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Obsidian sourcing of artifacts from the Late Formative site of La Puntilla in the Southern Nasca Region, Peru

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ABSTRACT

We report X-Ray Fluorescence (XRF) analyses of 88 obsidian artifacts from the Early Horizon (aka Formative Period) site of La Puntilla in the Southern Nasca Region (SNR) of south-central Peru. The sample includes a range of artifact types, including 19 projectile points, 21 bifaces (some likely point fragments), 2 cores, 5 utilized flakes, and 41 unmodified flakes. All 88 items are assigned to Quispisisa, the closest obsidian source to the site and the dominant obsidian source in the SNR, despite other sources, such as Jampatilla, being just 20% further in distance. The lack of source diversity suggests that obsidian trade and acquisition during the Early Horizon (ca. 800 BCE – AD 100), especially the Late Formative phase (300 BCE – AD 100) in the SNR, focused on regulated movement of goods through particular trade corridors connecting the Andean highlands and lowlands. We then contextualize the La Puntilla data in a broader spatio-temporal context by combining all previously published SNR obsidian geochemical data. Results show that obsidian source diversity increases during Intermediate Periods in the SNR, and constricts during Horizons, including the Early Horizon, likely reflecting changes in the organization and control of exchange networks in the Andes.

1. Introduction

Obsidian remains one of the best archaeological materials for documenting inter-regional exchange globally (Frahm, 2025; Freund, 2013; Hughes and Smith, 1993; Shackley, 1998). Because obsidian is useful for a wide range of common human activities, it was widely conveyed over landscapes where it occurs. As well, because sources are spatially discrete, relatively uncommon, and often display unique geochemical signatures, tracing the movement of artifacts back to original location of collection is relatively straightforward. When multiple obsidian sources are available, diachronic changes in source diversity can inform on changes in the structure and connectedness of ancient human societies (e.g. Schaefer et al., 2023).

The chronology of the Central Andean region is noted for a number of cycles alternating between horizons, where many aspects of material culture homogenize spatially and temporally, and intermediate periods, where material culture is more heterogenous with local expressions in style (Rowe, 1960, 1967). These periods are typically interpreted as representing times of increased religious and/or political integration (horizons), such as under the Wari or Inka Empires, and periods of greater fragmentation (intermediate periods) (Rowe, 1962). This perspective has been instrumental in the SNR for understanding the evolution of human societies (e.g., Conlee, 2003, 2014; Conlee et al., 2021; Kantner and Vaughn, 2012; Van Gijseghem, 2006; Vaughn, 2006, 2009). How access to various raw materials fluctuated across these periods is of much interest in Andean archaeology, and in this regard obsidian studies have much to offer.

Here we report new obsidian sourcing data from a single site dating to a single chronological period, in the Southern Nasca Region (SNR) of south-central Peru. In the discussion we contextualize the new data by assembling all previously published obsidian geochemical data from the SNR that we are aware of, and compare how obsidian source diversity at this site and this time period compares to source diversity in preceding and subsequent time periods. Through this analysis, we show how obsidian distribution networks diversified (expanded) and narrowed (contracted) over time in the region.

2. Site and sample

We focus on the site of La Puntilla (Fig. 1). The site falls within the

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hyper-arid SNR, with little local rainfall, but characterized by intermittent streams that fill with waters from annual rains in the Andean highlands. Stream-side locations were popular for human habitation, providing water for drinking water and crop irrigation.

La Puntilla sits on a steep, rocky promontory near the confluence of two of these streams, the Aja and Tierras Blancas, less than 5 km east of the modern city of Nasca. Surface artifacts and a small number of radiocarbon dates place site occupation primarily within the later part of the Formative Period (200 BCE – AD 100; see Table 1), a period that includes the "proto-Nasca" phase (aka Nasca 1; ca 100 BCE – AD 1), a time of ethnogenesis that precedes the famous Nasca civilization.

