.386	46	18	12.3	174	13	40	42	27.8
92-1.284.11	3.629	737	104	1.438	51	19	25.4	191	37	54	403	41.8
92-1.284.12	3.676	1109	249	1.202	35	17	23.3	190	38	44	396	43.3
92-1.284.13	3.305	244	251	1.202	221	31	22.5	263	bdl	226	309	271.8
92-1.284.14	3.797	1099	192	1.605	53	23	25.4	179	42	60	445	51.0
92-1.284.16	4.157	2163	623	2.061	191	31	39.4	319	bdl	99	1032	106.4
92-1.284.17	3.887	1208	213	1.093	57	18	36.1	171	40	47	439	45.6
92-1.284.18	4.528	1820	466	2.132	174	26	40.0	307	bdl	107	1103	110.2
92-1.284.19	3.610	325	454	1.187	268	30	29.8	264	bdl	238	312	274.5
92-1.284.20	4.134	1478	124	1.580	66	20	24.0	200	40	66	420	48.6
92-1.284.21	3.798	3667	251	1.956	37	20	18.9	198	40	72	438	50.4
92-1.284.22	3.312	1340	478	1.516	66	25	30.8	197	35	50	415	50.3
92-1.284.23	3.713	1749	352	2.192	239	27	35.1	330	bdl	102	1060	110.1
92-1.284.24	3.939	1615	343	1.417	58	22	28.8	193	43	61	425	41.5
92-1.284.25	3.961	1081	291	0.889	41	17	23.3	172	24	59	240	42.4
92-1.284.26	3.967	1589	264	1.479	58	18	24.6	167	39	59	407	50.4
92-1.284.27	4.07	1268	387	2.159	201	24	34.1	308	bdl	106	1064	102.8
92-1.284.28	3.894	2539	456	1.576	76	20	23.3	194	42	53	462	53.7
92-1.284.29	3.995	1762	182	1.435	42	16	22.0	198	30	58	431	39.6
92-1.284.30	3.854	2152	303	1.262	46	10	25.1	188	43	49	405	49.0
92-1.284.31	3.556	1259	348	0.877	53	21	23.7	183	18	48	243	44.7
92-1.284.32	4.053	338	184	0.750	51	17	16.5	208	20	23	91	11.4
92-1.284.33	4.859	1649	163	1.484	60	20	16.1	188	35	65	426	44.5
92-1.284.34	3.676	1310	367	1.884	106	23	27.5	228	46	57	459	45.1
92-1.284.35	3.519	1056	344	0.739	31	19	25.8	197	27	28	98	9.0
92-1.284.36	3.937	1722	414	1.149	52	18	20.1	162	35	56	354	43.9
92-1.284.37	3.470	1298	260	1.756	80	15	29.3	205	46	53	463	44.0
92-1.285.01	3.231	1259	406	2.201	137	34	18.7	199	59	74	574	56.5
92-1.285.02	4.826	1429	336	1.210	70	15	23.3	190	36	44	405	41.9
92-1.285.03	4.148	2132	600	1.821	84	20	16.5	165	50	60	537	44.5
92-1.285.04	4.190	695	291	1.181	225	32	31.0	270	bdl	227	300	288.4
92-1.285.05	4.309	2418	67	1.655	49	22	20.1	189	45	55	492	43.0
92-1.285.06	3.889	1813	335	1.423	45	30	34.9	194	43	44	433	45.8
92-1.285.10	3.500	1910	320	1.749	77	22	28.5	209	52	64	486	47.2
92-1.285.11	4.614	1258	531	1.779	51	26	24.5	160	45	58	477	48.9
92-1.285.12	4.133	1110	355	1.673	59	29	28.3	175	47	50	472	51.6
92-1.285.13	3.999	1385	236	1.487	101	17	21.5	165	43	67	437	54.2
92-1.286.01	4.955	1906	169	1.711	88	21	28.2	215	53	57	477	51.6
92-1.286.02	3.569	1877	256	1.767	54	23	25.0	175	48	75	478	48.1
92-1.286.03	4.267	1138	380	2.331	182	28	35.2	329	1	111	1154	111.1
92-1.286.04	4.283	1590	496	1.554	52	22	25.2	190	44	63	448	41.0
92-1.286.05	3.917	1529	412	1.632	70	19	22.2	187	36	70	436	54.6
92-1.286.06	3.794	1694	367	2.099	46	20	29.7	218	57	66	495	46.1
92-1.286.07	3.717	1176	111	1.634	53	16	27.9	206	47	46	428	38.0
92-1.286.08	3.806	1196	208	1.506	50	29	21.9	198	36	58	385	53.4

Table 1. Elemental abundances for obsidian specimens in lots 284–287 of the James M. Collins Collection. All values in ppm unless otherwise noted. Continued on next page.

ANID	K %	Ti	Mn	Fe %	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb
92-1.286.09	3.480	68	275	0.691	82	18	15.8	310	bdl	67	62	10.4
92-1.286.11	3.972	1464	200	1.564	11	26	29.7	195	43	59	421	43.5
92-1.286.12	3.904	1319	482	1.499	75	20	28.0	205	44	66	489	57.6
92-1.286.13	3.911	1083	133	1.458	43	19	36.4	231	23	72	362	43.5
92-1.286.14	3.676	815	243	1.530	48	16	23.9	176	41	66	385	44.0
92-1.286.15	4.652	1150	297	2.156	55	29	28.4	231	48	63	501	38.1
92-1.286.16	3.780	1377	481	1.964	56	12	14.1	166	51	59	546	53.2
92-1.286.17	3.425	1186	611	2.605	266	17	42.1	352	bdl	106	1219	125.4
92-1.286.18	3.654	214	371	1.353	276	29	26.7	302	bdl	242	341	316.9
92-1.286.19	3.721	1765	345	2.435	177	32	52.5	342	bdl	101	1236	114.5
92-1.286.20	4.134	1478	124	1.580	66	20	24.0	200	40	66	420	48.6
92-1.286.21	3.119	899	321	2.299	159	36	38.4	312	bdl	87	962	103.6
92-1.286.22	4.149	1775	357	2.418	74	14	33.3	215	64	72	599	60.6
92-1.286.23	3.00	702	211	2.341	230	20	41.3	337	bdl	92	1175	115.0
92-1.286.24	4.089	1714	245	2.121	47	12	21.1	172	55	64	519	52.3
92-1.286.25	3.792	963	329	0.632	41	20	20.7	117	64	28	78	11.8
92-1.286.26	4.709	588	226	1.505	67	18	19.5	210	35	53	442	53.9
92-1.286.27	4.315	2282	358	2.043	79	21	29.7	199	39	68	552	52.9
92-1.286.45	4.121	1783	225	1.952	68	22	25.0	171	59	59	530	52.6
92-1.286.48	3.871	1359	268	1.448	45	21	24.6	206	34	56	388	42.8
92-1.287.02	4.298	1433	253	0.969	11	23	22.9	217	27	28	111	13.5
92-1.287.03	4.354	3131	294	1.757	55	29	25.6	197	44	54	449	44.0

Table 1. Elemental abundances for obsidian specimens in lots 284–287 of the James M. Collins Collection. All values in ppm unless otherwise noted. Continued from previous page.

out of Portland, Oregon during the early 1970s (Di Giorgio and Di Giorgio 1986: 188). While this is no guarantee that the artifacts come from Oregon, it is an independent line of evidence congruent with all other available evidence suggesting that these artifacts originated in Oregon.

Our goal in this paper is first to provide a thorough inventory and description of these four lots. Second, we use artifact typological descriptions and obsidian sourcing data to evaluate the likelihood that these artifacts indeed come from Oregon. Third, we hope that by identifying the sources of these artifacts, we are able to narrow down their possible origin to a particular region or area within Oregon.

Methods

All artifacts were removed from their enclosed wooden frames and assigned unique sequential catalog numbers following the trinomial system used at SMU. This system combines the designation for the Collins Collections (92-1), the lot number within the collection, and a unique sequential number for each specimen within each lot. Thus, specimen 92-1.284.1 is the first artifact cataloged within lot 284 of the first collection accessioned in 1992. Throughout our paper, we withhold the “92-1” segment of these numbers for brevity.

After assignment of catalog numbers, various measurements were recorded for each specimen. Dimensions measured on each specimen include: maximum length, maximum blade width, neck/stem width, basal width, height of maximum blade width, and medial length. All measurements were made to the nearest whole millimeter using a digital calipers[1]. Typological designations for each specimen were made using various references (e.g., Ireland 1986; Justice 2002).

[1] Though not provided here, a copy of all metric, typological, and XRF data is freely available upon request to the corresponding author or to the SMU Department of Anthropology.

		K %	Ti	Mn	Fe %	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb
RGM-1	Cert.	3.57 ± .083	1619 ± 120	279 ± 31	1.301 ± .021	-32	15 ± 2	15 ± 1.3	150 ± 8	110 ± 10	-25	220 ± 20	8.9 ± .6
n = 10	Meas.	3.181 ± .168	516 ± 152	253 ± 74	1.459 ± .036	34 ± 10	17 ± 2	12.9 ± 1	158 ± 3	101 ± 2	19 ± 2	220 ± 4	10.5 ± .8
NIST 278	Cert.	3.453 ± .017	1469 ± 42	403 ± 15	1.427 ± .014	-55		12.4 ± .3	128 ± 1	63.5 ± .1			
n = 10	Meas.	3.419 ± .12	602 ± 201	473 ± 41	1.514 ± .04	45 ± 11	20 ± 2	10 ± 1.5	130 ± 3	59 ± 2	35 ± 2	284 ± 6	16.9 ± .7

Table 2. Certified (Cert.) and measured (Meas.) values for USGS RGM-1 (rhyolite) and NIST 278 (obsidian). Measured values are means based on ten separate assays.

