SOURCES OF OBSIDIAN ARTIFACTS

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A total of 32 flaked obsidian artifacts was recovered by the Desert Archaeology, Inc., investigations at the Clearwater site, AZ BB:13:6 (ASM), and the Tucson Presidio, AZ BB:13:13 (ASM). The elemental concentrations in 20 obsidian artifacts were analyzed by the energy dispersive X-ray fluorescence (EXRF) method to match them to the compositions of known obsidian sources in the Greater Southwest. The types of obsidian artifacts, their contexts, the ages of those contexts, and identified sources are summarized in Table 17.1. Elemental concentrations for the analyzed obsidian artifacts are shown in Table 17.2, and the periods and sample sizes of obsidian artifacts from archaeological sites in the Tucson Basin are listed in Table 17.3. Table 17.4 shows the sources of obsidian artifacts from archaeological sites in the Tucson Basin, by period. The locations of identified sources for obsidian artifacts from Clearwater and the Tucson Presidio, dating to the Cienega phase, the Hohokam periods, and the Spanish period, are illustrated in Figures 17.1-17.3, respectively.

ANALYSIS AND INSTRUMENTAL CONDITIONS

All the archaeological samples from Clearwater and the Tucson Presidio were 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. More essentially, through the analysis of international rock standards, these data allow for inter-instrument comparisons with a predictable degree of certainty.

The trace element analyses were performed in the Archaeological XRF Laboratory, Department of Earth and Planetary Sciences, University of California, Berkeley, using a Spectrace/Thermo™ *QuanX* energy dispersive x-ray fluorescence spectrometer. The spectrometer is equipped with an air-cooled Cu x-ray target with a 125-micron Be window, an x-ray generator that operates from 4-50 kV/0.02-2.0 mA at 0.02 increments, using an IBM PC-based microprocessor and WinTrace™ reduction software. The x-ray tube is operated at 30 kV, 0.14 mA, using a 0.05 mm (medium) Pd primary beam filter in an air path at 200 seconds livetime to generate x-ray intensity Kα-line data for elements titanium (Ti), manganese (Mn), iron (as FeT), thorium (Th) using Lα line, rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), and niobium (Nb). Weight percent iron ($Fe_2O_3^T$) can be derived by multiplying pp estimates by $1.4297(10^{-4})$.

Trace element intensities were converted to concentration estimates by utilizing a least-squares calibration line established for each element from the analysis of international rock standards certified by the National Institute of Standards and Technology (NIST), the U.S. 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 except iron, where a derivative is used to improve the fit for the high concentrations of iron, and thus, for all the other elements. Further details concerning the petrological choice of these elements in southwest obsidian is available elsewhere (Hughes and Smith 1993; Mahood and Stimac 1990; Shackley 1990, 1995, 1998, 2005).

Specific standards used for the best-fit regression calibration for elements titanium through niobium include basalt (G-2), andesite (AGV-1), GSP-1, syenite (SY-2), hawaiite (BHVO-1), syenite (STM-1), quartz latite (QLO-1), obsidian (RGM-1), diabase (W-2), basalt (BIR-1), mica schist (SDC-1), tonalite (TLM-1), shale (SCO-1), all U.S. Geological Survey standards, basalt (BR-N) from the Centre de Recherches Pétrographiques et Géochimiques in France, and obsidian (JR-1 and JR-2) from the Geological Survey of Japan (Govindaraju 1994). In addition to the reported values here, nickel, copper, zinc, and gallium were measured, but these are rarely useful in discriminating glass sources and are not generally reported.

The data from the WinTrace™ software were translated directly into Excel for Windows software for manipulation, and on into SPSS for Windows for statistical analyses. To evaluate these quantitative determinations, machine data were compared with measurements of known standards during each run. RGM-1 is analyzed during each sample run for obsidian artifacts to check machine calibration (see

Table 17.1. Information about obsidian artifacts from the Rio Nuevo archaeological investigations, in temporal order.

