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Background

In 1974 and 1975, a study of Peruvian archaeological obsidian at the Lawrence Berkeley National Laboratory (LBNL) identified a distinctive chemical composition of obsidian utilized in artifacts. For ease of reference it was called Pampas Type obsidian. Pampas Type obsidian was one of eleven common kinds of obsidian utilized in pre-Hispanic times in what now is Peru.[1] Pampas Type obsidian was documented as common only in the samples from sites in the Carhuarazo Valley of southern Ayacucho (Figure 1).[2] These obsidian artifacts had been collected by William Isbell, Patricia Knobloch, and Katharina Schreiber during a project of archaeological explorations (Burger and Asaro 1977:21-31, 1979:310-311). In the LBNL study, obsidian of the Pampas Type was found to be present, but less frequent, in some regions adjacent to the Carhuarazo Valley.

The diagnostic trace element composition of Pampas Type obsidian was determined at LBNL by the analysis of archaeological obsidian by instrumental neutron activation analysis (n=7) and X-ray fluorescence (n=36). These results suggested a single distinctive geological source of obsidian that was relatively homogenous in composition and was easily distinguishable on chemical grounds from the other major and minor obsidian types (Burger and Asaro 1979: tables 1, 2B). The scarcity or absence of Pampas Type obsidian outside the Carhuarazo region suggested that the geological source was probably located somewhere in this area. Subsequently, Schreiber encountered small unworked obsidian nodules near Huaycahuacho; these materials came from a secondary deposition, apparently eroded from the primary geological source of the obsidian (Burger and Asaro 1977:310). Samples from Huaycahuacho were analyzed at LBNL and were found to match the composition of the Pampas Type obsidian (Asaro and Burger unpublished data).

In 1981, Schreiber located the primary deposit of geological obsidian at Jampatilla during an archaeological survey near Huaycahuacho, and she obtained geological obsidian samples from three loci within this source

[1]In the original LBNL study, eight types of obsidian were identified as having been exploited with some frequency, and another eight distinctive chemical compositions were documented as existing among a small group of rare artifacts. Subsequent research on the obsidian of Cuzco by Burger in collaboration with Sergio Chávez and Karen Mohr Chávez (Burger *et al.* n.d.) indicates that at least three of these "rare types" were frequently used in the southern highlands. Additional obsidian sources are known to exist further south in Bolivia and Chile.

[2]Although we refer to the valley here as the Carhuarazo Valley, this is not a name that is used locally. Today, the river that flows north through this valley has a series of names, including Mayobamba, Sondondo, Jatun Mayo, Yanamachay, and Pampamarca, derived often from the name of whatever local village it passes at a particular point. Older maps of the valley indicate the name Carhuarazo for the river; hence this name is used to refer to the valley (Schreiber 1992:132).

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(Figure 2). Obsidian workshop areas and associated sites were also encountered. In 1991, archaeologist José Ccencho, a resident of Huaycahuacho, returned to the obsidian source at Jampatilla and made more detailed observations of the deposits and workshop areas.

Two years later, Michael Glascock and Hector Neff of the Missouri University Research Reactor (MURR) began to collaborate with Burger on additional studies of Central Andean obsidian, and six samples from the Jampatilla source were analyzed by instrumental neutron activation at MURR. The results of these analyses definitively confirmed that Jampatilla was the source of the Pampas Type obsidian. This article presents a description of the Jampatilla geological source, summarizes the analytical methods and results of the trace element analyses at MURR, compares them with the earlier LBNL data, and then briefly explores some of the archaeological implications of the identification of the Jampatilla source in light of the existing provenience studies of obsidian artifacts.

The Jampatilla Obsidian Source: Location and Geology

The Jampatilla source is located 3-4 km to the east-northeast of the town of Huaycahuacho, Lucanas Province, Department of Ayacucho (Figure 2).[3] It is found about 55 km north in a straight line from the town of Puquio and about 125 km south of the city of Ayacucho (Figure 1).

The local geology is characterized by Tertiary-Quaternary basalt flows at elevations exceeding 4000 meters above sea level (masl), producing broad tablelands that surround the valley to the east, west, and south (INGEMMET 1975). Where exposed, the basalt has a columnar aspect, indicating slow cooling. Steep-walled valleys were eroded into this tableland by fluvial activity, exposing the underlying deposits of Tertiary tuffs between elevations of 2950 and 4000 masl. These tuff deposits vary in density and produce local topography characterized by gentle slopes, nearly level shelves, and very steep cliff faces. Below 3600 masl, soils are moderately well developed in gently sloping and level areas, and support local agriculture. Below elevations of 1950 masl, fluvial action has exposed Cretaceous-Tertiary sandstone formations. Soils are poorly developed in these areas.

