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Source Provenance of Obsidian Artifacts from Archaic Sites in the Northern Sea of Cortez, Mexico

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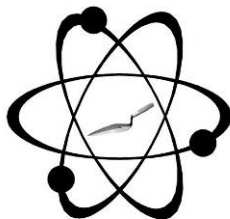
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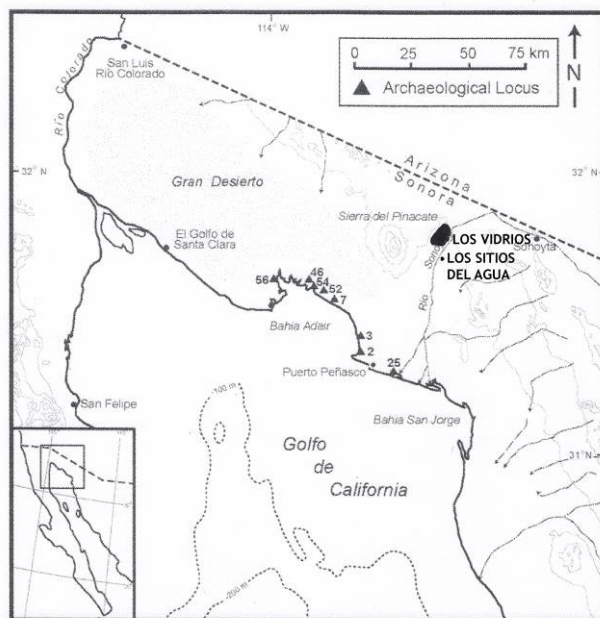


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**SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM ARCHAIC SITES IN THE  
NORTHERN SEA OF CORTEZ, MEXICO**



by

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Report Prepared for

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31 July 2015

## INTRODUCTION

The analysis here of 31 obsidian artifacts indicates a relatively diverse assemblage. While most of the artifacts were produced from known sources in the northern Sonoran Desert, a substantial proportion were produced from two, as yet, unlocated sources likely in the region of the northern state of Sonora, Mexico, and never seen before north of the U.S.-Mexico border, indeed anywhere.

## LABORATORY SAMPLING, ANALYSIS AND INSTRUMENTATION

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

### Trace Element Analyses

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

squares empirical peak deconvolution, gross peak intensities and net peak intensities above background.

The analysis for mid Zb condition elements Ti-Nb, Pb, Th, the x-ray tube is operated at 30 kV, using a 0.05 mm (medium) Pd primary beam filter in an air path at 200 seconds livetime to generate x-ray intensity Ka-line data for elements titanium (Ti), manganese (Mn), iron (as  $\text{Fe}_2\text{O}_3^T$ ), cobalt (Co), nickel (Ni), copper, (Cu), zinc, (Zn), gallium (Ga), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), niobium (Nb), lead (Pb), and thorium (Th). Not all these elements are reported since their values in many volcanic rocks are very low. Trace element intensities were converted to concentration estimates by employing a least-squares calibration line ratioed to the Compton scatter established for each element from the analysis of international rock standards certified by the National Institute of Standards and Technology (NIST), the US. Geological Survey (USGS), Canadian Centre for Mineral and Energy Technology, and the Centre de Recherches Pétrographiques et Géochimiques in France (Govindaraju 1994). Line fitting is linear (XML) for all elements but Fe where a derivative fitting is used to improve the fit for iron and thus for all the other elements. When barium (Ba) is analyzed in the High Zb condition, the Rh tube is operated at 50 kV and up to 1.0 mA, ratioed to the bremsstrahlung region (see Davis 2011; Shackley 2011). Further details concerning the petrological choice of these elements in Southwest obsidians is available in Shackley (1988, 1995, 2005; also Mahood and Stimac 1991; and Hughes and Smith 1993). Nineteen specific pressed powder standards are used for the best fit regression calibration for elements Ti-Nb, Pb, Th, and Ba, include G-2 (basalt), AGV-2 (andesite), GSP-2 (granodiorite), SY-2 (syenite), BHVO-2 (hawaiite), STM-1 (syenite), QLO-1 (quartz latite), RGM-1 (obsidian), W-2 (diabase), BIR-1 (basalt), SDC-1 (mica schist), TLM-1 (tonalite), SCO-1 (shale), NOD-A-1 and NOD-P-1 (manganese) all US Geological Survey standards, NIST-278 (obsidian), U.S. National Institute

of Standards and Technology, BE-N (basalt) from the Centre de Recherches Pétrographiques et Géochimiques in France, and JR-1 and JR-2 (obsidian) from the Geological Survey of Japan (Govindaraju 1994).