AZ (ASM) Site No.	Feature No.	Field No.	Period/Phase	Context	Artifact Type	Source
BB:13:6	3364	9248	Unnamed phase of Early Agricultural period	Pit structure	Flake	Unknown
BB:13:13	409	4104	San Pedro or Cienega phase	American Territorial period pit	San Pedro point	Tank Mountains
BB:13:6	0	5596	Early Cienega phase	Sheet trash	Cienega Short point	Antelope Creek/ Mule Mountains
	20	6781	Late Cienega phase	Roasting pit	Biface tip	Tank Mountains
	9357	8471	Late Cienega phase	Big house	Flake	Government Mountain
		8355b	Late Cienega phase	Big house	Flake	Los Vidrios
		8355c	Late Cienega phase	Big house	Flake	Tank Mountains
		9026	Late Cienega phase	Big house	Flake	Government Mountain
BB:13:13	406	3525	Hohokam Colonial period?	Pit structure	Flake	Blue/San Francisco River
BB:13:6	0	5605	Hohokam Sedentary period	Sheet trash	Sedentary point	Superior
BB:13:13	0	3473	Hohokam Classic period	Sheet trash	Classic point tip	Sauceda Mountains
BB:13:6	0	5230	Protohistoric or Spanish period	Alluvium	Sobaipuri point	Sand Tanks
	178	6520a	Spanish period	Pit	Flake	Mule Creek
		6520b	Spanish period	Pit	Flake	Los Vidrios
	3000	7970	Spanish period	Mission wall	Flake	Burro Creek
BB:13:13	371	2439	Spanish period?	American Territorial period pit	Point tip	Tank Mountains
	0	2694	Spanish period?	Backhoe backdirt	Point tip	Los Vidrios
		2694	Spanish period	Disturbed area	Point tip	Los Vidrios
		3377	Mexican period	Sheet trash	Sobaipuri point	Sauceda Mountains

Table 17.2). Compilation and discussion of RGM-1 analyses are available at http://www.swxrflab.net/analysis.htm. Source assignments were made with reference to the source standard library at Berkeley (Shackley 1995, 1998, 2005), Baugh and Nelson (1987), Glascock et al. (1999), and Nelson (1984).

RESULTS AND DISCUSSION

The majority of the assemblage from the Clearwater and Tucson Presidio sites were made of materials procured from sources in the Sonoran Desert, including (in order of increasing distance) the Sand Tanks, Sauceda Mountains, Los Vidrios, and Tank Mountains sources (see Table 17.1). However, the earliest obsidian artifacts, dating to the Cienega phase (circa 800 B.C.-A.D. 50), did not come from the closest sources, but rather, from sources between 200 km and 400 km away (source distances are shown in Table 17.4). This fits with a previous observation that obsidian was procured from diverse sources, including some from great distances, during the Cienega phase in southern Arizona (Shackley 2005). It does not, however, fit with the previous model of a contracted obsidian procurement pattern during the Late Archaic/Early Agricultural period, compared with the extensive procurement pattern of the preceding Middle Archaic period (e.g., Roth 2000; Shackley 1990, 1996, 1999, 2002, 2005).

Table 17.2. Elemental concentrations for the obsidian samples from the Rio Nuevo Archaeology project, by state. (All measurements in parts per million [ppm]).

Sample	Titanium	Manganese	Iron	Rubidium	Strontium	Yttrium	Zirconium	Niobium	Source
BB-13-6-20-6781	1,135	502	7,923	142	138	21	127	9	Tank Mountains
BB-13-6-3000-7970	684	567	7,550	337	5	81	92	45	Burro Creek
BB-13-6-3364-9248	1,928	674	7,523	91	59	13	56	52	Unknown
BB-13-6-5012	1,742	620	25,956	148	40	85	712	52	Arizona unknown A
BB-13-6-5230	1,157	584	9,300	151	14	29	241	25	Sand Tanks
BB-13-6-5596	895	344	7,614	223	14	33	103	14	Antelope Creek/Mule Mountains
BB-13-6-5605	1,261	542	6,075	118	19	22	91	30	Superior
BB-13-6-8355-9357a	2,860	83	2,651	3	5	-3	8	24	Not obsidian
BB-13-6-8355-9357b	1,050	252	12,800	236	10	59	211	40	Los Vidrios
BB-13-6-8355-9357c	1,358	486	8,125	146	137	9	122	10	Tank Mountains
RNA-2-AZ-BB-13-6-178-6520-a	874	318	7,328	195	26	32	104	22	Antelope Creek/Mule Mountains
RNA-2-AZ-BB-13-6-178-6520-b	1,070	244	11,504	228	20	70	205	28	Los Vidrios
RNA-2-AZ-BB-13-6-5-9423	929	408	8,158	223	23	36	114	30	Antelope Creek/Mule Mountains
RNA-2-AZ-BB-13-6-9357-9026	726	526	7,116	109	73	17	66	48	Government Mountain
RNA-8-A&B-AZ-BB-13-6-9357-8471	946	736	8,973	117	95	18	80	51	Government Mountain
BB-13-13-2583	976	254	11,321	243	14	70	223	36	Los Vidrios
BB-13-13-2694	1,088	251	11,833	239	17	73	211	32	Los Vidrios
BB-13-13-3146	1,050	575	6,395	121	22	25	91	34	Superior
BB-13-13-3377	1,490	373	9,929	162	109	23	191	15	Sauceda Mountains
BB-13-13-3473	1,606	517	10,633	158	76	24	201	12	Sauceda Mountains
BB-13-13-371-2439	1,240	461	7,805	160	145	12	110	19	Tank Mountains
BB-13-13-376-2605	1,575	531	13,906	111	136	15	92	23	Cow Canyon?
BB-13-13-409-4101	1,388	273	10,098	140	136	22	156	8	Tank Mountains
RNA-12-AZ-BB-13-13-2849	973	214	10,233	238	17	63	202	39	Los Vidrios
RNA-12-AZ-BB-13-13-3349	1,310	552	17,248	139	85	56	351	26	Unknown
RNA-12-AZ-BB-13-13-3496	1,298	373	8,355	158	68	28	195	31	Sauceda Mountains
RNA-12-AZ-BB-13-13-376-2638	940	267	11,230	242	13	70	216	21	Los Vidrios
RNA-12-AZ-BB-13-13-376-3809	1,089	202	10,338	220	7	55	202	32	Los Vidrios
RNA-12-AZ-BB-13-13-376-3826	1,002	610	7,971	369	5	75	96	38	Burro Creek
RNA-12-AZ-BB-13-13-376-3897	1,661	962	35,410	263	25	116	1,495	111	Antelope Wells
RNA-12-AZ-BB-13-13-406-3525	747	530	6,916	200	21	31	71	21	Blue/San Francisco River
RNA-12-AZ-BB-13-13-4424	1,193	434	7,783	170	150	15	126	16	Tank Mountains
RGM1-H1	1,663	349	13,262	151	116	22	219	17	Standard
RGM1-H1	1,672	309	13,323	154	117	20	223	3	Standard
RGM1-S1	1,635	315	13,245	152	119	21	227	8	Standard