The east side of the valley, as viewed from Huaycahuacho, is a roughly semicircular basin flanked to the north and south by the Jampatilla and Toqsa ridges, respectively. The upper edge of the basin is formed by the exposed basalt cliffs that define the upper perimeter of the valley. Several outcrops of obsidian were recorded in July and August of 1981 during the course of an archaeological survey (Schreiber 1982, 1992:115-163). The largest outcrop was located along the north side of the Jampatilla ridge, where obsidian nodules up to 8 cm in diameter were observed in a deposit of loosely consolidated tuff at 3500 masl. A small area at the same elevation on the south side of the ridge was also recorded. The deposit may actually be continuous around the west end of the ridge, but the density of chipped obsidian debitage made it impossible to determine whether there was a natural deposit in this area as well.

A second outcrop was observed to the east and very near to the first, but separated from it by a steep-sided ravine, on the flanks of the basin. Here the deposit also comprised nodules within loosely consolidated tuff, but the nodules were somewhat larger than those of the ridge deposit, reaching 10-12 cm in diameter. The elevation of this deposit is some 25-50 m higher than the first.

A third deposit was observed on the north face of the Toqsa ridge, in very loosely consolidated tuff. This deposit, at 3450 masl, is somewhat lower than the larger Jampatilla deposits. Here the nodules were much smaller,

[3] Jampatilla Source Location:
Latitude-Longitude, general location: 14°13'S, 73°5'W
UTM coordinates of recorded deposits: north side ridge deposit: E 615500 to E 616100, N8428900;
south side ridge deposit: E 616200, N 8428750
hillside deposit: E 616800, N 8428700
Toqsa deposit: E 615700, N 8426200.

reaching only 4-5 cm, and in lower concentrations than elsewhere. This stratum may extend farther to the northeast toward the second outcrop, but the extreme steepness of the topography prevented further observation.

Very small nodules (1-2 cm in size) are seen throughout the Huaycahuacho area, eroding down from the source deposits. On the basin slopes where soils are moderately well developed, obsidian is observed in low frequencies in agricultural fields, but in higher frequencies on small hilltops and in exposed erosion cuts and ravines. Below 2950 masl, where soils are poorly developed, the density of obsidian nodules on the surface is high.

Although no systematic study has been conducted of the physical characteristics of Jampatilla Source obsidian, most of the material examined was of good purity and flaking quality. It varied in clarity from transparent colorless to black, and the coloration was uneven with black patches or streaks contrasting with colorless clear areas.

Archaeological Sites Associated with the Source

Archaeological sites associated with the Jampatilla Source were recorded both during the 1981 survey, and by a second survey undertaken by José Ccencho (Ccencho Huamaní 1991). Numerous workshop areas are found in the vicinity of the source, and some of these are quite large (Figure 2). The entire length of the summit of the Jampatilla ridge is littered with obsidian debitage in greater and lesser densities. In one area of high density it was estimated that there were in excess of 200 pieces of obsidian debitage per square meter. Another workshop area extends from the northwest end of the ridge and down the slope; it covers roughly 25 ha and is densely covered with lithic debris. Other workshop areas were recorded below the Jampatilla ridge to the west. Although finished tools were relatively rare at any of the workshops, the few projectile points observed range in date from the Preceramic Period through the Middle Horizon. The only major archaeological site, other than workshops, located adjacent to the Jampatilla ridge is Willkaya (Ay5-46), which was a small Huari imperial facility (Schreiber 1992: 155-157).

Neutron Analyses at MURR

Six source specimens were submitted to MURR from the Jampatilla Obsidian Source. This sample included obsidian from the three outcrops identified by Schreiber.

Sample Preparation and Analysis

Analytical samples were prepared at MURR from the Jampatilla source specimens by using a ceramic mortar and pestle to break off small fragments weighing 50-100 mg.

Samples were prepared for short irradiation by weighing 100 mg of material into small polyvials. Standards of the SRM-278 Obsidian Rock and SRM-1633a Fly Ash reference materials were similarly prepared. Samples for long irradiation were prepared by weighing 250-300 mg of fragments into high-purity quartz vials which were sealed in an oxygen torch flame. For the smaller samples, the short irradiation sample was transferred from the polyvial into a quartz vial. Further details concerning the procedures for sample preparation and standardization are available in Glascock *et al.* (1988).

MURR's pneumatic-tube irradiation system was used for short irradiation of all samples and standards. Samples were sequentially activated for five seconds in a thermal neutron flux of 8×10^{13} n cm^{-2} s^{-1}. Following activation, the samples were allowed to decay for 25 minutes before measurement on a high-resolution germanium detector for 12 minutes. By comparing the unknowns with the reference standards, the concentrations of five short-lived elements were determined: Cl, Dy, K, Mn, and Na.

The quartz vials containing the samples and standards for long irradiation were wrapped in aluminum foil and irradiated for 70 hours in a thermal neutron flux of 5×10^{13} n cm^{-2} s^{-1}. After irradiation, the samples were allowed to decay for 9-10 days before conducting a measurement for 2,000 seconds each to determine seven medium-lived elements: Ba, La, Lu, Nd, Sm, U, and Yb. After an additional decay of 4-5 weeks, the samples were measured for 10,000 seconds each to determine the following fifteen long-lived elements: Ce, Co, Cs, Eu, Fe, Hf, Rb, Sb, Sc, Sr, Ta, Tb, Th, Zn, and Zr.

