Title

Trace Element Analysis of Obsidian Artifacts from the Andes: New Perspectives on Pre-Hispanic Economic Interaction in Peru and Bolivia

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Publication Date
1977-06-01

Energy and Environment Division

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June 1977

Lawrence Berkeley Laboratory University of California/Berkeley

Prepared for the U.S. Energy Research and Development Administration under Contract No. W-7405-ENG-48

LBL-6343

LBL-6343

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New Perspectives on Pre-Hispanic Economic Interaction in Peru and Bolivia

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To be published in Spanish in 'Revista del Museo Nacional', Lima, Peru

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INTRODUCTION

This article is an introduction to the study of the distribution by trade of obsidian artifacts in ancient Peru and Bolivia. Obsidian tools were used as early as Preceramic times and continued to be popular through the Middle Horizon. The techniques of neutron activation analysis (NAA) and x-ray fluorescence (XRF) were used to identify eight main types of obsidian and to infer the locations of the natural obsidian sources. These data, in conjunction with the findings of the archaeological research, have been used to make observations on the changing patterns of regional and pan-regional economic interaction. The data are discussed in context of the role of obsidian in ancient Andean society and the social mechanisms by which this rare material was distributed.

Obsidian, a natural glass, has a hardness of 5.5 on the Moh scale (slightly harder than window glass) and is similar in chemical (but not structural) composition to granite. It is formed during volcanic activity by the cooling of viscuous lava rich in silica (over 65%) at a rate slow enough to allow volatiles to escape, but rapid enough to prevent crystallization. Because crystallization does not occur, obsidian has a vitreous luster and the ability to produce conchoidal fractures when struck. This fracturing characteristic is one of its most important qualities, for it produces the sharpest edge of all stone artifacts and makes obsidian amenable to precision chipping.

Obsidian suitable for the production of artifacts must come from geologically recent formations, usually Tertiary or younger, because it is unstable and devitrifies over time, losing the fracturing qualities for which it is valued. Moreover, even some geologically recent obsidian flows have not been suitable for chipping because of factors such as the presence of phenocrysts, spherical aggregates, or hydration due to groundwater. So, although obsidian has great potential for use in tools, it occurs rarely, if at all, in most areas.[1] In the Central Andes, obsidian deposits exist in the highlands of Ecuador, southern-central and southern Peru, and Bolivia.[2]

PROVENIENCE ANALYSIS

The relative scarcity of obsidian suitable for tools often resulted in the trade of obsidian over long distances. Archaeologists interested in ancient trade and communication have found the characteristics of obsidian useful in reconstructing these movements. Obsidian from archaeological sites can be matched with natural obsidian sources through the use of chemical fingerprinting methods.

The prominent visual qualities of obsidian are rarely of use in distinguishing different obsidian sources. Black, gray, clear, red, brown, streaked, and mottled obsidian can all occur in a single deposit. Unfortunately, this has misled many archaeologists, who have devoted time to sorting and counting their obsidian collections using these visual qualities.[3]

Research on Mesoamerican, North American, and Old World obsidian has shown that the most effective method of distinguishing different sources is through analysis of trace element composition. (A trace element is one that makes up less than one percent of the material being analyzed.) The implicit assumption behind such an approach is that the obsidian coming from any one source will have a characteristic trace element composition which can serve as a distinctive geochemical fingerprint. Moreover, the chemical heterogeneity of a single source must be small in comparison with the differences in composition between sources. These assumptions have been rigorously tested by Bowman, Asaro, and Perlman (1973, a & b). Their findings show that obsidian sources can be very homogeneous. Where this is not the case (as in the single obsidian source at Borax Lake in California), the variation is extraordinarily coherent. The patterning removes any difficulty in identification despite the variation in the source's trace element composition. Compositional homogeneity and coherent variation make provenience analysis less difficult for obsidian than for many other types of stone or ceramics. For example, neutron activation studies of quartzite statues and quarries in Egypt detected substantial compositional variation in a single quartzite source (Heizer et al., 1973). In contrast with obsidian, the production of pottery often alters the source material by the addition of foreign material used as temper or by the mixing of several clays from different sources. Further, clay sources are much more common than obsidian sources. Thus, provenience analysis of obsidian has especially great potential for revealing information on networks of exchange.

In order to be effective, the technique used for provenience analysis should be sensitive to elements present in very low quantities and should be able to measure many different elements. Three techniques have been used with some success. These are neutron activation analysis (NAA), x-ray fluorescence (XRF) and optical spectroscopy.[4] The precision of measurements in archaeological studies of obsidian provenience thus far has varied considerably; this has sometimes resulted in mistaken identifications and inability to distinguish between sources. The most accurate measurements published thus far have been made by Perlman, Asaro, and others using NAA.

Ideally, provenience studies of obsidian should begin with analysis of several samples taken from all possible sources which might have been used in antiquity. Unfortunately, in the Central Andes the study of igneous petrology has received little attention. Because obsidian use was minimal at the time of the Spanish conquest, the ethnohistoric record gives no clues for the location of obsidian sources. Therefore, neither geologists nor archaeologists have data useful to the location of obsidian sources. Because of this, it has been necessary to work in the opposite direction.

In this study, obsidian found at 94 archaeological sites in Peru and Bolivia was analyzed to determine its trace element compositions. These determinations were used to identify the different types of obsidian being used. Each of these obsidian types has a distinctive geochemical "fingerprint" which corresponds to an individual source of raw obsidian. Although the exact source locations are missing in all but one case, it has been found that each type of obsidian was used mainly within a circumscribed geographical area. Not surprisingly, studies of Old World obsidians show that the most intensive use of an obsidian type occurs near to the natural source. Thus, the patterned distributions of obsidian types probably provide a general indication of the source location in cases where sampling is adequate.

The two techniques used in this study were neutron activation analysis and x-ray fluorescence. Neutron activation was considered an essential technique because it allows for the high precision measurement of a large number of elements. It was relied on to distinguish between different types of obsidian found in archaeological contexts. This was done by determining absolute amounts of various trace elements. The results of these determinations have served as a guide for this study and will, no doubt, be useful in future research. The neutron activation technique used at the Lawrence Berkeley Laboratory is time consuming and costly. These factors limit the number of samples which can be run. In all, 141 samples were run for this study.

The findings of the neutron activation analysis were used to develop an x-ray fluorescence technique specifically designed to distinguish the different types of Andean obsidian. These tests, which used a more limited number of elements, were faster and less costly. An additional advantage of the XRF technique used here is that it is non-destructive. The XRF was used to analyze 812 samples.

By combining the accuracy of NAA with the large sample made feasible by XRF, sufficient data were generated to make possible some interesting archaeological inferences about the people of the ancient Andes. These data are summarized in Tables 1 through 6.

Previous published research on the provenience of Central Andean obsidian is minimal. Sergio J. Chavez and Karen Mohr-Chavez have applied NAA to obsidian from three sites in the Departments of Cuzco and Puno, Peru (Lynch, 1973). An XRF study of 32 pieces of Bolivian obsidian was published recently (Avila Salinas, 1975). There are disturbing differences between our results and those of Avila, although the samples analyzed from Tiahuanaco and Sora Sora were taken from the same obsidian fragments used in the study of Avila.[9]

NEUTRON ACTIVATION ANALYSIS

This section describes the NAA procedure used at the Lawrence Berkeley Laboratory for this study.[5] To begin, the obsidian sample is cleaned of surface dirt, usually by scrubbing with water. The fragment is then pulverized by hand using a mortar and pestle of agate. One hundred milligrams of obsidian powder is measured with a Mettler balance to an accuracy of 0.1 mg. The powder is thoroughly mixed with 50 mg of cellulose binder. (Previous studies have shown that cellulose does not contain disturbing levels of impurities.) The obsidian and cellulose mixture is made into a pill (1 cm x 0.12 cm) with a hand-operated press. The pills must be standard in size in order to maintain a reproducible geometric arrangement between pill and detector during the counting of the gamma-ray radioactivity. The pills are first encapsulated in 0.0025 cm polyethylene foil, and then placed on edge in a radial array inside a heavy-duty polyethylene capsule. Within the capsule is an 8-position jig which holds 5 unknown pills and three standards. One "standard pottery pill" is included in each tier, placed in diametrically opposed positions.

The pills are irradiated twice with neutrons in a reactor. The first irradiation lasts for 6 minutes at a flux of 1.7×10^{12} neutrons per cm^2/sec. During the irradiation the capsule is rotated, and this rotation, coupled with radial array of the pills, insures that all pills are exposed to the same flux pattern. Following this irradiation, the pills cool for $\sim$8 minutes while they are transported to the laboratory.

The effect of the neutron bombardment is to transform certain isotopes of the elements in the pills into radioactive species which emit gamma rays. These gamma rays have energies which are characteristic of and can be used to identify the different elements. When a pill is analyzed for its gamma rays after an irradiation, a fraction of the gamma rays strikes a solid-state Germanium detector. The detector absorbs their energy and converts it into electrical impulses proportional to the energy absorbed. A pulse height analyzer then sorts out the electrical pulses, making it possible to relate them to the different elements in the pills. This information is stored on magnetic tape. The accumulated information on the number of pulses of each energy level coming from an obsidian sample can then be converted into absolute abundances of the elements being measured in each pill. The calculations needed to do this are so time consuming that a computer is a necessary aid.

Following the short irradiation and counting, the pills are repackaged in high purity aluminum foil, placed in an aluminum capsule and irradiated again. This time they are bombarded for 8 hours at the maximum flux of the reactor (2×10^{13} neutrons per cm^2/sec). Each aluminum capsule contains two tiers of 12 pills on edge in a radial array. Each tier contains two standard pottery pills diametrically opposed. After irradiation the pills cool for 8 days and are then counted for 20 minutes each with a 1 cc high resolution Germanium[20] detector doped with lithium. The pills continue cooling for at least 2 weeks and are then recounted for periods of up to 3 hours each with a 7 cc Ge(Li) detector. Then they are counted again on the high resolution detector. Thus each pill is counted a total of 5 times. Each of the counts provides optimal measurements for the various trace and major elements depending on half-life, background and other factors. This NAA procedure is able to measure a large number of trace elements in the parts-per-million (ppm) range, some with a precision of measurement of less than one percent error. This high precision for many elements eliminates ambiguity in the characterization of obsidian sources. A large number of elements are found to be clearly diagnostic, thus ruling out lumping of sources with some chemical similarities.

The high precision of the technique is partially due to the use of standards made from an artificially enriched fine clay which is carefully analyzed for uniformity. For the best measured trace elements, a reproducibility of 0.4% or better has been achieved for the calibrated pottery standard. This is significant since the accuracy of analysis for each element cannot be greater than the accuracy of measurement for the corresponding element in the standard. To arrive at absolute quantification, the gamma ray intensities for each element are compared to its counterpart in the calibrated pottery standard. The main sources of error remaining in this procedure are background errors and statistical errors inherent in counting radioactive elements.

The effectiveness of this technique is demonstrated by the results of the tests run for 141 samples in this study.

Several obsidian samples from each of the different types of obsidian utilized were chosen for NAA on the basis of preliminary XRF results. Sampling from different geographical areas and time periods augmented this strategy. After the XRF technique was further refined on the basis of NAA results, NAA was used to analyze those samples which appeared in XRF tests as aberrant, ambiguous, or surprising from an archaeological perspective. A summary of the mean compositions of the best measured trace elements for each type of obsidian is presented in Table 1. The results for all runs have been included in the Appendix.

X-RAY FLUORESCENCE (Rapid Scan XRF, U.C. Berkeley)

In the Spring and Fall in 1973, R. Burger conducted rapid scan x-ray fluorescence tests on 380 pieces of Andean obsidian. An obsidian sample was excited by irradiation with energetic x rays. The elements in the obsidian sample then emitted a spectrum of x rays which were passed through a crystal and sorted so that they could be detected electronically. The relative intensities of each element were recorded in graph form as peaks of different heights. In these tests, the spectrum between niobium and rubidium was analyzed using a Norelco Universal Vacuum X-Ray Spectrograph with a tungsten tube, LiF{220} analyzing crystal, scintillation detector with pulse height discrimination, and an air path. Scanning of the spectrum occurred at 2 degrees per minute. Groupings of types of obsidian were made on the basis of strontium/rubidium/zirconium ratios, which were plotted on tri-coordinate graphs.

This technique, previously used by R. N. Jack, R. Heizer and others in Mesoamerica (Jack and Heizer, 1968), yielded ambiguous results when applied to Central Andean obsidian (Figure 2). Although this technique successfully sorted the samples into three groups, it was not clear whether these groups each represented single obsidian sources. This lack of discrete groups was resolved by testing a larger number of trace elements with greater precision using NAA. The NAA showed that two of the three groups established by rapid scan XRF did not represent material from discrete obsidian sources. One of the groupings was actually composed of material from four different sources.

X-RAY FLUORESCENCE (Lawrence Berkeley Laboratory)

A cross section of the Peruvian obsidian artifacts used in this work was analyzed by high precision NAA techniques to establish a number of chemical groups which were easily distinguishable from each other. From these studies it was found that many elements could be used to distinguish the Peruvian sources provided they were precisely measured. The expense of this type of measurement, however, precluded its use for large numbers of artifacts. It was deduced that measurements of the abundance of barium (Ba), even with relatively poor precision (~10%), would distinguish a preponderance of the chemical groups identified by NAA. Most ambiguities remaining after the Ba measurement could be resolved with a measurement of strontium (Sr) abundance, and the Sr precision of measurement could be somewhat poorer than that of the Ba. In order to minimize expenses, these two elements were measured by a simple x-ray fluorescence technique with a ^{241}Am radioactive source providing the exciting radiation. In the Ba measurement, the

60 keV gamma ray of ^{241}Am was used to excite the Ba atoms in the obsidian and produce Ba K-x rays. The Ba K-x rays and other radiations from the obsidian were detected with a silicon solid state detector, whose pulses were amplified and then collected and displayed as a spectrum with a 512-channel pulse height analyzer. There was a peak of In K-x rays in the spectrum caused by excitation of In in the detector system. This peak, which appeared in all Ba spectra, served as a reference point for defining the position of the Ba peak and its background region. The 60 keV gamma rays from the ^{241}Am source, besides exciting Ba (and other elements), also scattered from the obsidian and appeared in the spectrum as a broad peak (backscatter peak) somewhat lower than 60 keV. This peak was used as an efficiency monitor into which all Ba peak totals were divided. Cerium (Ce) was also measured in the Ba determination but because of its relatively poor precision of measurement (~10%), was not as useful as the Ba. However, it was treated in the same way as the Ba and its abundance determined in every run. Both abundances were determined by comparison with a standard of Guatemalan obsidian from El Chayal. The Ba and Ce abundances of the standard were 943 and 48.4 ppm respectively.

In the Sr measurement the radiation from the ^{241}Am was screened with a Cu absorber to reduce the intensity of the L-x rays. The 26.5 and 60 keV gamma rays of ^{241}Am struck a Ag target which then emitted Ag x rays,exciting Sr and other elements in the obsidian. The radiation from the obsidian was stored and displayed in the same manner as in the Ba measurement. There were prominent peaks of backscatter radiation (the coherently scattered radiation) which had the same energies as the Ag K-x rays and appeared in all spectra. The Ag K-α peak in the spectra was used as a reference point for defining the Sr and other peak positions and the background regions. There was also a broad peak, of scattered radiation (the incoherently scattered Ag K-x rays) which appeared at somewhat lower energy than the Ag K-α peak, and was used as an efficiency monitor. The Sr peak total was divided by this backscatter peak total for the abundance determination. The abundances were determined by comparing these ratios for the obsidian artifacts with those from a standard of El Chayal obsidian. Zirconium and rubidium were measured in the same way. The Sr, Zr, and Rb abundances of the standard, which were used for the calculation, were 164, 100 and 162 ppm respectively.

There was a background of backscatter radiation without any sample in place on the x-ray fluorescence system in both the Ba and Sr runs, which was subtracted from these spectrum. In the Ba runs, the ratio of Ba to backscatter peak for a given composition of obsidian varied with sample thickness; this variation introduced an error. The variation could be compensated for if the sample thickness were known, but this measurement of average thickness was too laborious for artifacts of indiscriminate size and shape. Fortunately, the backscatter peak counting rate is related to the average thickness, and an empirical calibration was made of this relationship. A correction was only necessary for the thicker artifacts, and this never exceeded 36%. No corrections were necessary for the Sr runs.

The obsidian samples were mounted on 0.00062 cm Mylar foils and held in place with Scotch tape. The Mylar foils, in turn, were mounted in a sample changer with 48 positions. The 48 positions held one standard of El Chayal obsidian, one empty position with only a Mylar foil, one empty position with a plastic plate and 45 obsidian artifacts. After a Ba run on 48 samples, the resulting samples were put through a Sr run (or vice versa). The standard was analyzed several times, and the artifacts were sometimes analyzed more than once as the sample changer would recycle during its normal operation. The spectra were dumped from the pulse height analyzer onto magnetic tape after each sample was analyzed. The magnetic tape was subsequently processed by the LBL central computer facilities. Sample changing, radiation counting and data transfer were all handled automatically.

In comparing the average Ba abundance for eight groups of Peruvian obsidian as measured by NAA and the XRF methods described above, the average difference was 3.8%. For Ce the average difference was 2.0%. This suggests that the calibration procedures for Ba and Ce in the XRF measurements were essentially correct. The root-mean-square deviations for Ba abundances as determined by the XRF measurements were usually better than 7%, which was more than sufficient to make the desired assignments of provenience. The results of the XRF measurements appear in Table 2.

OBSIDIAN USE

In order to assess the meaning of pre-Hispanic patterns of obsidian trade in Peru and Bolivia, it is necessary to understand the role obsidian played within ancient Andean society. This role was, most likely, always multi-faceted; it varied according to local economic systems, regional cultural traditions, the difficulty of obtaining obsidian, and other factors. However, it is possible to get some tentative ideas on the role of Andean obsidian by using the archaeological record.

Obsidian seems to have been used almost exclusively for the production of tools. Of such tools, points are by far the most common. Obsidian points are found wherever obsidian was used, and at most sites obsidian seems to have been used exclusively for points (e.g., Media Luna). At some sites, obsidian was secondarily used for other types of tools such as unifacial scrapers (e.g., San Nicolas, Pucara, Taraco, Casavilca), burins (e.g., Taraco), and gravers (e.g., Huancayo; Browman, 1970, p. 79). At many sites, obsidian flakes are found abundantly and it is probable that many of these also were utilized (e.g., Waywaka; Grossman, personal communication).

Andean obsidian points vary greatly in size, shape, and quality of chipping. Many of these served as points on darts projected by spear throwers. In Grave 16 at Asia, an obsidian point was found in association with spear throwers (Engel, 1963, p. 56), suggesting that this use of obsidian points dates back to Preceramic times. At Hacienda Ocucaje, in graves dating to Epoch 10 of the Early Horizon, obsidian points were found still hafted with gum (and in one case, cotton thread) to wooden foreshafts. These foreshafts were connected to longer cane shafts. F. Engel has published an illustration of an equally well-preserved obsidian dart from the Paracas Necropolis (1966, p. 180c). A Middle Horizon Tiahuanaco beaker (<u>kero</u>) depicts archers with bows and arrows tipped with black points; these may represent obsidian, since small obsidian points are found at Tiahuanaco (Posnansky, 1957, pl. XXa; Bennett, 1934, pp. 426-459).

Obsidian points also served as blades of knives and tips of spears. The use of obsidian knives in late Early Horizon and Early Intermediate Period times is documented in late Paracas and Nasca iconography. Chipping and fracture patterns on points from Media Luna in the Callango Basin, Ica confirm this (Burger, unpublished data).

From Ocucaje 8 to Nasca 6, the pottery styles of Nasca and Ica show representations of black tipped darts and knives. The more naturalistic of these depictions can be linked to archaeological finds of obsidian weapons at local contemporary sites. This has led Lawrence Dawson to hypothesize that many of these are representations of obsidian objects (personal communication). Beginning in Ocucaje 8 the hypothesized obsidian knives are associated with the taking of trophy heads in the iconography. These representations are extended to the textile medium in Epoch 1 of the Early Intermediate Period (D'Harcourt, 1962, pp. 110 and 112). Mythical beings such as the Oculate Being or the Killer Whale are often shown holding an obsidian knife in one hand, a trophy head in the other. After Nasca 3, representation of obsidian knives became uncommon, but obsidian darts often are shown. A Nasca 5 vessel in the Lowie Museum of Anthropology, Berkeley, shows warriors armed with obsidian darts and spear throwers; each of the warriors holds a trophy head and the composition of the scene suggests a raiding party in action.

Some further insights into the function of these obsidian-tipped projectiles have been found in the archaeological record. A most vivid case was the find of an obsidian point deeply imbedded in a human lumbar, at Mosojcancha Hacienda, Huancavelica. R. Ravines (1967, pp. 230-231) was able to determine that the obsidian projectile had penetrated its victim through the abdomen, causing immediate death. A similar find was made on the South Coast at Carhua. In this instance the obsidian-tipped weapon had pierced the arm of its human victim so forcefully that the point had penetrated to the other side of the arm bone (Engel, 1966, Fig. 59, p. 212).

Obsidian weapons were also used to hunt wild game. A Nasca 5 vessel in the Lowie Museum shows a hunting scene in which obsidian tipped darts sail through the air towards several wild camelids (probably guanacos).

Obsidian probably played an important role in the daily subsistence activities of ancient Andean people, especially in butchering of animals and shearing of domestic camelids. Raymond Gilmore speculated that "aboriginal shearing must have required special implements, perhaps obsidian knives." Some contemporary Andean pastoralists are known to use broken glass for shearing alpacas (Gilmore, 1950, p. 446). Utilitarian use of metal becomes evident only in late pre-Hispanic times (Late Intermediate Period and the Late Horizon) and until that point, sharp edges and chipping ease made obsidian one of the preferred materials for sharp-edged tools.

Obsidian also probably served a host of other functions. For example, Julio C. Tello discovered a medical kit at Cerro Colorado, Paracas which included blood-stained obsidian knives, a <u>chachalote</u> tooth knife, balls of cotton, bandages, and thread. According to

Tello, the obsidian tools are of different sizes and shapes relating to the specialized medical role of each implement (Tello, 1929, p. 55).

The utilitarian emphasis on obsidian usage among ancient Andean peoples is based on archaeological inferences. Among other ancient societies, obsidian was used extensively for ritual and ornamental objects. Some examples of this are the ritual caches of eccentrically shaped symbols in obsidian which have been found throughout Mesoamerica during the Classic Period. In the Near East after 4000 BC, obsidian was traded almost exclusively for the production of objects such as bowls, statuettes, and tables (Dixon et al., 1968, pp. 38 and 46).

Today in Peru, obsidian is not utilized. In fact, the only verified case of its modern use is in the folk medicine of the Tuqsa area, Canchis Province, Department of Cuzco (Percy Paz, personal communication) where it is believed to have curative power. Such medicinal uses of obsidian occurred also in early Colonial times and perhaps much earlier (Cobo, 1956, p. 135).

In antiquity, obsidian undoubtedly had some ritual uses in the Central Andes. An early Nasca ritual knife has been illustrated by Disselhoff (1972, p. 277). This knife has an obsidian blade hafted in a delicately painted dolphin's palate; the knife is reminiscent of the knives held by deities in Nasca iconography. Besides this piece, David Browman has reported an obsidian mirror fragment in a Middle Horizon 2 context from Huancayo (1970, p. 86). Finally, in areas outside the network of obsidian exchange, such as the North Coast, the rare obsidian points were probably valued more as prestige objects than as tools.

In summary, obsidian was mined and distributed in the ancient Andes primarily to serve as tools necessary for subsistence activities and as weapons in warfare. Obsidian was a raw material essential to the daily existence of common people. In one sense, the distribution of obsidian may have more in common with the exchange of agricultural commodities or salt, than it did with either long distance trade in prestige goods such as lapiz lazuli, turquoise, or exotic pottery, or with commodities traded long distances for ritual purposes, such as spondylus and strombus shells. Thus, one should expect the patterns of obsidian exchange to differ from exchange patterns of these other trade goods and to reflect different kinds of social and economic interactions. Moreover, the mechanisms by which obsidian was procured and exchanged may also have been distinct from those of other rare raw materials.

QUISPISISA SOURCE

The most widely distributed Peruvian obsidian came from an obsidian flow at Quispisisa in the highlands near San Genaro, Castrovirreyna Province, Department of Huancavelica. It is located near the headwaters of the Pisco River, whose shores lead down into the Department of Ica. This river valley provided a natural route for the transport of highland goods, including obsidian, into the South Coast. The Quispisisa Source is also conveniently located for access to the Mantaro and Pampas river systems, which could have facilitated highland traffic in obsidian to the north and south. It appears that pre-Hispanic communities in the Central and Northern highlands almost exclusively used Quispisisa obsidian. Although the locations of most Peruvian obsidian sources are not known precisely, it is likely that Quispisisa is the northernmost geologic source of high grade obsidian in Peru. This factor, along with its strategic location, partially accounts for its wide distribution.