The Late Formative represents a transitional era marking broad changes in regional sociopolitical organization. This period was, among other things, characterized by endemic violent conflict between settlements. These conflicts seem to disappear during the Early Intermediate Period, as settlement locations move toward less defensible landforms (e.g., Vaughn, 2009), and an interregional pattern of interaction is established, centered around the massive ceremonial settlement of Cahuachi (Orefici, 2017; Silverman, 1993). This era also ushers in the golden age of the "Nasca lines" as an instrument of interregional integration (Conlee, 2016; Lambers, 2004; Reindel and Wagner, 2009). People from many different south coastal valleys, and perhaps beyond, gathered in the area periodically for what may be conceived of as festivals and/or pilgrimages (Kantner and Vaughn, 2012). Obsidian artifacts studied here come from excavated contexts from the PhD dissertation research at La Puntilla by co-author Hendrik Van Gijseghem (see Van Gijseghem, 2006), along with two projectile points (with no catalog numbers) collected during earlier unpublished survey work by Katharina Schreiber.

No local obsidian exists in the SNR, and all obsidian at La Puntilla was carried by people into the site, likely through use of llama caravans (Beresford-Jones et al., 2023; Mader et al., 2022; Siveroni, 2021). At least seven artifact-quality obsidian sources are within 250 km of La Puntilla and were quarried and used in prehispanic times (Burger et al., 2006; Burger and Glascock 2000a, 2000b; Tripcevich and Contreras, 2011), including two major sources, Quispisisa and Alca, and several minor sources, including Jampatilla, Lisahuacho, Potreropampa, Puzolana, and Anillo. Other sources of volcanic glass also exist, such as at Cerro Ticllago (Burger et al., 2006) and Yanarangra (Glascock et al., 2007), but these sources do not appear to have been used in significant amounts by people in the past. Chivay, another major source in Peru, is at a much greater distance from the site (Burger et al., 1998; Tripcevich et al., 2012).

Table 1
SNR chronology based on Vaughn et al. (2014) and Conlee et al., (2024).

Period	Approximate Calendar Years
Late Horizon	CE 1450–1532
Late Intermediate Period	CE 1000–1450
Middle Horizon	AD 650–1000
Early Intermediate Period	AD 100–650
Early Horizon	800 BCE–AD 100
Initial period	1800–800 BCE
Late Archaic	3000–1800 BCE
Middle Archaic	6000–3000 BCE
Early Archaic	10000–6000 BCE

All seven of these artifact-quality sources are located in the Andean highlands, generally along a NW-SE trending line (Dulanto et al., 2025; Glascock et al., 2007). Quispisisa is the closest to any given location within the SNR, as the condor flies, and is about 85 km from La Puntilla. By contrast, Jampatilla is about 105 km away, Lisahuacho, Potreropampa, and Puzolana are between 150–165 km distant, and Anillo and Alca are over 200 km. Terrain modeling using Tobler's hiking function (Tobler, 1993) suggests Quispisisa is about 20 h walk from La Puntilla (Eerkens et al., 2010). Further, the difference between straight-line paths (as the condor flies) and least-cost hiking paths to the different obsidian sources is minor, between 6% further (for Potreropampa) and 13% (for Puzolana), with Quispisisa at 11% and Jampatilla at 8%.

We selected 88 obsidian artifacts collected from La Puntilla during previous research projects, including survey and excavation, for provenance analysis. Sampling focused on areas of the site estimated to date to the Early Horizon (Van Gijseghem, 2006). We attempted to sample more-or-less equally and randomly among finished and formal artifacts, including all projectile points (n = 19) and biface fragments (n = 21), as well as production-related items, such as cores (n = 2), and a random



Fig. 1. Map showing location of La Puntilla relative to obsidian sources.

sample of unmodified flakes (n = 41 out of 203 total obsidian flakes). In addition, we also examined a small number of utilized flakes (n = 5) that show edge modification in the form of micro-chipping along one or more edges as a byproduct of use, but no further formal shaping or flaking.

A full technological analysis of the artifacts is beyond the scope of the paper. However, our random selection of flakes includes both larger and smaller items, as well as items with and without cortex. All lithic reduction follows a series of steps from nodule extraction to finished product (e.g., projectile point, knife). Whatever the reduction process in the SNR included, which is not well established, our sample is likely to represent reduction from relatively earlier in the sequence (larger items with cortex) and later in the sequence (smaller items lacking cortex), as documented in cross-cultural studies of stone tool production (Andrefsky, 1998).

Fig. 2 shows a sample of eight of the complete projectile points included in the study. A typology and/or point chronology has not been developed for the SNR. However, in our experience (see Eerkens et al., 2008, 2010, 2024), these forms are typical for the Early Horizon, as well as some earlier and later time periods (e.g., Late Archaic, EIP). For many projectile points, and a small number of bifaces that are likely point fragments, rather than analyzing the whole artifact, we removed a pressure small flake, which we had originally planned to run for Neutron Activation Analysis and Obsidian Hydration. Unfortunately, the latter analyses were never undertaken. Yet, rather than omit points from our analysis altogether, we performed XRF on these pressure flakes to still gain source information. For this reason, though the points and biface fragments are large and thick, these artifacts often plot with the "small" artifacts below in the figures showing geochemical results.