Results and Interpretation

Results for the six Jampatilla source samples are presented in Table 1. Earlier data from the LBNL for seven Pampas Type artifacts reported by Burger and Asaro (1977) are presented for comparison in Table 2. The LBNL data were normalized to the MURR standard through unpublished analyses of Perlman's Pottery Standard at MURR. Agreement between the best elements is quite good and strongly suggests that the artifacts of Pampas Type obsidian artifacts came from the Jampatilla source. This is further supported by two accompanying bivariate plots for Cs vs Hf and Ba vs Eu (Figures 3 and 4). The plots illustrate the compositional similarity of the Jampatilla source specimens and Pampas Type artifacts to one another and their differentiation from other significant obsidian types reported in the Berkeley study. Ninety-five percent confidence ellipses are shown surrounding each of the obsidian types.

Archaeological Ramifications

Confirmation that the Jampatilla Obsidian Source provided the raw material for artifacts of Pampas Type obsidian permits a more precise discussion of pre-Hispanic obsidian procurement and exchange in the south central highlands of Peru. The Jampatilla Obsidian Source appears to have been exploited throughout the prehistory of the Carhuarazo Valley (Table 3). As noted above, Schreiber identified lithics dating to the Preceramic Period at workshops near the obsidian outcrops. Although numerous Formative (*i.e.*, Initial Period/Early Horizon) sites have been located in the Carhuarazo Valley, and these are characterized by an abundance of obsidian artifacts, no samples have yet been analyzed. Obsidian from the Jampatilla Obsidian Source has been recovered at the Initial Period/Early Horizon sites of Waywaka in Andahuaylas and Hacha in Acarí. Subsequent use of Jampatilla obsidian during the Early Intermediate Period and Middle Horizon is suggested by the artifacts analyzed from Corralpata (Ay5-5) and Jincamocco (Ay5-6). The exploitation of the Jampatilla Source during the subsequent Late Intermediate Period and Late Horizon is implied by the results of our analyses from Willka Cahuana (Ay5-7) and Canichi (Ay5-1).

In the Central Andes, this pattern of prolonged exploitation of an obsidian source throughout the prehistoric sequence is by no means limited to Jampatilla. On the contrary, it is apparently common and has been well documented for Quispisisa obsidian (Burger and Asaro 1979). Metal tools never entirely replaced stone artifacts in pre-Hispanic times and obsidian, the sharpest and most easily flaked of lithic raw materials, continued to be popular until the Spanish Conquest. This was especially true in areas with nearby geological sources of obsidian.

The documentation of a small Huari outpost immediately adjacent to obsidian workshop areas and less than 1 km from the obsidian outcrops at Jampatilla suggests that the local representatives of the Huari state may have been interested in controlling exploitation of the obsidian source. Additional evidence that the Jampatilla Obsidian Source was a resource for the Huari state is reflected in the numerous obsidian artifacts of Jampatilla Source obsidian that have been recovered 10 km away at the local Huari administrative center of Jincamocco (Burger and Asaro 1979; Schreiber 1992:246). Our analysis at LBNL of 51 obsidian artifacts from Jincamocco indicated that 45% of them were made of obsidian from Jampatilla (Table 3).

While it might be tempting to see the Jampatilla Obsidian Source as one of the reasons for establishing the Huari administrative center in the Carhuarazo Valley, the existing evidence from Huari centers in other regions seems to indicate that Jampatilla obsidian was rarely exported during the Middle Horizon. Provenience studies of obsidian from the administrative centers at Huari (n=55), Pikillacta (n=8) and Cerro Baúl (n=29) have all failed to encounter examples of Jampatilla obsidian (Burger and Asaro 1979, unpublished data). The case of Cerro Baúl in the Osmore drainage is particularly interesting because obsidian artifacts made from Quispisisa obsidian were documented at the site, while obsidian from the closer source at Jampatilla was entirely absent from our sample of artifacts.

One of the unexpected features of pre-Hispanic obsidian procurement in the Carhuarazo Valley is the failure of the Jampatilla Source obsidian to dominate the assemblages of archaeological sites near the geological source. In the LBNL study (Burger and Asaro 1979), samples from four sites in the Carhuarazo Valley were analyzed. In three of these four sites, (Ay5-5, Ay5-6, and Ay5-7) obsidian from the Quispisisa source in Huancavelica outnumbers artifacts from the local obsidian source in our sample. While the Jampatilla source was located 10 km or less from these sites, acquisition of Quispisisa obsidian required a lengthy journey. Our sample and selection procedures from most sites is too small and unsystematic to permit anything approaching statistical significance, but the rough consistency between the sites is suggestive. Moreover, analyses of 51 artifacts from the Middle Horizon center of Jincamocco (Ay5-6) determined that the raw material for 47% of the artifacts were of Quispisisa obsidian, compared to only 45% from the more local source at Jampatilla. Ay5-1 and Ay5-7 are habitation sites that postdate the Middle Horizon, thus, the popularity of imported Quispisisa obsidian continued into late prehistoric times and was not merely a product of Huari domination. In fact, of the obsidian samples analyzed from these two late prehistoric villages, three samples (37.5%) were from the Quispisisa source. While the sample is small, it does not indicate a sharp drop in the procurement of obsidian from Huancavelica, despite the continued exploitation of the local source.