At the present time, the Quispisisa Source is the only verified source of archaeological obsidian. Rogger Ravines visited the flow and identified a quarry area (Petersen, 1970, p. 15), as well as a rock shelter (Ha3-21) below the quarry which was inhabited in antiquity. Obsidian samples collected by Ravines from the quarry and the shelter were analyzed by neutron activation and x-ray fluorescence at the Lawrence Berkeley Laboratory. Trace element analysis by NAA revealed that the chemical composition of the obsidian from the source area matched the composition of obsidian artifacts collected on archaeological sites from Huamachuco to Cuzco and from Trujillo to Acari. Three samples have been tested from the quarry itself. Forty-five samples from archaeological contexts were identified by NAA as coming from the Quispisisa Source. An additional 321 archaeological samples have been found, on the basis of XRF, to have come from the Quispisisa Source. The obsidian from Quispisisa displays great variety in its appearance; it is black, gray, streaked, nearly colorless, brownish red, or red speckled. There is also great variation in its degree of translucency. In terms of trace element composition, the source (or at least the parts of the source mined in antiquity) is quite homogeneous (see Appendix).

The Quispisisa mine was being exploited in the Preceramic, and the long distance movement of its obsidian constitutes some of the earliest concrete evidence of interzonal and interregional travel and exchange in the Andes. The excavations of the Ayacucho Archaeological-Botanical Project revealed a long Preceramic sequence. This is of special interest for the purposes of this article because it shows that obsidian tools were used in the Ayacucho area during these early times. Because only the preliminary findings of the Project are published, it is necessary to exercise caution in interpretation.

Sixty-five samples from seven of the early Ayacucho sites were analyzed (see Table 4). These samples came from sites in several micro-environmental zones: the tundra, the humid scrub forest, the desert, and the dry thorn forest. Samples from zones M-N and K of Jaywamachay are the oldest. According to MacNeish et al (1970), C^{14} determinations suggest that both samples predate 9000 BC. Our tests find that the obsidian for those flakes came from the Quispisisa Source. Thirty-seven samples come from levels associated with pre-Piki Phase materials. These obsidian tools and flakes were the products or by-products of a pre-agricultural society. Over 94% of the obsidian tested from these levels came from the Quispisisa Source. This mine continued to be the main source of obsidian during early agricultural times (Chihua and Cachi complexes) through the end of our sampling from the Ayacucho sequence, at around 800 BC.

Obsidian was found by Browman in materials from two of his Preceramic units: the Jurpac period (4700 BC to 2800 BC) and the Tinyari period (2800 BC to 1500/1000 BC). Triangular obsidian points and flakes were found in the assemblages of both periods (Browman, 1972, p. 75; also, personal communication). Further to the north in the Callejon de Huaylas, excavations at the Preceramic site of Quichqui Puncu encountered less than a dozen obsidian flakes (Lynch, 1970, p. 19); it can be inferred that obsidian use here was more rare than in Huancayo or Ayacucho. Quichqui Puncu was originally occupied about 7000 BC and was finally abandoned shortly after the introduction of ceramics (Lynch, 1970, p. 99); no precise provenience is provided for the obsidian flakes. Considering what is known of obsidian use during the Preceramic of Ayacucho and of later periods in Huancayo and the northern highlands, it is likely that this untested obsidian from Huancayo and Quichqui Puncu also comes from Quispisisa.

The site of San Nicolas, Nasca Province, Department of Ica is a well-known Preceramic shell mound, investigated first by Duncan Strong (1957) and later by Frederic Engel and Gary Vescelius (1963). Both Strong and Vescelius noted that obsidian is prevalent at the site. Strong recovered several hundred pieces of obsidian debitage, and Vescelius found two obsidian points and an obsidian scraper (1963, plate VII, la, b, c). The dating of San Nicolas is still problematic, but the discovery of cotton in excavations there suggests that it belongs to the late Preceramic (Bonavia and Ravines, 1972, p. 39). Forty-nine flakes from San Nicolas were tested and all of them were made from Quispisisa obsidian.

San Nicolas was not the only late Preceramic site on the South Coast to use obsidian. Obsidian artifacts are reported for Boca del Rio (Casavilca) in the Ica Valley; for Otuma near the Bahia de Independencia, Department of Ica; and for Asia in the Omas Valley, Department of Lima. Obsidian points and side scrapers have been found in refuse at these sites and at Asia obsidian points were included in two graves (Lanning 1963, p. 368, and 1967, pp. 72 and 78; Engel, 1963, p. 56). It is probable that the inhabitants of these sites also used Quispisisa obsidian.

A final piece of evidence for the Preceramic use of obsidian comes from La Cumbre in the Moche Valley (Ossa and Moseley, 1971). Out of nearly 4900 pieces of worked stone collected from this site, only one was made of obsidian. It was a point typologically distinct from other artifacts at the site (Ossa, personal communication). The point was tested by XRF and is made of Quispisisa obsidian. The dating of La Cumbre is unclear, but the artifact assemblage and other data suggest that it dates long before the Cotton Preceramic, perhaps as far back as the ninth millenium BC.

The evidence presented has some interesting implications for the understanding of the Preceramic. The material from Ayacucho documents the transport of obsidian from Quispisisa to Ayacucho in pre-agricultural times. Since the llama probably had not yet been domesticated, the obsidian must have been carried by travelers. The trip itself is slightly less than 200 kilometers round trip.[7] Not only would the trip have crossed several ecological zones, it would also have passed through new regions which would otherwise have been of little economic interest because of their similarity to local Ayacucho micro-environments. Such journeys may have played an important role in the spread of domesticates in the sierra. However, the mechanism of obsidian distribution during these early phases of the Preceramic was limited. Multiple small exchanges among hunters probably account for the rare appearances of obsidian at distant sites such as La Cumbre or Quichqui Puncu, although long trips by adventurous individuals should not be ruled out.

The utilization of Quispisisa obsidian continued in later Preceramic times and probably extended at least as far north as Huancayo. By the Cotton Preceramic, Quispisisa obsidian was being used by the people of the South Coast, as clearly seen at the site of San Nicolas. This is definitely an instance of early contact between the sierra and coast. The obsidian being transported from the Quispisisa Source, in these early times, seems to have been unworked or simply roughed-out, as evidenced by the considerable amount of debitage at the site.

The use of the Quispisisa obsidian source continued in the Initial Period. The scarcity of data on obsidian (and on most other subjects) during the Initial Period in Peru makes large patterns difficult to discern. The authors had access to information on two Initial Period sites on the South Coast: Erizo in the Department of Ica and Hacha in the Department of Arequipa (Rowe, 1963, pp. 5-6; and 1967, pp. 26 and 30). The inhabitants of both sites used obsidian artifacts. The three samples tested from Erizo were made of Quispisisa obsidian. Fifty-three pieces of obsidian from Hacha were tested; two-thirds of these came from the Quispisisa Source.

At roughly the same time, the residents of Waywaka (Andahuaylas Province, Department of Apurimac) were producing ceramics stylistically related to those found at Hacha and Erizo (Grossman, 1972a, p. 270).[8] Analysis of excavated obsidian from the relevant components, Muyu Moqo C-D, reveals that a fair proportion of the sampled obsidian (23%)

comes from the Quispisisa Source. At Waywaka, the appearance of low quantities of Quispisisa obsidian seems to occur throughout the Initial Period, but may increase in the last phase: Muyu Moqo C-D (see Table 5).

A second type of obsidian (Pampas Type) was found at both Waywaka and Hacha. These data strengthen arguments that direct communication between the coast and sierra existed in the Initial Period, and included a network which permitted the exchange of exotic goods, including obsidian. The round-trip from Hacha to Quispisisa exceeds 475 kilometers and the round trip from Waywaka is only 100 kilometers less.

During the Early Horizon, there was an unprecedented homogeneity in certain aspects of culture in northern and central Peru, which was due to Chavin influence. This influence is also evident in a modified form on the South Coast of Peru. The expansion of Chavin features has generally been attributed to the spread of a religious cult, centered in Chavin, Huari Province, Department of Ancash. Some scholars have postulated the existence of a large political unit and/or commercial network. The provenience data on obsidian provide support for the presence of an expanded commercial network which incorporated part of the North Highlands into an earlier network dating back to Preceramic times.

Quantities of obsidian are present in Early Horizon contexts in the Chavin area (Lumbreras and Amat, 1965/66, p. 173). Thirteen samples were tested from Qaucho, an Early Horizon site on the bank of the Rio Mosna, opposite The Temple of Chavin (Tello, 1960, p. 149). Samples were also tested from the Early Horizon settlement underneath the modern town of Chavin de Huantar (Rowe, 1962, p. 5) and from the Temple area. All of the samples proved to have been brought from the Quispisisa Source, over 460 kilometers distant (one-way). It is probably significant that the only obsidian discovered at Kotosh by the Tokyo University Expedition had Kotosh Chavin Period associations (Izumi and Sono, 1963, pp. 124 and 151; Izumi and Terrada, 1972, pp. 149 and 257). At the nearby site of Shillacoto, which lacked Chavin style material, the Japanese found no obsidian.

Further south, the old network of obsidian exchange seems to continue. Obsidian was tested from three Early Horizon sites in the Huancayo area (JuM 801-B, JuM 704, JuM 685). These sites belong to the Pirwapuquio Phase, which is roughly contemporary to the important developments at Chavin (Browman, 1970). All eight of the samples were from Quispisisa. This obsidian was also used during Chavin and pre-Chavin phases at Ataura, a nearby site in the Central Highlands (see Table 6).

Obsidian was the most common chipping stone material found at the Early Horizon site of Chuncuimarca (15 km north of Huancavelica) (Ravines, 1969/70). Dwight Wallace found two obsidian points at a flake associated with Ocucaje Phase 3 materials from Cerrillos, Ica (1962; personal communication). Two fragments of obsidian excavated by Thomas C. Patterson from Chavin levels in the Ancon Tank site, on the Central Coast, were tested by NAA and found to be from the Quispisisa Source.

Analysis indicates that Quispisisa obsidian trade continued in the Central Highlands and South Coast after the decline of Chavin influence in the late Early Horizon. In fact, Browman notes an apparent increase of obsidian in sites of this period (Cochongos Phase) in Huancayo. Samples tested from JuM 613 were imported from Quispisisa. At about the same time in Ica (Ocucaje Phase 9) two important sites were occupied. These sites, the urban settlement of Media Luna and the fortified site of Tajahuana, are noted for abundance of obidian artifacts, especially large bi-faces. All of the 31 samples of obsidian tested from Media Luna came from Quispisisa; samples from Tajahuana likewise show the dominance of Quispisisa obsidian. Small samples taken from other late Early Horizon sites in Ica reflect the same pattern of obsidian utilization. These additional samples came from Cerro Prieto (Ocucaje 9), Santa Lucia (Ocucaje 8), Ocucaje A (Ocucaje 9, early Early Intermediate Period). Other parts of the South Coast also used obsidian from Quispisisa. One such site was Chincha-Site D. An obsidian fragment recovered there by Max Uhle was from the Quispisisa Source. Engel has discovered obsidian artifacts associated with late Early Horizon settlement at Tambo Colorado in the Pisco Valley (1957, pp. 38-39). William Isbell recently located a late Early Horizon or Early Intermediate Period highland site several kilometers south of the town of Cabana Sur, Lucanas Province, Department of Ayacucho. At this site (Ay5-5 or Coracorral Pata), over half of the obsidian tested came from Quispisisa.

Trade in Quispisisa obsidian continued during the Early Intermediate Period in roughly the same areas as during the late Early Horizon, though perhaps on a lesser scale. Very little obsidian with good Early Intermediate Period associations was available for analysis from the South Coast. Samples from the sites of Paroma (Nasca Province, Department of Ica), Ocucaje B, and San Jose de Cordero (Pv 62-70, Provincia Ica, Department of Ica) probably are all associated with the Early Intermediate Period occupation. One of the fragments of Pv 62-70 comes from Cut A, Level 3 in a small excavation by Dorothy Menzel; it was associated with Nasca 7 material. All of these samples were made from Quispisisa obsidian. An obsidian point was found on the surface at Pv 48-1 in the Lurin Valley (Department of Lima) along with pottery dating to the Early Intermediate Period (Fung, 1970, p. 7).

Less is known of Early Intermediate Period use of Quispisisa obsidian in the highlands. At Waywaka, the Qasawirka style materials probably date to some time in the Early Intermediate Period (Grossman, 1972b). As in earlier periods, Quispisisa obsidian was used there in small quantities. Obsidian was also used in the Ayacucho area (Lumbreras, 1974, p. 135) and in Huancavelica (Ravines, 1967), both traditionally within the sphere of Quispisisa obsidian use.

The end of the Early Intermediate Period is marked by the rise of the Huari Empire, which spread through much of coastal and highland Peru during the early Middle Horizon. The site of Huari (Department of Ayacucho) is thought to have been the capital of this empire. Burger observed that the ruins of Huari are littered with obsidian debitage. The abundance of obsidian found in excavations at Huari by Vescelius suggests that Huari was importing obsidian on an unprecedented scale. Out of the 52 samples from Huari, 50 were of obsidian imported from Quispisisa. Of obsidian tested from Ay 5-6 (also called Jincamoqo or Cabana), a smaller Huari site in Lucanas

Province, Department of Ayacucho (Rowe, 1963, p. 14), slightly less than half came from Quispisisa.

It is during the Middle Horizon that Quispisisa obsidian has its widest distribution. A piece of obsidian from Quispisisa was found at Palestine (~700 m above sea level), a jungle site in the Department of Ayacucho which cross-dates with the Huari Empire (Weber, 1975, p. 242). Isbell recovered two pieces of obsidian from excavations on the Eastern slopes of the Andes at the site of Jargampata (personal communication); unfortunately, they were not available for analysis. Fragments of Quispisisa obsidian were even found in the Department of Cuzco, at the sites of Batun 'Urqo, Santa Barbara Baja (Cz 2-12), and Kallpitu (Cz 2-26). The dating of these fragments is problematic since they come from the surface of multi-component sites, but at least two of the sites include Huari influenced materials.

In the North Highlands, obsidian was exported at least as far as Marca Huamachuco (700 km north of Quispisisa). Three samples from the excavations of Theodore McCown were analyzed; all three were associated with material from the late Early Intermediate Period/early Middle Horizon occupation of the site (McCown, 1945, pp. 288-289). These obsidian fragments all were from the Quispisisa Source. McCown cited an additional 53 obsidian points collected by Uhle, who gave their provenience as Huamachuco. Two-thirds of these specimens were Quispisisa obsidian. The style of points and chipping technique are very similar to those found by McCown at Marca Huamachuco and it is probable that they either come from that site or from a contemporaneous site in the area. The only piece of obsidian discovered by J. Thatcher in his survey of sites in the Huamachuco area came from Marca Huamachuco (personal communication).

Obsidian was being distributed to other Middle Horizon sites in the Highlands between Ayacucho and Huamachuco. In the Huancayo area, Browman notes an increased amount of obsidian in the late Early Intermediate Period, which carries into the first two epochs of the Middle Horizon. Samples from sites of this time period (JuM 616 and JuM 618) proved to be from the Quispisisa mine. Bennett uncovered four obsidian points associated with early Middle Horizon ceramics in a deep stone-lined tomb at the site of Wilkawain (Huaras Province, Department of Ancash) (Bennett, 1944, pp. 30-31).

No Middle Horizon obsidian was analyzed from the South Coast and the authors are unaware of any Middle Horizon examples of obsidian found there. However, this could simply reflect the current state of archaelogical research in this area. On the North Coast, one of two obsidian fragments recovered by the Chan Chan--Moche Valley Project in the extensive surveys and excavations came from a Moche V graveyard. The obsidian point was found on the surface and thus has no direct associations. However, material from a nearby grave included a face-necked jar and a "Tiahuanacoid" sherd (Mosely, personal communication). If the point did indeed come from a Moche V grave, it may have been brought from one of the Huari settlements in the North Highlands, perhaps serving as a prestige item. This point is made of Quispisisa obsidian.

The decline of the Huari Empire seems to mark the end of widespread distribution of Quispisia obsidian. This occurs in the North Highlands, where Quispisisa obsidian use was a reflection of an intrusive political force, and in the Huancayo area, where Quispisisa obsidian had been used for many centuries. Moreover, obsidian is not found on the South Coast in post Middle Horizon times.

AYACUCHO TYPE OBSIDIAN

The source of this type of obsidian is not known. Artifacts made from it are known only from Preceramic occupations of sites in the Ayacucho area. It occurs at Iomachay (Ac 102), Ac 500, and Puente (Ac 158) (see Table 4). The sample tested from these sites is small, but it established that it was used as early as zone 13 at Puente (approximately 7100 BC) and as late as zone D of Ac 500 (approximately 3000 BC). In the sample tested, it was only common at sites in lower micro-environmental zones. The apparent absence of Ayacucho Type obsidian from all sites outside of Ayacucho suggests that it is probably local; however, Quispisisa Source obsidian seems to be quite common in the sites where Ayacucho Type obsidian was used.

It is worth noting that obsidian from this source was not found among the 52 samples tested from Huari, which is located near the sites where Ayacucho Type obsidian was used in Preceramic times. Presumably, the Huari Empire controlled the area where this obsidian comes from, but those responsible for the procurement of obsidian either chose not to exploit it or no longer had knowledge of its existence. Another possibility is that the obsidian deposit was small and was exhausted by its early exploitation.

ACARI TYPE OBSIDIAN

The source provenience for this type of obsidian is unknown. The only archaeological site sampled which exploited obsidian from this source is Hacha in the Acari Valley. Acari Type obsidian makes up about 19% of the pieces sampled from this Initial Period site. It should be borne in mind that Hacha is the southernmost site on the Peruvian coast sampled in this study. Thus, this source may have been popular along the untested southern coast of Arequipa and adjacent highlands.

PAMPAS TYPE OBSIDIAN

This type of obsidian comes from a yet unlocated site in southern Peru. Recent explorations by Kathy Schreiber indicate that it may come from near the town of Huaycahuacho in the Lucanas Province, Department of Ayacucho. This type of obsidian is commonly found at archaeological sites in the Cabana Sur/Andamarca area of southern Ayacucho (surveyed by William Isbell). Pampas Type obsidian was used at several of the sites sampled from this area: Ay 5-1 (Canichi), Ay 5-5 (Coracorral Pata), Ay 5-6 (Cabana or Jincamoqo), and Ay 5-7 (Kichiucu). About 43% of the obsidian tested from these four sites is of the Pampas Type. Ay 5-5 has been tentatively dated as late EH or EIP and Ay 5-6 is an early Middle Horizon site (Schreiber and Isbell, personal communication).

Pampas type obsidian was also utilized in the Andahuaylas area at the sites of Waywaka and Kunka Taka. The excavated material from Waywaka provides evidence that it was used throughout the Muyu Moqo phases (Initial Period), especially Muyu Moqo A and B; it continued to be used, though less frequently, in later times. At approximately the same time (Muyu Moqo C - D), points made from this obsidian were being used at Hacha in the Acari Valley.

The use of Pampas Type obsidian, as well as Quispisisa Source obsidian, in Andahuaylas and the South Coast provides evidence of an Initial period sphere of interaction, which is also reflected in ceramic styles. It is worth noting that the three areas where Pampas Type obsidian has been detected form a rough transect perpendicular to the coast, running up the Acari and Pampamarca Rivers.

The single sample of Pampas type obsidian identified from outside this transect was from Wimpilla in the Department of Cuzco. The long and complex occupation of Wimpilla makes it difficult to interpret the significance of this surface find.

ANDAHUAYLAS A TYPE OBSIDIAN

The source of Andahuaylas A obsidian is not known. Among the sites sampled, it is heavily represented at sites in the Andahuaylas area. At the site of Waywaka, Andahuaylas A Type obsidian provided more than 40% of the material tested. It was the most important type of obsidian used there during Initial Period and Early Intermediate Period times. Andahuaylas A Type is also the source of the four obsidian flakes found at the site of Qasawirka (Ap 2-1), a nearby site roughly contemporary with the Qasawirka phase (Early Intermediate Period) at Waywaka.

At Huari, the probable center of Middle Horizon expansion, one of the 52 pieces from the surface collection sampled was of the Andahuaylas A Type. Notably, the sole piece of Andahuaylas A Type obsidian from the Department of Cuzco was found at Pikillaqta, the local Huari administrative and/or military center during the Middle Horizon (Rowe, 1963, p. 14; and Sanders, 1973).

Andahuaylas A obsidian was also found at sites Ay 5-5 and Ay 5-1 in the Lucanas Province, southern Ayacucho.

As noted in the preceding section, sites in Andahuaylas and Lucanas have several types of obsidian in common and were probably part of the same sphere of interaction for some time. At Waywaka, a piece of Andahuaylas A obsidian was found amidst post-Middle Horizon 2 refuse in the uppermost disturbed level.

ANDAHUAYLAS B TYPE OBSIDIAN

Andahuaylas B Type obsidian is known from only three archaeological sites, all in the Andahuaylas region: Kunka Taka, Santa Elena, and Waywaka. Its use at Waywaka is concentrated in the later occupations of the site. It is scarce or altogether absent from the important early Muyu Moqo occupation of the site. Almost all of the Andahuaylas B Type obsidian is either found associated with the Waywaka Phase occupation (early Late Intermediate Period), in mixed material, or on the surface with late material. The source of this type of obsidian is unknown.

CUZCO TYPE OBSIDIAN

Cuzco Type obsidian is predominant at nearly all of the archaeological sites sampled in the Department of Cuzco. It has been identified at twenty-two archaeological sites in the provinces of Cuzco, Canchis, Anta, Paruro, Urubamba, and Quispicanchis. Cuzco Type obsidian rarely occurs at sites outside the Department of Cuzco. Its source remains unknown, despite explorations made by Sergio Chavez and Karen Mohr Chavez to locate the obsidian flow (personal communication). At the present time, the Department of Cuzco lacks a complete relative chronology, although many advances have been made in the last decade. An additional problem in evaluating our results is that many of the obsidian samples analyzed come from surface collections made at multi-component sites.

The Cuzco source was probably used during the Preceramic. The cave site of Huki Wasi, near Sicuani (District of Combopata, Canchis Province), has yielded obsidian points and flakes, including two flakes of Cuzco Type obsidian. The style of these points suggests a late Preceramic date; however, there are no definite associations and such a relative date is speculative (Percy Paz, personal communication; and Rowe, personal communication).

The most complete information on obsidian from the Southern Highlands is for the Early Horizon. These data shall be treated more fully in a separate article. Cuzco Type obsidian is the most common type associated with phases of Marcavalle style uncovered in excavations by P. Lyon and L. Barreda and by K. Mohr Chavez at the site of Marcavalle. This was also true of obsidian flakes associated with Marcavalle style ceramics excavated by E. Dwyer and J. Dwyer at Minaspata in the Lucre Valley, and stylistically related material at Pikicallepata near Sicuani. Ceramics of the subsequent style, Chanapata, are commonly associated with large quantities of obsidian debitage and small obsidian points (Rowe, 1944, p. 21, fig. 17; Yabar Moreno, 1972, p. 217). Obsidian samples from levels which yielded Chanapata style material at Minaspata and Marcavalle, and levels at Pikicallepata containing Chanapata-like material show a continued reliance on the Cuzco Type obsidian. Obsidian from surface collections at sites with Chanapata components also reveal utilization of the Cuzco Type (e.g., Cz 13-14, Cz 2-10). The Marcavalle and Chanapata styles are thought to be successive styles used in the Cuzco area during most of the Early Horizon (Rowe and Menzel, 1967, Chronological Tables).

The following style, Derived Chanapata or Pakallamoqo, is currently considered to have been used in the beginning of the Early Intermediate Period. Derived Chanapata and Cuzco Inca style ceramics, along with an abundance of obsidian artifacts, have been found on the twice-occupied Muyu 'Urqo (Cz 6-47) site. Since obsidian is very rare on Inca sites in the Cuzco area and extremely common at Chanapata style sites, most of the obsidian debitage found at Muyu 'Urqo probably is related to the Derived Chanapata occupation. Twelve of the thirteen samples tested from Muyu 'Urqo were Cuzco Type obsidian.

The interim between Derived Chanapata style and Early Inca or Kilke style is not yet well understood. The sites of Qotakalli and Tarawi (Cuzco Province) were occupied during this interim period and in later times (Rowe and Lyon, personal communication). A small sample of obsidian tested from these sites proved to be from the Cuzco source.

Obsidian use during Inca times in Cuzco was extemely rare. This is evidenced by the scarcity of obsidian on Cuzco sites of Inca origin surveyed by Rowe and his students. The same conclusion was reached independently by Jose Gonzales in his study of Inca lithics from Cuzco (personal communication). The occasional use of obsidian at Late Intermediate Period/Late Horizon sites is attested to by rare finds of obsidian flakes at Coricancha, Machu Picchu, Catacasallaqta, and Mawqallaqta. Single samples from three of these sites were determined to be made from Cuzco Type obsidian.