3. Methods

We carried out analysis using a portable Bruker Tracer III instrument operating with a silicon drift detector. Samples were analyzed for 180 s at 40 KeV. We used a combination copper/titanium/aluminum filter to eliminate lower energy X-rays and reduce background scatter under the five main elements of interest (Rb, Sr, Y, Zr, and Nb). Fe and Mn are also reported but are less reliable on smaller/thinner artifacts (Ferguson, 2012). Analyses took place 2009–2010, but are reported for the first time here.

Elemental concentrations were calculated using a calibration set developed at MURR prior to the development of the current calibration set (Glascock and Ferguson, 2012), but the calculated results are very similar for most obsidian sources, including Quispisisa. Smaller/thinner artifacts tend to shift to slightly lower concentrations for the primary elements (Rb-Nb) (Ferguson, 2012). In such cases, the ratio of elements is more conservative than the absolute values (Frahm, 2024:25). Below, while we are confident these smaller artifacts are correctly assigned to Quispisisa, they tend to extend outside the statistically-generated confidence ellipses generated based on thicker baseline source samples, and the distribution of larger and thicker artifacts. As mentioned above, many of these smaller items represent pressure flakes removed from projectile points.

4. Results

Results from the XRF analyses are provided in Table 2, including catalog numbers, artifact type, the estimated percentage of cortex on the dorsal surface of the artifact (if any), maximum length, maximum width, and maximum thickness. Also shown are parts per million estimates for eight elements including Manganese, Iron, Thorium, Rubidium, Strontium, Yttrium, Zirconium, and Niobium.