The data from the WinTrace software were translated directly into Excel for Windows software for manipulation and on into SPSS for Windows (ver. 21) for statistical analyses. In order to evaluate these quantitative determinations, machine data were compared to measurements of known standards during each run. RGM-1 a USGS obsidian standard is analyzed during each sample run for obsidian artifacts to check machine calibration (Table 1). Source assignments were made by reference to Hinojosa-Prieto (2015); Martynec et al. (2011) and Shackley (1995, 2005 and updated at <http://swxrflab.net/swobsrscs.htm>; see Tables 1 and 2 and Figure 1.

### **Major and Minor Oxide Analysis**

The group of unknown samples were subjected to major and minor oxide analyses to determine rock type for future research. The two well known sources in northern Sonora, Los Sitios del Agua and Los Vidrios are Tertiary rhyolites as part of the bimodal Sierra Pinacate Volcanic Field. The oxide analysis determined whether the "unknowns" were also rhyolites, possibly related to the Sierra Pinacate field (Table 3 and Figure 3).

Analysis of the major oxides of Si, Al, Ca, Fe, K, Mg, Mn, Na, and Ti is performed under the multiple conditions elucidated below. This fundamental parameter analysis (theoretical with standards), while not as accurate as destructive analyses (pressed powder and fusion disks) is usually within a few percent of actual, based on the analysis of USGS RGM-1 obsidian standard (see also Shackley 2011). The fundamental parameters (theoretical) method is run under conditions commensurate with the elements of interest and calibrated with 11 USGS standards (RGM-1, rhyolite; AGV-2, andesite; BHVO-1, hawaiite; BIR-1, basalt; G-2, granite; GSP-2,

granodiorite; BCR-2, basalt; W-2, diabase; QLO-1, quartz latite; STM-1, syenite), and one Japanese Geological Survey rhyolite standard (JR-1). See Lundblad et al. (2011) for another set of conditions and methods for oxide analyses.

### CONDITIONS OF FUNDAMENTAL PARAMETER ANALYSIS<sup>1</sup>

#### Low Za (Na, Mg, Al, Si, P)

Voltage	6 kV	Current	Auto <sup>2</sup>
Livetime	100 seconds	Counts Limit	0
Filter	No Filter	Atmosphere	Vacuum
Maximum Energy	10 keV	Count Rate	Low

#### Mid Zb (K, Ca, Ti, V, Cr, Mn, Fe)

Voltage	32 kV	Current	Auto
Livetime	100 seconds	Counts Limit	0
Filter	Pd (0.06 mm)	Atmosphere	Vacuum
Maximum Energy	40 keV	Count Rate	Medium

#### High Zb (Sn, Sb, Ba, Ag, Cd)

Voltage	50 kV	Current	Auto
Livetime	100 seconds	Counts Limit	0
Filter	Cu (0.559 mm)	Atmosphere	Vacuum
Maximum Energy	40 keV	Count Rate	High

#### Low Zb (S, Cl, K, Ca)

Voltage	8 kV	Current	Auto
Livetime	100 seconds	Counts Limit	0
Filter	Cellulose (0.06 mm)	Atmosphere	Vacuum
Maximum Energy	10 keV	Count Rate	Low

<sup>1</sup> Multiple conditions designed to ameliorate peak overlap identified with digital filter background removal, least squares empirical peak deconvolution, gross peak intensities and net peak intensities above background.

<sup>2</sup> Current is set automatically based on the mass absorption coefficient.