Table 17.3. Periods and sample sizes of obsidian artifacts from archaeological sites in the Tucson Basin.

Middle Archaic Period
AZ AA:12:181 (ASM) (*n* = 2)
La Paloma, AZ BB:9:127 (ASM) (*n* = 3)
Owl Head Butte, AZ AA:8:194 (ASM) (*n* = 7)
Tates Hills, AZ AA:12:84 (ASM) (*n* = 5)
West Branch, AZ AA:16:3 (ASM) (*n* = 1)
Upper Bajada, Late Archaic/Early Agricultural Period
AZ AA:12:84 (ASM) (*n* = 13)
Angus, AZ AA:8:133 (ASM) (*n* = 1)
Coffee Camp, AZ AA:6:19 (ASM) (*n* = 3)
HK, AZ AA:8:166 (ASM) (*n* = 7)
La Paloma, AZ BB:9:127 (ASM) (*n* = 3)
Early Agricultural Period
Unnamed Phase
Clearwater, AZ BB:13:6 (ASM) (*n* = 1)
San Pedro or Cienega Phase
Tucson Presidio, AZ BB:13:13 (ASM) (*n* = 1)
San Pedro Phase
Las Capas, AZ AA:12:111 (ASM) (*n* = 8)
Cienega Phase
Clearwater, AZ BB:13:6 (ASM) (*n* = 6)
Cortaro Fan, AZ AA:12:486 (ASM) (*n* = 1)
Santa Cruz Bend, AZ AA:12:746 (ASM) (*n* = 6)
Stone Pipe, AZ BB:13:425 (ASM) (*n* = 2)
Hohokam Colonial Period?
Tucson Presidio, AZ BB:13:13 (ASM) (*n* = 1)
Hohokam Sedentary Period
Clearwater, AZ BB:13:6 (ASM) (*n* = 1)
Sunset Mesa, AZ AA:12:10 (ASM) (*n* = 8)
West Branch, AZ AA:16:3 (ASM) (*n* = 16)
Hohokam Classic Period
Marana site complex (*n* = 178)
Tucson Presidio, AZ BB:13:13 (ASM) (*n* = 1)
Protohistoric or Spanish Period
Clearwater, AZ BB:13:6 (ASM) (*n* = 1)
Spanish Period
Clearwater, AZ BB:13:6 (ASM) (*n* = 3)
Tucson Presidio, AZ BB:13:13 (ASM) (*n* = 3)
Mexican Period
Tucson Presidio, AZ BB:13:13 (ASM) (*n* = 1)

Recent data, however, suggest such a contraction may have occurred during the San Pedro phase (1200-800 B.C.), the phase preceding the Cienega phase. The small sample of obsidian artifacts from the San Pedro phase (*n* = 8) in the Tucson Basin, all from the Las Capas site, AZ AA:12:111 (ASM), is limited to sources within 150-200 km (Shackley et al. 2006). Among the recovered samples from Cerro Juanaqueña in northwestern Mexico, the only other San Pedro phase site that has yielded obsidian, the four identified sources are also within 150-200 km of the site (Shackley 1999). This pattern may indicate restricted access and/or reduced movements to obsidian sources during the San Pedro phase, probably related to reduced residential mobility and the use of fewer resource zones during that interval (Shackley 1996).