Every piece of obsidian within the four lots was assayed using a Bruker III-V X-ray fluorescence spectrometer. The Tracer III-V uses a Rh-based tube set to operate at 40 kV and 25µa, and a thermoelectrically cooled silicon detector. We used a set of 40 well-characterized obsidian specimens described by Glascock and Ferguson (2012) to construct a calibration/quantification curve for our assays. Our calibration method also included NIST 610, a synthetic glass standard, and the recommended values provided by Jochum et al. (2011). This protocol and the calibration routing permit quantification of the following major, minor, and trace elements: K, Ti, Mn, Fe, Zn, Ga, Th, Rb, Sr, Y, Zr, and Nb. Elemental abundances determined for each specimen are provided in Table 1. Check standards consisting of pressed-discs (4 g of powder with 0.9 g of cellulose binder) of NIST 278 (obsidian rock) and USGS RGM-1 (Glass Mountain rhyolite) were run periodically during our assays and processed using identical quantification procedures. Measured values (mean of 10 assays) and certified values for these reference materials are presented in Table 2.

Results

Lots 284–287 contain a total of 136 artifacts and one piece of cryptocrystalline silicate (CCS) that shows no evidence of human modification. Ninety-six (70.5%) of these are bifacial (n = 93) or unifacial (n = 3) projectile points. Other flaked-stone artifacts include five large bifacial knives, 12 unifacial and bifacial scrapers, 19 bifacial and unifacial awls or perforators, and 3 flakes (one of which exhibits usewear). Non-flaked-stone artifacts in the assemblage include two awls made on bone, one bone bead, one Olivella bead, one bead made on an as-yet unidentified lithic material, one piece of coiled brass, and one mussel-shell valve that has been perforated with a single hole. Here, our attention is focused on those artifacts made on obsidian.

Seventy-five of the artifacts in the lots are made on obsidian, the vast majority of these (n = 69) are hafted projectile points. Morphologically, the projectile points fit well within typological units created for the northern Great Basin and the southern Columbia Plateau (Table 3, Figures 1-7). Small corner-, side-, and basal-notched arrowheads are the most common forms in the assemblage (n = 34). Large corner- and side-notched forms consistent with the Elko Series are the second most common (n = 28). Seventeen points in the collection are a shouldered and stemmed form with concave bases that fit comfortably within the Pinto Series, though some of these might be better classified as Gatecliff Split Stem. Four of the specimens represent forms of the Western Stemmed Tradition, including two large stemmed Haskett points, one large stemmed Lind Coulee point, and one small stemmed point that we have classified as a heavily resharpened Lake Mojave, though we note this point form appears very similar to what Beck and Jones (2015: 137–138) refer to as "Dugway Stubby" points from the Dugway Proving Ground in northwestern Utah.

Series	Type	Obs	FGV	CCS	Other
Stemmed					
	Haskett		1		1
	Lake Mojave				1
	Lind Coulee	1			
Black Rock/Humboldt					
	Concave Base	10	1	1	
Elko					
	Corner Notched	19	1	1	
	Eared	6			
	Side Notched	1			
Pinto					
	Barbed	1			
	Sloping Shoulder	4		2	1
	Square Shoulder	7	1	1	
Small Side Notched					
	Desert	9	1	1	
	Sierra (Tri-notch)			3	
Corner- and Basal Notched					
	Cottonwood Triangular	2		4	1
	Eastgate Expanding Stem	1		3	
	Rose Spring Corner Notched	6			
	Middle Columbia River Basal Notched			1	
	Upper Columbia Stemmed	1			
	Wallula Contracting Stem	1			
Miscellaneous					
	Broken biface	1			
	Knife	2		3	
	Scraper	2	1	7	
	Awl/Perforator	2	1	8	2

Table 3. Cross-tabulation of projectile point types made on obsidian, fine-grained volcanics (FGV), cryptocrystalline silicates (CCS), and other lithic materials.

Catalog ID	Type	Source
92-1.284.01	Elko Eared	Browns Bench
92-1.284.02	Elko Corner Notched	Browns Bench
92-1.284.03	Elko Corner Notched	Browns Bench
92-1.284.04	Pinto Square-Shoulder	Cannonball Mountain
92-1.284.05	Elko Eared	Browns Bench
92-1.284.06	Wallula Contracting Stem	Browns Bench
92-1.284.07	Northern Side Notched	Browns Bench
92-1.284.08	Elko Corner Notched	Browns Bench
92-1.284.09	Elko Eared	Cannonball Mountain
92-1.284.10	Pinto Sloping-Shoulder	Timber Butte
92-1.284.11	Awl/Perforator	Browns Bench
92-1.284.12	Elko Corner Notched	Browns Bench
92-1.284.13	Elko Corner Notched	Big Southern Butte
92-1.284.14	Humboldt Concave Base	Browns Bench
92-1.284.16	Elko Eared	Cannonball Mountain
92-1.284.17	Elko Side Notched	Browns Bench
92-1.284.18	Pinto Square-Shoulder	Cannonball Mountain
92-1.284.19	Cottonwood Triangular	Big Southern Butte
92-1.284.20	Elko Corner Notched	Browns Bench
92-1.284.21	Lind Coulee	Browns Bench
92-1.284.22	Upper Columbia Stemmed	Browns Bench
92-1.284.23	Elko Corner Notched	Cannonball Mountain
92-1.284.24	Humboldt Concave Base	Browns Bench
92-1.284.25	Pinto Square-Shoulder	American Falls
92-1.284.26	Pinto Barbed	Browns Bench
92-1.284.27	cf. Humboldt	Cannonball Mountain
92-1.284.28	Pinto Square-Shoulder	Browns Bench
92-1.284.29	Awl/Perforator	Browns Bench
92-1.284.30	Pinto Sloping-Shoulder	Browns Bench
92-1.284.31	Elko Corner Notched	American Falls
92-1.284.32	Elko Corner Notched	Owyhee
92-1.284.33	Elko Corner Notched	Browns Bench
92-1.284.34	Rose Spring Corner Notched	Browns Bench
92-1.284.35	Pinto Sloping-Shoulder	Owyhee
92-1.284.36	Humboldt Concave Base	Browns Bench
92-1.284.37	Rose Spring Corner Notched	Browns Bench
92-1.285.01	Northern Side Notched	Browns Bench
92-1.285.02	Humboldt Concave Base	Browns Bench
92-1.285.03	Pinto Square-Shoulder	Browns Bench
92-1.285.04	Elko Corner Notched	Big Southern Butte
92-1.285.05	Humboldt Concave Base	Browns Bench
92-1.285.06	Elko Corner Notched	Browns Bench
92-1.285.10	Rose Spring Corner Notched	Browns Bench

Table 4. Source assignments and typological designations for obsidian artifacts in lots 284–287 of the James M. Collins Collection. Continued on next page.

Catalog ID	Type	Source
92-1.285.11	Elko Corner Notched	Browns Bench
92-1.285.12	Elko Corner Notched	Browns Bench
92-1.285.13	Pinto Square-Shoulder	Browns Bench
92-1.286.01	Elko Corner Notched	Browns Bench
92-1.286.02	Elko Eared	Browns Bench
92-1.286.03	Northern Side Notched	Cannonball Mountain
92-1.286.04	Humboldt Concave Base	Browns Bench
92-1.286.05	Northern Side Notched	Browns Bench
92-1.286.06	Humboldt Concave Base	Browns Bench
92-1.286.07	Humboldt Concave Base	Browns Bench
92-1.286.08	Humboldt Concave Base	Browns Bench
92-1.286.09	Elko Corner Notched	Unknown
92-1.286.11	Northern Side Notched	Browns Bench
92-1.286.12	Pinto Square-Shoulder	Browns Bench
92-1.286.13	Elko Corner Notched	Browns Bench
92-1.286.14	Cottonwood Triangular	Browns Bench
92-1.286.15	Northern Side Notched	Browns Bench
92-1.286.16	Rose Spring Corner Notched	Browns Bench
92-1.286.17	Northern Side Notched	Cannonball Mountain
92-1.286.18	Pinto Sloping-Shoulder	Big Southern Butte
92-1.286.19	Elko Corner Notched	Cannonball Mountain
92-1.286.20	Eastgate Expanding Stem	Browns Bench
92-1.286.21	Rose Spring Corner Notched	Cannonball Mountain
92-1.286.22	Desert Side Notched	Browns Bench
92-1.286.23	Rose Spring Corner Notched	Cannonball Mountain
92-1.286.24	Elko Eared	Browns Bench
92-1.286.25	Elko Corner Notched	Malad
92-1.286.26	Northern Side Notched	Browns Bench
92-1.286.27	Ovate scraper	Browns Bench
92-1.286.45	Ovate scraper	Browns Bench
92-1.286.48	Medial fragment	Browns Bench
92-1.287.02	Lanceolate knife	Owyhee
92-1.287.03	Lanceolate knife	Browns Bench

Table 4. Source assignments and typological designations for obsidian artifacts in lots 284–287 of the James M. Collins Collection. Continued from previous page.