How can this patterning be explained? The types of volcanic glass from Jampatilla and Quispisisa are visually similar. Although some samples from Quispisisa do show some distinctive qualities, such as red spots from iron impurities, most obsidian from the two sources is indistinguishable without laboratory analysis. In general, the visual properties of obsidian do not seem to have been an important consideration in the selection of raw material for what were usually crude utilitarian lithic flakes and tools. Thus, appearance does not seem to have been the reason that exotic obsidian from Quispisisa and elsewhere was sought with such great frequency. An alternative possibility is that the geological character of Jampatilla Obsidian Source made its raw material inferior to that of Quispisisa from a technological perspective for some purposes, and as a consequence of this, obsidian from distant sources at Quispisisa was imported despite easy access to raw material from the local source.

Exploration of this hypothesis would require more detailed studies of the geological deposits and workshops at Jampatilla and other sources. Nevertheless, it is worth noting that the investigations at the Jampatilla outcrops have only encountered obsidian as relatively small nodules. Of the three primary outcrops located, the largest nodules of obsidian encountered measured only 10-12 cm and in some portions of the primary deposit obsidian nodules measured only 4-5 cm. This pattern contrasts with that of some other obsidian sources, where massive blocks of high quality obsidian can be observed. A 10-12 cm obsidian nodule, while large enough to produce a small projectile point or utilizable flakes, presents inherent technological limitations, particularly when compared to obsidian found in larger form. While information available is insufficient for any conclusive statements, further research into this question is warranted.

Schreiber has argued that in Middle Horizon times, a major road that passed alongside of the Jampatilla obsidian deposit connected the site of Huari in the highlands of Ayacucho with Nazca on the southern Peruvian coast via the Carhuarazo Valley (Schreiber 1984:274). Given this long-standing pattern of movement, it might be presumed that obsidian from the

Jampatilla source would be found with some frequency at sites in these somewhat distant areas. Despite this expectation, no obsidian from the Jampatilla source has been documented from the eleven sites in Ayacucho (including Huari), although a substantial number (n=137) of obsidian artifacts has been analyzed from sites of different ages in this region (Burger 1981; Burger and Asaro 1978, 1979). Similarly, Jampatilla source obsidian was not encountered in the sample tested (n=52) at LBNL from two sites (San Nicolás and Poroma) in the Nazca drainage (Burger and Asaro 1979:table. 3). The highland trunk of a second pre-Hispanic road passing through the Carhuarazo Valley led northeast to the Cuzco Valley (Schreiber 1987:276, figure 5); this early road was used later by the Incas. Over three hundred obsidian artifacts from sites of different ages have been analyzed from Cuzco, but only a single artifact proved to be made of material from the Jampatilla source (Burger and Asaro 1979:311). Unfortunately, it comes from the site of Wimpilla, a poorly known multi-component site, and the explanation of this anomalous surface find remains elusive.

Thus, the existing evidence suggests that the Jampatilla Source was exploited largely by and for the local populations of the Carhuarazo Valley. Building upon our discussion of the popularity of imported Quispisisa obsidian in the Carhuarazo Valley, it can be suggested that the reasons for the limited distribution of Jampatilla obsidian in distant areas may have more to do with the geology of the Jampatilla obsidian deposit than it does with the marginalization or isolation of the Carhuarazo Valley from the rest of southern Peru in pre-Hispanic times.

Nevertheless, obsidian from the Jampatilla Obsidian Source was occasionally utilized at sites outside the Carhuarazo Valley. One of the areas for which this has been documented is the lower Acarí Valley, some 150 air kilometers from and 3300 meters in altitude below the obsidian source at Jampatilla. Another area that utilized obsidian from the Jampatilla Source is Andahuaylas, some 86 km away in the highlands to the northeast.

The evidence for the Acarí Valley comes from the site of Hacha. Hacha appears to have been a small agricultural village occupied during the end of the Initial Period and the beginning of the Early Horizon. Judging from the most recent studies by Riddell and Valdéz (1988) and Robinson (1994), the obsidian points that were recovered on the surface by Rowe, Menzel, and others (Rowe 1967) most likely date to the final episode in the site's occupational history (known as Haldas 2), probably during the Early Horizon. A radiocarbon measurement of 2590±200BP (UCR-2207) from a human burial associated with an obsidian point gives a rough idea of the age of the Hacha 2 component (Robinson 1994:14-17, figure 18). A sample of 64 points from Hacha was analyzed at LBNL, of which 7 (11%) came from the Jampatilla Source; 40 (62.5%) came from more distant Quispisisa.