In contrast, the currently available data for the Cienega phase in the Tucson Basin shows an extensive pattern of obsidian procurement. With the new data from the Rio Nuevo project, the list of identified obsidian sources for Cienega phase artifacts in the Tucson Basin has been expanded to include the distant western sources of Los Vidrios and the Tank Mountains, as well as the Government Mountain source far to the north. Obsidian from Los Vidrios could have been procured during expeditions to gather marine shells from the Gulf of California for making shell jewelry found at Cienega phase sites. Table 17.4 shows that the spatial scale of obsidian sources for Cienega phase farming communities in the Tucson Basin was much greater than is currently known for San Pedro phase farmers, and it was almost as extensive as the procurement ranges of Middle Archaic foraging bands and later pre-Classic and Classic Hohokam communities in the region.

The varied and extensive pattern of Cienega phase sources may have developed with a shift in procurement strategies to include more obsidian exchange rather than direct procurement, a shift first proposed by Shackley (1990). This interpretation is supported by the presence of artifacts manufactured from other nonlocal materials (for example, marine shells, rare stones, and exotic minerals) at Cienega phase sites in the Tucson Basin, indicating the development of long-distance exchange networks during this phase (Huckell 1995; Mabry 1998). For the obsidian from this phase, there is no fall-off curve in the number of artifacts in relation to increasing distances to sources, as would be expected to result from down-the-line exchange (Renfrew 1975). Including projectile points and flakes, the assemblage reported here also contradicts the previously known pattern noted by Roth (2000) of obsidian from Late Archaic/

Table 17.4. Sources of obsidian artifacts from archaeological sites in the Tucson Basin.

			Early Agricultural Period					
	Middle Archaic Period	Upper Bajada Late Archaic/ Early Agricultural Period	San Pedro Phase	Cienega Phase	Sedentary Period	Classic Period	Spanish Period	Mexican Period
Obsidian Sources (In order of distance)	(5 sites) (*n* = 18)	(6 sites) (*n* = 27)	(1 site) (*n* = 8)	(4 sites) (*n* = 16)	(3 sites) (*n* = 14)	(3 sites) (*n* = 179)	(2 sites) (*n* = 6)	(1 site) (*n* = 1)
Within 100-200 km								
Superior	3	5	–	1	3	7	–	–
Sauceda Mountains	1	–	5	–	2	153	–	1
Sand Tanks	–	–	1	–	2	–	–	–
Cow Canyon	2	16	1?	2	3	2	–	–
Los Vidrios	2	–	–	1	–	–	3	–
Within 200-300 km								
Mule Creek	3	–	–	3	3	5	1	–
Antelope Wells	4	3	–	1	–	–	–	–
Vulture	–	–	–	–	–	10	–	–
Gwynn Canyon	1	1	–	–	–	–	–	–
Tank Mountains	–	–	–	2	–	–	1	–
Within 300-400 km								
Burro Creek	–	–	–	–	–	–	1	–
Government Mountain	–	1	–	2	1?	–	–	–
Within 400-600 km								
Obsidian Ridge	1	–	–	–	–	–	–	–
Cerro del Medio	1	–	–	–	–	–	–	–
Unknown A	–	–	–	1	–	–	–	–
Unknown X	–	–	–	2	–	–	–	–
Unknown	–	1	1	–	–	2	–	–