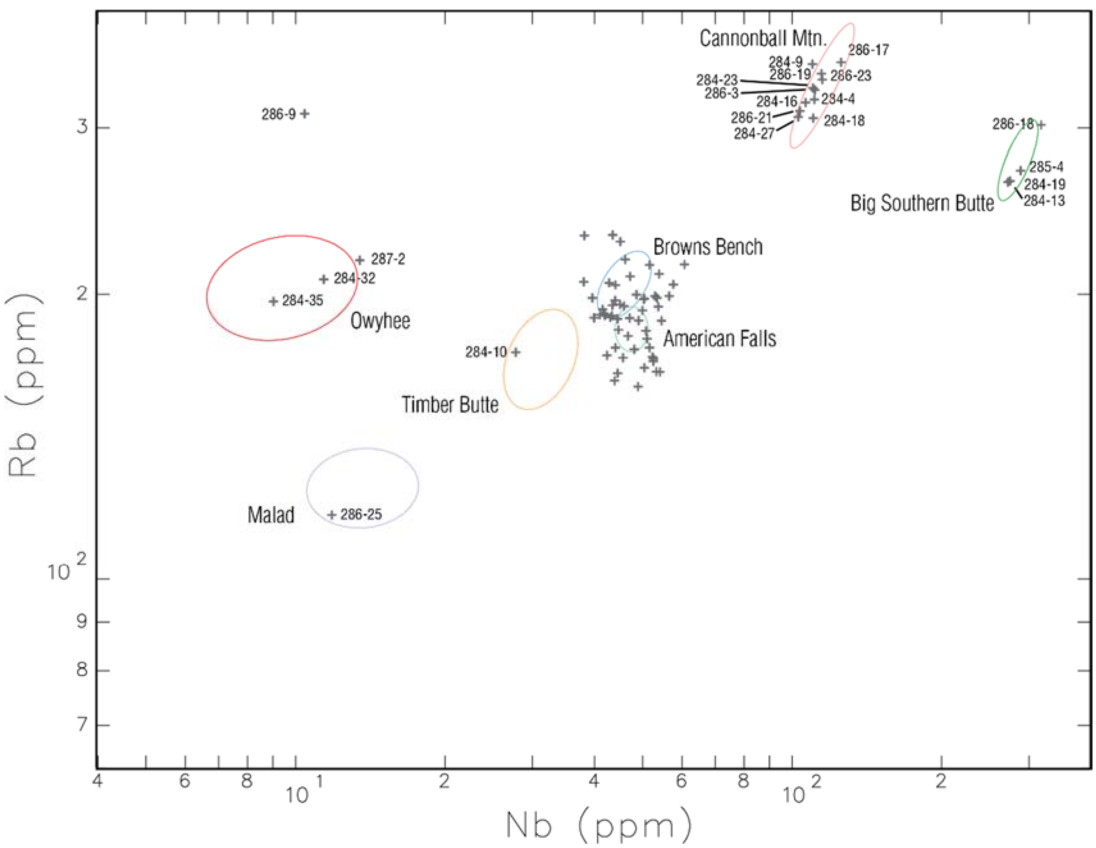


Figure 8. Bivariate plot of Y and Zr concentrations in obsidian artifacts from the James M. Collins Collection. Major obsidian sources are shown as 90% confidence ellipses.

Our XRF analysis reveals that a majority (n = 53) of these artifacts comes from the Browns Bench geochemical source in south-central Idaho and neighboring portions of Utah and Nevada (Figures 8 and 9). Eleven artifacts are made on obsidian from the Cannonball Mountain source locality. Thus, nearly 85% of the obsidian in these lots derives from two major sources located on either side of the Snake River in Idaho. The Big Southern Butte, Owyhee, and American Falls sources are represented in low amounts (5, 4, and 3% respectively). One artifact each from the Timber Butte and Malad sources are also present. One Elko Corner-Notched point in the collection comes from an as-yet unidentified source. Table 4 lists the catalog number, typological designation, and obsidian source for each of the pieces in the collection.

Discussion and Conclusion

Despite some ambiguity regarding the origins of these materials, available textual evidence suggests they come from Oregon. Our typological designations for these pieces suggest they are consistent with materials from the northern Great Basin, thus an Oregon provenance—particularly a southeastern Oregon provenance—would not be unreasonable. Similarly, the obsidian sources represented in the assemblage (Figure 10) are among the most commonly used sources in southwestern Idaho and the northern Great Basin (Black 2015; Fowler 2014; Holmer 1997; Willson 2007).

None of the major obsidian sources of southeastern Oregon and northern Nevada are represented (e.g., Buck Spring, Coyote Wells, Venator, Whitehorse). Indeed, the sources present in the collection, and the frequencies

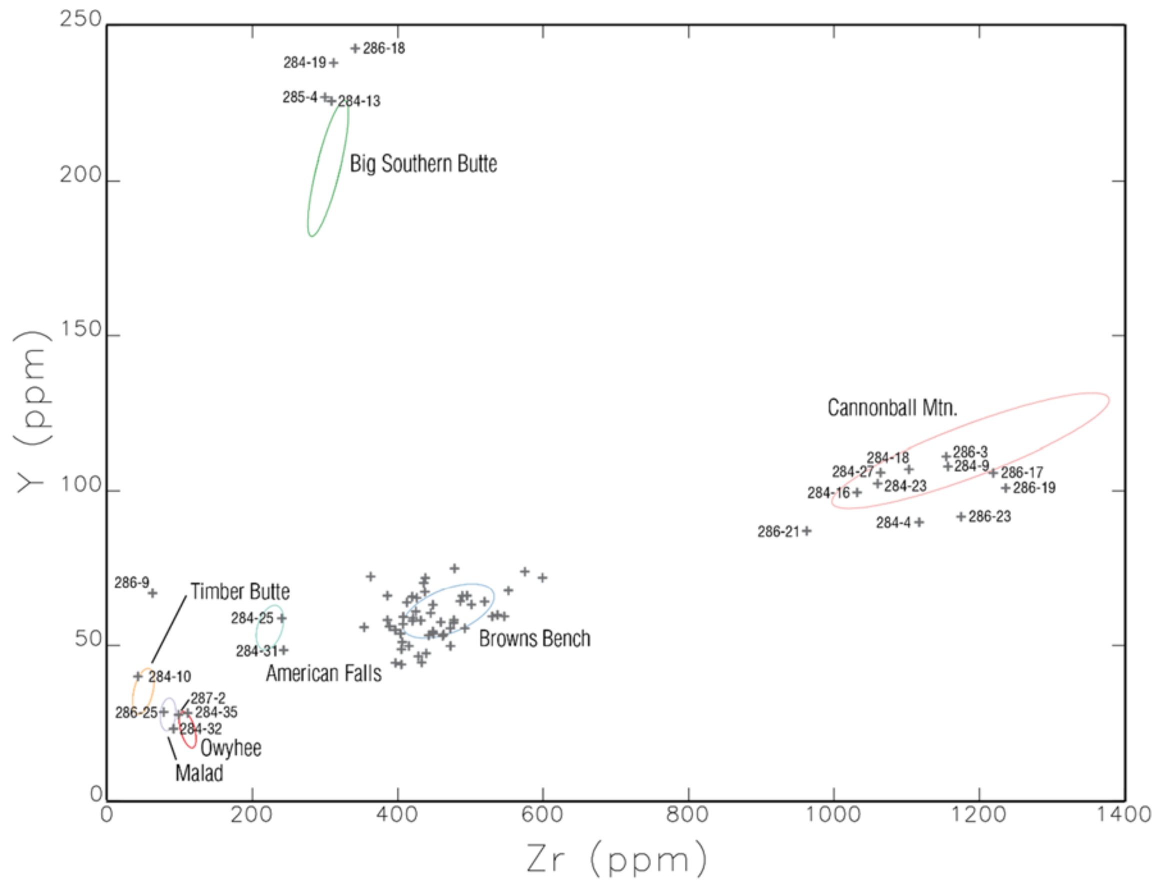


Figure 9. Bivariate plot of Rb and Nb concentrations in obsidian artifacts from the James M. Collins Collection. Major obsidian sources are shown as 90% confidence ellipses.

with which they are present, are similar to what Willson (2007: 19–21) documents for southwestern Idaho. Could this mean that the artifacts come from the very southeast corner of Oregon, in southern Malheur County (i.e., along the Owyhee River)? Given the available evidence as to the archaeological origin(s) of these pieces, we propose that this is the current best guess, as the Owyhee River drains in to the Snake River, and the Owyhee uplands straddle the border between Oregon and Idaho.

Unfortunately, there is minimal information relating to the origin of the artifacts in these four lots. Here, we have tried to tease as much information as possible from these artifacts based on general typology and geochemistry. We concede that the absence of any documentation regarding how Collins obtained these items, or from where they were originally collected renders their ability to provide significant archaeological information near nil. Yet, *some* information can still be obtained that may be useful for integrating into broad-scale studies of lithic procurement patterns (e.g., Fowler 2014; Jones et al. 2003).

Perhaps additional work with the Collins Collection will uncover some paperwork that allows us to confirm the original context of these pieces. Until such time, we believe that the most research value of these lots comes from their typological designations and obsidian-source determinations. The absence of detailed provenience should not be viewed as an *a priori* reason to conclude that an artifact collection cannot provide any research-related information. Rather, the

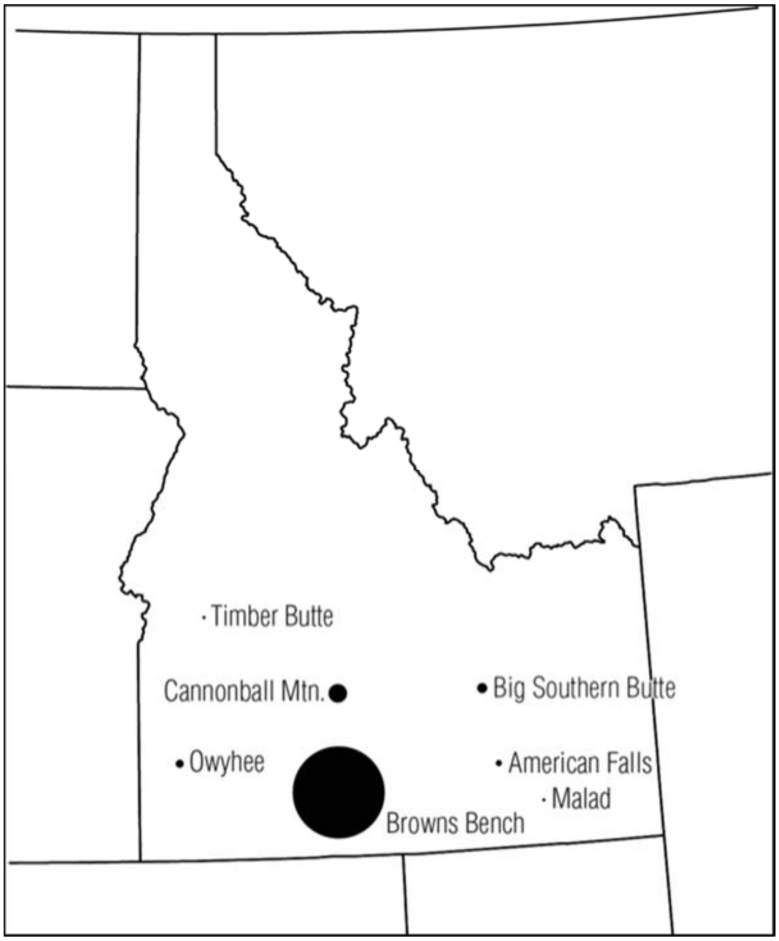


Figure 10. Obsidian sources represented in lots 284–287 of the James M. Collins Collection. Dots are proportional to the percentage of obsidian artifacts assigned to each source. Note that obsidian from both the Cannonball Mountain and Browns Bench sources can be found in secondary deposits along the Snake River Plain.

limited provenience of such collections places limitations on what *kinds* of information a collection. In this vein, we could conceptualize provenience as a probabilistic statement, rather than a binary declaration.