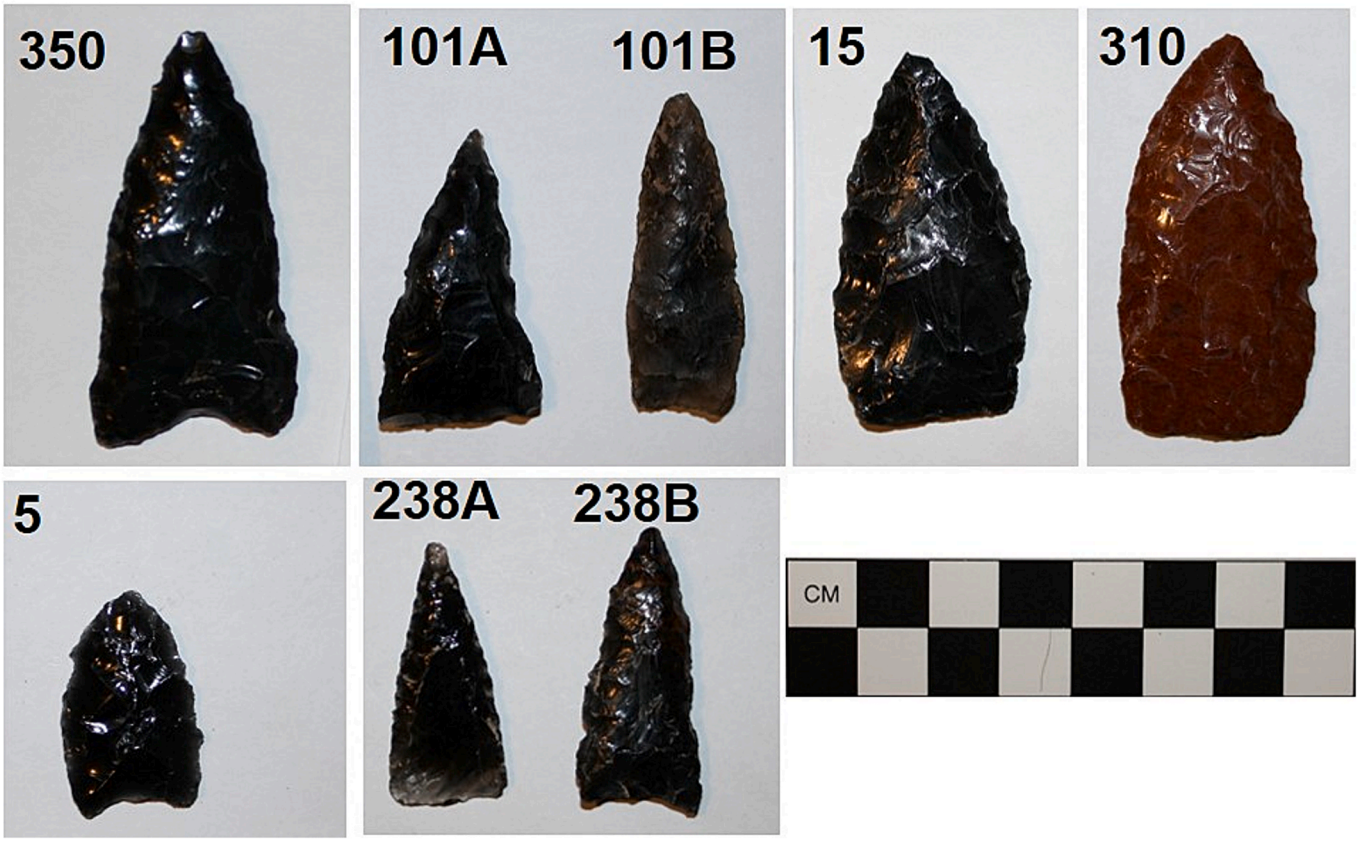


Fig. 2. Example obsidian projectile points included in sample.

Table 2
Artifacts included in La Puntilla sample with morphometric data and pXRF element concentrations.