## DISCUSSION

This is the first relatively large scale analysis of archaeological obsidian from the northern Sea of Cortez to my knowledge. While the presence of Los Vidrios and Los Sitios del Agua sources that are just upstream along the Rio Sonoyta from these sites is expectable, the artifacts produced from the, as yet, unlocated sources is new (Shackley 1995, 2005; see Figure 2 here). They are certainly rhyolite glasses as seen on the TAS plot (see Table 3 and Figure 3). Given that most of these "unknown" location obsidian cores and debitage exhibit cortical material, I would predict that they are relatively nearby, and likely part of the bimodal Sierra Pinacate Volcanic Field (Donnelly 1974; Gunderson et al. 1986; Gutmann et al. 2000). Some of these samples have relatively high alkalis typical of the mafic volcanics in northwest Mexico, which could also indicate genetic similarity (Gunderson et al. 1986). The rhyolites of the Sierra Pinacate region have not been studied extensively, so more solid inferences are not possible at this time.

The other surprise, was the one artifact produced from the Saucedo Mountains source located north of Ajo, Arizona on the Barry Goldwater Air Force Range in Maricopa County (Sample 5, SON:8:5:7; Table 1). As far as I know, this is the first evidence of an artifact produced from an obsidian source located north of the border down in Sonoran sites. This suggests that these Archaic fisher-gatherers had a somewhat extensive procurement range, not uncommon among Archaic hunter-gatherers in the Southwest (Shackley 1989, 1996).

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

Sample	Site	Ti	Mn	Fe	Zn	Rb	Sr	Y	Zr	Nb	SOURCE
1	SON:B:5:7	576	23	1249	96	22	15	67	211	27	Los Vidrios
			6	8		8					
2	SON:B:5:7	330	44	2153	83	11	14	41	396	6	SON Unknown C
			6	0	2	5	0				
4	SON:B:5:7	198	32	1738	66	11	77	45	431	7	SON Unknown D
			1	3	3	2					
5	SON:B:5:7	162	29	1262	60	15	10	25	179	20	Sauceda Mtns
			7	5	3	9	7				
6	SON:B:5:7	567	24	1282	96	24	16	72	219	28	Los Vidrios
			2	3		3					
7	SON:B:5:7	560	22	1251	86	22	15	67	213	30	Los Vidrios
			9	6		9					
8	SON:B:5:7	335	43	2172	10	11	13	46	388	2	SON Unknown C
			9	6	7	2	2	5			
16	SON:B:5:7	362	47	2217	10	11	14	44	399	13	SON Unknown C
			2	4	3	0	4	4			
22	SON:B:5:7	118	48	2070	19	14	14	83	703	51	Los Sitios del Agua
			8	9	1	1	4				
40	SON:B:5:7	139	48	2094	18	14	16	80	698	48	Los Sitios del Agua
			9	5	7	8	0				
51	SON:B:5:7	372	48	2404	10	92	13	43	396	6	SON Unknown C
			4	9	6	4	4				
67	SON:B:5:8	119	50	2103	17	14	14	89	736	46	Los Sitios del Agua
			0	3	1	4	7				
77	SON:B:11:1	645	22	1307	13	24	16	69	216	30	Los Vidrios
			8	0	6	0					
80-1	SON:B:11:1	648	25	1327	11	24	16	69	218	29	Los Vidrios
			1	7	2	8					
80-2	SON:B:11:1	637	25	1350	16	24	17	66	219	28	Los Sitios del Agua
			5	0	5	9					
87-1	SON:B:11:1	139	45	2027	17	13	19	79	683	53	Los Vidrios
			8	7	8	4	7				
87-2	SON:B:11:1	615	22	1300	11	24	14	69	216	31	Los Vidrios
			9	6	2	2					
87-3	SON:B:11:1	391	55	2468	12	93	13	43	406	7	SON Unknown C
			8	8	0	2	1				
97	SON:B:11:1	154	28	1402	35	21	14	53	172	23	Los Vidrios
			3	2	4	9	8				
115-1	SON:B:11:1	778	26	1411	12	26	15	74	231	33	Los Vidrios
			8	3	7	4					
115-2	SON:B:11:1	618	24	1292	10	23	14	71	215	30	Los Vidrios
			0	2	5	6					
115-3	SON:B:11:1	638	25	1302	11	23	16	68	214	31	Los Vidrios
			1	4	4	6					
115-4	SON:B:11:1	643	24	1362	16	25	14	73	219	35	Los Vidrios
			5	0	7	1					
115-5	SON:B:11:1	657	23	1271	15	22	16	62	207	33	Los Vidrios
			8	9	5	7					
115-6	SON:B:11:1	899	25	1326	16	23	15	65	206	33	Los Vidrios
			2	7	3	9					
129	SON:B:11:1	665	25	1354	14	24	15	69	218	28	Los Vidrios
			4	0	5	9					