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SOURCE CHARACTERIZATION OF OBSIDIAN ARTIFACTS FROM SIX SITES IN THE JORNADA MOGOLLON REGION OF SOUTHERN NEW MEXICO

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Abstract
The results of a small obsidian sourcing study are presented here to contribute to a better understanding of local and nonlocal obsidian procurement in the Jornada Mogollon region of southern New Mexico. Sixteen artifacts from six Archaic/Pueblo period sites were sourced using energy-dispersive X-ray fluorescence (EDXRF) spectrometry. Fourteen artifacts derive from four geochemically distinct sources that the primary outcrop is in the Jemez Mountains of northern New Mexico, but are also present in Rio Grande gravels in southern New Mexico. The remaining two artifacts derive from a nonlocal source (Gwynn/Ewe Canyon), and a geographically unknown source. These data are contextualized and results corroborate other studies from the region.

Introduction

Sourcing obsidian artifacts to understand prehistoric trade, mobility, and social interaction through time and across space is a critical component of twenty-first-century archaeological research in the North American Southwest and the Mexican Northwest (Arakawa et al. 2011; Dolan et al. 2017a,b; Duff et al. 2012; Ferguson et al. 2016; Liebmann 2017; Mills et al. 2013; Shackley 2005; Taliaferro et al. 2010). As a result of recent cultural resource management (CRM) projects, university field schools, and thesis and dissertation research, our understanding of which obsidian sources people used in southern New Mexico has increased tremendously (Dolan 2016; Kenmotsu et al. 2014; Putsavage 2015; Sedig 2015; Taliaferro 2004; Taylor-Montoya et al. 2014; VanPool et al. 2013).

Much of the archaeological investigation in the Jornada Mogollon region of southern New Mexico and west Texas comes from CRM projects as a result of actions required by Section 106 of the National Historic Preservation Act. Obsidian artifacts are found in this region, and archaeologists geochemically source the obsidian because the information gained helps to answer archaeological questions. However, the sourcing results are often hidden in the “gray” CRM literature and can be difficult to access. The goal of this paper is present obsidian sourcing data that derived from a recent CRM project to contribute to a better understanding of local and nonlocal obsidian procurement in the Jornada Mogollon region.

Sites and Artifacts Sampled

Survey and excavations were conducted at six sites near the Las Cruces fairgrounds in Doña Ana County, New Mexico (Figure 1). The sites date to the Middle to Late Archaic through the Pueblo period, and 15 pieces of

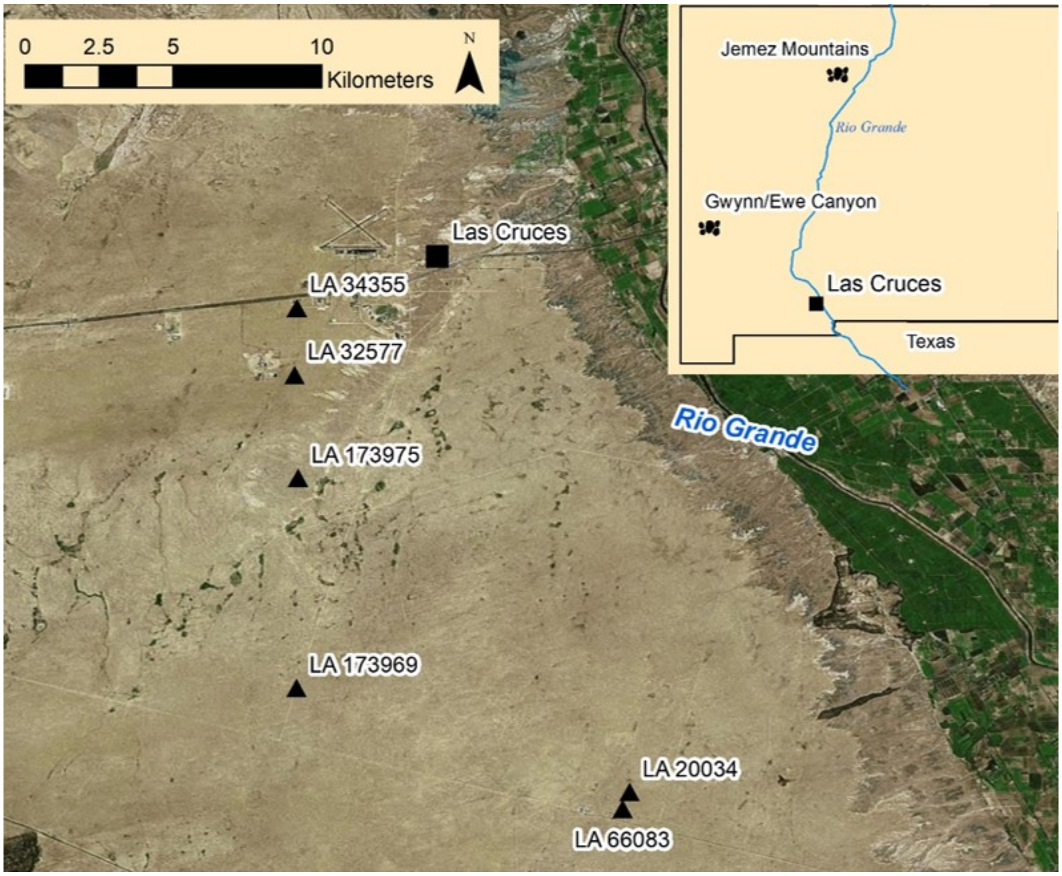

Figure 1. Location of the six sites investigated.

obsidian debitage and one projectile point were recovered and sourced.

Site LA 34355 dates to the Late Archaic/Early Mesilla phase based on a calibrated radiocarbon date of A.D. 0–200, and due to the presence of Middle and Late Archaic projectile points. Two obsidian flakes and one projectile point that resembles an Armijo style (Justice 2002:137–138; Figure 2) from the site were sourced.

Site LA 32577 dates to the Late Mesilla phase based on a calibrated radiocarbon date of A.D. 980–1050, and due to the presence of El Paso Brown, Alma Plain, El Paso Polychrome, and Seco Corrugated pottery. Early, Middle, and Late Archaic non-obsidian projectile points were also present at the site. Four obsidian flakes were sourced.

Site LA 173975 dates to the Early Mesilla phase based on a calibrated radiocarbon date of A.D. 640–710, and due to the presence of El Paso Brown, Alma Plain, Three Circle Neck and Mimbres Corrugated pottery. In addition, a non-obsidian Middle Archaic and a Pueblo Side-Notched arrow point were recovered. Two obsidian flakes from the site were sourced

Site LA 173969 dates to approximately A.D. 950–1150 based on the presence of El Paso Brown, El Paso Polychrome, and Mimbres Black-on-white Style III Classic pottery. Two non-obsidian Late Archaic projectile points were also found on the site. Two obsidian flakes were sourced.

Site LA 20034 dates to approximately A.D. 400–1400 based on the presence of El Paso Brown pottery, but Early and Middle

Figure 2: Armijo style projectile point from site LA 34355.

non-obsidian Archaic projectile points were found, along with a Pueblo Side-notched arrow point. Two obsidian flakes were sourced.

Site LA 66083 dates to the Early Mesilla phase based on a calibrated radiocarbon date of A.D. 530–640, and due to the presence of El Paso Brown and Alma Plain pottery. Two Middle Archaic non-obsidian projectile points were present. Three obsidian flakes were sourced.

Results and Discussion

Shackley (2016) sourced the 16 obsidian artifacts using EDXRF spectrometry. This established method accurately and reliably characterizes the trace elements of obsidian without destroying the artifact. See Shackley (2005, 2011) and http://swxrflab.net/analysis.htm for more information on instrumentation, methods, and procedures.

Six obsidian sources were identified (Table 1; Figure 3). The artifacts characterize to Cerro Toledo Rhyolite (n = 11), El Rechuelos (n = 1), Bearhead Rhyolite (n = 1), Canovas Canyon Rhyolite (n = 1), Gwynn/Ewe Canyon (n = 1), and unknown (n = 1). The unknown source is geochemically distinct from all other sources, but the geographic location is unknown. The location may be near the international four corners near the United States and Mexico border (Shackley 2005).