Cat #	Art. Type	Cort	Len	Wid	Thick	Mn	Fe	Th	Rb	Sr	Y	Zr	Nb
2	Point	5%	35.6	20.1	5.1	194	5798	10	136	117	5	72	7
5	Point	0	30.9	19.8	3.6	201	6789	13	168	137	9	89	9
15A	Point	0	48.8	26.4	6.4	226	5824	12	149	133	8	77	5
15B	Point	0			6.1	243	6475	12	117	120	10	61	6
16	Point	0	57.7	31.5	7.2	325	6342	11	149	131	9	70	4
101A	Point	0	38.9	22.7	8	246	5971	13	120	121	4	67	5
101B	Point	0	43.9	16.1	5.6	190	4805	12	120	118	10	65	6
208	Point	0		23.4	7.2	262	5584	14	151	127	14	93	10
236	Point	0	43	18.6	7.4	338	5643	15	141	130	3	65	4
238A	Point	0	39.1	17.7	5.8	247	5382	12	126	123	6	64	3
238B	Point	0	36.4	16.4	5.3	239	6225	10	154	134	11	84	6
310	Point	0	55.3	27.4	7.2	262	6248	12	125	121	5	66	5
319	Point	0	41.9	21.6	7.4	307	5554	14	155	142	10	87	8
323	Point	0	25.3	18.3	5.5	339	6840	14	133	113	5	61	5
332	Point	0		17.4	6.7	237	5549	14	154	134	10	88	6
350	Point	0	47.6	24.1	5.8	342	6210	18	133	121	5	64	6
354	Point	0		26	6.9	251	5600	15	146	121	7	66	5
n/a	Point	0	25.5	19.6	4.8	311	5212	16	166	145	11	97	11
n/a	Point	0	40.4	18.7	4.9	290	6159	12	126	108	4	61	4
2	Biface	0			9.5	358	5803	17	168	153	9	90	10
9	Biface	0			6	230	5100	10	124	123	6	70	6
16	Biface	0			5	183	5571	12	126	115	8	66	6
18	Biface	0			5.7	280	5699	12	156	124	7	81	7
20	Biface	0		16.2	5.2	278	5436	11	157	135	10	88	10
108A	Biface	0			6.1	309	5463	11	140	121	13	81	6
208B	Biface	0				269	6196	13	141	127	11	87	8
209	Biface	0		23.2	5.3	389	5550	17	164	149	10	92	9
211	Biface	0	16.6	11	2.8	280	6474	13	166	148	11	91	10
223A	Biface	0		30.9	8.3	234	5116	9	126	123	7	67	5
223B	Biface	0			6.5	247	4948	13	128	120	9	65	6
224	Biface	0			6.1	229	5635	12	152	128	10	85	7
248	Biface	0			3.7	264	5669	11	112	114	9	69	5
301	Biface	0			5.5	214	5174	9	90	93	6	51	3
314	Biface	0			7	289	5588	10	123	107	7	64	5
320A	Biface	0			6.9	242	5947	15	154	145	8	82	7
320B	Biface	0				265	5740	16	155	139	12	93	8
324A	Biface	0			6.4	336	6934	12	144	136	8	74	6
324B	Biface	0				305	5761	15	167	148	13	96	10
334C	Biface	0			7.1	243	5591	14	160	131	7	89	10
335	Biface	0		28	7.9	385	6776	13	125	118	4	57	3
18	Core	50%	19.3	31.5	24.8	320	5963	14	163	149	9	96	10
346	Core	30%	26.1	21.6	13.6	322	6114	12	157	147	12	88	10
18	Flaketool	20%			6.8	318	5718	14	163	143	9	94	9
23	Flaketool	50%	27.8	33.4	7.9	158	6534	21	164	166	11	86	8
250	Flaketool	0	18	10.9	3.2	289	5928	12	167	146	10	93	10
324	Flaketool	0	21.9	14.6	9	301	5263	13	152	127	11	86	10
353	Flaketool	0	11.4	17.4	4.9	232	5848	16	153	135	11	88	7
10	Flake	Platf.	17.1	11.4	3.1	283	5807	15	172	161	11	96	10
18	Flake	Platf.	21.4	15	4	337	6268	12	169	142	12	97	9
18	Flake	0	8.5	16.2	2.4	306	6219	13	157	137	10	84	8
18	Flake	0	7.3	10.1	2.4	192	5992	11	132	121	5	68	7
20	Flake	20%	13.1	13	6.9	130	6955	14	140	126	8	80	6
104	Flake	0	17.3	8.4	1.8	247	5845	15	151	140	11	88	6
105	Flake	10%	10.6	13.1	2.5	281	6207	17	173	153	9	94	8
108A	Flake	0	26.6	14.1	3.3	253	5948	18	166	146	10	88	9
108B	Flake	0	14.3	12.4	3.8	273	5609	11	158	149	9	84	7
110	Flake	0	24.3		5.5	354	5426	14	154	137	12	97	10
208	Flake	0	10.1	7.2	1.3	274	7094	16	182	173	8	88	10
209A	Flake	0	21.1	16	5.1	285	6328	15	175	142	12	105	12
209B	Flake	0	11.7	15.3	2.6	323	6967	14	169	141	10	88	10
209C	Flake	0	20.7	14.6	3.2	269	6091	18	173	161	13	96	11
209D	Flake	0	7.2	22.3	4.6	168	4165	12	128	117	11	77	5
209E	Flake	0		23.7	6.2	229	5805	14	161	148	10	94	8
209F	Flake	0	4.4	7.8	1.2	279	6741	10	172	155	6	80	8
209G	Flake	0	9.5	9.4	2.7	223	5967	19	146	127	7	81	7
209H	Flake	0		18	6.1	288	5511	13	145	132	10	88	7
211A	Flake	0	7.5	12.8	2.6	197	5728	11	132	127	9	76	7
211B	Flake	0	11.8	12	4.4	314	8123	20	157	132	12	87	9
224A	Flake	20%	22.1	12.5	3.3	266	5970	15	169	163	12	94	9
224B	Flake	0	20.8	10.7	3.8	317	6974	14	180	163	11	93	7
224C	Flake	0	17.1	15.7	5.7	184	5790	13	149	125	11	88	7
224D	Flake	0	11.2	13.5	2.3	233	5812	14	160	125	7	91	10
238A	Flake	0		28.7	7.5	286	5574	15	165	143	13	98	10
238B	Flake	0	18.5	23.1	8	319	5736	12	148	121	8	81	8

(*continued on next page*)

Table 2 (*continued*)