As noted, outside of the Department of Cuzco, Cuzco Type obsidian is rarely found. Only two fragments of Cuzco obsidian were identified from Waywaka (Andahuaylas Province), one with Qasawirka style associations and the other in a mixed Muyu Moqo context; this constitutes less than 2.5% of the samples tested from Waywaka.

The appearance of small quantities of Cuzco Type obsidian in some of the lower levels of Taraco and Qaluyu, and the reciprocal occurrence of Titicaca Basin Type obsidian at Marcavalle and Pikicallepata, testify to communication between these two areas during Early Horizon times. Other samples of Cuzco Type obsidian found on the surface of multi-component sites in Puno leave open the possibility of other contact between the two areas in later times.

In other areas of Peru, the distribution of Cuzco Type obsidian seems to have been linked to the new lines of movement and communication established by the Huari Empire. A single piece of Cuzco Type obsidian was identified from Huari and five samples of it were found at Jincamoqo, the Huari center in Lucanas Province. Compatible with these findings, but still surprising, was the discovery that a third of the obsidian tested from Huamachuco (Department of La Libertad) had come from the Cuzco source. Although only one of these pieces has a definite provenience (Marca Huamachuco, surface), the argument can be made that the presence of these pieces in the North was due to Huari expansion into the area.

TITICACA BASIN TYPE OBSIDIAN

Obsidian of the Titicaca Basin Type occurs at archaelogical sites in southern Peru and northern Bolivia. The source of this type of obsidian is not yet located. Unworked obsidian of this type was found by Burger near the modern town of Llalli, Melgar Province, Department of Puno. However, two attempts to locate a source in this vicinity have failed.

All eight archaeological sites in the Department of Puno from which obsidian samples were taken used Titicaca Basin Type obsidian. At Taraco 93.5% of the 153 samples tested were of this type. At Qaluyu, Titicaca Basin Type obsidian provided material for sixteen of the seventeen samples analyzed (94%). According to Kidder (1943), obsidian debitage also is plentiful at the sites of Pucara (p. 17), Ayrampuni (p. 20), and Incatunuhuiri (p. 15).

At the site of Tumuku (Chucuito Province, Department of Puno), obsidian points and debitage were found on the surface along with lithics of other materials. At least part of the obsidian from this surface material dates to the Preceramic (Felix Palacios, 1974). At Tumuku, in contrast to the other Puno sites sampled, the Titicaca Basin Type was not the only important source of obsidian used.

Obsidian analyzed from excavations at Qaluyu and Taraco indicate that the Titicaca Basin Type was being exploited in the Puno area throughout Early Horizon times. The prevalence of Titicaca Basin Type obsidian at the sites of Huki Wasi, Pikicallepata, Suyu, and Yanamancha, all in the Sicuani area, further testifies to early economic and social interaction going on between Cuzco and Puno. The occurrence of Titicaca Basin obsidian is heavier in this intermediate area around Sicuani than it is in the area around Cuzco proper. At Pikicallepata, Titicaca Basin Type obsidian makes up slightly more than 20% of the sample. It was even more prevalent in the small samples taken from the neighoring sites of Suyu and Yanamancha.

In the Cuzco area, Titicaca Basin Type obsidian made up about 10% of the material analyzed from the Early Horizon site of Marcavalle. In the Puno area, Cuzco Type obsidian made up about 6% of obsidian sampled for Qaluyu and is also found in Early Horizon levels at Taraco.

Surprisingly, Titicaca Basin Type obsidian was more common than the Cuzco Type in the small sample from the early but poorly known site of Huki Wasi (Canchis Province, Department of Cuzco). It is possible that the use of these two obsidian types in Canchis goes back to Preceramic times. In the Puno area, the use of the Titicaca Basin source was apparently long lived and this obsidian is present in quantity even at the late site of Sillustani (Arturo Ruiz Estrada, personal communication; Margaret Hoyt, personal communication).

Titicaca Basin Type obsidian was also used on the Bolivian side of Lake Titicaca. All of the obsidian tested from Tiahuanaco came from this source. Two samples of obsidian from Qallamarka (Kallamarka), a site twelve kilometers southeast of Tiahuanaco, also came from this source. These two samples were found in excavations associated with pre-Middle Horizon ceramic material (M. Portugal Zamora, personal communication).

RARE AND UNIQUE TYPES OF OBSIDIAN

The eight obsidian types described in the previous sections were all present in relatively large quantities at one or more archaeological sites. Ninety-eight percent of the samples analyzed belonged to one of these types. However, there were cases in which unique or nearly unique samples were analyzed. Future work may prove that some of these obsidian samples came from sources important in antiquity, but scarce in the sample upon which this study is based. Others will probably remain anomalous.

Two of three pieces sampled from Tumuku (Department of Puno) were made from a rare obsidian type. However, the sample from this part of the Central Andes is especially poor, and the source of the Tumuku type obsidian is potentially an important one.

Three samples from Waywaka had a trace element composition distinct from the other obsidian analyzed. One of the fragments of this type occurred with Muyu Moqo C-D associations; another appeared in mixed Muyu Moqo refuse. The third was found on the surface.

Single unique samples have been found at Muyu 'Urqo (Cuzco Province, Department of Cuzco), Uchcumachay (Department of Junin), and Jaywamachay (Department of Ayacucho). The latter sample came from a surface collection and was not encountered among the 30 excavated samples analyzed from Jaywamachay. This sample has some chemical similarities to Andahuaylas A Type obsidian and may have some geological relationship with it.

Some samples from geological sources of low quality obsidian were analyzed for comparison with obsidian from archaeological sites. Two of these were from Arequipa and one was from Ayacucho. The low grade source in Ayacucho was located by the Ayacucho Archaeological-Botanical Project near Tukumachay and was considered a potential source of obsidian for sites in that area. Neither it nor the two Arequipa sources matched any obsidian analyzed from archaeological sites.

MODELS OF DISTRIBUTION MECHANISMS

The provenience and distribution data on obsidian, or on any other material, do not in themselves provide adequate data for inferences on the mechanisms of distribution and the kinds of social interaction associated with it. The absence of both a complex market sytem and a large merchant class in Peru at the time of the Conquest should act to caution the projection of models of trade developed in Mesoamerica or the Near East. Because of the distinct character of the Central Andes, it may be worthwhile to present some models of pre-Hispanic obsidian distribution drawn from ethnographic and ethnohistoric research.

Travel and trade are basic components of adaptation to the vertical zonation of the Central Andes. Some occupants of the lower and upper puna zones traditionally spend at least part of the dry season in other lower ecological zones exchanging animal products for foods, especially corn, grown in lower elevations. Study of the energy flow in Nuñoa has shown that it is this exchange, favorable in terms of energy use to the puna dwellers, that allows the current human adaptation to continue successfully (Thomas, 1973, p. 137; Custred, 1974, p. 280). It also seems that having part of the population leave in the dry season with their herd minimizes strain on the environment during the puna's least productive season. Such trips are usually made by male heads of households, often accompanied by a son (Flores Ochoa, 1968, p. 130;

Custred, 1974, p. 257). These trips are known to exceed 400 kilometers (round trip) in southern Peru (Flores Ochoa, 1968, p. 132). Sometimes special stops are made along the way to acquire additional highland products, such as salt or pottery, which will make the exchange even more favorable (Custred, 1974, pp. 278-279; Flores Ochoa, 1968, p. 131). In some cases, products are still exchanged by barter. The trading partners may be acquaintances from other zones, related by fictive kinship (compadrazco), or blood relatives. In some ethnohistoric cases, members of communities settled in other zones to insure exchange (Diez de San Miguel, 1964). The distribution of obsidian could have been integrated into this basic Andean economic pattern of zone interdependence without difficulty.

Obsidian occurs in geologically recent volcanic formations commonly found in the upper puna (usually above 12,500 ft). Such spots would have been more accessible to ancient puna dwellers and their camelid herds than to the agricultural people of the lower zones. Further, the possession of llamas as pack animals would have given the puna dwellers an added advantage in obsidian trade. The actual mining of obsidian could have been done by traveler-merchants or by permanent residents at the mine. Such miners could have been independent or have been settled as colonists by other communities.

Even in cases where a community controls all of the basic zones of food production, interzonal trade is often pursued as a desirable subsistence strategy (Mayer, 1971, pp. 188-189). In modern cases, where the subsistence system is highly self-sufficient, trade is used to secure rare materials from beyond the local system (Brush, 1974,

p. 282). Rare but necessary goods such as obsidian can serve as an impetus for establishing economic and social networks outside the area used to produce a full range of agricultural products.

It is possible that specialized or semi-specialized merchants did play a role in distributing obsidian and other exotic goods in the Andes. Merchants did exist in pre-Hispanic Peru, as evidenced by Lizarraga's description of Chincha (Department of Ica) merchants who traded gourds as far off as Chucuito (Department of Puno) (1909, p. 519). The work of Rostorowski (1970) has demonstrated that these merchants were both numerous and important. Peddlers in the Peruvian highlands currently bring non-local goods into relatively isolated communities (Webster, 1971, p. 180). The present importance of markets is due in part to Spanish influence and changes in the transportation system, but the importance of pre-Conquest markets cannot be ruled out.

Another model is that of nationalized obsidian sources, mined for a centralized government and distributed by it. In Inca times, the mining of certain valuable materials (gold, silver, etc.) was under strict government control (Sancho de la Hoz, 1938, Chapt. XVIII). Tools and weapons were produced through the labor tax, stored in local and regional government storehouses, and distributed by the government to the general populace (<u>mita</u> laborers, the army, etc.).

The bartering of goods which occurs during trips to outside areas has been observed ethnographically; excellent descriptions of such exchanges are provided by Mayer (1971) and Burchard (1974). These descriptions clarify the importance of individual relationships in the exchange structure. Such an exchange structure serves, and would have served, as an excellent mechanism for the diffusion of information on technological innovation, religious concepts, and other cultural traits. The informal and formal economic relations between individuals of different areas appear as patterns of interaction when viewed from a regional or supra-regional perspective, and can be partially inferred from material remains (such as obsidian) by the archaeologist. The identification, through provenience analysis of obsidian, of such interaction spheres in the prehistoric record has more than purely economic implications.

The hypothetical mechanisms of procurement and distribution outlined here are not all mutually exclusive. It is possible that several coexisted in different areas or were used in conjunction. In addition, the appearance of exotic obsidian at a site is not necessarily due to exchange or government distribution; it may be a byproduct of people travelling for other purposes and leaving part of their personal tool kit. This could occur with soldiers sent to a foreign province carrying obsidian tipped arms produced in the area where they were originally stationed. Large-scale movements of troops and civilian populations under the Inca might have resulted in this kind of phenomenon. A second case would be that of a puna dweller on a long trip who breaks his knife while in the distant community and must either rework or discard it.

DISCUSSION

A combination of neutron activation analysis and x-ray fluorescence was successful in identifying sixteen types of obsidian from archaeological sites in Peru and Bolivia; at least eight of these were of importance in antiquity. The distribution of each type of obsidian is limited in space and time, and it is possible, even with our limited sample, to tentatively identify several spheres of obsidian exchange. Distribution of obsidian is assumed to reflect economic, social and political patterns which are often larger and more complex than the matter of the obsidian itself. As these spheres of interaction are based on chemical data from trace element analysis of obsidian, their identification is independent of the body of archaeological interpretations based on style analysis of ceramics and other artifacts. Thus, obsidian analysis can be used as a type of control on other kinds of archaeologial inferences. It can also be used in conjunction with other archaeological materials for the study of economic spheres, long distance movement and exchange, and the social interaction and information exchange usually associated with these.

In this capacity, the distribution of Quispisisa Source obsidian is especially interesting. It seems to have been used intensively in a core area which included Huancayo, Huancavelica, Ayacucho, and Ica. The existence of this obsidian interaction sphere goes back to the Preceramic and continues intact until the decline of the Huari Empire. Other areas to the south of this core area (Andahuaylas, Lucanas, and Acari) also used obsidian from Quispisisa, despite their access to many other types of obsidian. No other major sources of obsidian seem to have been available to the highlands north of this core area. The data on the use of Quispisisa obsidian substantiate the presence of coastal/highland contact in southern Peru beginning in Preramic times, as seen at San Nicolas (Department of Ica).

Based on our obsidian analysis, two other major spheres of interaction can be identified in the South Highlands: one in the Titicaca Basin and the other in Cuzco. The sample from the Sicuani area suggests that settlements there were probably on the southern edge of the Cuzco sphere, dating as far back as the Preceramic. The obsidian data are highly compatible with earlier views on Andean culture history.
The absence of Titicaca Basin Type and Cuzco Type obsidians in other parts of Peru suggests cultural and economic isolation, which is also reflected in ceramic styles. Rowe, for example, has noted the difficulty of cross dating the sequence of Cuzco and Puno to the Ica "master sequence" using ceramic style or traded ceramics (1966, p. 17). Obsidian analysis also provides evidence of trade between inhabitants of Cuzco and Puno in the Early Horizon.

It is also notable that major changes in patterns of obsidian distribution occur during the spread of Chavin influence and the expansion of the Huari Empire. Both of these phenomena had been recognized earlier using ceramics, architecture, and other material. During Chavin times, obsidian from Quispisisa was brought to Chavin in quantity, indicating a modification in the economic structure of the Central Andes. Indeed it is reasonable that economic as well as religious forces must have been responsible for the cultural homogeneity which came into existence in much of Peru at that time.

A different pattern of obsidian distribution occurred during the period of the Huari Empire. Not only was Quispisisa obsidian brought into areas which did not traditionally have access to obsidian (i.e., northern highlands, eastern slopes of the Andes, etc.), but also pieces of exotic obsidian are found in areas which used other types of obsidian. Thus Quispisisa Source and Andahuaylas A Type obsidians are found in Cuzco, and Cuzco Type obsidian is found at Middle Horizon centers at Jincamoqo (Department of Ayacucho), Huari (Department of Ayacucho) and even Marca Huamachuco (Department of La Libertad). In these cases, factors other than expansion of trade networks and proximity of obsidian sources must have played a part. Perhaps this difference is indicative of movements of troops, administrators, and/or populations. An alternative hypothesis is that this distribution reflects idiosyncracies in the poorly understood Huari system of storage and redistribution. It is interesting that the pattern of obsidian trade seems to have foreshadowed the Middle Horizon frontier in the Sicuani area, between Huari and Tiahuanaco. This cultural boundary was reflected in obsidian distribution by Early Horizon, and perhaps Preceramic, times.

The scarcity of obsidian artifacts from the Central and North Coast throughout Andean prehistory has been substantiated by extensive work in the Rimac and Lurin Valleys (Thomas Patterson, Edward Lanning, personal communication), the Chillon Valley (Tom Dillehay, personal communication), the Nepeña Valley (Donald Proulx, personal communication), the Viru Valley (Michael West, personal communication), and the Moche Valley (Michael Mosley, personal communication). The reasons for its absence may be sought in cultural and economic patterns. This information suggests that obsidian traded into the highlands north of Quispisisa travelled by a highland route, rather than by way of the coast.

This study is preliminary in nature and hopefully will serve to stimulate future in-depth studies of the provenience of archaeological obsidian in the Central Andes and the nature of its distribution in pre-Hispanic times. One of the top priorities for future research is the location of the obsidian flows which served as sources in ancient times. When an obsidian source is located, it would be desirable to take samples from different parts of the flow, making note of the spot from which each sample is taken, in order to detect chemical heterogeneity within a single deposit. Care should be taken to distinguish quarry areas from workshops where large quantities of obsidian debris accumulated.

Another priority should be securing samples from sites in areas not covered by this study. One important gap is the coastal and highland areas of Arequipa, Moquegua, and Tacna. It is known that obsidian was used in Arequipa beginning in Preceramic times (Eloy Lunares Malaga, personal communication; Neira, 1969, pp. 45,64; Bonavia and Ravines, 1972, pp. 40-41). It is anticipated that new types of obsidian may be encountered in further sampling.

In the study of obsidian from extensively excavated sites, quantification of obsidian artifacts is an important step in evaluating the intensity of obsidian trade at a given time. The study of intersite variation in the types of obsidian and the frequency and context of its use would also be productive. Such studies should lead to a more sophisticated understanding of obsidian's uses by different segments of the society. Investigations should be conducted at obsidian sources themselves to gain insight into the technology of procurement and the groups responsible for the mining.

Ultimately, Andean obsidian must be understood within the context of a large inventory of ancient goods (perishable and resilient, scarce and common) which were traded both locally and for long distances. Few of these other trade goods have received the attention they deserve. Interest among Andean archaeologists is increasing (e.g., Paulsen, 1974) and with improved scientific techniques at their disposal we can look forward to much additional information on other ancient trade goods. When studies of obsidian artifacts and other trade goods are integrated, the changing patterns of trade and social interaction in the ancient Andes should be greatly clarified.

Acknowledgments

This article has been possible only because of the cooperation of many colleagues and friends. Special thanks are due to Luis Barreda M., Harry Bowman, David Browman, Sergio and Karen Chavez, Lawrence Dawson, Ned and Jane Dwyer, José Gonzales, Joel Grossman, Joachim Hempel, Gary Ho, Peggy Hoyt, William Isbell, Lowie Museum of Anthropology (Berkeley), Patricia Lyon, Thomas Lynch, Richard S. MacNeish, Ramiro Matos Mendieta, Clement Meighan, Dorothy Menzel, Helen Michel, Michael Moseley, Antoinette Nelken-Terner, Paul Ossa, Felix Palacios, Thomas C. Patterson, Percy Paz, Carlos Ponce Sangines, Maks Portugal, Vianne Ramirez, Rogger Ravines, Scott Raymond, John H. Rowe, Alfredo Sandoval Millones, Kathy Schreiber, Helaine Silverman Mayer, University of California Archaeological Research Facility, Gary Vescelius, Robert Vierra.

Work performed under the auspices of the U. S. Energy Research and Development Administration.

Fig. 1. Map of Peru indicating archaeological sites and geological deposits from which obsidian has been tested in this study.

Key to Figure 1.

1. Trujillo (Uhle), Moche V Cemetary
2. La Cumbre
3. Marca Huamachuco
4. Chavin de Huantar (Castillo, Pueblo, Qaucho)
5. Uchcumachay
6. Ancon
7. Ataura
8. PJuM616
9. PJu618 (Calpish)
10. PJuM704 (Pirwapuquio)
11. PHa4-8
12. Palestina
13. Ac100 (Pikimachay), Ac102 (Iomachay)
14. Huari, Ac300, Camino Antiguo
15. Ac158 (Puente)
16. Ac500, Ac351 (Tukumachay)
17. Ac335 (Jaywamachay)
18. PHa3-21 (Abrigo), Mina de Quispisisa
19. Chincha, Sitio D
20. Alto de las Brujas, Pisco
21. Cerro Prieto (PV62-27), San Jose de Cordero (PV62-70)
22. Tajahuana
23. Erizo, La Venta (PV62-141A), Ocucaje A, Ocucaje B
24. Media Luna
25. San Nicolas

26. Paroma

27. Hacha

28. Waywaka, Qasawirka, Kunka Taka, Santa Elena

29. Ay5-1, Ay5-5 (Coracorral Pata) Ay5-6 (Jincamoqo o Cabana), Ay5-7

30. Cz2-26 (Kallpitu), Cz2-10, Bandoja, Santa Barbara Baja

31. Qhataqasallaqta, Cebolla Wayqo, Qhasapata, Marcavalle, Qotakalli, Tarawi, Wimpilla, Coricancha

32. Minaspata, Pikillaqta

33. Batan 'Urqo

34. Mawqallaqta

35. Lasawpata, Choque Puquio, Queruro

36. Chinchiramoqo

37. Huki Wasi

38. Yanamancha, Suyu, Pikicallepata

39. Llalli

40. Pucara, Qaluyu

41. Taraco

42. Juliaca, Sillustani

43. Incatunuhuiri

44. Juli

45. Tiahuanaco, Qallamarka

46. Tumuku

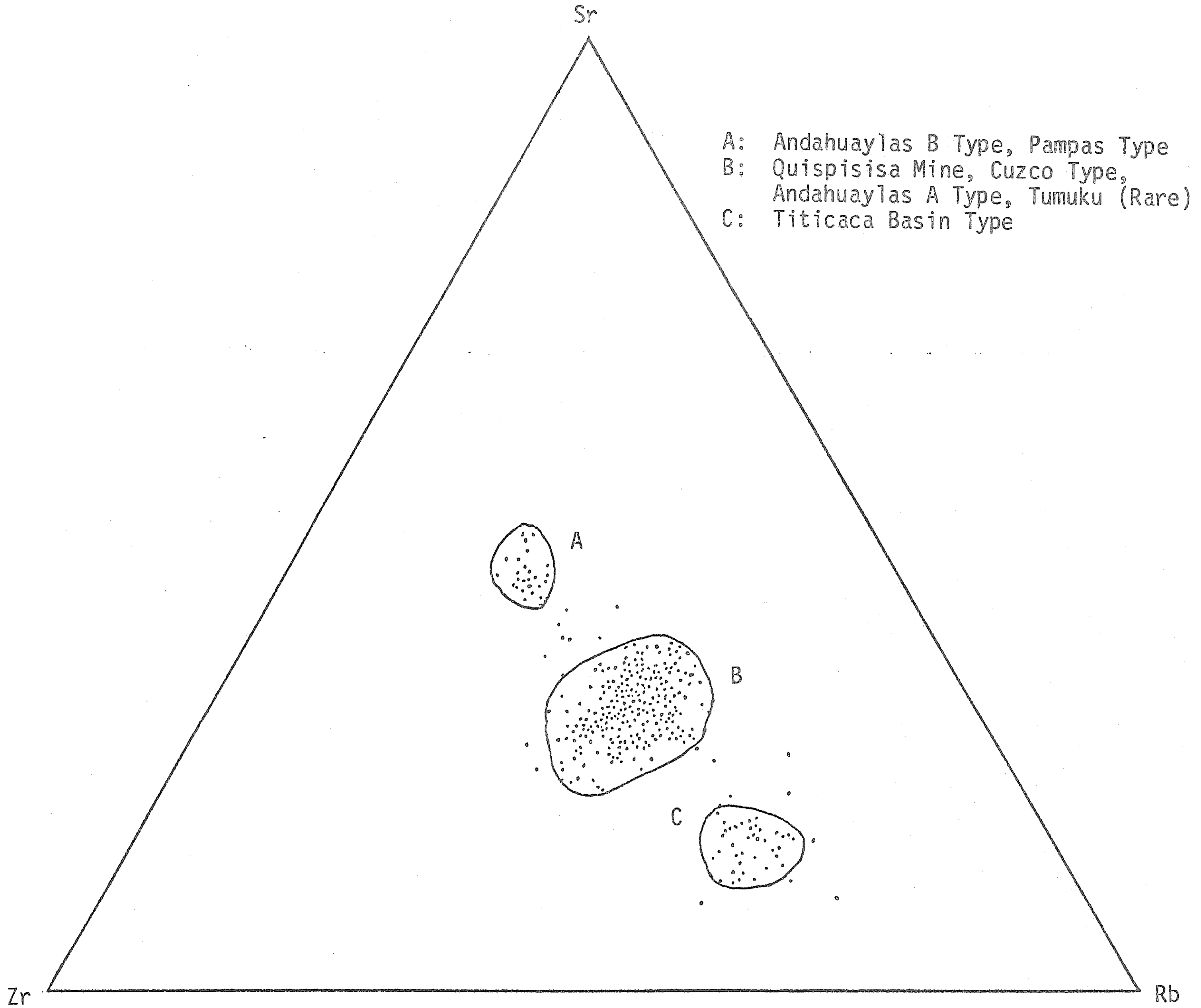

Fig. 2. Graphic presentation of XRF measurements made at the Department of Geology, University of California, Berkeley. This initial study using only Sr, Rb, and Zr was unable to distinguish between many of the principal types of obsidian. The graph demonstrates the way in which the Pampas Type and Andahuaylas B Type were lumped in cluster A while the Quispisisa Source, the Cuzco Type, the Andahuaylas A Type, and the rare Tumuku Type were all included in cluster B. This confusion of types made it necessary to seek the more sophisticated techniques employed at the Lawrence Berkeley Laboratory, the results of which are seen in Tables 1 and 2 in the Appendix.

Table 1A. Mean compositions and standard deviations determined by neutron activation at the Lawrence Berkeley Laboratory: Major types.