In the Andahuaylas area, excavations and surveys by Joel Grossman provided an excellent sample (n=84) from the Waywaka site and a small sample (n=2) from the nearby Kunka Taka site (Burger and Asaro 1979:table 5; Grossman 1985). At Waywaka, about 20% of the obsidian artifacts analyzed were made of obsidian brought from the Jampatilla Source, and examples of the Jampatilla obsidian were found in all of the site's phases, including those preceding and coeval with the Hacha projectile points. As noted previously (Burger and Asaro 1979:31), the presence of Jampatilla obsidian in Waywaka and Hacha suggests a pattern of cultural and economic interaction running up the Acarí and Sondondo Rivers. Such a pattern of interaction would have traversed the axis of the Andes and linked ecologically disparate but complementary zones in the manner discussed by John Murra (1972) and others (*e.g.*, Flores Ochoa 1968). The presence in small quantities of Andahuaylas A Type and Andahuaylas B Type obsidian at Hacha, collectively constituting 6% of the sample, (Burger and Asaro 1993:211, table 11) reinforces the argument that such an exchange network spanning these diverse ecological habitats existed during the beginning of the Early Horizon (if not before). The geological sources for Andahuaylas A and Andahuaylas B obsidian have yet to be located, but given the restricted range of artifacts made from this material, it is likely that the obsidian deposits will be found somewhere in the Department of Apurímac, perhaps in the Andahuaylas region, where these types constitute the majority of the obsidian utilized (Burger and Asaro 1979:311, tables. 4, 5). This sphere of interaction linking Andahuaylas with Acarí would have functioned independently of the Chavín sphere of interaction which never reached this far south. Moreover, the continued appearance of Jampatilla obsidian in the later occupation layers at Waywaka and the late site of Kunka Taka (as well as the continued presence of Andahuaylas A Type obsidian in the Carhuarazo Valley) suggests that this pattern persisted long after the Early Horizon.

The relatively restricted distribution of Jampatilla obsidian beyond the Carhuarazo Valley has parallels with many other kinds of Peruvian obsidian. These obsidian types, because of their localized distribution, might be considered as deriving from "minor" sources. Obsidian types of localized importance that were only rarely carried beyond the hinterland of their respective source area include the Acarí Type, the Ayacucho Type, the Andahuaylas A Type, and the Andahuaylas B Type. In contrast, raw material from the Quispisisa Obsidian Source, the Alca Obsidian Source (Cuzco Type obsidian), and the Chivay Obsidian Source (Titicaca Basin Type obsidian) all had pan-regional distributions.[4] These sources can be considered of "major" importance, particularly from the perspective of long-distance exchange networks. Why some sources of obsidian, like the one at Jampatilla, remained minor, while others achieved pan-regional significance remains an intriguing problem. Its resolution will require consideration of the geological quality and location of the different sources, as well as the mechanisms of exchange, and the changing socio-economic and political contexts in which this exchange occurred.

[4]The source of the Titicaca Basin Type obsidian has been identified in the Chivay area and the source of Cuzco Type obsidian has been discovered at Alca in the Cotahuasi area. Both of these "major" sources are located in the Department of Arequipa (Burger and Asaro 1993; Burger *et al.* 1998a, 1998b).

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Table 1. Element concentrations in obsidian source specimens from the Jampatilla source.

Element	*anid RLB039*	*anid RLB040*	*anid RLB041*	*anid RLB042*	*anid RLB043*	*anid RLB044*
Ba (ppm)	785	753	754	778	744	771
La (ppm)	40.4	40.7	40.6	40.7	40.0	40.5
Lu (ppm)	0.431	0.437	0.458	0.435	0.433	0.441
Nd (ppm)	27.4	27.1	29.2	27.1	27.4	27.3
Sm (ppm)	5.35	5.45	5.48	5.39	5.30	5.36
U (ppm)	8.18	8.29	8.36	8.11	8.21	7.78
Yb (ppm)	2.55	2.57	2.55	3.00	2.77	2.61
Ce (ppm)	75.3	76.6	76.0	75.5	75.0	76.3
Co (ppm)	0.553	0.572	5.61	0.566	0.553	0.573
Cs (ppm)	12.3	12.4	12.3	12.4	12.4	12.4
Eu (ppm)	0.975	1.008	0.994	1.003	0.986	1.003
Fe (%)	0.868	0.889	0.887	0.883	0.877	0.886
Hf (ppm)	4.84	4.92	4.91	5.28	4.83	4.94
Rb (ppm)	152	153	153	155	153	155
Sb (ppm)	1.742	1.708	1.712	1.749	1.706	1.698
Sc (ppm)	2.33	2.38	2.35	2.36	2.34	2.36
Sr (ppm)	354	385	411	388	335	356
Ta (ppm)	1.61	1.61	1.61	1.65	1.61	1.63
Tb (ppm)	0.688	0.688	0.713	0.682	0.617	0.638
Th (ppm)	12.5	12.6	12.5	12.5	12.5	12.5
Zn (ppm)	61.4	80.7	80.4	81.4	81.0	82.0
Zr (ppm)	205	202	194	215	195	214
Cl (ppm)	602	659	621	614	583	628
Dy (ppm)	4.94	4.55	4.26	4.92	4.54	4.50
K (%)	4.01	3.63	3.69	3.94	4.12	3.60
Mn (ppm)	641	622	639	648	639	635
Na (%)	3.58	3.51	3.55	3.62	3.57	3.56

ppm -- parts per million

Table 2. Comparison between mean concentrations and standard deviations for Jampatilla source specimens and Pampas-type artifacts.