133	SON:B:11:1	757	26	1375	14	25	16	71	223	30	Los Vidrios
			2	6	2	8					
136	SON:B:11:1	786	25	1339	17	24	19	67	222	26	Los Vidrios
			3	5	3	4					
156	SON:B:11:1	650	23	1285	96	24	14	74	217	31	Los Vidrios
			6	8		1					
157-1	SON:B:11:1	681	25	1339	91	25	17	75	227	30	Los Vidrios
			2	3		7					
157-2	SON:B:11:1	452	57	2750	13	10	14	48	409	9	SON Unknown C
		8	6	3	0	4	1				
RGM1-S4		148	28	1371	34	14	10	26	214	10	standard
		8	2	1		6	5				
RGM1-S4		150	28	1372	38	14	10	26	216	7	standard
		0	1	5		6	5				

Table 2. Crosstabulation of site by source.

SOURCE		Site			Total
		SON:B:11:1	SON:B:5:7	SON:B:5:8	
Los Sitios del Agua	Count	1	2	1	4
	% within SOURCE	25.0%	50.0%	25.0%	100.0%
	% within Site	5.3%	18.2%	100.0%	12.9%
	% of Total	3.2%	6.5%	3.2%	12.9%
Los Vidrios	Count	16	3	0	19
	% within SOURCE	84.2%	15.8%	0.0%	100.0%
	% within Site	84.2%	27.3%	0.0%	61.3%
	% of Total	51.6%	9.7%	0.0%	61.3%
Sauceda Mtns	Count	0	1	0	1
	% within SOURCE	0.0%	100.0%	0.0%	100.0%
	% within Site	0.0%	9.1%	0.0%	3.2%
	% of Total	0.0%	3.2%	0.0%	3.2%
SON Unknown C	Count	2	4	0	6
	% within SOURCE	33.3%	66.7%	0.0%	100.0%
	% within Site	10.5%	36.4%	0.0%	19.4%
	% of Total	6.5%	12.9%	0.0%	19.4%
SON Unknown D	Count	0	1	0	1
	% within SOURCE	0.0%	100.0%	0.0%	100.0%
	% within Site	0.0%	9.1%	0.0%	3.2%
	% of Total	0.0%	3.2%	0.0%	3.2%
Total	Count	19	11	1	31
	% within SOURCE	61.3%	35.5%	3.2%	100.0%
	% within Site	100.0%	100.0%	100.0%	100.0%
	% of Total	61.3%	35.5%	3.2%	100.0%

Table 3. Major and minor oxides for the "unknown" samples, and RGM-1 USGS rhyolite standard.

Sample	Site	Na <sub>2</sub> O	MgO	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	K <sub>2</sub> O	CaO	TiO <sub>2</sub>	MnO	Fe <sub>2</sub> O <sub>3</sub>
		%	%	%	%	%	%	%	%	%
51	SON B:5:7	3.835	0.758	8.377	71.71	5.676	5.779	1.287	0.17	11.19
4	SON B:5:7	3.878	2.883	12.62	72	3.553	1.675	0.403	0.052	3.487
2	SON B:5:7	2.985	0.11	8.539	72.1	6.16	5.572	1.465	0.18	11.62
16	SON B:5:7	3.582	0.667	8.204	68.8	6.38	6.105	1.545	0.206	13.07
87-3	SON B:11-1	3.573	0.377	8.099	71.2	6.328	5.833	1.412	0.198	11.62
157-2	SON B:11-1	4.448	0.453	7.848	69.3	5.661	7.087	1.382	0.178	12.13
RGM1-S4		4.121	0	12.94		4.834	1.387	0.273	0.044	2.195