	Dy	Mn	U	Ba	Sb
Quispisisa Source	1.71 ± 0.09	365 ± 7	8.66 ± 0.15	733 ± 22	1.31 ± 0.12
Ayacucho Type	1.44 ± 0.11	449 ± 9	4.67 ± 0.05	232 ± 19	0.27 ± 0.05
Acarí Type	2.31 ± 0.09	553 ± 11	6.23 ± 0.05	633 ± 23	0.56 ± 0.07
Pampas Type	4.51 ± 0.13	576 ± 11	6.54 ± 0.06	791 ± 22	1.90 ± 0.15
Andahuaylas A Type	2.50 ± 0.10	505 ± 10	4.36 ± 0.09	374 ± 14	0.29 ± 0.08
Andahuaylas B Type	2.20 ± 0.10	447 ± 9	3.47 ± 0.07	1084 ± 26	0.26 ± 0.06
Cuzco Type	2.06 ± 0.10	476 ± 10	3.23 ± 0.05	1040 ± 23	0.17 ± 0.05
Titicaca Basin Type	3.05 ± 0.11	720 ± 14	7.25 ± 0.07	144 ± 13	0.88 ± 0.11

	Th	Eu	Ce	Hf	Ta	Yb
Quispisisa Source	20.69 ± 0.48	0.429 ± 0.009	51.9 ± 0.9	3.29 ± 0.8	1.1 ± 0.02	1.15 ± 0.03
Ayacucho Type	16.28 ± 0.24	0.292 ± 0.006	40.7 ± 0.6	3.76 ± 0.07	1.78 ± 0.01	0.84 ± 0.03
Acarí Type	17.70 ± 0.14	0.366 ± 0.007	42.0 ± 0.6	2.99 ± 0.7	1.36 ± 0.01	1.34 ± 0.03
Pampas Type	13.83 ± 0.14	1.031 ± 0.023	80.6 ± 2.6	5.01 ± 0.18	1.56 ± 0.03	2.78 ± 0.05
Andahuaylas A Type	18.37 ± 0.21	0.599 ± 0.011	42.9 ± 0.8	3.32 ± 0.7	1.22 ± 0.01	1.22 ± 0.02
Andahuaylas B Type	19.60 ± 0.49	0.951 ± 0.012	107.1 ± 1.6	5.29 ± 0.10	1.04 ± 0.01	1.04 ± 0.05
Cuzco Type	14.76 ± 0.12	0.495 ± 0.010	58.5 ± 1.4	3.56 ± 0.14	0.90 ± 0.01	1.09 ± 0.04
Titicaca Basin Type	25.03 ± 0.26	0.288 ± 0.007	43.0 ± 1.1	3.85 ± 0.11	1.69 ± 0.04	1.67 ± 0.04

	Sm	La	Sc	Fe%	Cs
Quispisisa Source	2.49 ± 0.05	27.6 ± 1.0	1.51 ± 0.04	0.577 ± 0.018	11.38 ± 0.24
Ayacucho Type	1.98 ± 0.02	22.6 ± 0.7	1.72 ± 0.05	0.491 ± 0.015	3.99 ± 0.12
Acarí Type	2.62 ± 0.03	20.3 ± 0.8	2.03 ± 0.02	0.467 ± 0.010	7.09 ± 0.17
Pampas Type	5.16 ± 0.05	43.2 ± 1.6	2.58 ± 0.03	0.928 ± 0.020	12.73 ± 0.29
Andahuaylas A Type	3.46 ± 0.04	19.7 ± 0.6	1.84 ± 0.03	0.473 ± 0.015	5.49 ± 0.14
Andahuaylas B Type	4.82 ± 0.05	58.7 ± 1.5	1.99 ± 0.02	0.894 ± 0.044	4.29 ± 0.15
Cuzco Type	3.30 ± 0.03	29.6 ± 0.7	1.95 ± 0.03	0.565 ± 0.015	2.90 ± 0.13
Titicaca Basin Type	3.66 ± 0.04	19.2 ± 0.8	3.38 ± 0.03	0.506 ± 0.07	10.21 ± 0.37

Notes: 1. Abundance values are in parts-per-million (ppm) for all elements except Fe, which is in percent.
2. The standard deviation is the greater of the root-mean-square deviation or the standard deviation in the counting of the radioactivity.

Notes to Table 1A.

Quispisisa Source: based on 48 samples, including 3 from the obsidian mine. The archaeological sites at which the samples were found and the number analyzed in this work by neutron activation were: Pampa Media Luna (1), San Nicolas (3), Erizo (1), Huari (3), Waywaka (4), Marca Huamachuco (2), Trujillo (1), Hacha (2), Jaywamachay (7), La Banda, Dist. Chavin (3), Uchcumachay (6), Jincamoqo (2), Ataura (2), Jalpacocha (1), Iomachay (1), Ancon (2), Ac300 (2), Cebolla Waiqo (1). The average standard deviation for the best 22 elements tested is 4.12%.

Ayacucho Type: based on 3 samples from the archaeological site of Iomachay and one from Ac500. The average standard deviation for the best 22 elements tested is 5.83%.

Acari Type: based on 2 samples from the archaeological site of Hacha. The average standard deviation for the best 20 elements is 3.19%.

Pampas Type: based on 7 samples from the archaeological sites of Jincamoqo (1), Jalpacocha (1), Canichi (1), and Waywaka (4). The average standard deviation for the best 22 elements tested is 3.77%.

Andahuaylas A Type: based on 12 samples from the archaeological sites of Waywaka (8), Qasawirka (3), and Santa Elena (1). The average standard deviation for the 22 best elements tested is 6.38%.

Andahuaylas B Type: based on 5 samples from the archaeological sites of Waywaka (2), and Knunka Taka (3). The average standard deviation for the 20 best elements tested is 4.59%.

Cuzco Type: based on 24 samples from the archaeological sites of Muyu 'Urqo (3), Minaspata (1), Marcavalle (2), Suyu (3), Qotakalli (1), Taraco (4), Jincamoqo (2), Coricancha (1), Pakallamoqo (1), Aqawllay (1), Incatunuhuiri (1), Huari (1), Waywaka (1), Yanamancha (1), Huamachuco (1). The average standard deviation for the 20 best elements tested is 6.64%.

Titicaca Basin Type: based on 21 samples from the archaeological sites of Qaluyu (1), Pucara (1), Juli (1), Sillustani (1), Juliaca (1), Incatunuhuiri (1), Tumuku (1), Sora Sora (3), Marcavalle (2), Llalli (5), Tiahuanaco (2), Pukupata (1), Suyu (1). The average standard deviation for the best 10 best elements tested is 3.25%.

Elements not listed in Table 1:

As: The precision of the measurements for As is low but results suggest that it may eventually be useful to distinguish types of obsidian. Arsenic is found in small quantities in most cases but is somewhat larger in the Acari type, larger still in the Titicaca Basin and largest in the Pampas type (see Appendix).

Co: Despite low precision in the measurement of Co, it is clear that Co occurs in much smaller quantities in the Andahuaylas A type, Cuzco type, Ayacucho type, and Acari type than in the other four major types.

Table 1B. Mean compositions and standard deviations determined by neutron activation at the Lawrence Berkeley Laboratory: Rare types.

	Dy	Mn	U	Ba	Sb	Th	Eu	Ce
Rare Type 1: Tumuku (2)	1.47 ± 0.10	493 ± 10	3.40 ± 0.05	567 ± 19	0.12 ± 0.05	13.57 ± 0.14	0.433 ± 0.008	52.4 ± 0.9
Rare Type 2: Jaywamachay*	1.59 ± 0.10	508 ± 10	4.54 ± 0.04	312 ± 14	0.24 ± 0.05	15.44 ± 0.17	0.344 ± 0.006	42.9 ± 0.8
Rare Type 3: Muyu 'Urqo*	1.58 ± 0.10	630 ± 13	6.82 ± 0.05	9 ± 13	0.22 ± 0.06	30.31 ± 0.30	0.101 ± 0.004	51.6 ± 0.9
Rare Type 4: Waywaka (3)	2.14 ± 0.11	486 ± 10	4.75 ± 0.07	961 ± 24	0.40 ± 0.07	19.80 ± 0.17	0.773 ± 0.010	82.8 ± 1.1
Rare Type 5: Uchcumachay*	1.30 ± 0.08	340 ± 7	9.77 ± 0.08	946 ± 12	1.61 ± 0.15	20.61 ± 0.17	0.286 ± 0.006	33.3 ± 0.7
Rare Type 6: Taraco and Chinchiramoqo (1 sample each)	2.18 ± 0.10	451 ± 9	4.49 ± 0.05	816 ± 24	0.42 ± 0.06	17.51 ± 0.13	0.544 ± 0.009	66.6 ± 0.9
Rare Type 7: Wimpilla*	7.68 ± 0.11	311 ± 6	3.08 ± 0.04	1194 ± 28	0.52 ± 0.08	7.66 ± 0.07	0.547 ± 0.010	52.8 ± 0.7
Rare type 8: Wimpilla*	2.36 ± 0.08	412 ± 8	8.33 ± 0.06	574 ± 19	0.06 ± 0.04	35.08 ± 0.22	0.528 ± 0.009	85.5 ± 0.9

	Hf	Ta	Yb	Sm	La	Sc	Fe%	Cs	Rb
Rare Type 1: Tumuku (2)	3.63 ± 0.08	0.97 ± 0.01	1.06 ± 0.03	2.14 ± 0.02	29.7 ± 0.8	1.71 ± 0.02	0.550 ± 0.020	3.39 ± 0.12	143 ± 7
Rare Type 2: Jaywamachyay*	3.86 ± 0.09	1.94 ± 0.01	0.95 ± 0.03	2.34 ± 0.02	21.7 ± 0.6	1.87 ± 0.02	0.540 ± 0.020	3.80 ± 0.11	124 ± 9
Rare Type 3: Muyu 'Urqo*	4.77 ± 0.10	1.40 ± 0.01	1.50 ± 0.04	1.53 ± 0.01	28.9 ± 0.7	1.74 ± 0.02	0.510 ± 0.02	4.40 ± 0.11	229 ± 9
Rare Type 4: Waywaka (3)	4.45 ± 0.09	0.83 ± 0.01	1.09 ± 0.03	4.22 ± 0.02	44.2 ± 1.0	1.72 ± 0.02	0.707 ± 0.020	5.95 ± 0.15	166 ± 7
Rare Type 5: Uchcumachay*	2.51 ± 0.07	1.12 ± 0.01	0.93 ± 0.03	1.77 ± 0.7	17.9 ± 0.7	1.38 ± 0.02	0.380 ± 0.010	11.22 ± 0.24	173 ± 6
Rare Type 6: Taraco and Chinchiramoqo (1 sample each)	3.13 ± 0.08	1.00 ± 0.01	1.28 ± 0.03	3.20 ± 0.01	34.8 ± 0.8	2.04 ± 0.02	0.570 ± 0.01	5.80 ± 0.16	176 ± 5
Rare Type 7: Wimpilla*	4.07 ± 0.08	0.80 ± 0.01	5.67 ± 0.06	5.88 ± 0.02	24.5 ± 0.8	4.1 ± 0.03	0.570 ± 0.02	2.51 ± 0.13	81 ± 4
Rare Type 8:	4.68 ± 0.08	1.48 ± 0.01	1.74 ± 0.03	3.44 ± 0.01	47.1 ± 0.9	2.34 ± 0.02	0.69 ± 0.02	6.32 ± 0.16	241 ± 5

Notes: 1. Abundance values are in parts-per-million (ppm) for all elements except Fe, which is in percent.
* When only a single sample was measured, the error is the standard deviation in counting the radioactivity.

Table 2. Selected trace element composition of Andean obsidian: x-ray fluorescence analysis made at Lawrence Berkeley Laboratory (in parts-per-million)

Obsidian Type	Sample Size	Ba	Ce	Rb	Sr	Zr
Titicaca Basin	60	126	41.1	331	54	101
Ayacucho	8	220	42.8	154	89	90
Andahuaylas A	26	396	44.3	211	99	77
Acari	10	626	43.2	156	89	86
Quispisisa	60	735	52.0	233	155	93
Pampas	36	799	78.6	212	346	196
Cuzco	52	1019	58.4	165	106	104
Andahuaylas B	9	1128	100.0	179	359	193

Table 3. Summary of obsidian analyzed by x-ray fluorescence and neutron activation.

	Quispisisa Source	Ayacucho Type	Acari Type	Pampas Type	Andahuaylas A Type	Andahuaylas B Type	Cuzco Type	Titicaca Basin Type	Rare Types	Unclassified Types	Samples analyzed by NAA	Samples analyzed by XRF
Mina de Quispisisa	3										3	4
Ha 3-21, Abrigo	4											4
Ha 4-8	1											1
San Nicolas	49										3	46
Erizo	3										3	2
Media Luna	31										1	30
Tajahuana	4											5
Ocucaje A	1											1
Ocucaje B	2											2
San Jose de Cordero	2											2
Santa Lucia	1											1
La Venta	1											1
Cerro Prieto	1											1
PV 62-128	1											1
Paroma	3											3
PV 62-141A	1											1
PV 62-74	1											1
Alto de las Brujas, Pisco	1											1
Chincha D	1											1
Hacha	35		10	6						2	4	53
Ac 355 (Jaywamachay)	30								1		8	23
Ac 158 (Puente)	9	3									2	10
Ac 102 (Iomachay)	3	3									4	6
Ac 351 (Tukumachay)	3											3
Ac 500	4	2									1	6
Ac 300	10										2	10
Ac 100 (Pikimachay)	1										1	
Huari	50				1						3	50
Ayacucho, via antigua	2											2
Palestina	1											1
Ataura	6									1		7
PJuM 613	3											3
PJuM 616	2									1		3
PJuM 618	2											2
PJuM 685	1											1
PJuM 704	1											1

Table 3. Continued.

	Quispisisa Source	Ayacucho Type	Acari Type	Pampas Type	Andahuaylas A Type	Andahuaylas B Type	Cuzco Type	Titicaca Basin Type	Rare Types	Unclassified Types	Samples analyzed by NAA	Samples analyzed by XRF
Town of Chavin	1											1
Temple of Chavin	3											3
Qaucho	13										3	12
Uchcumachay	9								1		7	10
Marca Huamachuco	3						1				3	3
Huamachuco (Uhle)	9						5					14
La Cumbre	1											1
Cementerio Moche V	1											1
Trujillo (Uhle)	3										1	[illegible]
Ancon	2										2	
PAy 5-1	1			3	1						1	5
PAy 5-5 (Coracorral Pata)	6			4	1							11
PAy 5-6	24			22			5				8	50
PAy 5-7	2			1								3
Qasawirka					4						3	1
Waywaka	15			16	33	11	2		3		22	71
Kunka Taka				1		1					1	1
Santa Elena						1					1	
Marcavalle							26	3		2	3	28
Minas Pata							9				2	7
Muyu 'Urqo							12		1		3	10
Qotakalli							3			1	1	4
Tarawi							1					1
PCz 13-14							1				1	1
Pikillaqta					1						1	
Wimpilla				1			1				2	4
Kallpitu	1											1
Coricancha							1				1	
PCz 2-10							2				1	2
Bandoja							1					1
Santa Barbara Baja	1						1					2
Queruro							1					1
Mawqallaqta							1					1
Qhasapata							1					1
Lasawpata							3					3
Cebolla Wayqo	1											2
Batan 'Urqo	1						1					2

Table 3. Continued.

	Quispisisa Source	Ayacucho Type	Acari Type	Pampas Type	Andahuaylas A Type	Andahuaylas B Type	Cuzco Type	Titicaca Basin Type	Rare Types	Unclassified Types	Samples analyzed by NAA	Samples analyzed by XRF
Qhataqasallaqta							1					1
Pukupata							1	1			1	1
Choque Puquio							1			1		2
Pakallamoqo							1				1	
Chinchiramoqo									1		1	1
Yanamancha							3	2			2	3
Suyu							4	2			4	2
Pikikallepata							11	3			14	
Huki Wasi							2	3		1		6
Taraco							10	143			4	153
Qaluyu							1	16			1	16
Juli								2			1	1
Incatunuhuiri							1	9			2	8
Aqawallay							2				1	1
Juliaca								1			1	
Sillustani								1			1	
Pucara								1			1	
Tumuku								1	2		3	
Kallamarka								2				2
Tiahuanaco								16			2	14
Llalli								7			6	1
Sora Sora								3			3	

Table 4. Analysis of obsidian from the excavations of the Ayacucho Archaeological-Botanical Project

Sites Sampled	Microenvironmental Zone*
Ac 100 (Pikimachay)	dry thorn forest
Ac 102 (Iomachay)	dry thorn forest
Ac 158 (Puente)	desert
Ac 300	tundra
Ac 335 (Jaywamachay)	humid scrub forest
Ac 351 (Tukumachay)	tundra
Ac 500	humid scrub forest

Site	Zone	Phase*	Tentative Dates*	Quispisisa Source	Ayacucho Type
Ac 100	f-2	Puente	7000 BC	1	
Ac 102	8	Puente	7300 BC	1	
	7	Jaywa	5600 BC	2	
	6	Chihua	3600 BC		3
Ac 158	XIII	Puente	7100 BC		1
	XII	Puente	6900 BC		1
	XI	Jaywa	5900 BC	2	
	IX	Piki	5300 BC	1	
	VIII	Piki	5200 BC	1	
	VII	Piki	4900 BC	2	1
	VI	Piki	4720 BC	1	
	V	Piki	4520 BC	1	
	I	Chihua	4000 BC	1	
Ac 300	C-north	Jaywa	5500 BC	6	
	C-south	Chihua	3100 BC	4	
Ac 335	M-N	Ayacucho	10000 BC	1	
	K		9020 BC	3	
	J-2	Huanta	7940 BC	3	
	I	Puente	7610 BC	2	
	H	Puente	7030 BC	2	
	G	Puente	6850 BC	2	
	F	Jaywa	6550 BC	5	
	E	Jaywa	6490 BC	1	
	D	Jaywa	6410 BC	5	
	C	Jaywa	6300 BC	4	
Ac 351	C-2	Cachi	2500 BC	2	
	C-1	Cachi	1800 BC	1	
Ac 500	F	Puente	7300 BC	2	
	E	Piki	4600 BC	1	
	D-1	Chihua	3000 BC	[illegible]	3

*data from MacNeish et al., 1970; and MacNeish, personal communication

Table 5. Analysis of obsidian from excavations at the site of Waywayka, Andahuaylas Province, Department of Apurimac.*

Phases	Andahuaylas A Type	Andahuaylas B Type	Quispisisa Source	Pampas Type	Cuzco Type	Rare Type From Waywaka
Muyu Moqo A	10		2	4		
Muyu Moqo A/B	2			5		
Muyu Moqo B	2			3		
Muyu Moqo A/B/C-D	3		2	1	1	1
Muyu Moqo B/C-D	1			1		
Muyu Moqo C-D	7		3	1		1
Muyu Moqo C-D/ Qasawirka	2	1	2			
Qasawirka	5		2		1	
Qasawirka/Middle Horizon 1-2	1			1		
Surface and Plow Zone (mainly post-MH2)	1	7	1	1		1
Mixed	1	4	3			

* Excavations by Joel W. Grossman (1972).

Table 6. Analysis of obsidian from excavations at two sites in the Department of Junin.*

	Quispisisa Source	Rare Type	Relative Date
Uchcumachay, Yauli Province			
Pit 1, strata 4BW	1		Late Preceramic
Pit 2, strata 4CE	1		Late Preceramic
Pit 2, strata 2	1		Early Intermediate Period
Pit 4, strata 4		1	Early Intermediate Period
Pit 5, strata 5	1		Jaywa/Piki
Profile A, 18-20 m	1		(Probably Late Preceramic)
Profile A, 24-26 m	4		(Probably Late Preceramic)
Ataura, Jauja Province			
Quadrant C-11, strata 5	1		Pre-Chavin
Quadrant C-1, strata 1	1		Chavinoid
Surface	4		

* Excavations directed by Ramiro Matos Mendieta. Relative dates were provided by Ramiro Matos Mendieta and Peter Kaulicke.

APPENDIX

ELEMENTAL ABUNDANCES BY NEUTRON ACTIVATION ANALYSIS

(PARTS PER MILLION OR PERCENT IF INDICATED BY % AFTER CHEMICAL SYMBOL)