Element		*Jampatilla source specimens analyzed at MURR (n=6)*			*Pampas-type artifacts analyzed at Berkeley (n=7)*[a]		
Ba	(ppm)	764	±	16	794	±	22
Ce	(ppm)	75.8	±	0.6	77.7	±	2.5
Cl	(ppm)	618	±	25		---	
Co	(ppm)	0.56	±	0.01	0.61	±	0.08
Cs	(ppm)	12.4	±	0.1	12.8	±	0.3
Dy	(ppm)	4.62	±	0.26	4.23	±	0.12
Eu	(ppm)	0.995	±	0.013	1.03	±	0.02
Fe	(%)	0.882	±	0.008	0.898	±	0.018
Hf	(ppm)	4.95	±	0.16	5.09	±	0.18
K	(%)	3.83	±	0.22	3.45	±	0.18
La	(ppm)	40.5	±	0.3	42.8	±	1.6
Lu	(ppm)	0.44	±	0.01		---	
Mn	(ppm)	637	±	9	584	±	10
Na	(%)	3.57	±	0.04	3.33	±	0.04
Nd	(ppm)	27.6	±	0.8		---	
Rb	(ppm)	153	±	1	155	±	8
Sb	(ppm)	1.72	±	0.02	1.84	±	0.14
Sc	(ppm)	2.35	±	0.02	2.45	±	0.03
Sm	(ppm)	5.39	±	0.06	5.44	±	0.04
Sr	(ppm)	371	±	28	280	±	65
Ta	(ppm)	1.62	±	0.02	1.76	±	0.03
Tb	(ppm)	0.67	±	0.04		---	
Th	(ppm)	12.5	±	0.1	13.3	±	0.1
U	(ppm)	8.16	±	0.20	7.80	±	0.07
Yb	(ppm)	2.68	±	0.18	2.63	±	0.05
Zn	(ppm)	78	±	8		---	
Zr	(ppm)	204	±	9		---	

ppm -- parts per million

[a] Normalized to MURR through unpublished analyses of Perlman's Pottery standard relative to the SRM-278 Obsidian Rock reference standard previously conducted at MURR.

Table 3. Archaeological sites with artifacts of Jampatilla and other types of obsidian.

	Jampatilla source	*Quispisisa source*	*Andahuay-las A type*	*Alca source*	*Andahuay-las B Type*	*Acarí type*	*Other types*
Sites in the Cara-huarazo Valley							
▸ PAy 5-1	3	1	1				
▸ PAy 5-5	4	6	1				
▸ Jincamocco	22	24		5			
▸ PAy 5-7	1	2					
Sites in the Pampas Valley							
▸ Waywaka	16	15	33	2	11		3
▸ Kunka Taka	1				1		
Site in the Acarí Valley							
▸ Hacha	7	40	2		2	12	1
Site in the Cuzco Valley							
▸ Wimpilla	1			1			2

Figure 1. Map of southwestern Peru showing the location of obsidian sources and archaeological sites mentioned in the article.