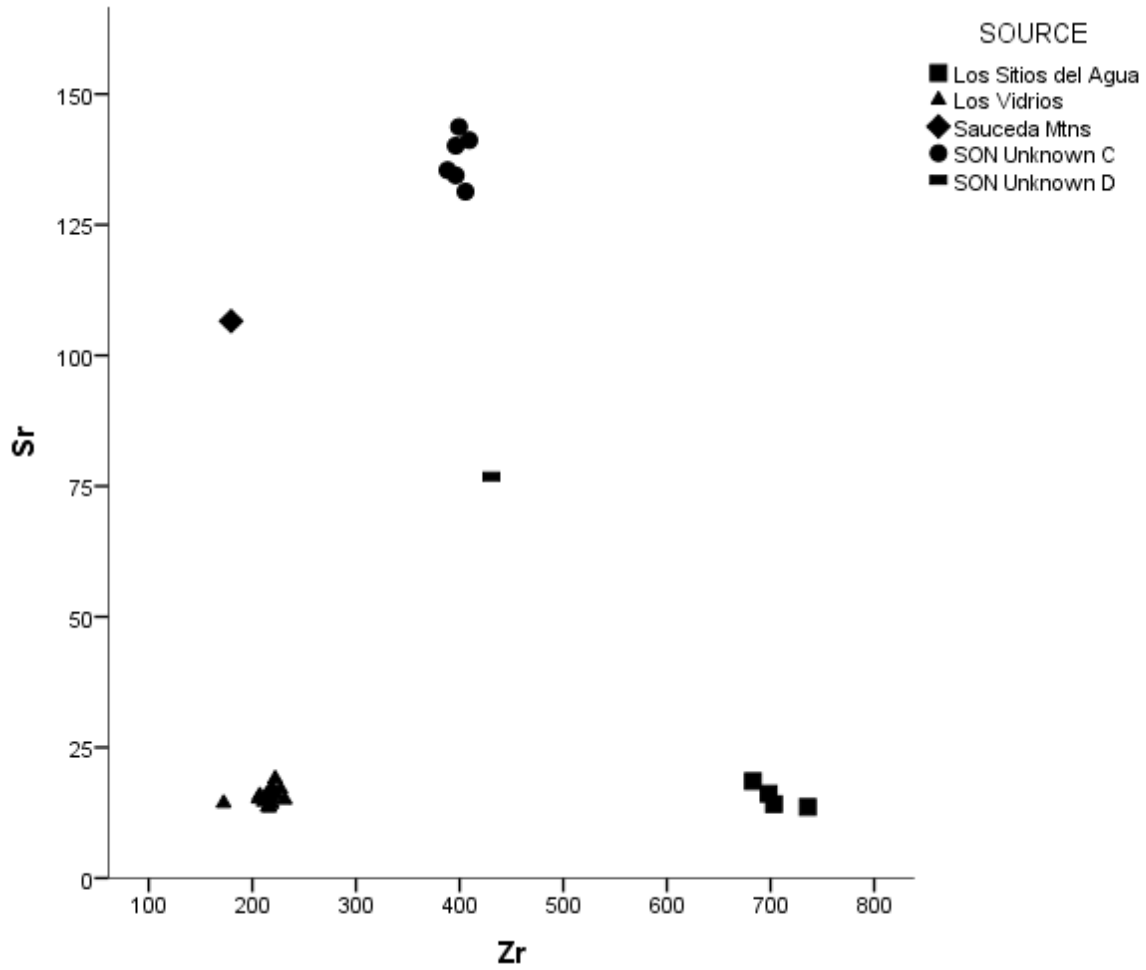


Figure 1. Zr versus Sr bivariate plot of the elemental concentrations for all the archaeological specimens from all sites.