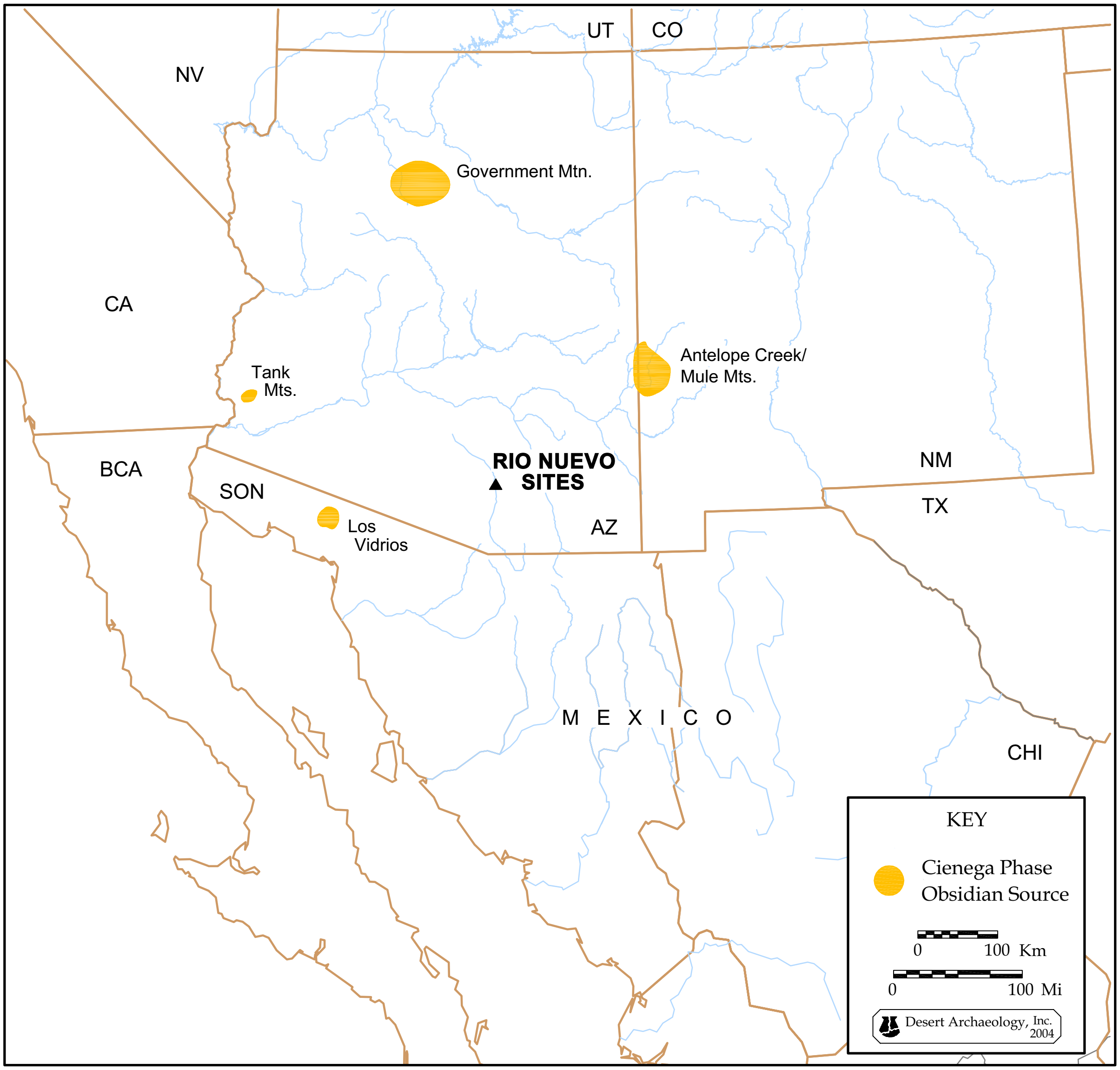

Figure 17.1. Identified material sources of Cienega phase obsidian artifacts from the Rio Nuevo sites.

Early Agricultural period contexts being limited to flakes and shatter. However, the total assemblage of Cienega phase obsidian artifacts in the Tucson Basin is still a very small sample, and these patterns will likely change with new data.

The assemblage of Hohokam obsidian artifacts from the Clearwater site and the Tucson Presidio is very small (*n* = 3), but it adds to the recently available data on pre-Classic Hohokam obsidian procurement by the inhabitants of the Tucson Basin. The data now available from the Clearwater and Tucson Presidio sites (this report); the Sunset Mesa site, AZ AA:12:10 (ASM) (Shackley 2000); and the West Branch site, AZ AA:16:3 (ASM) (Shackley 2004), provide the first glimpses of Sedentary period obsidian procurement patterns in the Tucson Basin.

The total Sedentary period assemblage from this region (*n* = 14) includes projectile points and flakes. The Superior and Mule Creek (Blue/San Francisco River) sources are represented by artifacts from the Clearwater and Tucson Presidio sites, while a variety of other sources are represented in the Sunset Mesa and West Branch assemblages. The majority of obsidian artifacts dating to this period are from sources within 200 km to the north and west, with one possibly coming from Government Mountain, 400 km away to the north. The overall pattern fits with previous observations that pre-Classic obsidian was procured from the nearest sources, probably directly by the inhabitants of each community, with obsidian tool manufacture conducted on-site rather than at the sources (Shackley 2005).