Cat #	Art. Type	Cort	Len	Wid	Thick	Mn	Fe	Th	Rb	Sr	Y	Zr	Nb
247	Flake	10%	12.7	14.9	4.2	230	5883	14	147	119	9	80	6
248	Flake	0		16.3	1.7	385	6996	19	180	162	10	94	11
323	Flake	0	22.5	18.3	5	283	5785	14	169	161	13	101	10
324A	Flake	0	11.8	19.3	3.2	274	6162	17	166	140	11	95	9
324B	Flake	0	9	15.4	3.2	230	5898	12	162	139	7	86	9
324C	Flake	0	11.6	7.5	6.6	267	5113	14	150	130	10	91	9
346A	Flake	0	13.5	19.5	3.5	231	6434	12	152	139	8	87	7
346B	Flake	0	10.8	11.1	3.2	265	5584	10	154	133	11	83	8
346C	Flake	0	19.7	24	7.3	235	5851	12	164	131	7	88	10
352	Flake	0	9.5	20.7	4	283	5677	16	151	136	12	93	10
404	Flake	0	24.3	28.3	8.3	233	5656	14	136	117	9	85	7
408A	Flake	30%	10	21.4	12.1	191	6028	15	165	142	9	89	9
408B	Flake	0	11.4	11	4.6	254	5189	17	147	137	10	88	9
408C	Flake	Platf.	18.5		3.6	293	5970	15	177	148	14	103	10

Notes: Art. Type = Artifact type; Cort. = Percent of cortex on dorsal surface; Platf. = cortex on flake platform; Len = artifact maximum length (mm); Wid = artifact maximum width (mm); Thick = artifact maximum thickness (mm); Flaketool = Utilized flake; Element values given in parts per million estimates; "n/a" – survey artifact from previous research with no catalog number given.

5. Discussion

Statistical analyses of the elemental compositions shows that all 88 artifacts derive from the Quispisisa source. Clear separation of all the potential sources is not possible in a single two dimensional elemental plot, thus we use four elements, Rb, Zr, Sr, and Nb to help assign artifacts to source. Fig. 3 (Rb vs. Zr, note log-10 scales) shows the separation of most of the regional sources from Quispisisa. As shown, La Puntilla artifacts fall along a diagonal, with thinner items falling lower in both elements from the main cluster. All artifacts span the Quispisisa and Potreropampa ellipses, with no overlap with any other regional sources. Fig. 4 (Sr vs. Nb) is used to show separation between Quispisisa and Potreropampa (and Jampatilla). Importantly, artifacts fall on a different diagonal consistent with the Quispisisa source, and not with Potreropampa or Jampatilla.

The artifacts, all assigned to Quispisisa, include cortical flakes and core fragments, consistent with earlier stage reduction, as well as finished products, consistent with later stage products (Andrefsky, 1998). Together, this suggests that local inhabitants were receiving (or perhaps directly procuring) nodules of Quispisisa obsidian and were transforming it into a range of tools, from simple flake tools to more formal projectile points and knives. This interpretation is consistent with quarrying evidence at the Quispisisa source indicating removal of intact nodules and minimal at-source reduction (Tripcevich and Contreras, 2011).

The dominance of Quispsisa obsidian at La Puntilla is not surprising. Previous geochemical studies in the SNR show that Quispisisa obsidian comprises about 96–98% of all artifacts (over 600 items; Eerkens et al.,