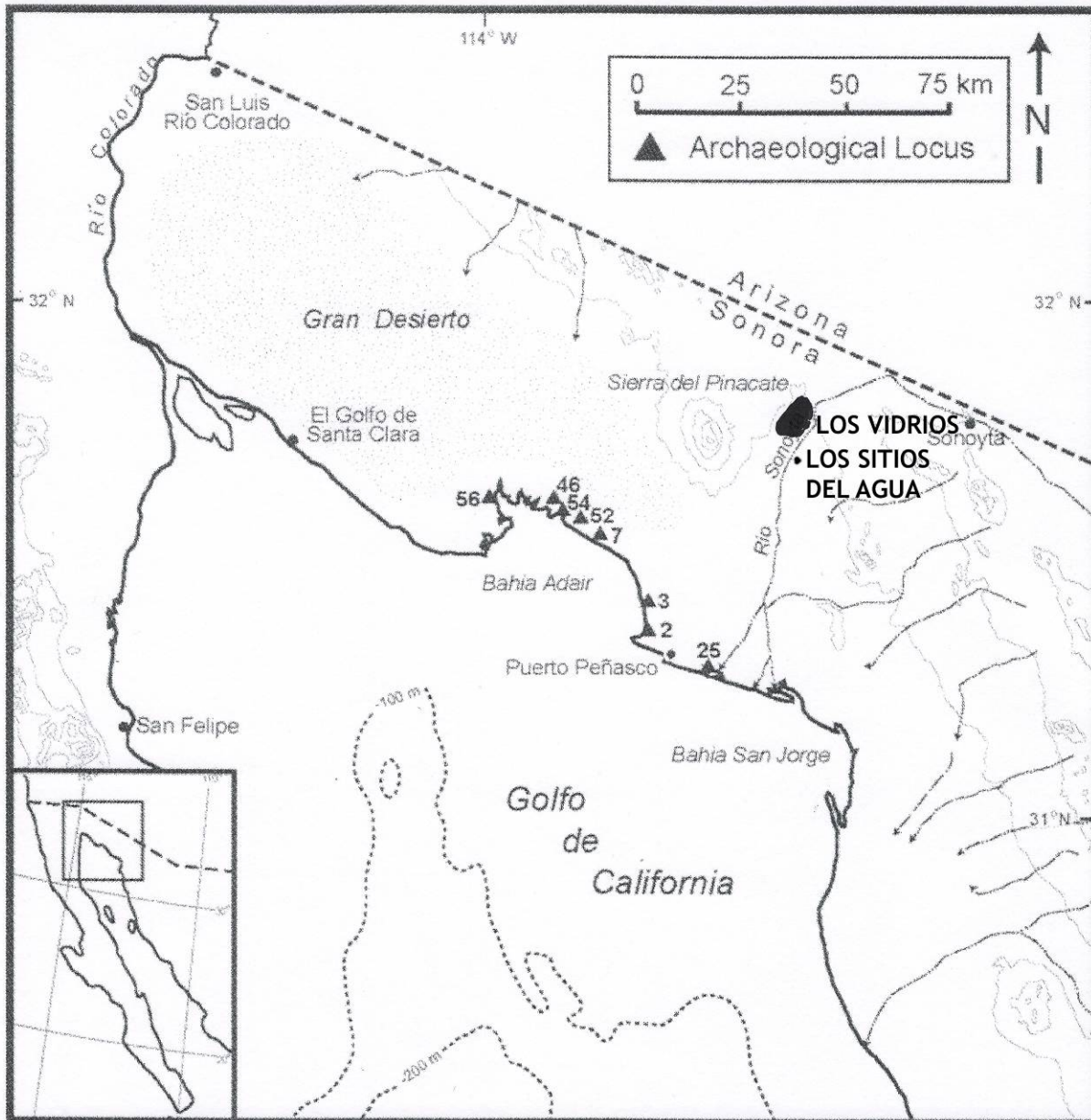


Figure 2. General location of the region, the approximate locations of the two dominant sources in northern Sonora, and the location of project sites (from Mitchell et. al. 2015).