Fourteen of the artifacts (87.5 percent) derive from four sources that the primary outcrop is in the Jemez Mountains in northern New Mexico. Even though the primary outcrops of Cerro Toledo Rhyolite, El Rechuelos, Canovas Canyon Rhyolite, and Bearhead Rhyolite obsidian are located over 400 kilometers north of Las Cruces, these obsidians are also found in southern New Mexico in Rio Grande gravels (Church 2000; Glascock et al. 1999; Shackley 2005, 2013; Shackley et al. 2016). As a result, people at these sites likely collected obsidian locally rather than getting the material from further north. Obsidian from Rio Grande gravels consist of small cobbles that require bipolar reduction to start making formal and informal stone tools. The artifacts show signs of bipolar reduction including, shattered, or pointed platforms, and force applied at opposite ends of the flake.

The Armijo projectile point from LA 34355 derives from the Gwynn/Ewe Canyon source in western New Mexico, and is approximately 200 km "as the crow flies" from the site. Projectile points and small flakes are often from nonlocal sources (Doyel 1996; Eerkens et al. 2007). Since no Gwynn/Ewe Canyon flakes were found at LA 34355, this point was not manufactured on site. Instead, someone brought the point to the site as a finished tool.

How does this small study compare with other sourcing studies near Las Cruces?

Sample	Site	Mn	Fe	Zn	Rb	Sr	Y	Zr	Nb	Ba	Source
22A	LA 173975	425	10656	39	116	46	23	107	57		Canovas Canyon
Unit 1-4	LA 173975	485	12386	151	205	14	66	176	93		Cerro Toledo Rhyolite
27A	LA 173969	857	12614	199	490	17	86	140	224		Unknown
28	LA 173969	548	12480	109	216	9	63	185	98		Cerro Toledo Rhyolite
42	LA 20034	465	11946	110	203	11	64	177	96		Cerro Toledo Rhyolite
39	LA 20034	486	11807	119	199	9	62	173	94		Cerro Toledo Rhyolite
3B	LA 32577	479	11857	97	198	11	63	179	99		Cerro Toledo Rhyolite
106	LA 32577	499	11879	99	201	9	68	178	98		Cerro Toledo Rhyolite
111	LA 32577	476	12126	103	201	10	64	177	102		Cerro Toledo Rhyolite
126	LA 32577	410	11557	89	182	9	58	164	88		Cerro Toledo Rhyolite
7	LA 34355	438	11363	89	184	9	67	167	98		Cerro Toledo Rhyolite
18	LA 34355	492	12480	109	226	11	69	191	104		Cerro Toledo Rhyolite
60	LA 34355	395	11061	49	210	26	31	147	20	12	Gwynn/Ewe Canyon
85A	LA 66083	523	12511	106	213	9	61	184	102		Cerro Toledo Rhyolite
84	LA 66083	420	10730	55	158	14	22	75	47		El Rechuelos
40	LA 66083	547	11870	51	95	93	27	127	38		Bearhead Rhyolite
RGM1-S4		305	13607	39	141	110	26	224	11	800	Standard

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

Dolan et al. (2017a) sourced 78 obsidian artifacts from two El Paso phase (A.D. 1200–1450) pueblos, and the results are similar. Jemez Mountains obsidian was predominantly used, and specifically, Cerro Toledo Rhyolite was used the most. El Rechuelos and Canovas Canyon obsidian were also part of the El Paso phase assemblage.

Other sources identified in the Dolan et al. (2017a) study include debitage and projectile points from Horace Mesa and Grants Ridge. Both sources are from the Mount Taylor Volcanic Field in northwestern New Mexico. Mount Taylor obsidian is also present in Rio Grande gravels (Church 2000; Shackley 1998), but no Mount Taylor obsidian was found during this present study.

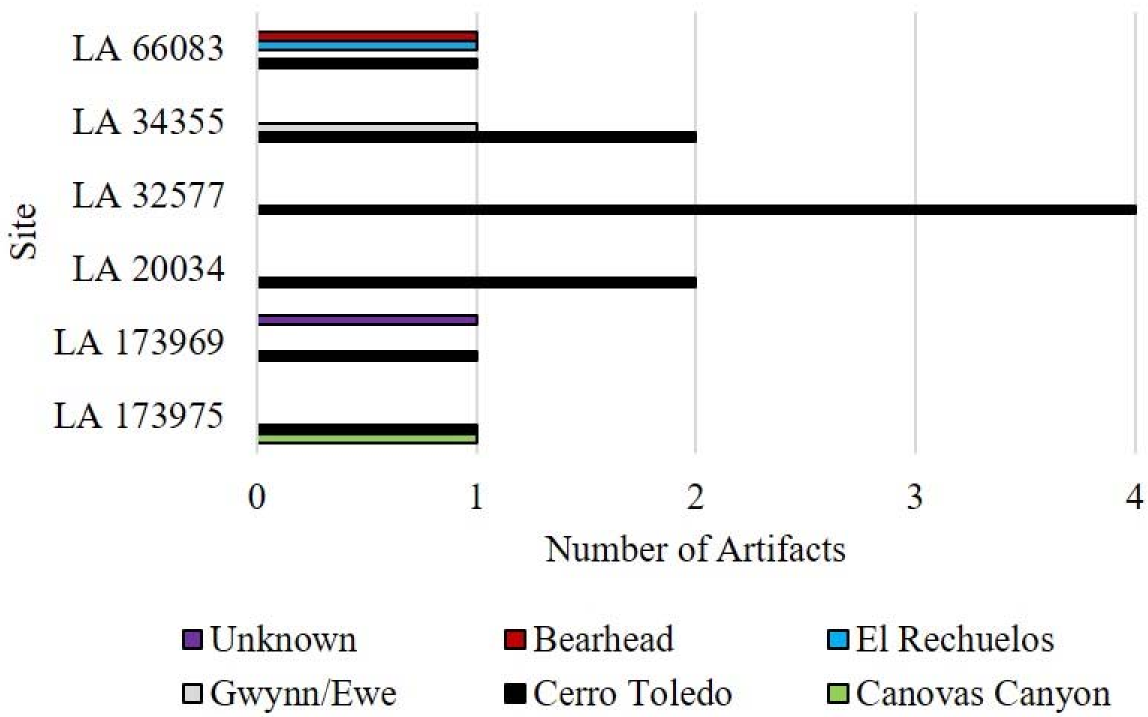

Figure 3: Obsidian source results by site.

In addition to obsidian in Rio Grande gravels, Dolan et al. (2017) found artifacts from nonlocal sources in western Arizona (Cow Canyon), New Mexico (Red Hill and Mule Creek), and northern Chihuahua (Sierra Fresnal) at the two sites. Fifty percent of the obsidian projectile points sourced to non-Jemez Mountains/Rio Grande gravels (e.g., Mule Creek), but the other 50 percent sourced to Cerro Toledo and Mount Taylor. The Dolan et al. (2017a) study, however, did not find any use of Gwynn/Ewe Canyon obsidian.

Conclusion

The results of the EDXRF sourcing analyses presented here are consistent with previous Jornada Mogollon obsidian sourcing studies. In particular, people primarily used obsidian that they collected locally along Rio Grande gravels in southern New Mexico, particularly Cerro Toledo Rhyolite. However, projectile points sometimes come from nonlocal obsidian, as shown in this study and others.

This paper contributes to a growing understanding of Jornada Mogollon obsidian procurement. While only 16 artifacts were sourced, future studies will be able to compare and contrast these data to elucidate procurement patterns through time to obtain a more complete picture of social interaction, obsidian resource economy, and mobility in southern New Mexico.

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AN OBSIDIAN BIFACE FROM THE RIO BRAVO RANCH, KERN COUNTY, CALIFORNIA: DATING, TRACING, AND CULTURAL CONTEXT

Ryan S. Gerstner, Alan P. Garfinkel, Alexander Rogers, Jennifer J. Thatcher, and Alex Nyers

Abstract

A complete obsidian biface was recovered along the Kern River on the Rio Bravo Ranch near Bakersfield, California. X-ray fluorescence (XRF) trace element analysis placed the artifact 130 kilometers from its toolstone source at the West Sugarloaf obsidian subsource at the Coso Volcanic Field. Contemporary, source-specific, temperature-adjusted obsidian hydration analysis dates the biface to the late Newberry Period (ca 500 B.C. to 600 A.D.). The biface was transported from the Coso Volcanic Field over the Sierra Nevada during a period of peak obsidian biface production and intensive trans-Sierran obsidian export and exchange.

Introduction

The occasion for this study stems from the 2017 discovery of a complete obsidian biface along the banks of the Kern River on the Rio Bravo Ranch in Kern County, California. Since the 1950's the Nickel family has operated the Rio Bravo Ranch, a 16,000-acre citrus, almond, and walnut farm just east of Bakersfield, California. We were asked to research and date the biface to add to the existing public outreach at the Ranch. The character of this artifact is interesting, due to its size and the distance it traveled from the obsidian toolstone source. The goals of this study are: to identify the source of volcanic glass employed in the biface manufacture though quantitative X-ray fluorescence (XRF) trace element analysis; date the artifact utilizing contemporary, source-specific, temperature-adjusted obsidian hydration analysis; and finally, to place the Rio Bravo biface within its prehistoric context.

Background and Setting

The Rio Bravo obsidian biface was recovered from the rocky shoreline of the Kern River located along the southeastern rim of the San Joaquin Valley in the foothills of the southern Sierra Nevada Mountains. Here the Kern River makes an abrupt exit from the lower canyon and descends into the rolling valley foothills. The Rio Bravo Ranch sits at the interface between the Greenhorn and the Tehachapi Mountains - an element of the Transverse Range bridging the San Joaquin Valley to the west and the Mojave Desert to the east. Breckenridge Peak (7580') is the highest point in the general vicinity, located roughly 13 miles east of the Ranch. Highway 178 bisects the Ranch before ascending the narrow gorge of the Kern River Canyon. As the Kern River meanders on a westward trending path into the Central Valley, it is joined by Cottonwood Creek, near the location of the artifact's discovery.