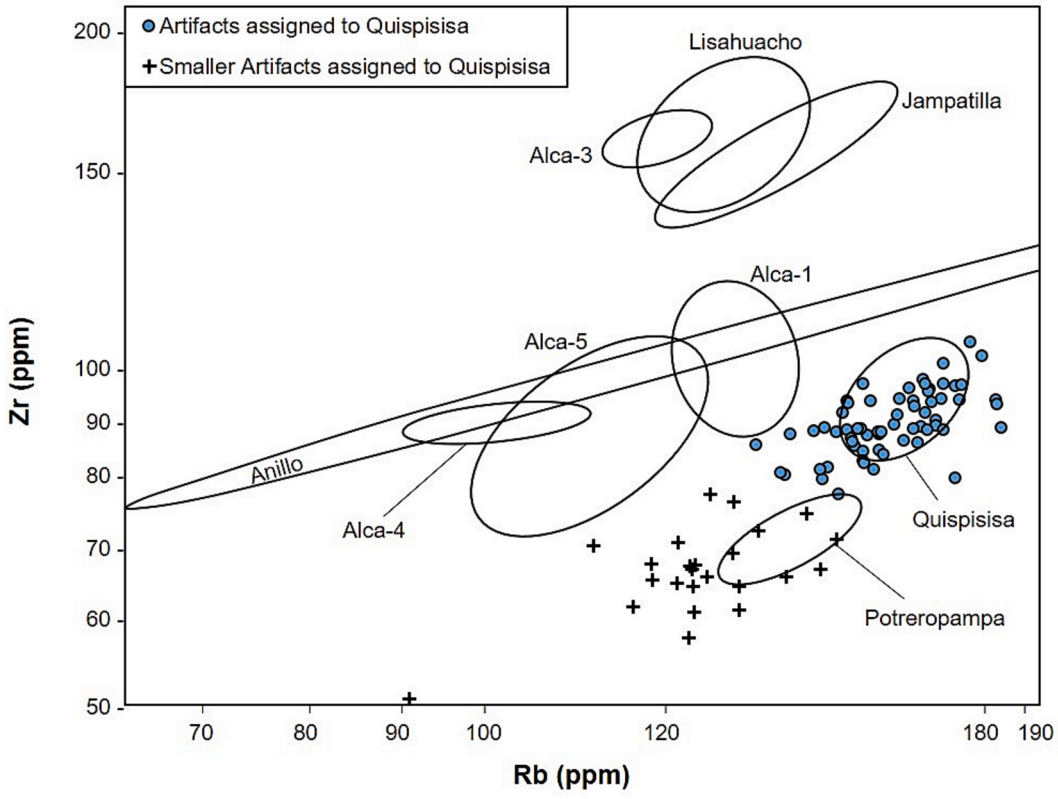


Fig. 3. Obsidian geochemical results for La Puntilla showing separation of most regional sources. Scatterplot shows log base-10 ppm concentrations for rubidium and zirconium. Ellipses represent 90 percent confidence intervals for membership in the source groups.

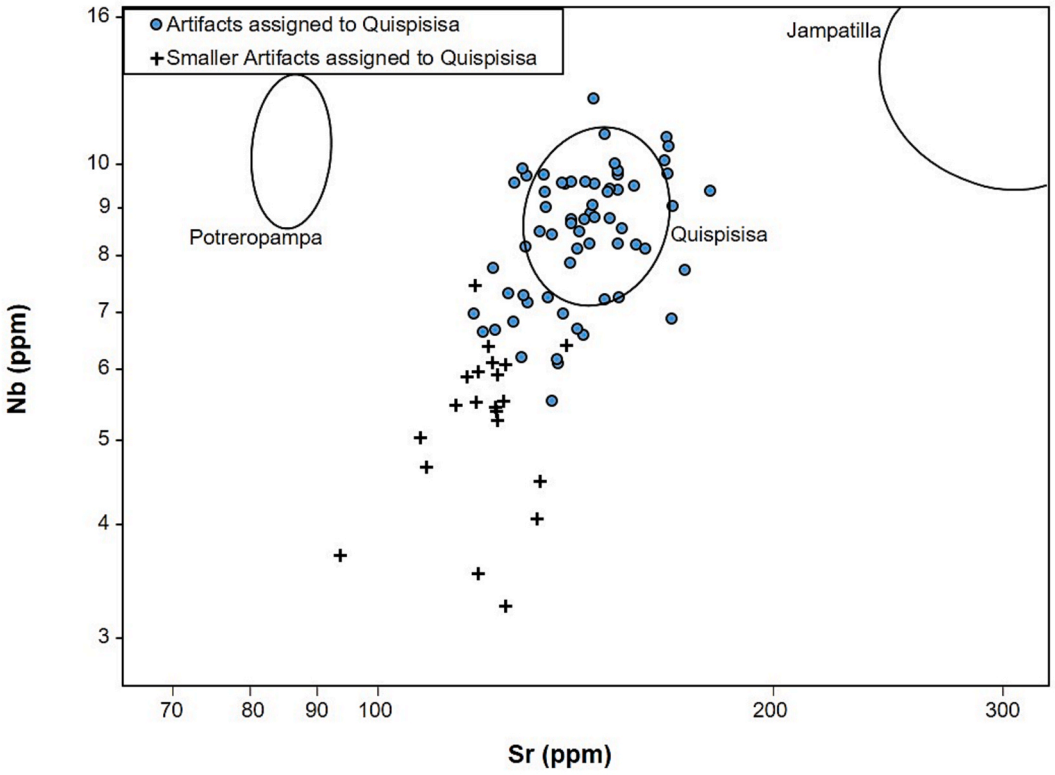


Fig. 4. Obsidian geochemical results for La Puntilla showing separation of Potreromampa, Jampatilla, and Quispisisa. Scatterplot shows log base-10 ppm concentrations for strontium and niobium. Ellipses represent 90 percent confidence intervals for membership in the source groups.