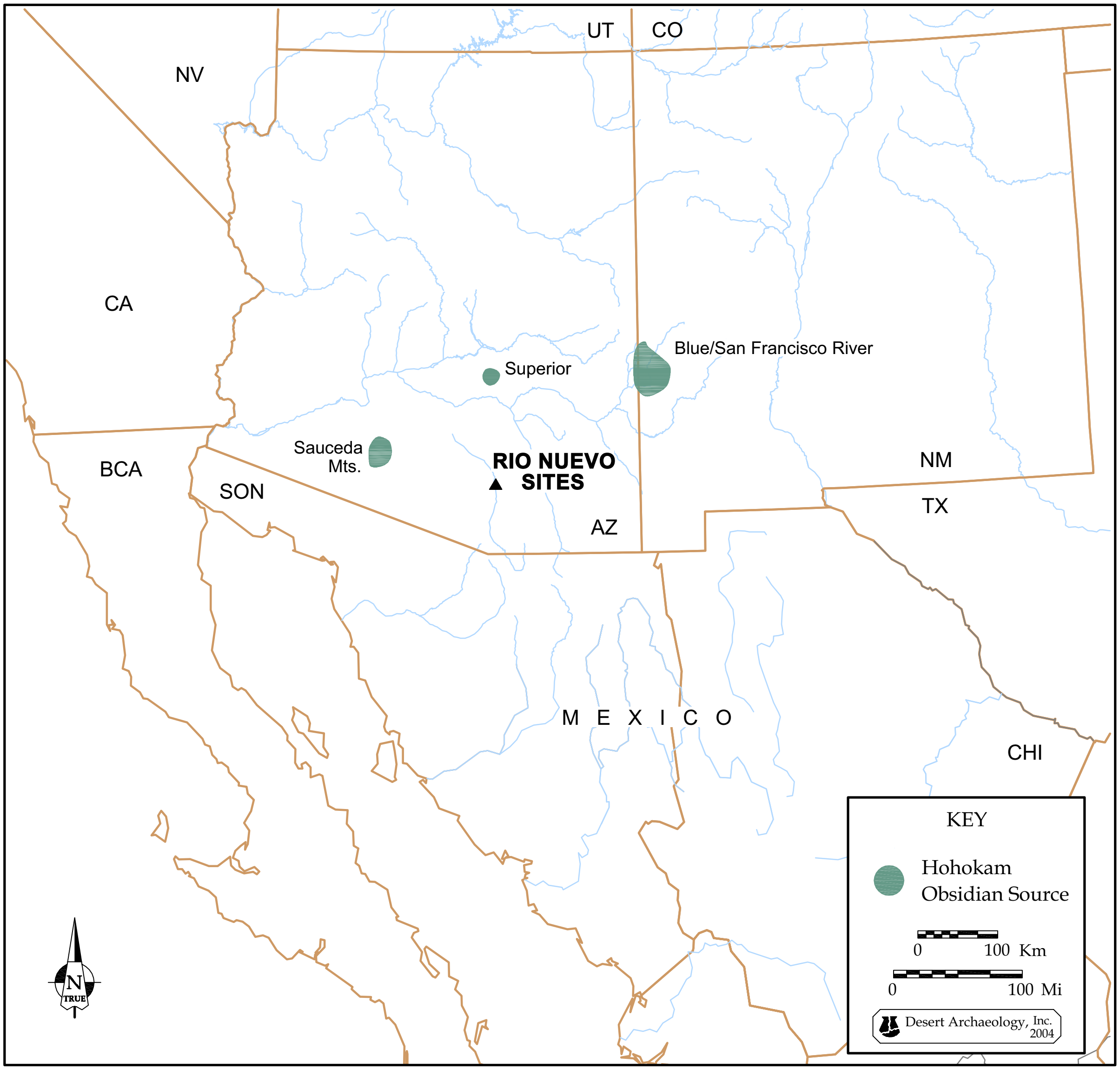

Figure 17.2. Identified material sources of Hohokam obsidian artifacts from the Rio Nuevo sites.

The single Classic period obsidian artifact recovered during this project, a projectile point tip from the Tucson Presidio, fits the previously known pattern of the relatively nearby Sauceda Mountains being the primary source for Classic period communities in the Tucson Basin (Bayman 1995). However, the second-most important source, the Vulture, near Wickenburg, Arizona, is some 250 km to the north. This contradicts the expectations of the down-the-line obsidian exchange proposed for most Classic period communities (cf. Bayman and Shackley 1999; Mitchell and Shackley 1995).

The analyses results for the Spanish period obsidian artifacts recovered from the Clearwater and Tucson Presidio sites (*n* = 6) provide the first information about the obsidian sources used during this early portion of the Historic era. A variety of sources are represented in the sample, all of them located at a distance between 200 km and 300 km away. This pattern contrasts with the prehistoric periods, when the closest sources to the Tucson Basin were well represented, if not predominant. Most of the Spanish period sources were located to the west, perhaps reflecting the difficulty that desert O'odham groups (Sobaipuri and Papago) faced in procuring obsidian from eastern sources after the intrusion of Apache groups into the highlands of the southern Southwest.