The Rio Bravo Ranch exhibits vegetation consisting of a valley grassland with notable oaks and sycamores along the river and its tributaries. The soil is a Quaternary alluvium and river terrace deposit superimposed over a Middle Miocene marine formation (Smith 1964). The area hosts a desert climate, receiving less than seven inches of annual rainfall. Within the Ranch the riparian zones along the Kern River and Cottonwood Creek are intact and represent their natural state.

History and Prehistory

In 1776, explorer and missionary Father Francisco Garcés traveled down Cottonwood Creek and emerged at the Kern River, where he crossed the river at Rio Bravo. Father Garcés encountered two *Yowlumne* villages, *Wawcoye* and *Hawsu*, before fording the Kern

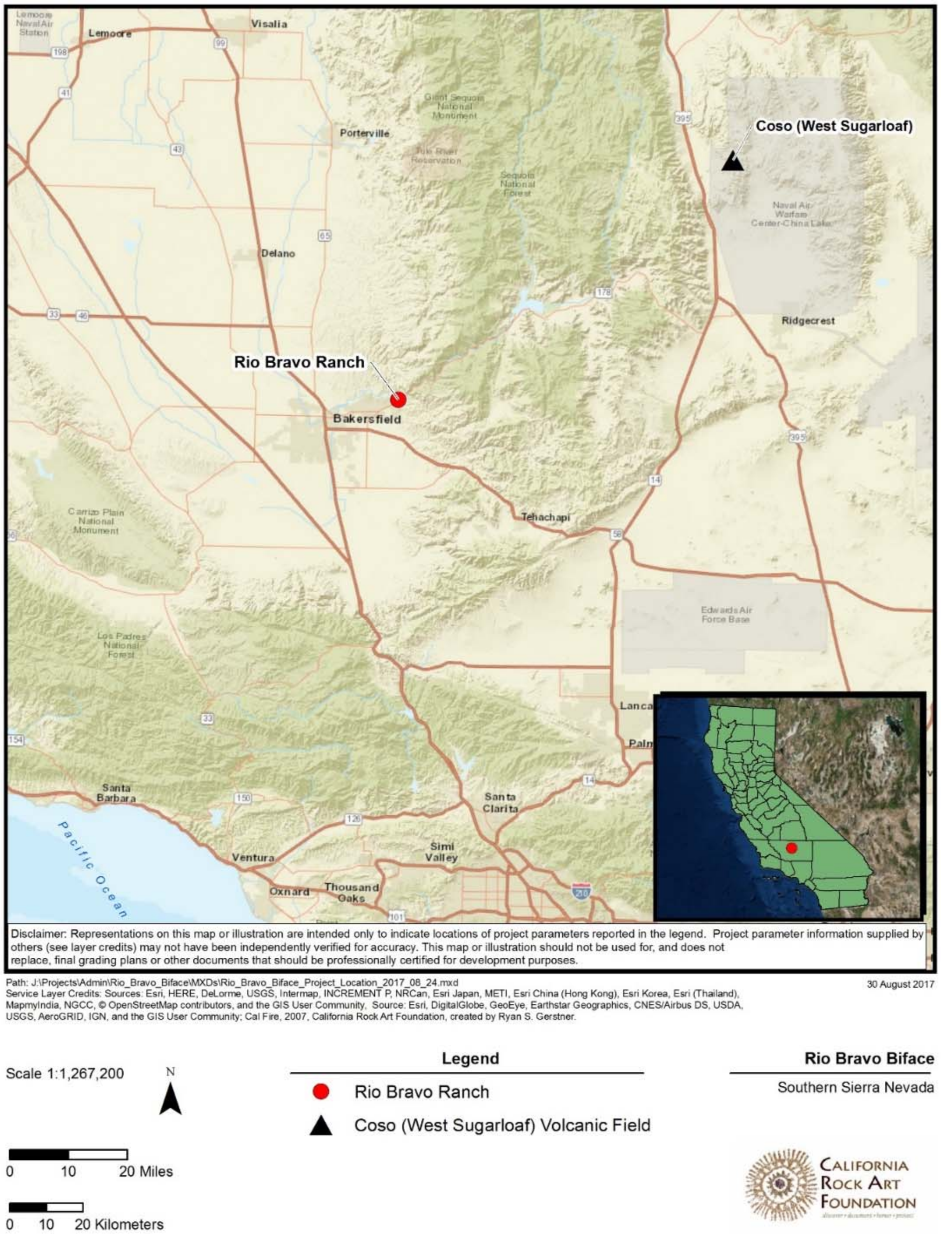

Figure 1. Regional location map.

with the help of local Indians. It wasn't until 1861 that Solomon Jewett and his family settled this land and tended sheep – a place which was previously coined 'Rio Bravo Ranch' by early Mexican settlers.

The *Yowlumne* tribe of Yokuts lived in this area, of which we have a great deal of ethnohistory (Latta 1977). The Ranch is host to two rock art sites containing red ochre pictographs of the Southern Sierra Painted style. The neighboring tribes are the Tübatulabal to the east, the Kawaiisu to the south, the Chumash to the west, and other Valley Yokuts groups to the north. The Yokuts embody a classic California Indian culture whose language is a Yok-Utian, a subgroup of the Penutian phylum (Golla 2011). Both Tübatulabal and Kawaiisu represent Uto-Aztecan affiliated peoples, although their languages are entirely different, while the Chumash denote a distinctive and isolated linguistic stock (Golla 2011). This diversity presents a fascinating cultural landscape with a significant cultural backdrop where these neighboring Californian groups actively engaged in a complex system of regional trade.

Excavations conducted at *Wawcoye* in 1980 by Dr. Robert A. Schiffman of California State University, Bakersfield, exposed two meters of stratified, cultural deposits representing ~2500 years of recurrent occupation (Alan Gold, personal communication 2017). Artifacts recovered from these excavations included obsidian debitage, shell beads and ornaments, and groundstone artifacts. Most of the shell beads were fashioned from the purple-olive shell (*Olivella biplicata*), and a number of beads were crafted of abalone shell (*Haliotis* spp). Chronologically diagnostic shell beads, the oldest of which are Olivella barrels and Abalone rings that date to ca. 500 B.C. (King 1990) place the earliest occupation of the site to the late Newberry Period.

Figure 2: Rio Bravo Biface

Metrics and Technology

The Rio Bravo biface (Fig. 2) measures 152.7 mm (length) x 59.1 mm (width) x 15.8 mm (thickness), and weighs 136 grams. The artifact is leaf-shaped with a tapered distal end, and displays hard-hammer percussion with parallel-transverse patterning. The dorsal face displays roughly 25% weathered cortex along half of the lateral margin, with several large bifacial thinning flake removals. The ventral face displays large thinning flakes from opposing margins meeting near the centerline. The artifact is biconvex to lenticular in cross section. The width to thickness ratio is 3.54, fitting into Callahan's biface reduction model as a Stage 3 biface (Andrefski, 1998). The Rio Bravo biface likely represents a portable toolstone core, from which flakes were produced for use as cutting implements, or further worked into formal tools such as projectile points, scrapers, or drills. Marginal retouch or use wear along the lateral edges of the biface suggests its possible use as a non-hafted knife.

Analysis

The biface was prepared and analyzed by Jennifer J. Thatcher at Willamette Analytics for obsidian hydration analysis, and submitted for XRF trace element analysis to Alex Nyers at the Northwest Research Obsidian Studies Laboratory, both located in Corvallis, Oregon. The obsidian hydration rim measures 6.4 microns, reported to the nearest 0.1 micron and represents the mean value of four readings. The measurements were taken using an Olympus BHT petrographic microscope with video micrometer unit and digital imaging video camera. Results from the XRF analysis identify the sub-source provenance of the obsidian toolstone as Coso obsidian source complex, with specific provenance identifying the West Sugarloaf subsource. West Sugarloaf is located 80 miles northeast from the biface discovery site, “as the crow flies”. The Coso Volcanic Field and its obsidian sources are found in the Sugarloaf Mountain vicinity in Inyo County within the confines of the Naval Air Weapons Station, China Lake near Ridgecrest, California in the western Mojave Desert.

Alexander (Sandy) Rogers, Director of Prehistory at the Maturango Museum, developed equations for calculating source-specific, obsidian hydration measurements into an approximate date (Rogers 2007, 2008a, 2008b, 2010a, 2010b, 2011a, 2011b). Using temperature data for Bakersfield from the Western Regional Climate center, a probable age range was constructed based on the rim measurement for both a surface provenience, and for buried contexts of 0.5, and 1.0-meter depths. The context of the biface in an erosional river channel suggests that the artifact was buried for some time and has only recently been exposed. Due to uncertainty, a conservative estimate for the age of the artifact based on a burial depth of 0.5 – 1.0 meters below surface, places the biface between 2395 +/- 608 yrs cal BP and 2242 +/- 508 yrs cal BP, within the late Newberry Period (ca. 500 BC to AD 600).

Context and Interpretation

By the Newberry Period (ca. 2000 B.C. to A.D. 600), Elko and Gypsum projectile point styles replaced the earlier Pinto forms in the western Great Basin and eastern California (Garfinkel 2007). The technology seen in the Rio Bravo biface is very similar to that seen in the Hay Ranch biface cache (n=58) which dates to the late Middle Archaic and was discovered in the Coso Range (Alexander Rogers, personal communication 2017). The Rio Bravo biface fits comfortably into the model of trans-Sierran trade of Coso obsidian exchange in the late Middle Archaic (Gilreath and Hildebrandt 1997).