	RUN	SAMPLE	AL %	DY	MN	NA %	K %	SR
				QUISPISISA SOURCE				
1	822 F	BURG-2	7.03 +/- .11	1.72 +/- .09	371 +/- 5	3.046 +/- .029	3.87 +/- .29	116 +/- 118
2	822 G	BURG-3	6.95 +/- .12	1.64 +/- .09	370 +/- 5	3.021 +/- .029	3.65 +/- .28	265 +/- 126
3	822 K	PURG-6	6.89 +/- .11	1.82 +/- .09	382 +/- 5	3.031 +/- .031	3.58 +/- .31	135 +/- 104
4	822 M	BURG-8	6.99 +/- .12	1.52 +/- .10	373 +/- 5	3.051 +/- .032	3.97 +/- .32	138 +/- 109
5	822 P	BURG-11	6.94 +/- .18	1.70 +/- .11	376 +/- 5	3.024 +/- .032	3.83 +/- .32	-6 +/- 114
6	822 U	BURG-16	6.99 +/- .20	1.79 +/- .09	373 +/- 5	3.003 +/- .031	4.09 +/- .32	134 +/- 88
7	822 W	BURG-18	6.90 +/- .11	1.80 +/- .09	369 +/- 4	2.952 +/- .031	4.26 +/- .37	132 +/- 95
8	822 X	BURG-19	7.24 +/- .13	1.66 +/- .09	359 +/- 4	2.898 +/- .031	4.03 +/- .36	127 +/- 96
9	822 Y	BURG-20	7.33 +/- .15	1.73 +/- .10	368 +/- 4	2.988 +/- .031	4.09 +/- .37	138 +/- 100
10	828 H	BURG-26	7.01 +/- .25	1.70 +/- .09	365 +/- 5	2.958 +/- .023	3.51 +/- .23	202 +/- 76
11	828 R	BURG-34	7.00 +/- .13	1.81 +/- .09	364 +/- 6	2.901 +/- .022	3.58 +/- .23	194 +/- 78
12	828 W	BURG-39	7.14 +/- .14	1.73 +/- .09	378 +/- 6	2.722 +/- .021	4.14 +/- .22	40 +/- 69
13	828 Y	BURG-41	7.04 +/- .19	1.63 +/- .10	382 +/- 7	2.919 +/- .022	3.42 +/- .21	270 +/- 79
14	845 E	BURG-43	7.16 +/- .10	1.83 +/- .08	371 +/- 3	2.977 +/- .018	4.00 +/- .23	193 +/- 65
15	845 Z	BURG-62	6.94 +/- .19	1.72 +/- .12	376 +/- 3	2.982 +/- .018	3.84 +/- .22	129 +/- 107
16	861 H	BURG-66	6.86 +/- .14	1.59 +/- .09	363 +/- 3	2.973 +/- .018	3.75 +/- .23	95 +/- 67
17	861 J	BURG-67	7.01 +/- .17	1.77 +/- .09	367 +/- 3	2.951 +/- .018	4.06 +/- .24	115 +/- 69
18	861 K	BURG-68	6.66 +/- .08	1.83 +/- .08	361 +/- 3	2.874 +/- .018	4.07 +/- .23	112 +/- 70
19	861 R	BURG-74	6.96 +/- .18	1.69 +/- .08	366 +/- 3	2.897 +/- .018	3.88 +/- .23	130 +/- 62
20	861 S	BURG-75	6.97 +/- .20	1.82 +/- .09	368 +/- 3	2.912 +/- .018	3.87 +/- .23	43 +/- 63
21	861 W	BURG-79	6.89 +/- .10	1.59 +/- .08	370 +/- 3	2.974 +/- .018	3.57 +/- .22	141 +/- 72
22	871 F	BURG-89	6.95 +/- .11	1.62 +/- .08	366 +/- 2	3.013 +/- .018	4.03 +/- .22	86 +/- 63
23	871 G	BURG-90	6.81 +/- .13	1.69 +/- .08	367 +/- 2	3.027 +/- .018	3.49 +/- .22	24 +/- 64
24	871 J	BURG-92	6.86 +/- .20	1.69 +/- .09	359 +/- 2	3.000 +/- .018	3.78 +/- .22	149 +/- 68
25	871 Q	BURG-97	6.41 +/- .10	1.69 +/- .08	358 +/- 2	2.970 +/- .018	3.92 +/- .22	2 +/- 63
26	871 T	BUR-100	6.82 +/- .17	1.71 +/- .09	355 +/- 2	2.983 +/- .018	3.55 +/- .22	142 +/- 68
27	871 X	BUR-104	6.61 +/- .13	1.68 +/- .09	355 +/- 3	2.968 +/- .018	3.63 +/- .22	154 +/- 69
28	871 Z	BUR-106	6.94 +/- .21	1.71 +/- .09	358 +/- 3	3.005 +/- .018	3.66 +/- .22	140 +/- 72
29	890 E	BUR-120	6.97 +/- .12	1.77 +/- .08	365 +/- 2	3.037 +/- .018	3.67 +/- .22	56 +/- 63
30	890 G	BUR-123	6.88 +/- .16	1.67 +/- .08	363 +/- 2	3.037 +/- .018	3.64 +/- .22	110 +/- 66
31	890 H	BUR-124	6.94 +/- .20	1.68 +/- .09	363 +/- 3	3.001 +/- .018	3.76 +/- .22	201 +/- 69
32	890 M	BUR-127	6.98 +/- .11	1.69 +/- .08	360 +/- 3	2.688 +/- .017	4.22 +/- .23	215 +/- 71
33	890 O	BUR-129	7.06 +/- .16	1.70 +/- .09	364 +/- 3	2.652 +/- .017	4.45 +/- .23	102 +/- 72
34	890 P	BUR-130	7.08 +/- .20	1.82 +/- .10	364 +/- 3	2.859 +/- .018	4.32 +/- .23	9 +/- 75
35	890 Q	BUR-131	6.73 +/- .08	1.68 +/- .08	363 +/- 3	2.577 +/- .016	4.76 +/- .23	160 +/- 65
36	890 R	BUR-132	6.67 +/- .10	1.66 +/- .09	364 +/- 3	2.919 +/- .018	3.88 +/- .24	107 +/- 73
37	890 U	BUR-135	6.71 +/- .17	1.59 +/- .10	363 +/- 3	2.992 +/- .018	4.14 +/- .22	111 +/- 73
38	890 V	BUR-136	6.88 +/- .09	1.87 +/- .08	366 +/- 3	3.026 +/- .018	4.09 +/- .22	89 +/- 68
39	890 X	BUR-138	6.56 +/- .12	1.73 +/- .10	361 +/- 3	3.002 +/- .019	3.87 +/- .25	214 +/- 82
40	890 Z	BUR-140	6.90 +/- .17	1.64 +/- .09	363 +/- 3	2.344 +/- .015	5.06 +/- .22	237 +/- 72
41	893 F	BUR-108	6.97 +/- .14	1.84 +/- .08	360 +/- 2	2.709 +/- .017	4.01 +/- .22	96 +/- 68
42	893 G	BUR-109	6.80 +/- .16	1.68 +/- .09	364 +/- 3	3.011 +/- .018	4.00 +/- .22	110 +/- 71
43	893 H	BUR-110	6.45 +/- .21	1.63 +/- .09	358 +/- 3	2.905 +/- .018	3.67 +/- .21	239 +/- 74
44	893 O	BUR-115	6.93 +/- .14	1.55 +/- .09	365 +/- 3	2.990 +/- .018	3.77 +/- .22	95 +/- 72
45	893 P	BUR-116	6.74 +/- .17	1.68 +/- .09	366 +/- 3	3.029 +/- .018	3.87 +/- .22	53 +/- 73
46	914 S	ANCO-2	7.12 +/- .11	1.88 +/- .09	370 +/- 3	3.020 +/- .018	3.69 +/- .23	114 +/- 70
47	914 T	ANCO-1	6.74 +/- .13	1.72 +/- .09	369 +/- 3	3.003 +/- .018	3.84 +/- .23	154 +/- 72
48	890 T	BUR-136	6.48 +/- .13	1.76 +/- .09	359 +/- 3	2.920 +/- .018	3.79 +/- .22	218 +/- 72
				ANDAHUAYLAS A TYPE				
49	822 E	BURG-1	7.04 +/- .10	2.57 +/- .09	507 +/- 6	3.171 +/- .030	4.71 +/- .32	324 +/- 136
50	822 N	BURG-9	6.89 +/- .14	2.58 +/- .11	511 +/- 7	3.044 +/- .032	4.44 +/- .34	261 +/- 126
51	822 O	BURG-10	7.08 +/- .16	2.50 +/- .11	505 +/- 7	3.076 +/- .032	4.55 +/- .34	33 +/- 119
52	822 T	BURG-15	7.12 +/- .17	2.42 +/- .10	514 +/- 6	2.625 +/- .028	5.06 +/- .36	151 +/- 90
53	823 O	BURG-7	6.84 +/- .16	2.59 +/- .13	488 +/- 5	3.121 +/- .032	4.21 +/- .34	148 +/- 105
54	828 O	BURG-31	6.85 +/- .21	2.51 +/- .11	497 +/- 7	3.094 +/- .024	3.89 +/- .26	165 +/- 86
55	828 Q	BURG-33	7.13 +/- .13	2.34 +/- .09	507 +/- 7	2.946 +/- .023	4.06 +/- .26	75 +/- 80
56	828 T	BURG-36	7.03 +/- .19	2.57 +/- .10	504 +/- 7	2.981 +/- .023	3.82 +/- .25	127 +/- 86
57	828 Z	BURG-42	7.25 +/- .25	2.42 +/- .11	518 +/- 8	2.997 +/- .023	3.51 +/- .22	81 +/- 82
58	845 J	BURG-47	7.12 +/- .20	2.50 +/- .10	502 +/- 3	2.971 +/- .018	4.08 +/- .24	68 +/- 76
59	845 Y	BURG-61	6.84 +/- .15	2.36 +/- .12	509 +/- 4	3.071 +/- .019	4.26 +/- .24	91 +/- 112
60	871 E	BURG-88	6.73 +/- .09	2.61 +/- .09	498 +/- 3	2.964 +/- .018	4.27 +/- .24	43 +/- 67
				CUZCO TYPE				
61	822 H	BURG-4	7.14 +/- .14	1.99 +/- .10	480 +/- 6	3.323 +/- .031	4.01 +/- .30	50 +/- 128
62	822 J	BURG-5	7.10 +/- .17	2.14 +/- .10	477 +/- 6	3.300 +/- .031	3.72 +/- .30	-38 +/- 131
63	822 O	BURG-12	6.92 +/- .12	2.17 +/- .09	481 +/- 6	3.339 +/- .034	4.15 +/- .34	216 +/- 89
64	822 R	BURG-13	7.14 +/- .13	1.98 +/- .09	485 +/- 6	3.339 +/- .034	3.60 +/- .33	143 +/- 88
65	822 S	BURG-14	6.77 +/- .14	1.96 +/- .09	475 +/- 6	3.318 +/- .034	3.94 +/- .33	154 +/- 90
66	822 V	BURG-17	7.09 +/- .10	1.95 +/- .09	466 +/- 5	3.185 +/- .033	4.41 +/- .39	145 +/- 101
67	828 E	BURG-23	7.18 +/- .16	2.08 +/- .09	477 +/- 6	3.239 +/- .025	3.83 +/- .25	78 +/- 73
68	828 G	BURG-25	7.55 +/- .22	2.06 +/- .10	469 +/- 6	3.283 +/- .025	3.76 +/- .25	142 +/- 78
69	828 J	BURG-27	6.96 +/- .33	2.14 +/- .10	475 +/- 6	3.239 +/- .025	3.78 +/- .25	191 +/- 84
70	828 X	BURG-40	7.11 +/- .17	2.08 +/- .10	476 +/- 7	3.114 +/- .023	3.59 +/- .23	174 +/- 80
71	845 F	BURG-44	8.05 +/- 1.67	2.02 +/- .09	477 +/- 3	3.245 +/- .019	3.79 +/- .24	94 +/- 72
72	845 G	BURG-45	7.28 +/- .13	2.13 +/- .10	488 +/- 3	3.272 +/- .019	3.61 +/- .24	123 +/- 74
73	845 O	BURG-51	7.05 +/- .16	2.09 +/- .10	478 +/- 3	3.214 +/- .019	3.39 +/- .24	136 +/- 71
74	845 P	BURG-52	6.98 +/- .34	1.88 +/- .11	477 +/- 3	3.235 +/- .019	3.93 +/- .25	100 +/- 76
75	845 Q	BURG-53	7.14 +/- .11	2.28 +/- .09	479 +/- 4	3.254 +/- .019	3.95 +/- .24	157 +/- 82
76	871 O	BURG-95	6.96 +/- .21	2.05 +/- .10	469 +/- 3	3.308 +/- .020	4.28 +/- .26	33 +/- 82
77	893 T	BUR-122	6.89 +/- .14	2.00 +/- .10	476 +/- 3	3.345 +/- .020	3.57 +/- .23	78 +/- 68
78	890 K	BUR-126	6.99 +/- .10	1.91 +/- .09	471 +/- 3	3.339 +/- .020	3.59 +/- .24	61 +/- 75
79	890 N	BUR-128	6.93 +/- .13	1.90 +/- .10	471 +/- 3	3.305 +/- .020	3.71 +/- .24	211 +/- 81
80	890 S	BUR-133	7.18 +/- .12	1.99 +/- .10	463 +/- 3	3.259 +/- .019	3.85 +/- .24	17 +/- 75
81	914 O	BUR-143	6.72 +/- .21	2.15 +/- .12	473 +/- 4	3.319 +/- .024	3.90 +/- .28	106 +/- 98
82	914 P	BUR-144	6.57 +/- .24	2.13 +/- .11	472 +/- 4	3.354 +/- .023	3.93 +/- .27	243 +/- 96
83	914 Q	BUR-145	7.12 +/- .09	2.27 +/- .18	475 +/- 4	3.342 +/- .020	3.62 +/- .24	40 +/- 126
84	914 R	BUR-146	7.13 +/- .10	2.18 +/- .09	487 +/- 3	3.363 +/- .020	3.79 +/- .25	96 +/- 76
				TITICACA BASIN TYPE				
85	823 P	BURG-22	7.33 +/- .20	2.95 +/- .15	703 +/- 7	3.273 +/- .033	4.04 +/- .36	97 +/- 118
86	828 F	BURG-24	7.20 +/- .18	2.93 +/- .11	720 +/- 8	3.180 +/- .024	3.88 +/- .27	26 +/- 85
87	828 K	BURG-28	7.26 +/- .14	3.17 +/- .11	708 +/- 8	3.196 +/- .024	4.35 +/- .29	111 +/- 88
88	828 M	BURG-29	7.20 +/- .16	3.08 +/- .12	711 +/- 8	3.262 +/- .025	4.10 +/- .28	161 +/- 92
89	828 U	BURG-37	7.42 +/- .25	3.00 +/- .12	730 +/- 9	3.125 +/- .024	3.39 +/- .26	-4 +/- 98
90	845 H	BURG-46	7.41 +/- .16	3.02 +/- .11	730 +/- 5	3.225 +/- .019	3.82 +/- .26	-11 +/- 85
91	845 K	BURG-48	6.94 +/- .08	3.08 +/- .10	718 +/- 5	3.117 +/- .019	3.95 +/- .27	85 +/- 77
92	845 M	BURG-49	7.16 +/- .20	3.12 +/- .11	724 +/- 5	3.164 +/- .019	4.16 +/- .27	43 +/- 81
93	845 N	BURG-50	7.27 +/- .25	3.00 +/- .11	723 +/- 5	3.170 +/- .019	3.64 +/- .26	98 +/- 83
94	845 R	BURG-54	7.27 +/- .13	3.11 +/- .11	731 +/- 5	3.218 +/- .019	4.20 +/- .26	147 +/- 94
95	861 F	BURG-63	6.99 +/- .09	3.07 +/- .10	730 +/- 4	3.323 +/- .020	3.48 +/- .25	147 +/- 80
96	861 F	BURG-64	7.07 +/- .10	2.88 +/- .10	725 +/- 4	3.340 +/- .020	3.70 +/- .25	50 +/- 81
97	861 G	BURG-65	6.95 +/- .12	2.97 +/- .11	727 +/- 4	3.317 +/- .020	4.25 +/- .26	9 +/- 84
98	861 M	BURG-69	6.87 +/- .10	3.02 +/- .11	728 +/- 4	3.315 +/- .020	3.86 +/- .25	79 +/- 85
99	861 N	BURG-70	6.73 +/- .11	3.11 +/- .11	712 +/- 5	3.118 +/- .019	3.41 +/- .25	202 +/- 92
100	861 O	BURG-71	7.04 +/- .14	3.12 +/- .11	723 +/- 5	3.161 +/- .019	3.38 +/- .25	48 +/- 93
101	861 P	BURG-72	6.64 +/- .17	2.94 +/- .12	715 +/- 5	3.118 +/- .019	3.77 +/- .25	39 +/- 94
102	861 T	BURG-76	7.37 +/- .54	3.17 +/- .11	726 +/- 4	3.305 +/- .020	3.97 +/- .25	-8 +/- 87
103	861 U	BURG-77	6.89 +/- .39	2.84 +/- .12	713 +/- 4	3.286 +/- .020	3.42 +/- .24	-12 +/- 89
104	861 V	BURG-78	6.93 +/- .09	3.14 +/- .10	717 +/- 5	3.148 +/- .019	3.81 +/- .25	14 +/- 85
105	861 Z	BURG-82	6.91 +/- .18	2.82 +/- .11	718 +/- 5	3.135 +/- .019	3.56 +/- .25	-5 +/- 93

RUN	SAMPLE	AL%	DY	MN	NA%	K%	SR
PAMPAS TYPE							
106 870 S	BURG-84	7.72 +/- .13	4.66 +/- .11	586 +/- 4	3.480 +/- .021	3.31 +/- .25	447 +/- 89
107 870 T	BURG-85	7.68 +/- .14	4.70 +/- .11	592 +/- 4	3.498 +/- .021	3.78 +/- .25	293 +/- 86
108 871 H	BURG-91	7.71 +/- .17	4.42 +/- .10	567 +/- 4	3.438 +/- .020	3.62 +/- .24	305 +/- 80
109 871 M	BURG-93	7.87 +/- .15	4.50 +/- .11	576 +/- 4	3.383 +/- .021	3.62 +/- .26	227 +/- 87
110 871 N	BURG-94	8.00 +/- .18	4.50 +/- .11	573 +/- 4	3.429 +/- .021	3.76 +/- .26	266 +/- 89
111 871 U	BUR-101	8.07 +/- .25	4.36 +/- .11	569 +/- 4	3.457 +/- .020	3.47 +/- .25	281 +/- 84
112 871 V	BUR-102	7.68 +/- .11	4.44 +/- .10	569 +/- 4	3.445 +/- .020	3.34 +/- .24	283 +/- 80
ANDAHUAYLAS B TYPE							
113 822 Z	BURG-21	7.57 +/- .18	2.24 +/- .11	451 +/- 5	3.148 +/- .033	5.04 +/- .40	219 +/- 112
114 828 P	BURG-32	7.52 +/- .29	2.10 +/- .11	449 +/- 6	3.161 +/- .024	4.26 +/- .26	413 +/- 99
115 870 R	BURG-83	7.37 +/- .11	2.13 +/- .09	450 +/- 3	3.216 +/- .019	3.84 +/- .24	333 +/- 78
116 890 F	BUR-121	7.14 +/- .14	2.35 +/- .09	442 +/- 3	3.209 +/- .019	4.13 +/- .24	333 +/- 74
117 890 W	BUR-137	7.37 +/- .10	2.17 +/- .09	445 +/- 3	3.088 +/- .018	4.66 +/- .24	313 +/- 79
AYACUCHO TYPE							
118 893 J	BUR-111	7.20 +/- .37	1.48 +/- .10	449 +/- 3	2.980 +/- .018	4.22 +/- .23	153 +/- 79
119 893 K	BUR-112	6.81 +/- .08	1.37 +/- .08	443 +/- 3	2.878 +/- .018	4.51 +/- .23	111 +/- 70
120 893 M	BUR-113	6.82 +/- .10	1.57 +/- .09	452 +/- 3	3.033 +/- .018	4.19 +/- .23	109 +/- 73
121 893 N	BUR-114	6.97 +/- .12	1.34 +/- .09	453 +/- 3	3.414 +/- .020	3.78 +/- .23	38 +/- 76
122 893 E	BUR-107	6.65 +/- .12	1.52 +/- .09	509 +/- 3	3.294 +/- .020	3.64 +/- .24	196 +/- 77
ACARI TYPE							
123 893 R	BUR-118	6.76 +/- .10	2.35 +/- .09	554 +/- 3	3.196 +/- .019	3.94 +/- .24	124 +/- 67
124 893 S	BUR-119	6.61 +/- .11	2.28 +/- .10	553 +/- 3	3.177 +/- .019	3.41 +/- .23	-63 +/- 68
OTHER CHEMICAL COMPOSITIONS OF OBSIDIAN ARTIFACTS							
FOUND AT TUMUKU							
125 828 N	BURG-30	7.18 +/- .18	1.46 +/- .10	492 +/- 6	2.640 +/- .021	5.31 +/- .28	31 +/- 78
126 861 Y	BURG-81	6.78 +/- .14	1.48 +/- .10	495 +/- 3	2.923 +/- .018	4.61 +/- .24	74 +/- 80
FOUND AT JAYWAMACHAY							
127 828 V	BURG-38	7.10 +/- .13	1.59 +/- .10	508 +/- 7	3.109 +/- .023	3.64 +/- .23	0 +/- 75
FOUND AT MUYU URCO							
128 828 S	BURG-35	6.88 +/- .16	1.58 +/- .10	630 +/- 8	3.296 +/- .025	3.59 +/- .26	45 +/- 91
FOUND AT WAYWAKA							
129 871 P	BURG-96	7.87 +/- .29	2.13 +/- .11	483 +/- 3	3.629 +/- .022	3.40 +/- .25	176 +/- 89
130 871 Y	BUR-105	7.28 +/- .17	2.12 +/- .10	480 +/- 3	3.645 +/- .021	3.96 +/- .24	260 +/- 82
131 914 N	BUR-142	7.41 +/- .17	2.17 +/- .11	494 +/- 4	3.648 +/- .025	3.73 +/- .27	229 +/- 94
FOUND AT UCHCUMACHAY							
132 871 W	BUR-103	6.79 +/- .11	1.30 +/- .08	340 +/- 2	2.991 +/- .018	3.83 +/- .22	-22 +/- 65
FOUND AT TARACO (BURG-125) AND CHINCHIRAMOQO (BURG-141)							
133 890 J	BUR-125	7.12 +/- .26	2.19 +/- .09	450 +/- 3	2.960 +/- .018	3.96 +/- .23	237 +/- 75
134 914 M	BUR-141	7.02 +/- .14	2.16 +/- .10	451 +/- 3	2.956 +/- .021	3.92 +/- .26	121 +/- 84
FOUND AT CUZCO							
135 890 Y	BUR-139	6.65 +/- .14	7.68 +/- .11	311 +/- 2	3.257 +/- .019	3.70 +/- .22	64 +/- 72
136 893 Q	BUR-117	6.73 +/- .08	2.36 +/- .08	412 +/- 3	3.057 +/- .018	3.90 +/- .23	70 +/- 60
GEOLOGICAL SAMPLES FROM PERU							
AYACUCHO SOURCE							
137 845 X	BURG-60	6.60 +/- .12	1.27 +/- .10	393 +/- 3	2.165 +/- .014	4.47 +/- .22	156 +/- 95
SACHACA, AREQUIPA							
138 861 Q	BURG-73	7.44 +/- .17	2.83 +/- .10	599 +/- 4	3.166 +/- .019	3.77 +/- .26	259 +/- 74
YURI, AREQUIPA							
139 861 X	BURG-80	7.29 +/- .12	2.53 +/- .10	672 +/- 4	2.397 +/- .015	4.97 +/- .25	174 +/- 84
HIGH SILICA GLASS ARTIFACTS FOUND IN THE MANTARO VALLEY SAMPLES JUM625 AND JUM616							
140 871 R	BURG-98	.02 +/- .02	.05 +/- .02	3 +/- 0	.019 +/- .001	.05 +/- .02	12 +/- 6
141 871 S	BURG-99	.17 +/- .03	.34 +/- .02	10 +/- 0	.019 +/- .001	.10 +/- .03	25 +/- 10