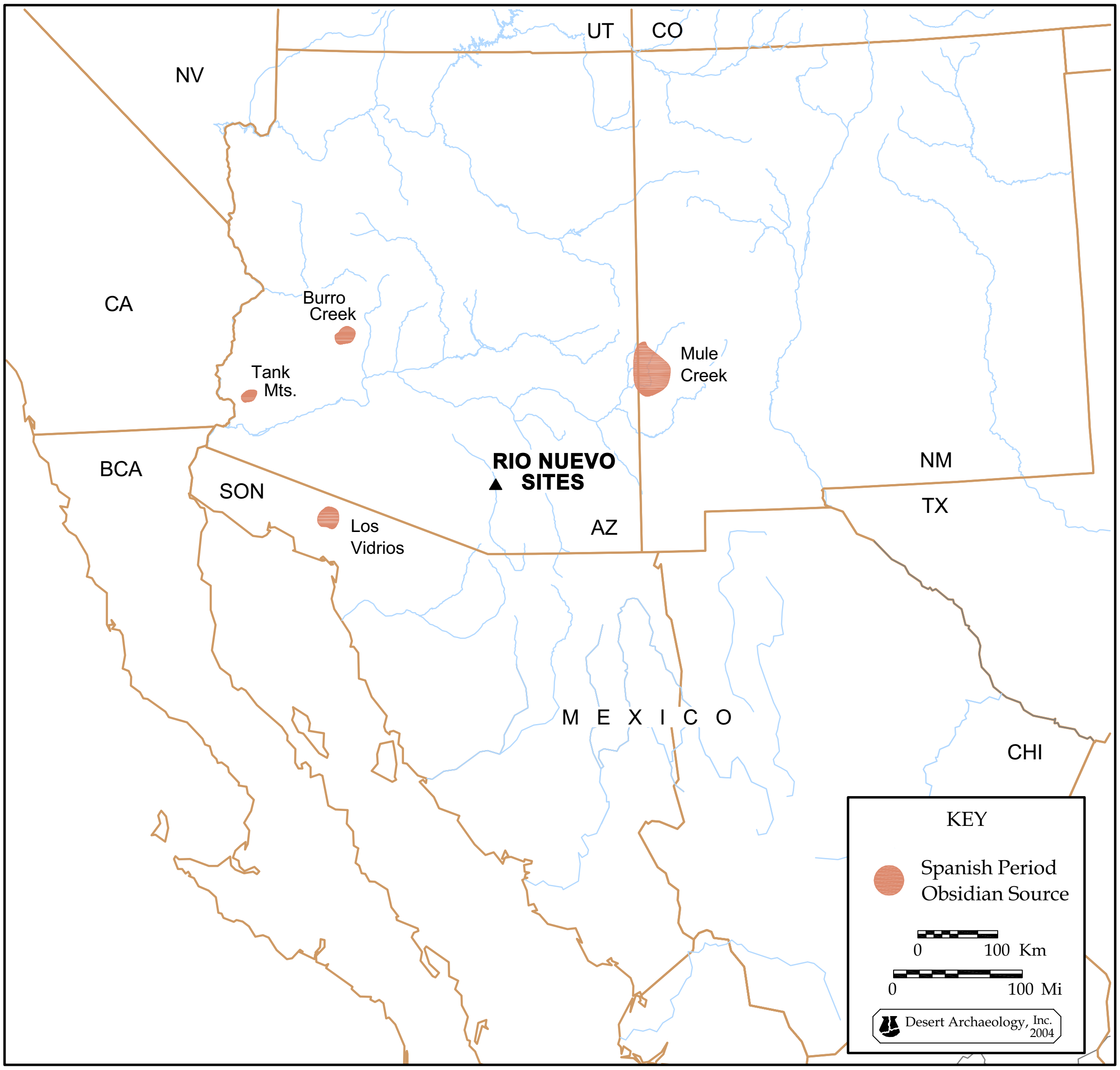

Figure 17.3. Identified material sources of Spanish period obsidian artifacts from the Rio Nuevo sites.

REFERENCES CITED

Baugh, Timothy G., and Fred W. Nelson, Jr.
1987 New Mexico Obsidian Sources and Exchange on the Southern Plains. *Journal of Field Archaeology* 14:313-329.

Bayman, James M.
1995 Rethinking "Redistribution" in the Archaeological Record: Obsidian Exchange at the Marana Platform Mound. *Journal of Anthropological Research* 51:37-63.

Bayman, James M., and M. Steven Shackley
1999 Dynamics of Hohokam Obsidian Circulation in the North American Southwest. *Antiquity* 73:836-845.

Glascock, M. D., R. Kunselman, and D. Wolfman
1999 Intrasource Chemical Differentiation of Obsidian in the Jemez Mountains and Taos Plateau, New Mexico. *Journal of Archaeological Science* 26:861-868.