The artifact was transported over the Sierra Nevada during a peak period of biface production and trans-Sierran obsidian exchange. This period is marked by specialized biface manufacturing sites containing characteristic blanks and preforms (Garfinkel et al. 2004; Gilreath and Hildebrandt 1997; Lengner 2013). Biface production during the Newberry Period was perhaps ten times greater than the preceding Little Lake Period (ca. 5000 – 2000 B.C.) or the later part of the Haiwee Period (ca. A.D. 600 – 1300), correlating with increased trade across the Sierra Nevada and into the Central Valley (Garfinkel et al. 2004; Hildebrandt and McGuire 2002). Within the Trans-Sierran exchange system, obsidian quarries in the east were regionally controlled, and palm-sized, percussion-shaped bifaces were produced and traded over the crest to west valley populations (McGuire et al. 2011).

In addition to technologic change, this period of biface manufacture is marked by an increased emphasis on large game hunting, intensified rock art production (Coso Representational Rock Art Tradition), and the manufacture of split twig figurines in the eastern Mojave Desert (Garfinkel et. al. 2015; Lengner 2003). According to accounts by *Wahumchah*, a Yokuts informant in the 1930’s, Yowlumne traders would regularly exchange animal hides for volcanic glass where, “a bundle of forty tanned deer skins brought about fifty pounds of obsidian” (Latta 1977). The Rio Bravo biface offers insight into prehistoric obsidian trade and adds to the growing story of California’s prehistory.

Acknowledgments

This study was made possible by the Nickel family of the Rio Bravo Ranch, who is committed to stewardship and the preservation of cultural heritage. The Rio Bravo obsidian biface was recovered in 2017 by Adele R. Nickel, to whom this study is dedicated.

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COMMENT CONCERNING THE PAPER "NEW ANALYSES OF LATE HOLOCENE OBSIDIANS FROM SOUTHERN PATAGONIA (SANTA CRUZ PROVINCE, ARGENTINA)" BY HUGO G. NAMI, MARTIN GIESSO, ALICIA CASTRO AND MICHAEL D. GLASCOCK (IAOS Bulletin No. 57, Summer 2017; p. 13-24)

Charles R Stern
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The paper by Nami et al. (2017) presents some very interesting information concerning unworked obsidian pebbles found along the Atlantic coast of Argentine Patagonia, but apparently derived from the Pampa del Asador source area in the Andean precordillera located over 400 km to the west. They attribute the presence of these pebbles so far from the main source area to geologic processes associated with the generation of the "Rodados Tehuelches" and/or "Patagónicos" or "Gravas Tehuelches". This is an important and valuable contribution to the understanding of the spatial extent of the widespread secondary source area for Pampa del Asador type obsidian in Patagonia.

They also present analysis of 16 samples of obsidian from two archaeological sites, 14 from the Alero del Valle (AV) and two from Aristizábal Cave (AC), located further to the south in the region of the Pali Aike volcanic field in Santa Cruz Province. They attribute in their Table 3 these 16 samples to three unknown sources *a*, *b,* and *c*. However, all previous analyses of >300 samples of obsidian artifacts from the area of the Pali Aike volcanic field, as well as from archaeological sites in all the extended area of southernmost Patagonia, including from Monte León to the northeast, from Lago Argentino to the west, and from numerous sites in Magallanes, Chile, to the south and southwest, have been found to be obsidians derived from three well known sources (Stern, 2017): green obsidian from Seno Otway (type SO), grey-green banded obsidian from a source west of Cordillera Baguales (type CB), and black obsidian from Pampa del Asador.

I consider it unlikely that their 16 new samples from these two archaeological sites would not contain any of these well documented obsidian types, and only contain obsidians from unknown sources. I suggest instead that in fact all 16 of their obsidian samples do correspond to the known obsidians in the region: Unknown Source *a* to CB, Source *b* to SO, and Source *c* to PDA1 obsidian. Table 1 summarizes their XRF data compared to averages of published ICP-MS analyses of the three previously known obsidian types in the region (Stern, 2017), and Figure 1 plots Sr versus Nb content for these data. Both this figure and the table illustrate the similarity, given the different analytical techniques (XRF versus ICP-MS) and different standards used to obtain the data, of their Unknown Types *a*, *b,* and *c* with CB, SO, and PDA1 obsidian, respectively. Nami et al. "presume that Unknown Source *b* could potentially match Cordillera Baguales" obsidian, but actually it is their Unknown Source Type *a* of 12 artifacts from Alero del Valle that matches CB type obsidian (Fig. 1). Charlin (2009) previously concluded that this is the most common obsidian type in the archaeological sites within the Pali Aike volcanic field.

I believe it is important that the correct source identification of the 16 obsidian samples from the Pali Aike volcanic field area be acknowledged so that the suggestion that these obsidians are derived from unknown sources not continue to be propagated in the literature.

Further confusion in this paper results from the fact that their Figure 3 is described as

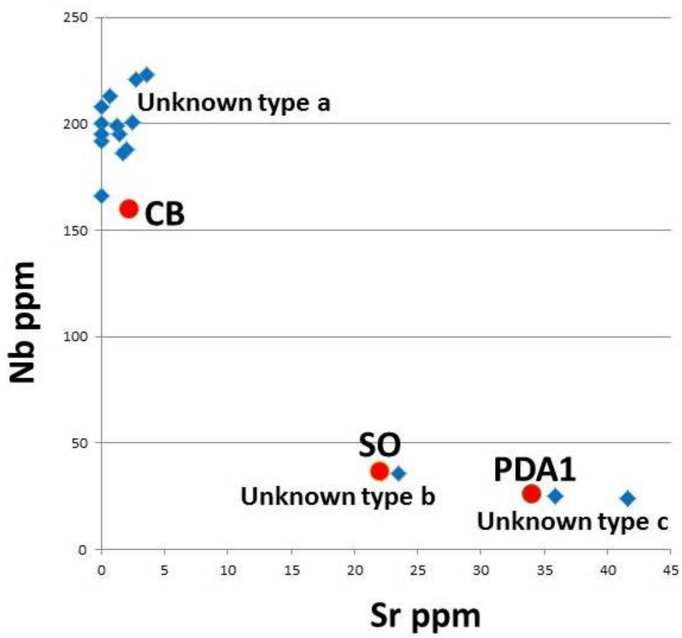

Figure 1. Plot of Sr versus Nb contents (in ppm) for Unknown Types *a*, *b* and *c* (diamonds) from Nami et al. (2017) compared to average values of CB, SO and PDA1 obsidians (circles) from Stern (2017).

a plot of Sr versus Rb, when it actually plots Zr versus Rb. The say the figure shows the separation of three obsidian types, but not what types each field corresponds to. The most populated field in the figure, with relatively low Zr, actually corresponds to their data for the three different obsidian types PDA1, PDA2, and SO obsidian, which have overlapping Zr and Rb contents. The field in the figure with somewhat higher Zr is PDA3 obsidian and that with both high Zr and high Rb is CB (their Unknown Type *a*) obsidian. They comment in their Table 3 that PA (PDA) type 3 (PDA3) obsidian is characterized by low Sr, when actually it is the PDA obsidian type with the highest Sr. PDA2 has low Sr, not PDA3, Finally there are numerous errors involving misidentifying of the three PDA obsidian types in their Table 2.

Unfortunately, poor critical editing of this paper greatly distracts from what should have been a good contribution to obsidian studies in southernmost South America.

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	Sr	Nb	Th	Zr	Y	Rb
Unknown type a or SCAV-01						
SCAV1	0	200	43	806	138	354
SCAV2	0	192	43	756	123	304
SCAV3	2	188	37	793	122	332
SCAV4	0	208	43	858	145	377
SCAV5	3.6	223	47	936	150	421
SCAV6-11	1.7	186	42	736	124	340
SCAV-12	2.8	221	40	895	141	369
SCAV13	2.5	201	37	808	128	335
SCAV14-15	0	166	34	700	122	315
SCAV16	0.7	213	42	867	144	337
SCAV19	1.4	195	42	807	129	350
SCAV20	0	195	43	837	136	372
Average	**1.2**	**199**	**41**	**817**	**134**	**351**
Std	1.2	15	3.4	64	10	30
CB	**2.2**	**160**	**45**	**693**	**129**	**294**
Std	2.2	16	4.5	69	13	29
Unknown type b or SCAV-02						
SCAV17	22.2	35.4	19.9	142	36	182
SCAV18	23.5	35.4	19.9	141	37.1	195
Average	**22.9**	**35.4**	**19.9**	**142**	**36.6**	**189**
Std	0.65	0.0	0.0	1.0	0.55	6.7
SO	**22.0**	**37.0**	**22.9**	**132**	**37.0**	**170**
Std	2	3.7	2.3	13.2	3.7	17
Unknown type c or SCCA-1						
SCCA1	35.9	25	20.8	138	32.9	223
SCCA2	41.6	24.2	25.3	156	42.3	247
Average	**38.8**	**24.6**	**23.1**	**147**	**37.6**	**235**
Std	2.9	0.4	2.3	9.0	4.7	11.9
PDA1	**34**	**26**	**18.7**	**132**	**33**	**196**
Std	3.4	2.6	1.9	13	3.3	20

Table. 1. Comparison of trace-element concentrations (in ppm) of samples from Nami et al. (2017) and published analysis of average Cordillera Baguales (CB), Seno Otway (SO) and Pampa del Asador 1 (PDA1) obsidians from Stern (2017).

REPLY TO COMMENT BY CHARLES R. STERN CONCERNING THE PAPER "NEW ANALYSES OF LATE HOLOCENE OBSIDIANS FROM SOUTHERN PATAGONIA (SANTA CRUZ PROVINCE, ARGENTINA)" BY HUGO G. NAMI, MARTIN GIESSO, ALICIA CASTRO AND MICHAEL D. GLACOCK (IAOS Bulletin No. 57, Summer 2017; p. 13-24).