RUN		SAMPLE	AS	U	BA	SM	LA	CO
				QUISPISISA SOURCE				
1	822 F	BURG-2	15.6 +/- 1.1	8.502 +/- .053	736 +/- 22	2.463 +/- .009	27.33 +/- .64	.55 +/- .05
2	822 G	BURG-3	15.1 +/- 1.1	8.518 +/- .053	717 +/- 21	2.482 +/- .009	27.59 +/- .63	.61 +/- .05
3	822 K	BURG-6	15.8 +/- 1.1	8.396 +/- .053	758 +/- 21	2.465 +/- .009	26.69 +/- .63	.52 +/- .05
4	822 M	BURG-8	14.5 +/- 1.1	8.374 +/- .052	731 +/- 21	2.440 +/- .009	26.89 +/- .62	.46 +/- .05
5	822 P	BURG-11	14.9 +/- 1.1	8.467 +/- .053	709 +/- 21	2.461 +/- .009	27.71 +/- .63	.55 +/- .05
6	822 U	BURG-16	13.6 +/- 1.1	8.715 +/- .053	755 +/- 20	2.506 +/- .009	27.80 +/- .64	.53 +/- .05
7	822 W	BURG-18	14.9 +/- 1.1	8.627 +/- .053	736 +/- 20	2.476 +/- .009	27.82 +/- .64	.48 +/- .05
8	822 X	BURG-19	14.9 +/- 1.1	8.602 +/- .053	730 +/- 20	2.470 +/- .009	28.02 +/- .64	.46 +/- .05
9	822 Y	BURG-20	15.5 +/- 1.1	8.630 +/- .053	739 +/- 20	2.506 +/- .009	28.40 +/- .63	.60 +/- .05
10	828 H	BURG-26	14.9 +/- 1.2	8.668 +/- .057	755 +/- 20	2.508 +/- .010	28.09 +/- .68	.41 +/- .04
11	828 R	BURG-34	13.6 +/- 1.2	8.633 +/- .058	733 +/- 19	2.476 +/- .010	28.02 +/- .68	.50 +/- .05
12	828 d	BURG-39	16.7 +/- 1.2	8.733 +/- .058	722 +/- 19	2.514 +/- .010	28.26 +/- .68	.49 +/- .05
13	828 V	BURG-41	14.1 +/- 1.2	8.711 +/- .058	741 +/- 19	2.492 +/- .010	27.90 +/- .68	.55 +/- .05
14	845 E	BURG-43	15.2 +/- 1.2	8.553 +/- .057	725 +/- 22	2.520 +/- .010	27.10 +/- .67	.56 +/- .05
15	845 Z	BURG-62	16.3 +/- 1.3	8.728 +/- .058	752 +/- 20	2.490 +/- .010	27.42 +/- .66	.56 +/- .05
16	861 H	BURG-66	13.7 +/- 1.8	8.376 +/- .102	689 +/- 22	2.382 +/- .015	26.88 +/- .92	.55 +/- .06
17	861 J	BURG-67	15.8 +/- 1.8	8.374 +/- .102	706 +/- 22	2.401 +/- .015	24.34 +/- .91	.53 +/- .06
18	861 K	BURG-68	13.9 +/- 1.8	8.269 +/- .101	675 +/- 22	2.402 +/- .015	26.21 +/- .92	.47 +/- .06
19	861 R	BURG-74	14.2 +/- 1.9	8.642 +/- .111	749 +/- 24	2.422 +/- .016	27.47 +/- .98	.40 +/- .06
20	861 S	BURG-75	15.5 +/- 1.9	8.636 +/- .110	709 +/- 24	2.398 +/- .016	26.23 +/- .96	.58 +/- .06
21	861 W	BURG-79	15.4 +/- 2.0	8.627 +/- .111	696 +/- 23	2.420 +/- .016	26.33 +/- .99	.50 +/- .06
22	871 F	BURG-89	12.4 +/- 1.6	8.834 +/- .072	762 +/- 19	2.534 +/- .013	29.40 +/- .80	.50 +/- .05
23	871 G	BURG-90	13.7 +/- 1.6	8.728 +/- .071	723 +/- 18	2.516 +/- .013	28.54 +/- .80	.57 +/- .05
24	871 J	BURG-92	17.3 +/- 1.7	8.879 +/- .072	748 +/- 19	2.520 +/- .013	28.05 +/- .80	.53 +/- .05
25	871 Q	BURG-97	18.1 +/- 2.0	8.675 +/- .069	757 +/- 19	2.521 +/- .013	28.44 +/- .80	.54 +/- .05
26	871 T	BUR-100	18.1 +/- 2.0	8.653 +/- .068	751 +/- 18	2.507 +/- .013	28.55 +/- .80	.52 +/- .05
27	871 X	BUR-104	15.6 +/- 1.9	8.638 +/- .069	750 +/- 18	2.540 +/- .013	28.95 +/- .81	.44 +/- .05
28	871 Z	BUR-106	19.7 +/- 2.0	8.753 +/- .069	749 +/- 18	2.522 +/- .013	28.79 +/- .82	.54 +/- .05
29	890 E	BUR-120	14.5 +/- 1.7	8.701 +/- .073	710 +/- 22	2.545 +/- .013	28.42 +/- .82	.69 +/- .06
30	890 G	BUR-123	17.0 +/- 1.8	8.741 +/- .073	730 +/- 23	2.513 +/- .013	27.66 +/- .83	.45 +/- .06
31	890 H	BUR-124	18.1 +/- 1.8	8.715 +/- .073	712 +/- 22	2.547 +/- .013	28.13 +/- .82	.44 +/- .06
32	890 M	BUR-127	15.6 +/- 1.7	8.634 +/- .072	713 +/- 22	2.479 +/- .013	27.72 +/- .81	.61 +/- .06
33	890 O	BUR-129	17.8 +/- 1.8	8.789 +/- .074	747 +/- 22	2.543 +/- .013	26.62 +/- .81	.56 +/- .06
34	890 P	BUR-130	18.7 +/- 1.8	8.731 +/- .074	738 +/- 23	2.532 +/- .013	29.46 +/- .85	.54 +/- .06
35	890 Q	BUR-131	14.7 +/- 1.6	8.797 +/- .071	748 +/- 21	2.525 +/- .012	27.10 +/- .79	.60 +/- .06
36	890 R	BUR-132	8.6 +/- 6.0	8.649 +/- .101	686 +/- 19	2.528 +/- .025	26.75 +/-1.57	.56 +/- .07
37	890 U	BUR-135	17.8 +/- 1.7	8.772 +/- .071	761 +/- 22	2.524 +/- .013	27.48 +/- .80	.47 +/- .06
38	890 V	BUR-136	14.6 +/- 1.7	8.832 +/- .072	701 +/- 21	2.524 +/- .013	26.21 +/- .79	.60 +/- .06
39	890 X	BUR-138	16.2 +/- 1.9	8.956 +/- .077	735 +/- 23	2.585 +/- .015	28.63 +/- .91	.49 +/- .06
40	890 Z	BUR-140	14.4 +/- 1.6	8.884 +/- .072	743 +/- 21	2.546 +/- .013	27.76 +/- .78	.55 +/- .06
41	893 F	BUR-108	15.2 +/- 1.4	8.723 +/- .062	737 +/- 21	2.479 +/- .010	26.49 +/- .70	.66 +/- .05
42	893 G	BUR-109	16.0 +/- 1.4	8.648 +/- .062	739 +/- 21	2.485 +/- .011	27.89 +/- .72	.65 +/- .05
43	893 H	BUR-110	15.6 +/- 1.4	8.642 +/- .062	750 +/- 21	2.477 +/- .011	28.23 +/- .71	.54 +/- .05
44	893 O	BUR-115	15.6 +/- 1.4	8.729 +/- .063	774 +/- 20	2.484 +/- .011	26.44 +/- .71	.50 +/- .05
45	893 P	BUR-116	17.6 +/- 1.5	8.797 +/- .063	763 +/- 20	2.532 +/- .011	26.69 +/- .71	.51 +/- .05
46	914 S	ANCO-2	14.4 +/- 1.1	8.447 +/- .055	707 +/- 25	2.438 +/- .009	25.95 +/- .68	.50 +/- .06
47	914 T	ANCO-1	14.7 +/- 1.1	8.381 +/- .055	710 +/- 25	2.445 +/- .010	26.54 +/- .68	.55 +/- .06
48	890 T	BUR-134	15.8 +/- 1.6	8.522 +/- .069	718 +/- 21	2.420 +/- .012	26.76 +/- .79	.49 +/- .06
				ANDAHUAYLAS A TYPE				
49	822 E	BURG-1	3.8 +/- 1.0	4.179 +/- .037	361 +/- 21	3.364 +/- .009	19.28 +/- .59	.26 +/- .04
50	822 N	BURG-9	6.3 +/- 1.0	4.239 +/- .036	360 +/- 17	3.446 +/- .010	19.53 +/- .57	.16 +/- .04
51	822 O	BURG-10	3.5 +/- 1.0	4.276 +/- .036	384 +/- 17	3.426 +/- .010	18.32 +/- .57	.14 +/- .04
52	822 T	BURG-15	3.8 +/- 1.0	4.349 +/- .036	396 +/- 16	3.466 +/- .010	20.66 +/- .56	.15 +/- .04
53	823 O	BURG-7	2.0 +/- 1.0	4.337 +/- .036	369 +/- 13	3.463 +/- .010	20.26 +/- .56	.16 +/- .03
54	828 O	BURG-31	3.0 +/- 1.1	4.388 +/- .038	380 +/- 16	3.488 +/- .011	19.87 +/- .61	.10 +/- .03
55	828 Q	BURG-33	4.5 +/- 1.1	4.427 +/- .039	350 +/- 15	3.482 +/- .011	20.06 +/- .61	.12 +/- .03
56	828 Y	BURG-36	3.0 +/- 1.1	4.477 +/- .039	361 +/- 15	3.481 +/- .011	19.56 +/- .61	.13 +/- .03
57	828 Z	BURG-42	3.4 +/- 1.1	4.423 +/- .039	372 +/- 15	3.487 +/- .011	19.96 +/- .61	.17 +/- .03
58	845 J	BURG-67	4.7 +/- 1.1	4.425 +/- .039	387 +/- 17	3.498 +/- .011	20.14 +/- .60	.16 +/- .04
59	845 Y	BURG-61	2.6 +/- 1.2	4.412 +/- .039	383 +/- 16	3.475 +/- .011	19.37 +/- .59	.10 +/- .03
60	871 E	BURG-88	3.9 +/- 1.4	4.425 +/- .046	388 +/- 14	3.483 +/- .013	19.49 +/- .68	.08 +/- .03
				CUZCO TYPE				
61	822 H	BURG-4	3.7 +/- 1.1	3.164 +/- .033	1009 +/- 25	3.249 +/- .009	28.65 +/- .65	.24 +/- .04
62	822 J	BURG-5	1.7 +/- 1.0	3.170 +/- .033	1030 +/- 25	3.245 +/- .009	29.58 +/- .64	.20 +/- .04
63	822 Q	BURG-12	2.1 +/- 1.0	3.155 +/- .033	1014 +/- 24	3.266 +/- .009	30.71 +/- .65	.29 +/- .04
64	822 R	BURG-13	3.3 +/- 1.1	3.262 +/- .033	1019 +/- 24	3.328 +/- .009	29.49 +/- .65	.35 +/- .04
65	822 S	BURG-14	1.0 +/- 1.0	3.213 +/- .033	1033 +/- 24	3.298 +/- .009	30.44 +/- .65	.22 +/- .04
66	822 V	BURG-17	4.1 +/- 1.0	3.252 +/- .033	1056 +/- 24	3.261 +/- .009	28.82 +/- .64	.27 +/- .04
67	828 E	BURG-23	2.4 +/- 1.1	3.244 +/- .034	1047 +/- 24	3.311 +/- .010	29.48 +/- .69	.27 +/- .03
68	828 G	BURG-25	1.5 +/- 1.1	3.195 +/- .034	1044 +/- 24	3.291 +/- .010	29.23 +/- .69	.26 +/- .03
69	828 J	BURG-27	2.6 +/- 1.1	3.299 +/- .034	1073 +/- 24	3.304 +/- .010	29.40 +/- .69	.38 +/- .04
70	828 X	BURG-40	2.7 +/- 1.1	3.267 +/- .035	997 +/- 22	3.324 +/- .011	30.02 +/- .70	.26 +/- .03
71	845 F	BURG-44	1.0 +/- 1.1	3.207 +/- .035	1066 +/- 26	3.311 +/- .010	29.88 +/- .69	.24 +/- .04
72	845 G	BURG-45	2.0 +/- 1.2	3.224 +/- .035	1066 +/- 25	3.360 +/- .010	30.46 +/- .69	.23 +/- .04
73	845 O	BURG-51	1.2 +/- 1.2	3.261 +/- .035	1039 +/- 25	3.345 +/- .010	28.82 +/- .69	.32 +/- .04
74	845 P	BURG-52	1.4 +/- 1.2	3.252 +/- .036	1046 +/- 25	3.293 +/- .010	29.29 +/- .69	.26 +/- .04
75	845 Q	BURG-53	4.6 +/- 1.2	3.247 +/- .034	1039 +/- 24	3.278 +/- .010	29.28 +/- .67	.25 +/- .04
76	871 O	BURG-95	.8 +/- 1.5	3.252 +/- .040	1025 +/- 22	3.286 +/- .013	30.04 +/- .82	.24 +/- .04
77	893 T	BUR-122	1.2 +/- 1.2	3.317 +/- .037	1074 +/- 22	3.334 +/- .011	29.38 +/- .72	.29 +/- .04
78	890 K	BUR-126	2.7 +/- 1.5	3.322 +/- .043	1035 +/- 26	3.368 +/- .013	30.06 +/- .85	.27 +/- .04
79	890 N	BUR-128	1.7 +/- 1.6	3.243 +/- .043	1027 +/- 26	3.321 +/- .013	28.96 +/- .84	.25 +/- .04
80	890 S	BUR-133	2.8 +/- 1.5	3.200 +/- .041	1055 +/- 26	3.348 +/- .013	30.74 +/- .82	.19 +/- .04
81	914 O	BUR-143	3.3 +/- 1.2	3.164 +/- .039	1038 +/- 29	3.287 +/- .011	29.38 +/- .77	.23 +/- .05
82	914 P	BUR-144	3.3 +/- 1.1	3.190 +/- .036	1010 +/- 28	3.250 +/- .010	29.55 +/- .72	.29 +/- .04
83	914 Q	BUR-145	1.7 +/- 1.1	3.142 +/- .036	1015 +/- 29	3.288 +/- .010	30.06 +/- .71	.25 +/- .05
84	914 R	BUR-146	2.2 +/- 1.1	3.138 +/- .036	1027 +/- 29	3.252 +/- .010	28.82 +/- .70	.29 +/- .04
				TITICACA BASIN TYPE				
85	823 P	BURG-22	9.0 +/- 1.1	7.304 +/- .050	156 +/- 12	3.682 +/- .011	19.96 +/- .58	.43 +/- .05
86	828 F	BURG-24	7.2 +/- 1.1	7.271 +/- .051	142 +/- 15	3.652 +/- .011	19.50 +/- .62	.36 +/- .05
87	828 K	BURG-28	9.2 +/- 1.2	7.271 +/- .051	142 +/- 15	3.688 +/- .011	19.31 +/- .62	.48 +/- .05
88	828 M	BURG-29	7.3 +/- 1.2	7.224 +/- .051	134 +/- 15	3.633 +/- .011	18.59 +/- .61	.34 +/- .04
89	828 U	BURG-37	9.7 +/- 1.2	7.292 +/- .052	134 +/- 14	3.663 +/- .012	19.65 +/- .63	.29 +/- .04
90	845 H	BURG-46	8.4 +/- 1.2	7.203 +/- .052	149 +/- 17	3.673 +/- .011	19.36 +/- .62	.33 +/- .05
91	845 K	BURG-48	10.5 +/- 1.2	7.215 +/- .052	154 +/- 16	3.641 +/- .011	17.28 +/- .61	.33 +/- .05
92	845 M	BURG-49	8.3 +/- 1.2	7.234 +/- .052	130 +/- 16	3.643 +/- .011	19.29 +/- .62	.40 +/- .05
93	845 N	BURG-50	8.2 +/- 1.2	7.232 +/- .052	171 +/- 16	3.695 +/- .012	19.90 +/- .63	.32 +/- .05
94	845 R	BURG-54	6.4 +/- 1.2	7.169 +/- .051	129 +/- 15	3.596 +/- .011	19.45 +/- .61	.45 +/- .05
95	861 E	BURG-63	7.0 +/- 1.7	7.355 +/- .094	141 +/- 16	3.688 +/- .017	18.57 +/- .86	.38 +/- .06
96	861 F	BURG-64	9.5 +/- 1.8	7.408 +/- .094	139 +/- 16	3.689 +/- .017	19.60 +/- .86	.39 +/- .06
97	861 G	BURG-65	7.1 +/- 1.7	7.081 +/- .092	140 +/- 16	3.561 +/- .017	19.24 +/- .85	.33 +/- .06
98	861 M	BURG-69	9.4 +/- 1.8	6.875 +/- .091	139 +/- 15	3.498 +/- .017	17.13 +/- .84	.40 +/- .06
99	861 N	BURG-70	8.6 +/- 1.8	7.035 +/- .093	116 +/- 15	3.556 +/- .017	18.31 +/- .86	.47 +/- .06
100	861 O	BURG-71	9.2 +/- 1.8	7.077 +/- .093	151 +/- 16	3.543 +/- .017	17.60 +/- .85	.30 +/- .06
101	861 P	BURG-72	7.4 +/- 1.8	7.176 +/- .094	128 +/- 15	3.558 +/- .017	16.99 +/- .84	.38 +/- .06
102	861 T	BURG-76	7.1 +/- 1.8	7.061 +/- .098	142 +/- 16	3.486 +/- .018	18.41 +/- .90	.28 +/- .06
103	861 U	BURG-77	7.1 +/- 1.8	7.045 +/- .097	152 +/- 16	3.412 +/- .017	19.25 +/- .89	.32 +/- .06
104	861 V	BURG-78	8.9 +/- 1.8	7.284 +/- .100	143 +/- 16	3.499 +/- .018	20.14 +/- .90	.44 +/- .06
105	861 Z	BURG-82	9.7 +/- 1.9	7.319 +/- .100	139 +/- 16	3.587 +/- .018	19.51 +/- .89	.35 +/- .06

RUN	SAMPLE	AS	U	BA	SM	LA	CO
PAMPAS TYPE							
106 870 S	BURG-84	16.6 +/- 1.9	6.542 +/- .061	830 +/- 23	5.140 +/- .017	43.88 +/-1.00	.59 +/- .06
107 870 T	BURG-85	15.5 +/- 1.8	6.564 +/- .061	802 +/- 22	5.152 +/- .017	45.27 +/-1.01	.56 +/- .06
108 871 H	BURG-91	10.0 +/- 1.7	6.566 +/- .060	788 +/- 20	5.128 +/- .017	42.44 +/-1.00	.70 +/- .06
109 871 M	BURG-93	12.8 +/- 1.8	6.616 +/- .061	769 +/- 20	5.090 +/- .017	42.41 +/-1.00	.59 +/- .06
110 871 N	BURG-94	12.0 +/- 1.8	6.545 +/- .060	764 +/- 20	5.144 +/- .017	43.66 +/-1.01	.75 +/- .06
111 871 U	BUR-101	13.2 +/- 2.0	6.435 +/- .058	789 +/- 20	5.157 +/- .017	40.19 +/- .98	.56 +/- .06
112 871 V	BUR-102	11.5 +/- 2.0	6.487 +/- .058	794 +/- 20	5.203 +/- .017	44.24 +/-1.02	.57 +/- .06
ANDAHUAYLAS B TYPE							
113 822 Z	BURG-21	2.2 +/- 1.1	3.468 +/- .035	1111 +/- 25	4.811 +/- .012	58.82 +/- .85	.69 +/- .05
114 828 P	BURG-32	2.7 +/- 1.2	3.395 +/- .036	1091 +/- 25	4.798 +/- .013	57.15 +/- .92	.65 +/- .05
115 870 R	BURG-83	4.6 +/- 1.6	3.424 +/- .044	1082 +/- 26	4.789 +/- .016	60.00 +/-1.16	.68 +/- .05
116 890 F	BUR-121	2.2 +/- 6.2	3.484 +/- .069	1044 +/- 25	4.822 +/- .027	57.85 +/-1.96	.54 +/- .06
117 890 H	BUR-137	3.2 +/- 1.8	3.574 +/- .050	1093 +/- 29	4.881 +/- .017	58.88 +/-1.24	.68 +/- .06
AYACUCHO TYPE							
118 893 J	BUR-111	4.7 +/- 1.1	4.604 +/- .042	231 +/- 16	1.975 +/- .009	21.50 +/- .64	.20 +/- .04
119 893 K	BUR-112	3.0 +/- 1.1	4.663 +/- .042	259 +/- 16	1.956 +/- .009	22.54 +/- .64	.43 +/- .04
120 893 M	BUR-113	3.7 +/- 1.1	4.705 +/- .042	227 +/- 16	1.979 +/- .009	23.16 +/- .66	.28 +/- .04
121 893 N	BUR-114	3.0 +/- 1.2	4.720 +/- .043	212 +/- 17	1.996 +/- .009	23.01 +/- .68	.26 +/- .04
122 893 E	BUR-107	1.3 +/- 1.1	4.595 +/- .043	208 +/- 17	2.217 +/- .009	18.82 +/- .64	.48 +/- .05
ACARI TYPE							
123 893 R	BUR-118	5.4 +/- 1.2	6.225 +/- .050	616 +/- 19	2.608 +/- .010	19.69 +/- .63	.25 +/- .04
124 893 S	BUR-119	6.2 +/- 1.2	6.241 +/- .050	649 +/- 19	2.622 +/- .010	20.85 +/- .63	.36 +/- .04
OTHER CHEMICAL COMPOSITIONS OF OBSIDIAN ARTIFACTS							
FOUND AT TUMUKU							
125 828 N	BURG-30	1.0 +/- 1.0	3.385 +/- .033	577 +/- 17	2.121 +/- .009	30.04 +/- .66	.29 +/- .03
126 861 Y	BURG-81	.4 +/- 1.7	3.407 +/- .068	556 +/- 20	2.148 +/- .014	29.44 +/- .99	.21 +/- .04
FOUND AT JAYWAMACHAY							
127 828 V	BURG-38	3.2 +/- 1.1	4.537 +/- .039	312 +/- 14	2.341 +/- .009	21.69 +/- .63	.19 +/- .03
FOUND AT MUYU URCO							
128 828 S	BURG-35	2.3 +/- 1.1	6.820 +/- .050	9 +/- 13	1.523 +/- .009	28.89 +/- .69	.09 +/- .03
FOUND AT WAYWAKA							
129 871 P	BURG-96	1.6 +/- 1.6	4.846 +/- .050	968 +/- 22	4.249 +/- .015	43.75 +/-1.01	.23 +/- .04
130 871 Y	BUR-105	6.0 +/- 1.9	4.766 +/- .048	979 +/- 22	4.245 +/- .015	46.53 +/-1.03	.19 +/- .04
131 914 N	BUR-142	5.5 +/- 1.2	4.628 +/- .043	936 +/- 28	4.132 +/- .011	41.48 +/- .84	1.09 +/- .07
FOUND AT UCHCUMACHAY							
132 871 W	BUR-103	13.3 +/- 1.8	9.772 +/- .075	946 +/- 21	1.765 +/- .012	17.90 +/- .68	.18 +/- .04
FOUND AT TARACO (BURG-125) AND CHINCHIRAMOQO (BURG-141)							
133 890 J	BUR-125	4.7 +/- 1.5	4.531 +/- .049	818 +/- 23	3.193 +/- .013	35.05 +/- .88	.33 +/- .05
134 914 M	BUR-141	5.1 +/- 1.0	4.443 +/- .041	813 +/- 25	3.202 +/- .010	34.54 +/- .75	.54 +/- .05
FOUND AT CUZCO							
135 890 Y	BUR-139	2.6 +/- 1.5	3.076 +/- .042	1194 +/- 28	5.879 +/- .017	24.45 +/- .78	.28 +/- .05
136 893 Q	BUR-117	2.3 +/- 1.2	8.325 +/- .061	574 +/- 19	3.442 +/- .012	47.09 +/- .90	.54 +/- .05
GEOLOGICAL SAMPLES FROM PERU							
AYACUCHO SOURCE							
137 845 X	BURG-60	3.1 +/- 1.0	4.500 +/- .038	288 +/- 14	1.955 +/- .008	27.93 +/- .61	.16 +/- .03
SACHACA, AREQUIPA							
138 861 Q	BURG-73	4.2 +/- 1.8	1.518 +/- .063	1145 +/- 31	4.471 +/- .018	48.85 +/-1.26	.50 +/- .06
YURI, AREQUIPA							
139 861 X	BURG-80	8.2 +/- 1.8	1.584 +/- .059	1189 +/- 31	3.912 +/- .017	33.63 +/-1.04	.15 +/- .04
HIGH SILICA GLASS ARTIFACTS FOUND IN THE MANTARO VALLEY SAMPLES JUM625 AND JUM616							
140 871 R	BURG-98	.4 +/- .3	.852 +/- .014	4 +/- 2	.016 +/- .003	.28 +/- .10	.10 +/- .02
141 871 S	BURG-99	1.8 +/- .8	1.607 +/- .023	144 +/- 7	.277 +/- .005	2.12 +/- .30	.24 +/- .03