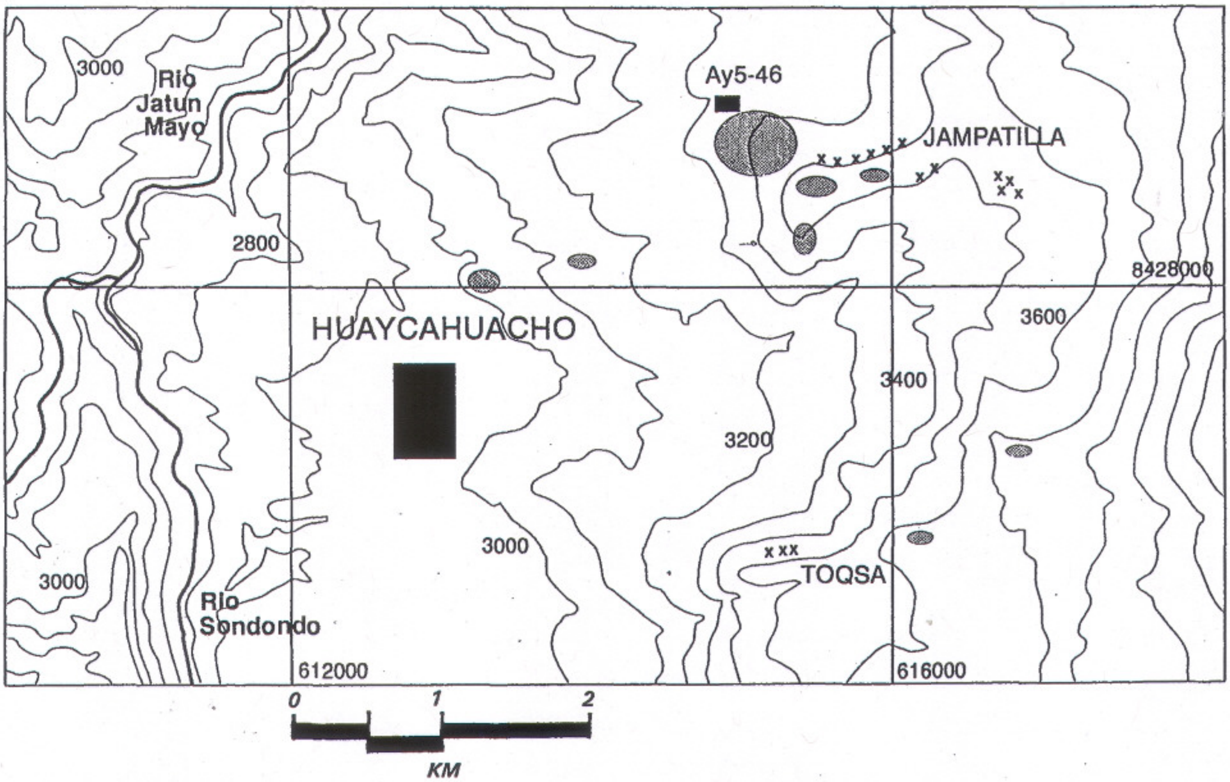

Figure 2. Map of the Jampatilla source. Obsidian outcrops observed in 1981 are marked with X's. Outcrops occur along the north side of the Jampatilla ridge and on the valley side to the southeast. Another smaller outcrop was observed on the north side of the Toqsa ridge. Shaded areas indicate prehistoric obsidian workshops. Ay5-46 is an archaeological site pertaining to the Huari Empire (AD 750-900). Map based on Carta Nacional, 1:100,000 series, sheet 29-0 "Querobamba," Instituto Geográfico Militar, Perú.