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Michael D. Glascock, Archaeometry Laboratory, University of Missouri Research Reactor, Columbia, Missouri, 65211

We have to thank Charles Stern for his comments on our paper on obsidian from southern Patagonia. He is correct that we missed the fact that the Unknowns *a, b,* and *c*, match samples analyzed by him as Cordillera Baguales, Seno Otway, and Pampa del Asador Subsource 1. The reason we missed this is that there is a difference in the calibration between Missouri University Research Reactor's pXRF and Stern's measurements by ICP-MS, and as can be seen in Stern's Table 1, Unknown *a*'s Zr and Rb are higher than Baguales. On page 23, we stated that "Alero del Valle 1 has some resemblance to Cordillera Baguales, based on Mn, Rb, Sr, and particularly a very high Zr", while indicating that "Pampa del Asador, Cordillera Baguales, and Seno Otway were the sources of obsidian for the Pali Aike region." In order to avoid future inconsistencies, it will be important to obtain source samples from the Cordillera Baguales source for comparison at MURR. Here we include two bivariate plots (Fig. 1 and Fig. 2) with all the samples analyzed in our paper and their correct determinations (Table 1). To conclude, twelve samples from Alero del Valle (SCAV01 to SCAV16, SCAV19, and SCAV20) correspond to the Cordillera Baguales source; the remaining from Alero del Valle (SCAV17 and 18) correspond to the Seno Otway source; and the two from Aristizábal Cave (SCCA1 and 2) correspond to Pampa del Asador Subsource 1 (PDA1).

Locality/ Site	**Samples (n)**	**Provenance**	**Observations**
NCC	28	PDA1	Analyzed by XRF and NAA
NCC	11	PDA2	Analyzed by XRF and NAA
NCC	2	PDA3	Analyzed by XRF and NAA Characterized by very low Sr
AV	12	CB	Analyzed by XRF Characterized by high Zr
AV	2	SO	Analyzed by XRF
AC	2	PDA1	Analyzed by XRF

Table 1. Sample data and method of analysis.

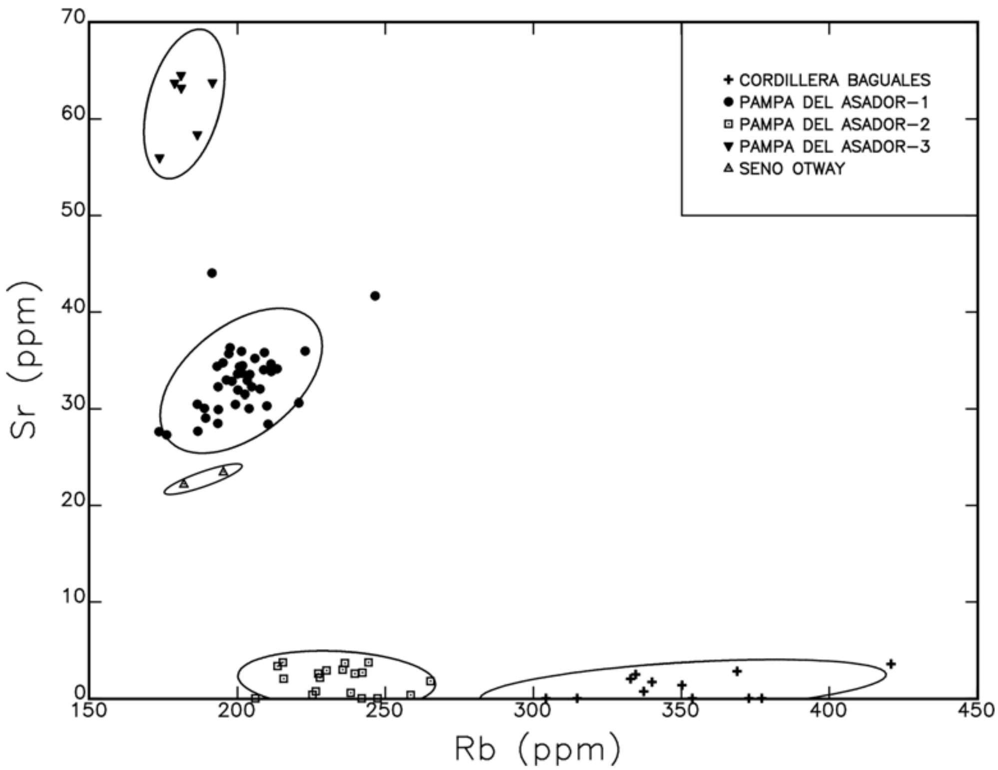

Figure 1. Scatterplot of Rb (ppm) and Sr (ppm).

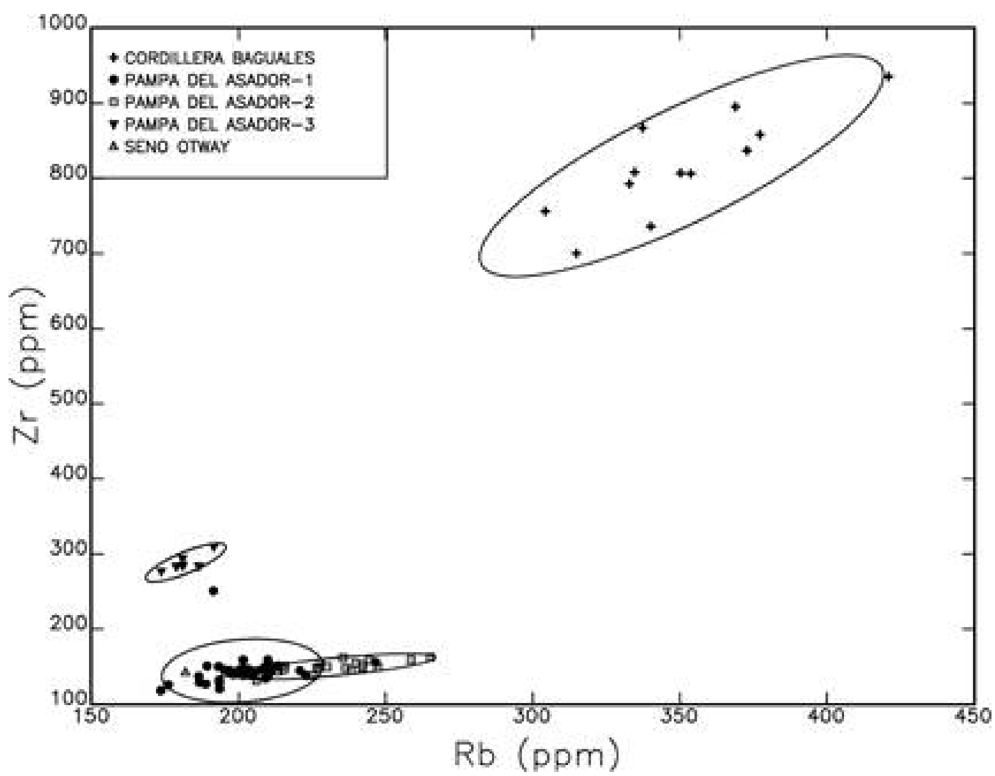

Figure 2. Scatterplot of Rb (ppm) and Zr (ppm).

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NOTE: Because membership fees are very low, the IAOS asks that all payments be made in U.S. Dollars, in international money orders, or checks payable on a bank with a U.S. branch. Otherwise, please use PayPal on our website to pay with a credit card.
http://members.peak.org/~obsidian/

For more information about membership in the IAOS, contact our Secretary-Treasurer:

Matthew Boulanger
Department of Anthropology
Southern Methodist University
P.O. Box 750336
Dallas, TX 75275-0336
U.S.A.
Boulanger.Matthew@gmail.com

Membership inquiries, address changes, or payment questions can also be emailed to Boulanger.Matthew@gmail.com

ABOUT THE IAOS

The International Association for Obsidian Studies (IAOS) was formed in 1989 to provide a forum for obsidian researchers throughout the world. Major interest areas include: obsidian hydration dating, obsidian and materials characterization ("sourcing"), geoarchaeological obsidian studies, obsidian and lithic technology, and the prehistoric procurement and utilization of obsidian. In addition to disseminating information about advances in obsidian research to archaeologists and other interested parties, the IAOS was also established to:

1. Develop standards for analytic procedures and ensure inter-laboratory comparability.
2. Develop standards for recording and reporting obsidian hydration and characterization results
3. Provide technical support in the form of training and workshops for those wanting to develop their expertise in the field.
4. Provide a central source of information regarding the advances in obsidian studies and the analytic capabilities of various laboratories and institutions

MEMBERSHIP RENEWAL FORM

We hope you will continue your membership. Please complete the renewal form below.

NOTE: You can now renew your IAOS membership online! Please go to the IAOS website at http://members.peak.org/~obsidian/ and check it out! Please note that due to changes in the membership calendar, your renewal will be for the next calendar year. Unless you specify, the *Bulletin* will be sent to you as a link to a .pdf available on the IAOS website.

___ Yes, I'd like to renew my membership. A check or money order for the annual membership fee is enclosed (see below).

___ Yes, I'd like to become a new member of the IAOS. A check or money order for the annual membership fee is enclosed (see below). Please send my first issue of the IAOS *Bulletin*.

___ Yes, I'd like to become a student member of the IAOS. I have enclosed either an obsidian-related article for publication in the IAOS *Bulletin* or an abstract of such an article published elsewhere. I have also enclosed a copy of my current student ID. Please send my first issue of the IAOS *Bulletin.*

NAME: ____

TITLE: ____________________ AFFILIATION: ____________________________

STREET ADDRESS: ____

CITY, STATE, ZIP: ____

COUNTRY: ____

WORK PHONE: ______________________ FAX: ____________________

HOME PHONE (OPTIONAL): _________________________________

EMAIL ADDRESS: ____

My check or money order is enclosed for the following amount (please check one):
___ $20 Regular
___ $10 Student (include copy of student ID)
___ FREE Student (include copy of article for the *IAOS Bulletin* and student ID)
___ $200 Lifetime

Please return this form with payment: (or pay online with PayPal http://members.peak.org/~obsidian/**)**

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