RUN		SAMPLE	EU	CE	HF	TA	YB
QUISPISISA SOURCE							
1	822 F	BURG-2	.432 +/- .007	51.03 +/- .60	3.36 +/- .06	1.122 +/-.006	1.114 +/- .021
2	822 G	BURG-3	.421 +/- .007	51.73 +/- .60	3.25 +/- .06	1.144 +/-.006	1.187 +/- .021
3	822 K	BURG-6	.422 +/- .007	52.07 +/- .61	3.28 +/- .06	1.117 +/-.006	1.143 +/- .021
4	822 M	BURG-8	.424 +/- .007	52.32 +/- .61	3.39 +/- .06	1.134 +/-.006	1.156 +/- .021
5	822 P	BURG-11	.424 +/- .007	51.03 +/- .60	3.28 +/- .06	1.118 +/-.006	1.154 +/- .021
6	822 U	BURG-16	.437 +/- .007	52.82 +/- .62	3.32 +/- .06	1.115 +/-.006	1.135 +/- .021
7	822 W	BURG-18	.438 +/- .007	51.94 +/- .61	3.22 +/- .06	1.103 +/-.006	1.169 +/- .021
8	822 X	BURG-19	.423 +/- .007	52.06 +/- .61	3.32 +/- .06	1.101 +/-.006	1.128 +/- .020
9	822 Y	BURG-20	.429 +/- .007	53.10 +/- .62	3.32 +/- .06	1.107 +/-.006	1.157 +/- .021
10	828 H	BURG-26	.434 +/- .007	52.64 +/- .93	3.47 +/- .09	1.129 +/-.007	1.171 +/- .032
11	828 R	BURG-34	.425 +/- .007	50.50 +/- .91	3.22 +/- .08	1.118 +/-.007	1.137 +/- .032
12	828 W	BURG-39	.428 +/- .007	51.99 +/- .93	3.30 +/- .09	1.149 +/-.007	1.153 +/- .033
13	828 Y	BURG-41	.428 +/- .007	53.66 +/- .94	3.33 +/- .09	1.127 +/-.007	1.103 +/- .032
14	845 E	BURG-43	.432 +/- .007	51.50 +/- .66	3.28 +/- .07	1.108 +/-.006	1.144 +/- .023
15	845 Z	BURG-62	.421 +/- .007	51.12 +/- .65	3.28 +/- .07	1.097 +/-.006	1.156 +/- .023
16	861 H	BURG-66	.422 +/- .009	52.48 +/- .81	3.39 +/- .08	1.104 +/-.008	1.129 +/- .028
17	861 J	BURG-67	.420 +/- .009	51.13 +/- .80	3.33 +/- .08	1.101 +/-.008	1.168 +/- .029
18	861 K	BURG-68	.415 +/- .009	50.77 +/- .80	3.31 +/- .08	1.098 +/-.008	1.121 +/- .028
19	861 R	BURG-74	.440 +/- .009	52.23 +/- .83	3.31 +/- .08	1.111 +/-.008	1.096 +/- .029
20	861 S	BURG-75	.435 +/- .009	51.99 +/- .83	3.31 +/- .08	1.105 +/-.008	1.137 +/- .029
21	861 W	BURG-79	.431 +/- .009	52.01 +/- .83	3.23 +/- .09	1.112 +/-.008	1.213 +/- .031
22	871 F	BURG-89	.430 +/- .007	52.03 +/- .82	3.26 +/- .08	1.129 +/-.007	1.198 +/- .030
23	871 G	BURG-90	.432 +/- .007	51.00 +/- .81	3.33 +/- .08	1.126 +/-.007	1.152 +/- .030
24	871 J	BURG-92	.442 +/- .008	51.06 +/- .81	3.27 +/- .08	1.124 +/-.007	1.144 +/- .030
25	871 Q	BURG-97	.427 +/- .010	52.98 +/-1.07	3.16 +/- .10	1.104 +/-.008	1.140 +/- .039
26	871 T	BUR-100	.420 +/- .007	51.78 +/- .82	3.32 +/- .08	1.125 +/-.007	1.140 +/- .029
27	871 X	BUR-104	.424 +/- .007	51.43 +/- .82	3.28 +/- .08	1.107 +/-.006	1.190 +/- .029
28	871 Z	BUR-106	.440 +/- .007	53.46 +/- .83	3.31 +/- .08	1.135 +/-.007	1.192 +/- .029
29	890 E	BUR-120	.434 +/- .009	52.78 +/- .73	3.20 +/- .08	1.117 +/-.007	1.170 +/- .025
30	890 G	BUR-123	.426 +/- .009	52.33 +/- .73	3.34 +/- .08	1.119 +/-.007	1.123 +/- .025
31	890 H	BUR-124	.423 +/- .009	51.94 +/- .73	3.39 +/- .08	1.107 +/-.007	1.197 +/- .025
32	890 M	BUR-127	.412 +/- .009	49.46 +/- .70	3.20 +/- .08	1.069 +/-.007	1.103 +/- .025
33	890 O	BUR-129	.427 +/- .009	52.99 +/- .74	3.27 +/- .08	1.114 +/-.007	1.149 +/- .025
34	890 P	BUR-130	.431 +/- .009	53.26 +/- .74	3.32 +/- .08	1.122 +/-.007	1.154 +/- .025
35	890 Q	BUR-131	.415 +/- .009	50.78 +/- .71	3.19 +/- .08	1.106 +/-.007	1.154 +/- .025
36	890 R	BUR-132	.428 +/- .009	51.83 +/- .76	3.36 +/- .08	1.106 +/-.007	1.162 +/- .027
37	890 U	BUR-135	.445 +/- .009	51.53 +/- .71	3.20 +/- .08	1.098 +/-.007	1.118 +/- .025
38	890 V	BUR-136	.437 +/- .009	52.25 +/- .72	3.23 +/- .08	1.112 +/-.007	1.178 +/- .025
39	890 X	BUR-138	.417 +/- .010	52.92 +/- .81	3.28 +/- .09	1.121 +/-.008	1.135 +/- .028
40	890 Z	BUR-140	.436 +/- .009	51.58 +/- .72	3.28 +/- .08	1.114 +/-.007	1.176 +/- .025
41	893 F	BUR-108	.440 +/- .008	50.96 +/- .69	3.19 +/- .07	1.113 +/-.006	1.141 +/- .024
42	893 G	BUR-109	.416 +/- .008	51.05 +/- .68	3.30 +/- .07	1.104 +/-.006	1.156 +/- .024
43	893 H	BUR-110	.426 +/- .008	51.89 +/- .69	3.24 +/- .07	1.116 +/-.006	1.140 +/- .024
44	893 O	BUR-115	.431 +/- .008	52.03 +/- .69	3.24 +/- .07	1.119 +/-.006	1.160 +/- .024
45	893 P	BUR-116	.453 +/- .008	52.81 +/- .70	3.32 +/- .07	1.130 +/-.006	1.182 +/- .025
46	914 S	ANCO-2	.412 +/- .007	51.91 +/- .79	3.28 +/- .08	1.108 +/-.006	1.136 +/- .027
47	914 T	ANCO-1	.426 +/- .007	51.54 +/- .79	3.30 +/- .08	1.093 +/-.006	1.167 +/- .027
48	890 T	BUR-134	.401 +/- .008	50.32 +/- .70	3.30 +/- .08	1.075 +/-.007	1.125 +/- .025
ANDAHUAYLAS A TYPE							
49	822 E	BURG-1	.580 +/- .008	43.50 +/- .54	3.27 +/- .06	1.209 +/-.006	1.198 +/- .021
50	822 N	BURG-9	.553 +/- .008	42.58 +/- .54	3.41 +/- .06	1.212 +/-.006	1.223 +/- .021
51	822 O	BURG-10	.544 +/- .008	42.71 +/- .54	3.38 +/- .06	1.222 +/-.006	1.213 +/- .021
52	822 T	BURG-15	.573 +/- .008	42.54 +/- .55	3.32 +/- .06	1.191 +/-.006	1.262 +/- .021
53	823 O	BURG-7	.548 +/- .007	42.26 +/- .57	3.19 +/- .06	1.237 +/-.006	1.222 +/- .022
54	828 O	BURG-31	.557 +/- .008	44.49 +/- .83	3.34 +/- .08	1.200 +/-.007	1.217 +/- .032
55	828 Q	BURG-33	.569 +/- .008	42.80 +/- .83	3.34 +/- .08	1.233 +/-.008	1.208 +/- .032
56	828 T	BURG-36	.559 +/- .008	42.96 +/- .82	3.41 +/- .08	1.224 +/-.008	1.237 +/- .033
57	828 Z	BURG-42	.555 +/- .008	42.43 +/- .83	3.27 +/- .08	1.223 +/-.008	1.239 +/- .033
58	845 J	BURG-47	.563 +/- .008	43.26 +/- .59	3.41 +/- .07	1.207 +/-.006	1.192 +/- .023
59	845 Y	BURG-61	.561 +/- .008	43.62 +/- .59	3.25 +/- .07	1.209 +/-.006	1.193 +/- .023
60	871 E	BURG-88	.549 +/- .008	41.08 +/- .72	3.26 +/- .08	1.212 +/-.007	1.205 +/- .030
CUZCO TYPE							
61	822 H	BURG-4	.495 +/- .007	58.41 +/- .63	3.73 +/- .07	.916 +/-.005	1.072 +/- .019
62	822 J	BURG-5	.500 +/- .007	58.65 +/- .63	3.58 +/- .06	.898 +/-.005	1.092 +/- .019
63	822 Q	BURG-12	.505 +/- .007	60.05 +/- .65	3.64 +/- .06	.901 +/-.005	1.098 +/- .019
64	822 R	BURG-13	.505 +/- .007	59.33 +/- .64	3.40 +/- .06	.909 +/-.005	1.076 +/- .019
65	822 S	BURG-14	.510 +/- .007	59.37 +/- .64	3.71 +/- .06	.899 +/-.005	1.114 +/- .019
66	822 V	BURG-17	.482 +/- .007	58.81 +/- .64	3.55 +/- .06	.881 +/-.005	1.113 +/- .019
67	828 E	BURG-23	.512 +/- .008	60.58 +/- .97	3.74 +/- .09	.910 +/-.006	1.173 +/- .030
68	828 G	BURG-25	.496 +/- .007	59.09 +/- .96	3.66 +/- .08	.902 +/-.006	1.164 +/- .030
69	828 J	BURG-27	.491 +/- .007	56.80 +/- .94	3.48 +/- .08	.900 +/-.006	1.093 +/- .030
70	828 X	BURG-40	.485 +/- .007	58.61 +/- .97	3.47 +/- .08	.899 +/-.006	1.094 +/- .030
71	845 F	BURG-44	.504 +/- .008	58.36 +/- .69	3.55 +/- .07	.904 +/-.005	1.087 +/- .022
72	845 G	BURG-45	.496 +/- .008	59.72 +/- .70	3.69 +/- .07	.887 +/-.005	1.086 +/- .022
73	845 O	BURG-51	.489 +/- .008	56.79 +/- .69	3.44 +/- .07	.879 +/-.005	1.063 +/- .022
74	845 P	BURG-52	.478 +/- .008	55.87 +/- .68	3.28 +/- .07	.867 +/-.005	1.029 +/- .022
75	845 Q	BURG-53	.495 +/- .007	55.99 +/- .67	3.49 +/- .07	.867 +/-.005	1.021 +/- .021
76	871 O	BURG-95	.483 +/- .008	58.22 +/- .86	3.40 +/- .08	.901 +/-.006	1.110 +/- .028
77	993 T	BUR-122	.497 +/- .008	59.81 +/- .73	3.67 +/- .07	.902 +/-.005	1.111 +/- .023
78	890 K	BUR-126	.497 +/- .009	61.28 +/- .78	3.73 +/- .08	.891 +/-.006	1.071 +/- .023
79	890 N	BUR-128	.499 +/- .009	61.02 +/- .78	3.57 +/- .08	.897 +/-.006	1.102 +/- .023
80	890 S	BUR-133	.509 +/- .009	59.38 +/- .76	3.57 +/- .08	.899 +/-.006	1.110 +/- .024
81	914 O	BUR-143	.487 +/- .008	60.13 +/- .90	3.50 +/- .08	.885 +/-.006	1.070 +/- .028
82	914 P	BUR-144	.500 +/- .008	60.10 +/- .86	3.39 +/- .08	.894 +/-.006	1.047 +/- .026
83	914 Q	BUR-145	.517 +/- .008	59.28 +/- .83	3.58 +/- .08	.893 +/-.005	1.047 +/- .025
84	914 R	BUR-146	.482 +/- .008	60.31 +/- .89	3.57 +/- .08	.900 +/-.006	1.091 +/- .028
TITICACA BASIN TYPE							
85	823 P	BURG-22	.290 +/- .006	42.98 +/- .60	3.84 +/- .07	1.673 +/-.007	1.648 +/- .027
86	828 F	BURG-24	.293 +/- .006	44.67 +/- .87	3.83 +/- .09	1.772 +/-.010	1.693 +/- .039
87	828 K	BURG-28	.286 +/- .006	44.71 +/- .88	4.02 +/- .10	1.714 +/-.010	1.697 +/- .039
88	828 M	BURG-29	.288 +/- .006	42.83 +/- .86	3.75 +/- .09	1.691 +/-.010	1.692 +/- .039
89	828 U	BURG-37	.287 +/- .007	42.85 +/- .94	3.83 +/- .10	1.702 +/-.010	1.686 +/- .042
90	845 H	BURG-46	.280 +/- .006	42.41 +/- .61	3.85 +/- .08	1.661 +/-.008	1.665 +/- .028
91	845 K	BURG-48	.295 +/- .006	42.38 +/- .61	3.91 +/- .08	1.670 +/-.008	1.655 +/- .028
92	845 M	BURG-49	.285 +/- .006	42.22 +/- .61	3.89 +/- .08	1.667 +/-.008	1.675 +/- .028
93	845 N	BURG-50	.285 +/- .006	41.69 +/- .61	3.60 +/- .08	1.644 +/-.008	1.641 +/- .028
94	845 R	BURG-54	.281 +/- .006	42.15 +/- .60	3.90 +/- .08	1.666 +/-.008	1.633 +/- .027
95	861 E	BURG-63	.296 +/- .008	44.56 +/- .76	3.93 +/- .09	1.715 +/-.010	1.702 +/- .035
96	861 F	BURG-64	.278 +/- .008	44.39 +/- .76	3.76 +/- .09	1.705 +/-.010	1.713 +/- .035
97	861 G	BURG-65	.274 +/- .008	41.56 +/- .74	3.76 +/- .09	1.672 +/-.010	1.682 +/- .034
98	861 M	BURG-69	.293 +/- .008	42.08 +/- .75	3.89 +/- .09	1.659 +/-.010	1.634 +/- .034
99	861 N	BURG-70	.286 +/- .008	42.11 +/- .74	3.89 +/- .09	1.673 +/-.010	1.681 +/- .035
100	861 O	BURG-71	.278 +/- .008	43.46 +/- .76	3.81 +/- .09	1.699 +/-.010	1.701 +/- .035
101	861 P	BURG-72	.293 +/- .008	44.05 +/- .76	3.92 +/- .09	1.688 +/-.010	1.695 +/- .035
102	861 T	BURG-76	.278 +/- .008	43.09 +/- .76	3.63 +/- .09	1.648 +/-.010	1.663 +/- .035
103	861 U	BURG-77	.282 +/- .008	40.62 +/- .75	3.57 +/- .09	1.629 +/-.010	1.590 +/- .035
104	861 V	BURG-78	.288 +/- .008	41.69 +/- .77	3.92 +/- .10	1.687 +/-.010	1.665 +/- .036
105	861 Z	BURG-82	.295 +/- .008	42.21 +/- .77	3.73 +/- .09	1.666 +/-.010	1.680 +/- .036

RUN	SAMPLE	EU	CE	HF	TA	YB
			PAMPAS TYPE			
106 870 S	BURG-84	1.043 +/- .013	81.64 +/-1.16	4.96 +/- .11	1.583 +/-.009	2.786 +/- .046
107 870 T	BURG-85	1.048 +/- .013	84.36 +/-1.16	5.03 +/- .11	1.587 +/-.009	2.838 +/- .047
108 871 H	BURG-91	1.027 +/- .012	80.37 +/-1.07	4.93 +/- .10	1.555 +/-.008	2.831 +/- .045
109 871 M	BURG-93	.991 +/- .012	75.81 +/-1.04	4.84 +/- .10	1.507 +/-.008	2.696 +/- .046
110 871 N	BURG-94	1.059 +/- .013	80.59 +/-1.08	4.90 +/- .10	1.560 +/-.008	2.801 +/- .045
111 871 U	BUR-101	1.013 +/- .012	79.95 +/-1.07	5.04 +/- .10	1.566 +/-.008	2.797 +/- .044
112 871 V	BUR-102	1.036 +/- .012	81.76 +/-1.08	5.38 +/- .10	1.593 +/-.008	2.733 +/- .044
			ANDAHUAYLAS B TYPE			
113 822 Z	BURG-21	.969 +/- .011	107.41 +/- .95	5.34 +/- .08	1.038 +/-.005	1.030 +/- .020
114 828 P	BURG-32	.940 +/- .011	108.68 +/-1.45	5.29 +/- .11	1.059 +/-.007	1.121 +/- .032
115 870 R	BURG-83	.953 +/- .012	108.49 +/-1.35	5.16 +/- .10	1.039 +/-.007	1.037 +/- .031
116 890 F	BUR-121	.945 +/- .013	105.60 +/-1.10	5.30 +/- .10	1.037 +/-.007	1.024 +/- .024
117 890 W	BUR-137	.948 +/- .013	105.23 +/-1.10	5.37 +/- .10	1.044 +/-.007	1.007 +/- .024
			AYACUCHO TYPE			
118 893 J	BUR-111	.287 +/- .006	40.49 +/- .59	3.79 +/- .07	1.770 +/-.008	.847 +/- .022
119 893 K	BUR-112	.291 +/- .006	40.73 +/- .59	3.84 +/- .07	1.781 +/-.008	.876 +/- .022
120 893 M	BUR-113	.300 +/- .006	40.97 +/- .60	3.67 +/- .07	1.780 +/-.008	.826 +/- .022
121 893 N	BUR-114	.288 +/- .006	40.70 +/- .59	3.76 +/- .07	1.791 +/-.008	.815 +/- .023
122 893 E	BUR-107	.332 +/- .007	38.96 +/- .58	3.85 +/- .07	1.991 +/-.009	.968 +/- .023
			ACARI TYPE			
123 893 R	BUR-118	.363 +/- .007	41.65 +/- .60	3.01 +/- .07	1.351 +/-.007	1.341 +/- .025
124 893 S	BUR-119	.369 +/- .007	42.36 +/- .61	2.98 +/- .07	1.364 +/-.007	1.330 +/- .025
			OTHER CHEMICAL COMPOSITIONS OF OBSIDIAN ARTIFACTS			
			FOUND AT TUMUKU			
125 828 N	BURG-30	.421 +/- .007	51.49 +/- .88	3.67 +/- .08	.937 +/-.006	1.046 +/- .029
126 861 Y	BURG-81	.445 +/- .009	53.31 +/- .82	3.58 +/- .08	.995 +/-.007	1.072 +/- .028
			FOUND AT JAYWAMACHAY			
127 828 V	BURG-38	.344 +/- .006	42.92 +/- .82	3.86 +/- .09	1.936 +/-.011	.953 +/- .032
			FOUND AT MUYU URCO			
128 828 S	BURG-35	.101 +/- .004	51.64 +/- .92	4.77 +/- .10	1.403 +/-.009	1.502 +/- .036
			FOUND AT WAYWAKA			
129 871 P	BURG-96	.785 +/- .010	82.20 +/-1.07	4.39 +/- .09	.840 +/-.006	1.083 +/- .029
130 871 V	BUR-105	.764 +/- .010	82.70 +/-1.07	4.28 +/- .09	.814 +/-.005	1.056 +/- .028
131 914 N	BUR-142	.777 +/- .010	83.40 +/-1.07	4.68 +/- .09	.816 +/-.006	1.119 +/- .028
			FOUND AT UCHCUMACHAY			
132 871 W	BUR-103	.286 +/- .006	33.29 +/- .66	2.51 +/- .07	1.164 +/-.007	.926 +/- .027
			FOUND AT TARACO (BURG-125) AND CHINCHIRAMOQO (BURG-141)			
133 890 J	BUR-125	.543 +/- .010	65.88 +/- .82	3.05 +/- .07	.989 +/-.007	1.249 +/- .025
134 914 M	BUR-141	.544 +/- .008	67.38 +/- .92	3.21 +/- .08	1.003 +/-.006	1.304 +/- .029
			FOUND AT CUZCO			
135 890 Y	BUR-139	.547 +/- .010	52.82 +/- .72	4.07 +/- .08	.800 +/-.006	5.672 +/- .058
136 893 O	BUR-117	.528 +/- .009	85.47 +/- .93	4.68 +/- .08	1.476 +/-.007	1.743 +/- .029
			GEOLOGICAL SAMPLES FROM PERU			
			AYACUCHO SOURCE			
137 845 X	BURG-60	.307 +/- .006	46.25 +/- .60	3.71 +/- .07	1.641 +/-.007	.744 +/- .020
			SACHACA, AREQUIPA			
138 861 Q	BURG-73	.845 +/- .013	92.66 +/-1.16	5.13 +/- .10	.760 +/-.006	1.601 +/- .033
			YURI, AREQUIPA			
139 861 X	BURG-80	.783 +/- .012	68.47 +/- .96	3.08 +/- .08	.802 +/-.007	1.418 +/- .031
			HIGH SILICA GLASS ARTIFACTS FOUND IN THE MANTARO VALLEY SAMPLES JUM625 AND JUM616			
140 871 R	BURG-98	.004 +/- .001	.29 +/- .10	.02 +/- .01	.004 +/-.001	.018 +/- .005
141 871 S	BURG-99	.067 +/- .003	2.58 +/- .22	.17 +/- .03	.032 +/-.001	.249 +/- .012