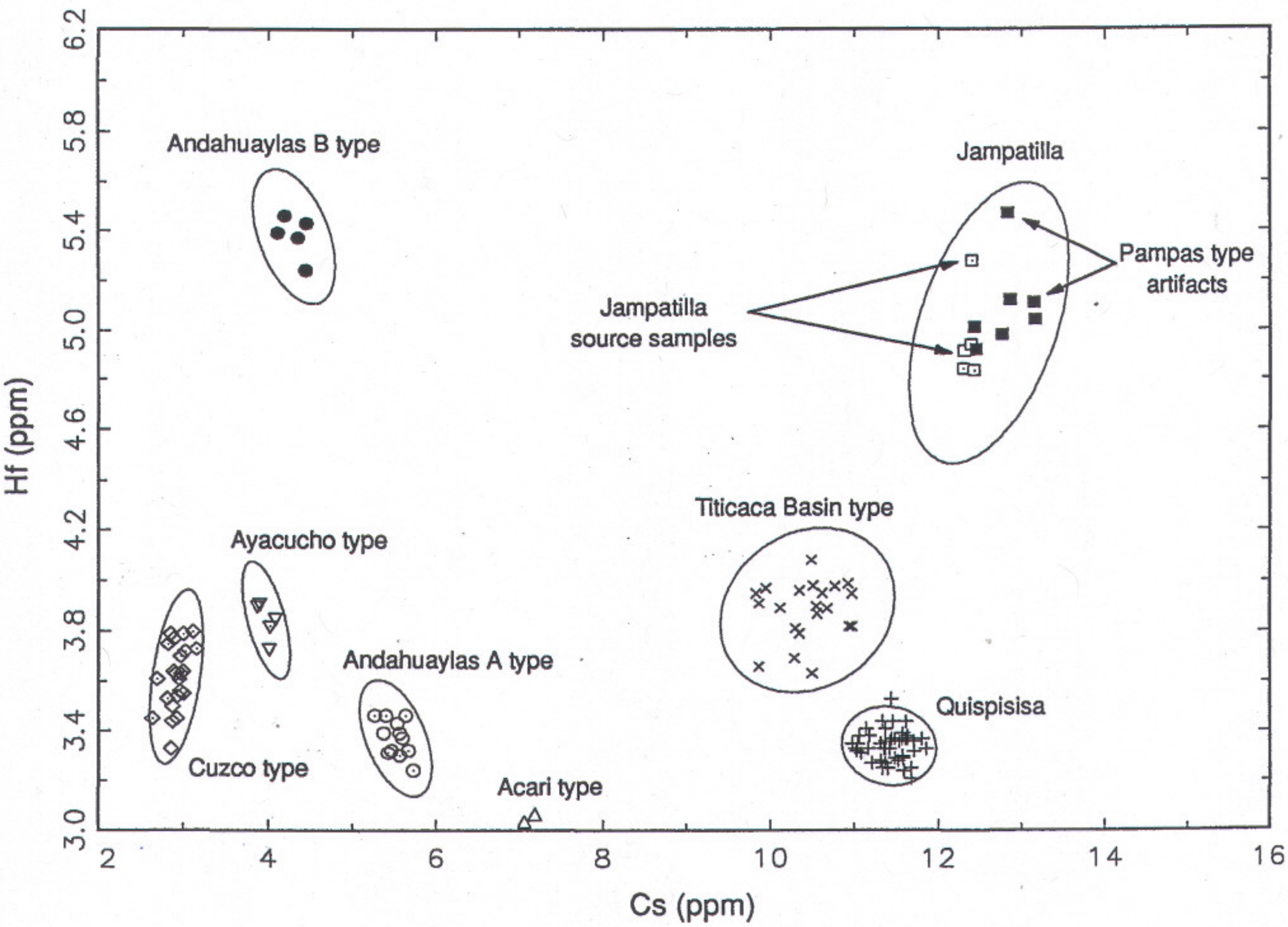

Figure 3. Bivariate plot of Cs vs. Hf for obsidian artifacts and source specimens from Peru analyzed at LBNL and MURR with 95% confidence ellipses surrounding source groups with five or more members. The confidence ellipse for the Jampatilla source samples and Pampas type artifacts was calculated after combining them into a single group.

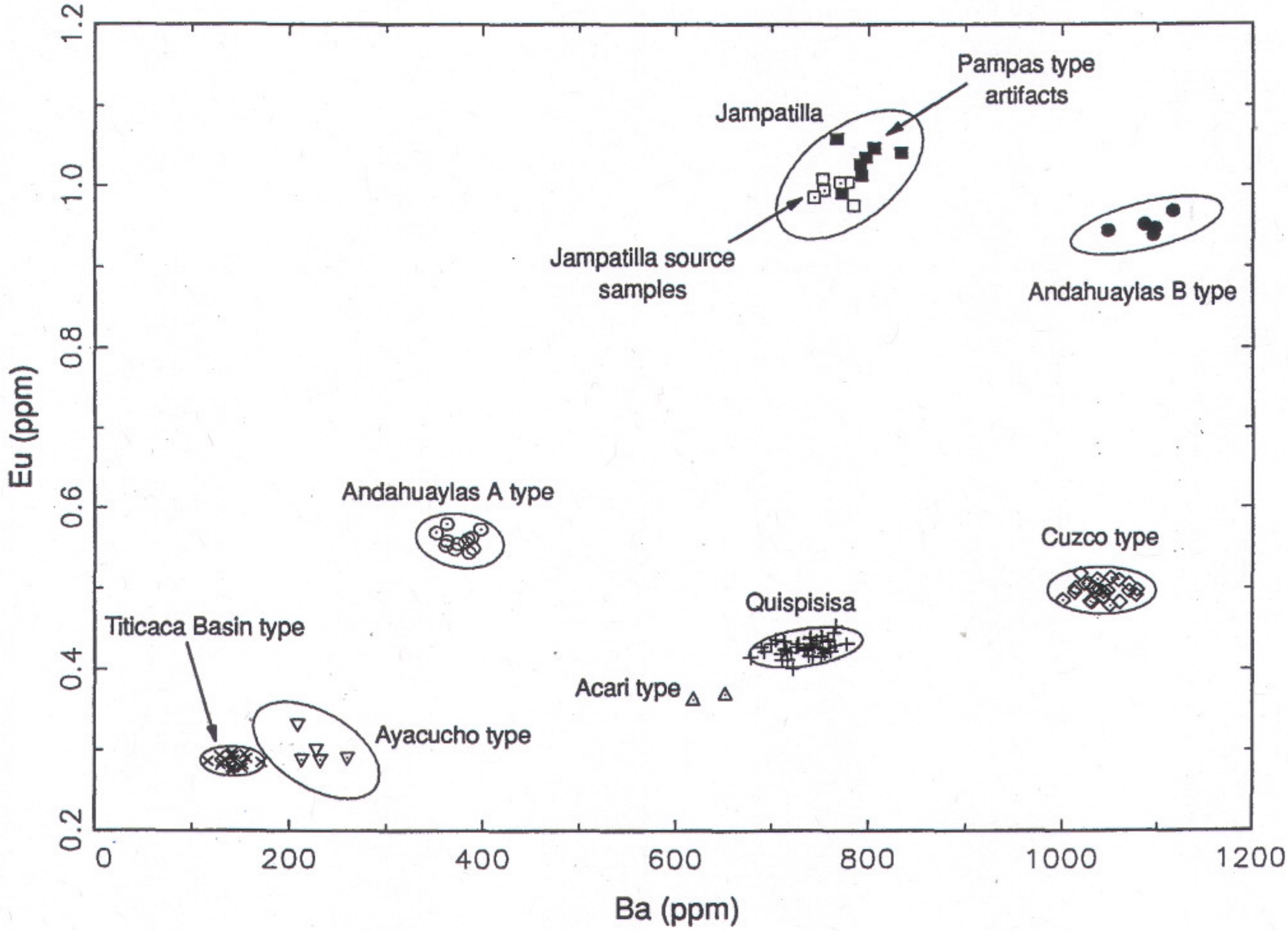

Figure 4. Bivariate plot of Ba vs. Eu for obsidian artifacts and source specimens from Peru analyzed at LBNL and MURR with 95% confidence ellipses surrounding source groups with five or more members. The confidence ellipse for the Jampatilla source samples and Pampas type artifacts was calculated after combining them into a single group.