Govindaraju, K.
1994 Compilation of Working Values and Sample Descriptions for 383 Geostandards. *Geostandards Newsletter* 18 (Special Issue).

Huckell, Bruce B.
1995 *Of Marshes and Maize: Preceramic Agricultural Settlements in the Cienega Valley, Southeastern Arizona*. Anthropological Papers No. 59. University of Arizona Press, Tucson.

Hughes, Richard E., and Robert L. Smith
1993 Archaeology, Geology, and Geochemistry in Obsidian Provenance Studies. In *Scale on Archaeological and Geoscientific Perspectives,* edited by J. K. Stein and A. R. Linse, pp. 79-91. Special Paper No. 283. Geological Society of America, Boulder.

Mabry, Jonathan B. (editor)
1998 *Archaeological Investigations of Early Village Sites in the Middle Santa Cruz Valley: Analyses and Synthesis,* 2 parts. Anthropological Papers No. 19. Center for Desert Archaeology, Tucson.

Mahood, G., and J. A. Stimac
1990 Trace-Element Partitioning in Pentellerites and Trachytes. *Geochimica et Cosmochimica Acta* 54:2257-2276.

Mitchell, Douglas R., and M. Steven Shackley
1995 Classic Period Hohokam Obsidian Studies in Southern Arizona. *Journal of Field Archaeology* 22:291-304.

Nelson, Fred W., Jr.
1984 X-Ray Fluorescence Analysis of Some Western North American Obsidians. In *Obsidian Studies in the Great Basi*n, edited by R. E. Hughes, pp. 27-62. Contributions of the University of California Archaeological Research Facility No. 45. University of California, Berkeley.

Renfrew, Colin
1975 Trade as Action at a Distance: Questions of Integration and Communication. In *Ancient Civilization and Trade*, edited by J. A. Sabloff and C. C. Lamberg-Karlovsky, pp. 3-60. University of New Mexico Press, Albuquerque.

Roth, Barbara J.
2000 Obsidian Source Characterization and Hunter-gatherer Mobility: An Example from the Tucson Basin. *Journal of Archaeological Science* 27:305-314.

Shackley, M. Steven
1990 *Early Hunter-Gatherer Procurement Ranges in the Southwest: Evidence from Obsidian Geochemistry and Lithic Technology*. Ph.D. dissertation, Department of Anthropology, Arizona State University, Tempe. University Microfilms International, Ann Arbor, Michigan.

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

1996 Range and Mobility in the Early Hunter-gatherer Southwest. In *Early Formative Adaptations in the Southern Southwest*, edited by B. J. Roth, pp. 5-16. Monographs in World Archaeology No. 25. Prehistory Press, Madison, Wisconsin.

1998 Geochemical Differentiation and Prehistoric Procurement of Obsidian in the Mount Taylor Volcanic Field, Northwest New Mexico. *Journal of Archaeological Science* 25:1073-1082.

Shackley, M. Steven
1999 Obsidian Sourcing. In *An Archaeological Investigation of Late Archaic Cerros de Trincheras Sites in Chihuahua, Mexico: Results of the 1998 Investigations*, by R. J. Hard and J. R. Roney, pp. 21-22. Special Report No. 25. Center for Archaeological Research, University of Texas at San Antonio.

2000 An Energy Dispersive X-ray Fluorescence (EDXRF) Analysis of Obsidian Artifacts from a Middle Rincon Component at Sunset Mesa (AZ AA:12:10 ASM), Tucson Basin, Arizona. In *Excavations at Sunset Mesa Ruin,* by M. W. Lindeman, pp. 261-282. Technical Report No. 2000-02. Desert Archaeology, Inc., Tucson.

2002 More than Exchange: Pre-Ceramic through Ceramic Period Obsidian Studies in the Greater North American Southwest. In *Geochemical Evidence for Long-Distance Exchange*, edited by M. D. Glascock, pp. 53-87. Bergin and Garvey, Westport, Connecticut.

2004 Obsidian Sourcing. In *Pots, Potters, and Models: Archaeological Investigations at the SRI Locus of the West Branch Site, Tucson, Arizona: Vol. 2. Synthesis and Interpretations*, edited by S. M. Whittlesey, p. 542. Technical Series No. 80. Statistical Research, Inc., Tucson.

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

Shackley, M. Steven, Jennifer Kahn, Elizabeth Eklund, and Caroline Ogasawara
2006 Source Provenience of Obsidian Artifacts from San Pedro Phase Contexts at Las Capas. In *Las Capas: Early Irrigation and Sedentism in a Southwestern Floodplain* (Draft), edited by J. B. Mabry. Anthropological Papers No. 28. Center for Desert Archaeology, Tucson.