RUN		SAMPLE	SC	FE %	CS	SB	TH	RB
				QUISPISISA SOURCE				
1	822 F	BURG-2	1.49 +/- .02	.58 +/- .01	11.30 +/- .23	1.24 +/- .10	21.01 +/- .13	186 +/- 4
2	822 G	BURG-3	1.52 +/- .02	.60 +/- .01	11.51 +/- .24	1.49 +/- .12	21.08 +/- .13	187 +/- 4
3	822 K	BURG-6	1.50 +/- .02	.58 +/- .01	11.31 +/- .23	1.35 +/- .11	21.15 +/- .13	188 +/- 4
4	822 M	BURG-8	1.49 +/- .02	.57 +/- .01	11.27 +/- .23	1.24 +/- .11	20.87 +/- .13	189 +/- 4
5	822 P	BURG-11	1.55 +/- .02	.57 +/- .01	11.79 +/- .24	1.39 +/- .11	21.09 +/- .13	193 +/- 4
6	822 U	BURG-16	1.51 +/- .02	.57 +/- .01	11.38 +/- .23	1.28 +/- .10	20.96 +/- .12	191 +/- 4
7	822 W	BURG-18	1.50 +/- .02	.57 +/- .01	11.30 +/- .23	1.20 +/- .10	20.82 +/- .12	188 +/- 4
8	822 X	BURG-19	1.51 +/- .02	.60 +/- .01	11.57 +/- .23	1.28 +/- .10	21.06 +/- .13	185 +/- 4
9	822 Y	BURG-20	1.53 +/- .02	.58 +/- .01	11.42 +/- .23	1.46 +/- .11	20.93 +/- .12	190 +/- 4
10	828 H	BURG-26	1.46 +/- .02	.59 +/- .02	11.37 +/- .22	1.42 +/- .14	20.80 +/- .22	191 +/- 9
11	828 R	BURG-34	1.51 +/- .02	.59 +/- .02	11.14 +/- .21	1.26 +/- .13	20.48 +/- .22	166 +/- 9
12	828 W	BURG-39	1.54 +/- .02	.59 +/- .02	11.25 +/- .21	1.28 +/- .13	20.97 +/- .22	193 +/- 9
13	828 Y	BURG-41	1.52 +/- .02	.61 +/- .02	10.99 +/- .21	1.13 +/- .12	20.90 +/- .22	191 +/- 10
14	845 E	BURG-43	1.52 +/- .02	.61 +/- .01	11.10 +/- .23	1.14 +/- .10	21.05 +/- .14	187 +/- 4
15	845 Z	BURG-62	1.51 +/- .02	.56 +/- .01	11.35 +/- .26	1.23 +/- .11	20.97 +/- .14	178 +/- 5
16	861 H	BURG-66	1.68 +/- .02	.55 +/- .02	11.55 +/- .31	1.25 +/- .14	20.93 +/- .18	164 +/- 5
17	861 J	BURG-67	1.47 +/- .02	.55 +/- .02	11.57 +/- .31	1.37 +/- .15	21.05 +/- .18	162 +/- 5
18	861 K	BURG-68	1.44 +/- .02	.55 +/- .02	11.64 +/- .31	1.38 +/- .15	20.96 +/- .18	164 +/- 5
19	861 R	BURG-74	1.51 +/- .02	.61 +/- .02	11.36 +/- .32	1.16 +/- .14	21.02 +/- .19	165 +/- 5
20	861 S	BURG-75	1.49 +/- .02	.59 +/- .02	11.38 +/- .32	1.33 +/- .15	20.93 +/- .19	158 +/- 5
21	861 W	BURG-79	1.48 +/- .02	.59 +/- .02	11.46 +/- .32	1.31 +/- .15	20.96 +/- .19	163 +/- 6
22	871 F	BURG-89	1.51 +/- .02	.57 +/- .02	11.01 +/- .23	1.33 +/- .14	21.16 +/- .18	185 +/- 6
23	871 G	BURG-90	1.48 +/- .02	.58 +/- .02	11.11 +/- .23	1.35 +/- .14	21.00 +/- .18	176 +/- 6
24	871 J	BURG-92	1.52 +/- .02	.58 +/- .02	10.96 +/- .23	1.45 +/- .15	21.26 +/- .18	179 +/- 6
25	871 Q	BURG-97	1.50 +/- .02	.57 +/- .02	11.61 +/- .25	1.39 +/- .13	21.03 +/- .17	184 +/- 6
26	871 Y	BUR-100	1.49 +/- .02	.59 +/- .02	11.50 +/- .24	1.39 +/- .13	20.85 +/- .17	165 +/- 6
27	871 X	BUR-104	1.45 +/- .02	.58 +/- .02	11.28 +/- .24	1.60 +/- .14	20.84 +/- .17	164 +/- 6
28	871 Z	BUR-106	1.51 +/- .02	.62 +/- .02	11.47 +/- .24	1.38 +/- .13	20.89 +/- .17	177 +/- 6
29	890 E	BUR-120	1.52 +/- .02	.57 +/- .02	11.61 +/- .29	1.35 +/- .12	19.86 +/- .13	183 +/- 4
30	890 G	BUR-123	1.51 +/- .02	.60 +/- .02	11.51 +/- .29	1.39 +/- .13	19.93 +/- .13	171 +/- 4
31	890 H	BUR-124	1.57 +/- .02	.57 +/- .02	11.39 +/- .29	1.31 +/- .12	20.07 +/- .13	179 +/- 4
32	890 M	BUR-127	1.50 +/- .02	.60 +/- .02	11.27 +/- .29	1.01 +/- .11	19.51 +/- .13	183 +/- 4
33	890 O	BUR-129	1.52 +/- .02	.55 +/- .02	11.65 +/- .30	1.29 +/- .12	19.98 +/- .13	179 +/- 4
34	890 P	BUR-130	1.52 +/- .02	.58 +/- .02	11.74 +/- .30	1.22 +/- .12	20.08 +/- .13	184 +/- 4
35	890 Q	BUR-131	1.47 +/- .02	.58 +/- .01	11.52 +/- .28	1.19 +/- .11	19.94 +/- .13	184 +/- 4
36	890 R	BUR-132	1.49 +/- .02	.56 +/- .02	11.07 +/- .27	1.34 +/- .12	19.97 +/- .13	186 +/- 4
37	890 U	BUR-135	1.53 +/- .02	.56 +/- .01	11.33 +/- .27	1.15 +/- .11	20.00 +/- .13	186 +/- 4
38	890 V	BUR-136	1.53 +/- .02	.56 +/- .01	11.25 +/- .27	1.26 +/- .11	20.10 +/- .13	182 +/- 4
39	890 X	BUR-138	1.52 +/- .02	.56 +/- .02	11.29 +/- .28	1.30 +/- .13	19.91 +/- .13	184 +/- 5
40	890 Z	BUR-140	1.50 +/- .02	.56 +/- .01	11.28 +/- .27	1.22 +/- .11	20.00 +/- .13	188 +/- 4
41	893 F	BUR-108	1.55 +/- .02	.57 +/- .01	11.53 +/- .25	1.24 +/- .11	20.96 +/- .14	187 +/- 4
42	893 G	BUR-109	1.55 +/- .02	.59 +/- .01	11.24 +/- .25	1.30 +/- .12	20.74 +/- .14	179 +/- 5
43	893 H	BUR-110	1.53 +/- .02	.56 +/- .01	11.42 +/- .25	1.35 +/- .12	20.88 +/- .14	173 +/- 4
44	893 O	BUR-115	1.50 +/- .02	.55 +/- .01	11.51 +/- .25	1.32 +/- .12	20.86 +/- .14	194 +/- 5
45	893 P	BUR-116	1.53 +/- .02	.57 +/- .01	11.54 +/- .25	1.46 +/- .13	21.17 +/- .14	181 +/- 5
46	914 S	ANCO-2	1.47 +/- .02	.57 +/- .01	10.95 +/- .20	1.43 +/- .21	20.27 +/- .10	174 +/- 7
47	914 T	ANCO-1	1.53 +/- .02	.58 +/- .01	10.97 +/- .20	1.83 +/- .26	20.26 +/- .10	172 +/- 7
48	890 T	BUR-134	1.49 +/- .02	.57 +/- .01	10.91 +/- .26	1.24 +/- .11	19.39 +/- .12	176 +/- 4
				ANDAHUAYLAS A TYPE				
49	822 E	BURG-1	1.87 +/- .02	.48 +/- .01	5.64 +/- .14	.43 +/- .06	18.45 +/- .11	170 +/- 4
50	822 N	BURG-9	1.83 +/- .02	.48 +/- .01	5.61 +/- .14	.36 +/- .05	18.46 +/- .11	168 +/- 4
51	822 O	BURG-10	1.81 +/- .02	.47 +/- .01	5.51 +/- .14	.36 +/- .05	18.51 +/- .11	174 +/- 4
52	822 T	BURG-15	1.87 +/- .02	.47 +/- .01	5.57 +/- .14	.27 +/- .05	18.60 +/- .11	171 +/- 4
53	823 O	BURG-7	1.82 +/- .02	.45 +/- .01	5.70 +/- .13	.23 +/- .05	18.25 +/- .11	171 +/- 4
54	828 O	BURG-31	1.84 +/- .02	.44 +/- .02	5.54 +/- .13	.35 +/- .07	18.26 +/- .19	177 +/- 9
55	828 Q	BURG-33	1.87 +/- .02	.49 +/- .02	5.35 +/- .13	.25 +/- .06	18.14 +/- .20	164 +/- 9
56	828 Y	BURG-36	1.86 +/- .02	.47 +/- .02	5.24 +/- .13	.25 +/- .06	18.16 +/- .20	167 +/- 9
57	828 Z	BURG-42	1.86 +/- .02	.50 +/- .02	5.44 +/- .13	.22 +/- .05	18.06 +/- .20	172 +/- 9
58	845 J	BURG-47	1.83 +/- .02	.47 +/- .01	5.37 +/- .14	.16 +/- .05	18.32 +/- .12	162 +/- 4
59	845 Y	BURG-61	1.84 +/- .02	.48 +/- .01	5.54 +/- .14	.28 +/- .05	18.46 +/- .12	160 +/- 4
60	871 E	BURG-88	1.79 +/- .02	.49 +/- .01	5.40 +/- .14	.26 +/- .06	18.75 +/- .16	169 +/- 6
				CUZCO TYPE				
61	822 H	BURG-4	1.93 +/- .02	.56 +/- .01	2.84 +/- .10	.12 +/- .04	14.68 +/- .10	142 +/- 4
62	822 J	BURG-5	1.91 +/- .02	.56 +/- .01	2.98 +/- .10	.12 +/- .04	14.70 +/- .10	142 +/- 4
63	822 Q	BURG-12	1.99 +/- .02	.57 +/- .01	2.96 +/- .10	.19 +/- .04	14.78 +/- .09	145 +/- 4
64	822 R	BURG-13	1.99 +/- .02	.55 +/- .01	2.91 +/- .10	.18 +/- .04	14.79 +/- .09	151 +/- 4
65	822 S	BURG-14	1.97 +/- .02	.56 +/- .01	2.88 +/- .10	.15 +/- .04	14.81 +/- .09	155 +/- 4
66	822 V	BURG-17	1.98 +/- .02	.55 +/- .01	2.94 +/- .10	.22 +/- .04	14.74 +/- .09	146 +/- 4
67	828 E	BURG-23	1.95 +/- .02	.59 +/- .02	3.10 +/- .10	.28 +/- .06	14.88 +/- .16	140 +/- 8
68	828 G	BURG-25	1.89 +/- .02	.55 +/- .02	3.01 +/- .10	.10 +/- .06	14.63 +/- .16	140 +/- 8
69	828 J	BURG-27	1.96 +/- .02	.58 +/- .02	2.92 +/- .10	.18 +/- .05	14.61 +/- .16	153 +/- 8
70	828 X	BURG-40	1.95 +/- .02	.60 +/- .02	2.80 +/- .09	.12 +/- .05	14.69 +/- .17	153 +/- 9
71	845 F	BURG-44	1.95 +/- .02	.56 +/- .01	2.68 +/- .10	.14 +/- .04	14.57 +/- .10	135 +/- 4
72	845 G	BURG-45	1.98 +/- .02	.58 +/- .01	2.81 +/- .10	.19 +/- .04	14.82 +/- .11	142 +/- 4
73	845 O	BURG-51	1.96 +/- .02	.58 +/- .01	2.86 +/- .10	.16 +/- .04	14.94 +/- .11	141 +/- 4
74	845 P	BURG-52	1.94 +/- .02	.57 +/- .01	2.84 +/- .10	.17 +/- .04	14.79 +/- .11	142 +/- 4
75	845 Q	BURG-53	1.95 +/- .02	.56 +/- .01	2.99 +/- .10	.23 +/- .04	14.76 +/- .10	141 +/- 4
76	871 O	BURG-95	1.91 +/- .02	.56 +/- .02	2.62 +/- .10	.14 +/- .05	14.81 +/- .14	128 +/- 6
77	893 Y	BUR-122	1.95 +/- .02	.54 +/- .01	3.14 +/- .11	.22 +/- .05	14.89 +/- .11	145 +/- 4
78	890 K	BUR-126	2.00 +/- .02	.58 +/- .01	2.99 +/- .13	.13 +/- .05	14.15 +/- .10	139 +/- 4
79	890 N	BUR-128	1.96 +/- .02	.56 +/- .01	2.90 +/- .13	.12 +/- .04	14.03 +/- .10	140 +/- 4
80	890 S	BUR-133	1.94 +/- .02	.55 +/- .01	2.96 +/- .12	.29 +/- .06	14.14 +/- .10	139 +/- 4
81	914 O	BUR-143	1.92 +/- .02	.55 +/- .01	2.95 +/- .10	.22 +/- .05	14.28 +/- .08	146 +/- 6
82	914 P	BUR-144	1.93 +/- .02	.57 +/- .01	2.86 +/- .09	.10 +/- .04	14.65 +/- .08	143 +/- 6
83	914 O	BUR-145	1.93 +/- .02	.56 +/- .01	2.88 +/- .09	.26 +/- .06	14.51 +/- .08	136 +/- 5
84	914 P	BUR-146	1.91 +/- .02	.55 +/- .01	2.90 +/- .09	.19 +/- .05	14.43 +/- .08	136 +/- 5
				TITICACA BASIN TYPE				
85	923 P	BURG-22	3.37 +/- .02	.51 +/- .01	10.49 +/- .21	.91 +/- .09	24.88 +/- .15	261 +/- 5
86	828 F	BURG-24	3.40 +/- .03	.52 +/- .02	10.62 +/- .22	.92 +/- .11	25.14 +/- .26	263 +/- 10
87	828 K	BURG-28	3.38 +/- .03	.50 +/- .02	10.43 +/- .21	.92 +/- .11	24.60 +/- .25	268 +/- 10
88	828 M	BURG-29	3.34 +/- .03	.50 +/- .02	10.24 +/- .21	.94 +/- .11	24.69 +/- .25	253 +/- 10
89	828 U	BURG-37	3.38 +/- .03	.50 +/- .02	10.06 +/- .20	1.09 +/- .12	24.82 +/- .26	257 +/- 11
90	845 H	BURG-46	3.41 +/- .02	.50 +/- .01	9.81 +/- .21	.73 +/- .08	25.22 +/- .16	263 +/- 5
91	845 K	BURG-48	3.41 +/- .02	.54 +/- .01	9.89 +/- .21	.73 +/- .08	25.08 +/- .16	261 +/- 5
92	845 M	BURG-49	3.31 +/- .02	.50 +/- .01	9.77 +/- .21	.76 +/- .08	25.10 +/- .16	249 +/- 5
93	845 N	BURG-50	3.39 +/- .02	.50 +/- .01	9.81 +/- .21	.84 +/- .08	25.22 +/- .17	274 +/- 5
94	845 R	BURG-54	3.36 +/- .02	.50 +/- .01	10.29 +/- .23	.95 +/- .09	25.10 +/- .16	251 +/- 5
95	861 E	BURG-63	3.38 +/- .03	.49 +/- .02	10.86 +/- .31	.93 +/- .12	25.50 +/- .21	241 +/- 6
96	861 F	BURG-64	3.38 +/- .03	.52 +/- .02	10.87 +/- .31	.90 +/- .12	25.74 +/- .22	244 +/- 6
97	861 G	BURG-65	3.36 +/- .03	.49 +/- .02	10.91 +/- .31	.92 +/- .12	25.34 +/- .21	235 +/- 6
98	861 M	BURG-69	3.28 +/- .03	.47 +/- .02	10.91 +/- .31	.83 +/- .11	24.98 +/- .21	224 +/- 6
99	861 N	BURG-70	3.37 +/- .03	.48 +/- .02	10.56 +/- .30	.87 +/- .11	25.48 +/- .21	216 +/- 6
100	861 O	BURG-71	3.39 +/- .03	.50 +/- .02	10.50 +/- .30	.91 +/- .12	25.50 +/- .21	244 +/- 6
101	861 P	BURG-72	3.36 +/- .03	.52 +/- .02	10.45 +/- .30	.89 +/- .12	25.50 +/- .21	231 +/- 6
102	861 T	BURG-76	3.26 +/- .03	.48 +/- .02	10.23 +/- .30	.71 +/- .11	24.72 +/- .22	220 +/- 6
103	861 U	BURG-77	3.25 +/- .03	.47 +/- .02	10.44 +/- .31	.87 +/- .12	24.46 +/- .22	220 +/- 6
104	861 V	BURG-78	3.37 +/- .03	.49 +/- .02	10.71 +/- .31	.73 +/- .11	25.14 +/- .22	228 +/- 6
105	861 Z	BURG-82	3.30 +/- .03	.48 +/- .02	10.29 +/- .30	.92 +/- .12	25.00 +/- .22	219 +/- 7

RUN		SAMPLE	SC	FES	CS	SB	TH	RB
PAMPAS TYPE								
106	870 S	BURG-84	2.59 +/- .02	.93 +/- .02	13.08 +/- .31	1.96 +/- .19	13.82 +/- .14	157 +/- 7
107	870 T	BURG-85	2.59 +/- .02	.90 +/- .02	13.07 +/- .31	1.89 +/- .18	14.03 +/- .14	157 +/- 7
108	871 H	BURG-91	2.57 +/- .02	.94 +/- .02	12.36 +/- .26	1.83 +/- .17	13.73 +/- .14	164 +/- 7
109	871 M	BURG-93	2.57 +/- .02	.92 +/- .02	12.38 +/- .26	2.11 +/- .19	13.82 +/- .14	150 +/- 7
110	871 N	BURG-94	2.54 +/- .02	.92 +/- .02	12.68 +/- .27	2.03 +/- .19	13.75 +/- .14	146 +/- 7
111	871 U	BUR-101	2.57 +/- .02	.93 +/- .02	12.78 +/- .27	1.71 +/- .15	13.79 +/- .14	145 +/- 7
112	871 V	BUR-102	2.64 +/- .02	.96 +/- .02	12.75 +/- .27	1.76 +/- .16	13.84 +/- .14	165 +/- 7
ANDAHUAYLAS B TYPE								
113	822 Z	BURG-21	1.99 +/- .02	.88 +/- .02	4.43 +/- .13	.31 +/- .05	20.15 +/- .12	159 +/- 4
114	928 P	BURG-32	1.97 +/- .02	.97 +/- .02	4.33 +/- .12	.24 +/- .06	19.77 +/- .21	164 +/- 10
115	870 R	BURG-83	2.00 +/- .02	.88 +/- .02	4.42 +/- .15	.19 +/- .06	19.89 +/- .17	156 +/- 6
116	890 F	BUR-121	2.00 +/- .02	.86 +/- .02	4.10 +/- .16	.27 +/- .06	18.96 +/- .12	152 +/- 4
117	890 W	BUR-137	1.98 +/- .02	.87 +/- .02	4.17 +/- .15	.31 +/- .06	19.25 +/- .12	157 +/- 4
AYACUCHO TYPE								
118	893 J	BUR-111	1.71 +/- .02	.51 +/- .01	4.07 +/- .12	.25 +/- .05	16.20 +/- .11	118 +/- 4
119	893 K	BUR-112	1.72 +/- .02	.48 +/- .01	3.86 +/- .12	.32 +/- .05	16.06 +/- .11	119 +/- 4
120	893 M	BUR-113	1.73 +/- .02	.49 +/- .01	4.00 +/- .12	.27 +/- .05	16.24 +/- .11	131 +/- 4
121	893 N	BUR-114	1.72 +/- .02	.48 +/- .01	4.01 +/- .12	.24 +/- .05	16.62 +/- .12	121 +/- 4
122	893 E	BUR-107	2.03 +/- .02	.49 +/- .01	3.89 +/- .13	.28 +/- .05	15.97 +/- .11	120 +/- 4
ACARI TYPE								
123	893 R	BUR-118	2.02 +/- .02	.46 +/- .01	7.15 +/- .17	.54 +/- .07	17.61 +/- .12	166 +/- 4
124	893 S	BUR-119	2.04 +/- .02	.47 +/- .01	7.02 +/- .17	.57 +/- .07	17.80 +/- .12	172 +/- 4
OTHER CHEMICAL COMPOSITIONS OF OBSIDIAN ARTIFACTS								
FOUND AT TUMUKU								
125	828 N	BURG-30	1.73 +/- .02	.55 +/- .02	3.41 +/- .10	.14 +/- .05	13.43 +/- .15	168 +/- 8
126	861 V	BURG-81	1.70 +/- .02	.55 +/- .02	3.36 +/- .14	.10 +/- .05	13.71 +/- .13	118 +/- 5
FOUND AT JAYWAMACHAY								
127	828 V	BURG-38	1.87 +/- .02	.54 +/- .02	3.80 +/- .11	.24 +/- .05	15.44 +/- .17	124 +/- 9
FOUND AT MUYU URCO								
128	828 S	BURG-35	1.74 +/- .02	.51 +/- .02	4.40 +/- .11	.22 +/- .06	30.31 +/- .30	229 +/- 9
FOUND AT WAYWAKA								
129	871 P	BURG-96	1.70 +/- .02	.69 +/- .02	5.77 +/- .15	.41 +/- .07	20.20 +/- .17	166 +/- 6
130	871 Y	BUR-105	1.67 +/- .02	.71 +/- .02	6.05 +/- .15	.38 +/- .07	19.70 +/- .17	161 +/- 6
131	914 N	BUR-142	1.74 +/- .02	.67 +/- .02	6.03 +/- .14	.34 +/- .07	19.34 +/- .10	176 +/- 7
FOUND AT UCHCUMACHAY								
132	871 W	BUR-103	1.38 +/- .02	.38 +/- .01	11.22 +/- .24	1.61 +/- .15	20.61 +/- .17	173 +/- 6
FOUND AT TARACO (BURG-125) AND CHINCHIRAMOOO (BURG-141)								
133	890 J	BUR-125	2.02 +/- .02	.59 +/- .02	5.78 +/- .18	.62 +/- .06	16.91 +/- .11	166 +/- 4
134	914 M	BUR-141	2.01 +/- .02	.56 +/- .01	5.68 +/- .13	.57 +/- .10	17.86 +/- .09	167 +/- 6
FOUND AT CUZCO								
135	890 Y	BUR-139	4.01 +/- .03	.57 +/- .01	2.51 +/- .13	.52 +/- .08	7.66 +/- .07	81 +/- 4
136	893 O	BUR-117	2.34 +/- .02	.69 +/- .02	6.32 +/- .16	.06 +/- .04	35.08 +/- .22	241 +/- 5
GEOLOGICAL SAMPLES FROM PERU								
AYACUCHO SOURCE								
137	845 X	BURG-60	1.56 +/- .02	.48 +/- .01	4.89 +/- .13	.27 +/- .05	16.00 +/- .11	196 +/- 4
SACHACA, AREQUIPA								
138	861 Q	BURG-73	2.44 +/- .02	.85 +/- .02	1.63 +/- .13	.27 +/- .07	11.36 +/- .12	109 +/- 6
YURI, AREQUIPA								
139	861 X	BURG-80	2.43 +/- .02	.62 +/- .02	2.27 +/- .14	.32 +/- .08	9.30 +/- .11	329 +/- 7
HIGH SILICA GLASS ARTIFACTS FOUND IN THE MANTARO VALLEY SAMPLES JUM625 AND JUM616								
140	871 R	BURG-98	.06 +/- .00	.04 +/- .00	.16 +/- .02	.07 +/- .03	.05 +/- .01	1 +/- 1
141	871 S	BURG-99	.69 +/- .01	.10 +/- .01	.20 +/- .04	1.23 +/- .12	.38 +/- .03	4 +/- 2

KEY TO APPENDIX

SAMPLE PROVENIENCE FOR NAA RESULTS

RUN #	
Quispisisa Source	
822 F	Pampa Media Luna, Dept. Ica
822 G	San Nicolas, Dept. Ica
822 K	Erizo, Dept. Ica
822 M	San Nicolas, Dept. Ica
822 P	Huari, Dept. Ayacucho
822 U	Waywaka, Dept. Apurimac
828 H	Trujillo, Dept. La Libertad
828 R	Hacha, Dept. Arequipa
828 W	Huamachuco, Dept. La Libertad
828 Y	Hacha, Dept. Arequipa
845 E	Waywaka, Dept. Apurimac
845 Z	Huari, Dept. Ayacucho
861 H	Quispisisa mine, Dept. Huancavelica
861 J	Quispisisa mine, Dept. Huancavelica
861 K	Quispisisa mine, Dept. Huancavelica
861 R	Jaywamachay, Dept. Ayacucho
861 S	Qaucho (Chavin), Dept. Ancash
861 W	Uchcumachay, Dept. Junin
871 F	Waywaka, Dept. Apurimac
871 G	Jincamoqo, Dept. Ayacucho
871 J	Jaywamachay, Dept. Ayacucho
871 Q	Waywaka, Dept. Apurimac

RUN #	SAMPLE PROVENIENCE
871 T	Qaucho (Chavin), Dept. Ancash
871 X	Qaucho (Chavin), Dept. Ancash
871 Z	Uchcumachay, Dept. Junin
890 E	Uchcumachay, Dept. Junin
890 G	Uchcumachay, Dept. Junin
890 H	Ataura, Dept. Junin
890 M	Jalpacocha, Dept. Ayacucho
890 O	Jaywamachay, Dept. Ayacucho
890 P	Jaywamachay, Dept. Ayacucho
890 Q	Iomachay, Dept. Ayacucho
890 R	Puente, Dept. Ayacucho
890 U	Uchcumachay, Dept. Junin
890 V	Ataura, Dept. Junin
890 X	Ac 300, Dept. Ayacucho
890 Z	Ac 300, Dept. Ayacucho
893 F	Jaywamachay, Dept. Ayacucho
893 G	Jaywamachay, Dept. Ayacucho
893 H	Jaywamachay, Dept. Ayacucho
893 O	Uchcumachay, Dept. Junin
893 P	Jincamoqo, Dept. Ayacucho
914 S	Ancon, Dept. Lima
914 T	Ancon, Dept. Lima
890 T	Cebolla Waiqo, Dept. Cuzco
Andahuaylas A Type	
822 E	Waywaka, Dept. Apurimac

RUN #	SAMPLE PROVENIENCE
822 N	Waywaka, Dept. Apurimac
822 O	Waywaka, Dept. Apurimac
822 T	Waywaka, Dept. Apurimac
823 O	Waywaka, Dept. Apurimac
828 O	Qasawirka, Dept. Apurimac
828 Q	Santa Elena, Dept. Apurimac
828 T	Waywaka, Dept. Apurimac
828 Z	Pikillaqta, Dept. Cuzco
845 J	Qasawirka, Dept. Apurimac
845 Y	Qasawirka, Dept. Apurimac
871 E	Waywaka, Dept. Apurimac
<u>Cuzco Type</u>	
822 H	Muyu 'Urqo, Dept. Cuzco
822 J	Minaspata, Dept. Cuzco
822 Q	Muyu 'Urqo, Dept. Cuzco
822 R	Minaspata, Dept. Cuzco
822 S	Marcavalle, Dept. Cuzco
822 V	Marcavalle, Dept. Cuzco
828 E	Suyu, Dept. Cuzco
828 G	Suyu, Dept. Cuzco
828 J	Incatunuhuiri, Dept. Puno
828 X	Qotakalli, Dept. Cuzco
845 F	Suyu, Dept. Cuzco
845 G	Yanamancha, Dept. Cuzco
845 O	Coricancha, Dept. Cuzco

RUN #	SAMPLE PROVENIENCE
845 P	Pakallamoqo, Dept. Cuzco
871 O	Waywaka, Dept. Apurimac
893 T	Huamachuco, Dept. La Libertad
890 K	Jincamoqo, Dept. Ayacucho
890 N	Jincamoqo, Dept. Ayacucho
890 S	Huari, Dept. Cuzco
914 O	Taraco, Dept. Puno
914 P	Taraco, Dept. Puno
914 Q	Taraco, Dept. Puno
914 R	Taraco, Dept. Puno
Titicaca Basin Type	
823 P	Juliaca, Dept. Puno
828 F	Suyu, Dept. Cuzco
828 K	Incatunuhuiri, Dept. Puno
828 M	Tumuku, Dept. Puno
828 U	Marcavalle, Dept. Cuzco
845 H	Sillustani, Dept. Puno
845 K	Pucara, Dept. Puno
845 M	Qaluyu, Dept. Puno
845 N	Juli, Dept. Puno
845 R	Pukupata, Dept. Cuzco
861 E	Sora Sora, Bolivia
861 F	Sora Sora, Bolivia
861 G	Sora Sora, Bolivia
861 M	Llalli, Dept. Puno

RUN #	SAMPLE PROVENIENCE
861 N	Llalli, Dept. Puno
861 O	Llalli, Dept. Puno
861 P	Llalli, Dept. Puno
861 T	Tiahuanaco, Bolivia
861 U	Tiahuanaco, Bolivia
861 V	Llalli, Dept. Puno
861 Z	Llalli, Dept. Puno
Pampas Type	
870 S	Waywaka, Dept. Apurimac
870 T	Waywaka, Dept. Apurimac
871 H	Jalpacocha, Dept. Ayacucho
871 M	Waywaka, Dept. Apurimac
871 N	Waywaka, Dept. Apurimac
871 U	Jincamoqo, Dept. Ayacucho
871 V	Canichi, Dept. Ayacucho
Andahuaylas B Type	
822 Z	Waywaka, Dept. Apurimac
828 P	Kunka Taka, Dept. Apurimac
870 R	Waywaka, Dept. Apurimac
890 F	Waywaka, Dept. Apurimac
890 W	Waywaka, Dept. Apurimac
Ayacucho type	
893 J	Iomachay, Dept. Ayacucho
893 K	Iomachay, Dept. Ayacucho
893 M	Iomachay, Dept. Ayacucho

RUN #	SAMPLE PROVENIENCE
893 N	Ac 500, Dept. Ayacucho
893 E	Puente, Dept. Ayacucho

<u>Acari Type</u>

893 R	Hacha, Dept. Arequipa
893 S	Hacha, Dept. Arequipa

FOOTNOTES

[1]In the Near East and Central Asia, for example, there are no obsidian deposits (Cann, et al., 1970).

[2]Archaeological work at sites in northern Chile has not encountered obsidian artifacts or chipping waste (Meighan, personal communication). Obsidian is abundant at many archaeological sites in Ecuador. Five samples in this study were analyzed by NAA from Chobshi Cave, an early site in the southern central highlands of Ecuador. Of the five samples tested, three different sources were represented. These three Ecuadorian types were chemically distinct from the obsidian analyzed from Peru and Bolivia. However, no obsidian was analyzed from sites north of Huamachuco and Trujillo. Whether or not Ecuadorian obsidian was traded into northern Peru remains an interesting question.

[3]There may be occasional exceptions to this, as for example, with the pearly gray obsidian of Melos or the green obsidian from Pachuca in central Mexico. Visual characteristics do not seem to be helpful in identifying the obsidian types analyzed in this study except in the case of red obsidian, which thus far seems to have come exclusively from the Quispisisa source.

[4]Optical spectroscopy has been used in several fascinating studies of obsidian trade in the Near East, the Aegean and the Mediterranean (Renfrew et al., 1965, 1966; Dixon et al., 1968; Cann et al., 1970). X-ray fluorescence studies have been used with interesting results in North America (Stevenson et al., 1971) and in Mesoamerica (Jack and Heizer, 1968; Cobean et al., 1971). The study by Cobean et al. is especially notable for its intensive study of a single site using

excavated material. In addition to the work done at the Lawrence Berkeley Laboratory at Berkeley, California, NAA analysis of obsidian from North America and the Near East has been conducted by the laboratory at the University of Michigan (Griffin et al., 1969; Wright, 1969).

[5]Those interested in a more detailed description of the more technical aspects of the neutron activation analysis used in this study and an element-by-element evaluation of its precision should consult earlier publications on NAA work done at the Lawrence Berkeley Laboratory (Perlman and Asaro, 1969). Since 1969, changes have been introduced to increase the accuracy of measurement for certain elements and to permit analysis of new elements (Bowman et al., 1973a and b).

[6]These findings come from "Ocucaje Phase 9 obsidian artifacts from Pampa Media Luna, Peru", an unpublished study by R. Burger.

[7]The distance figures presented in this article are in rough air mileage and as such underestimate the actual distance travelled along the paths of the sierra.

[8]Grossman has revised his original correlations with Hacha due to further study and new C^{14} results. He now correlates Muyu Moqo C-D with Hacha. This revision will be published in the Actas del Segundo Congreso del Hombre y Cultura Peruana, Trujillo.

9Avila considered his measurements to be only semi-quantitative and the differences in measurement and conclusions reached by us and Sabinas are very likely due to the semi-quantitative nature of the other work.

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