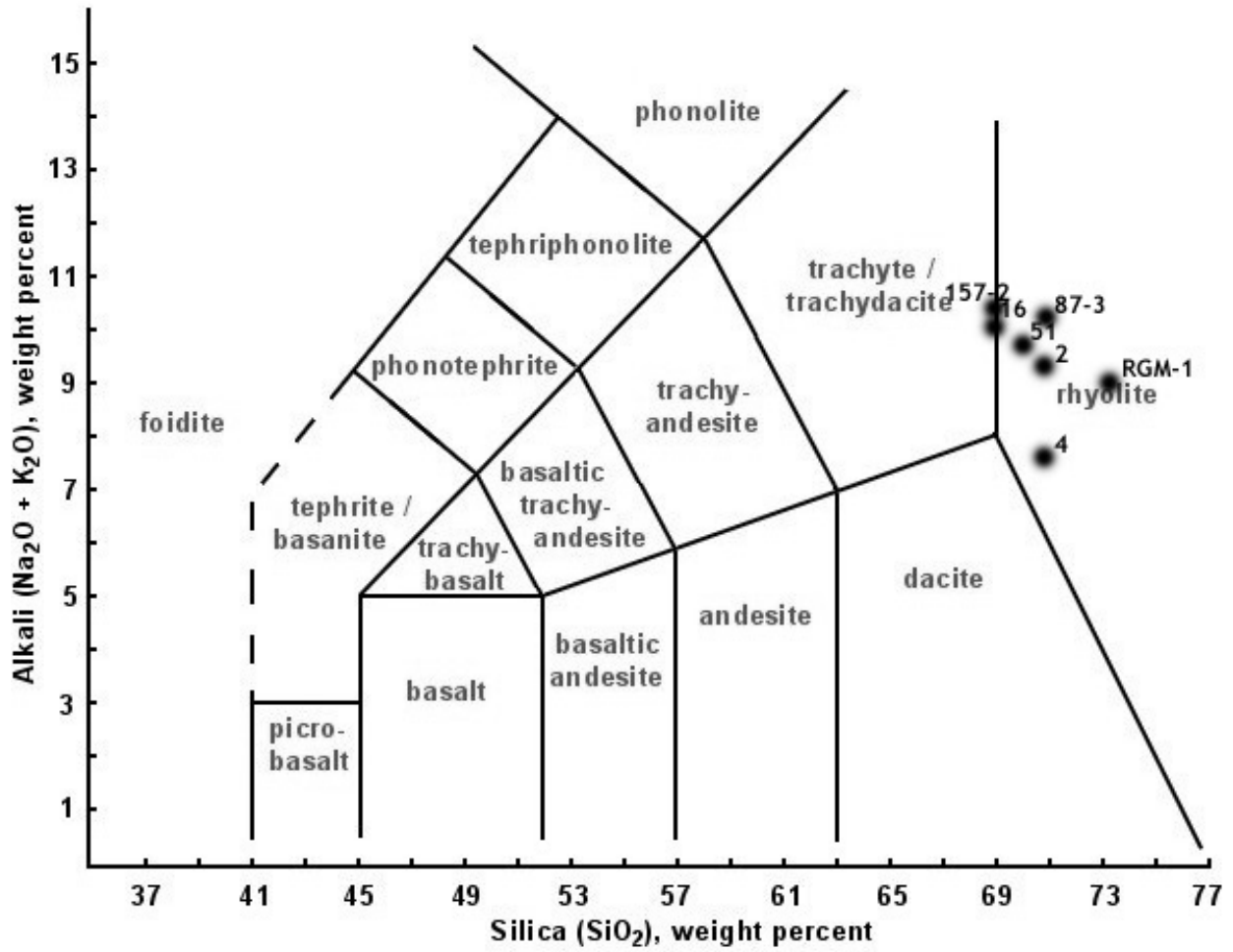


Figure 3. TAS plot of the "unknown" samples and RGM-1 USGS rhyolite standard.