2010; Conlee, 2016; Vaughn and Glascock, 2005). This is consistent with more geographically broad studies in Central Peru, showing that Quispisisa is the dominant source across the entire region (Burger and Asaro, 1978; Burger and Glascock, 2000a; Burger et al., 1984), though in areas closer to more minor sources, other obsidians increase in frequency (Burger and Glascock, 2000b; Burger et al., 2006). Burger and Glascock (2000a) suggest that down-the-line trade was the dominant mode of Quispisisa conveyance, especially during Archaic periods. That said, given the sample size of 88 artifacts, and given the overall degree of source diversity in the SNR (2–4% non-Quispisisa obsidian), we would expect at least some items from other sources, such as Jampatilla and Potreropampa, the next two most-common sources in the SNR. However, obsidian from these sources is not present within the La Puntilla dataset.

The findings from La Puntilla are consistent with previous obsidian studies focused on the Early Horizon. For example, Burger and colleagues (1984) document a reorganization in obsidian procurement at the premier Early Horizon ceremonial center of Chavín de Huantar. At this site, Quispisisa dominates the Early Horizon assemblage, despite the Puzolana source being about 20% closer in distance. Puzolana was used

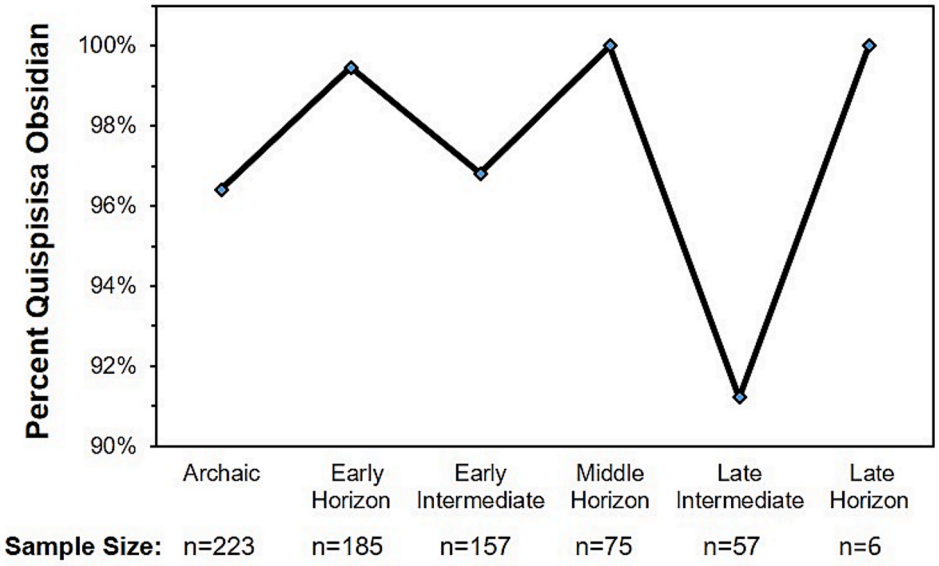


Fig. 5. Percent of Quispisisa obsidian across chronological periods in the SNR.

during the Archaic periods in the broader region (Burger and Glascock, 2000b). The behavioral changes in obsidian procurement at Chavín de Huantar, seem to have had down-the-line effects on obsidian moving into the SNR. The lack of source diversity at La Puntilla speaks to the organization of Early Horizon obsidian conveyance, which focused on exploitation and movement of a single source, in lieu of other minor sources. These patterns likely track broader patterns in trade during the Early Horizon (Matsumoto et al., 2018).

The data from La Puntilla also add to diachronic patterns. Combining results here with data from previous studies in the SNR (Eerkens et al., 2010; Conlee 2016; Vaughn and Glascock 2005), Fig. 5 tracks the percent of Quispisisa obsidian over temporal periods. As shown, the frequency of non-Quispisisa obsidian fluctuates slightly, but in a predictable manner. Horizons contain less than 1% non-Quispisisa, while Intermediate periods and the Archaic have over three times as much (though still always under 10%), including debitage and formal artifacts such as projectile points. This suggests that organized sociopolitical and/or religious entities focused their efforts on resource procurement and trade at a few major nodes (i.e., major obsidian sources), and either cut off or de-emphasized distribution networks from more minor and remote locations.

This more general finding is consistent with other recent studies on obsidian exploitation in the Andes. As Reid et al., (2025) show, the Wari Empire consolidated what was previously more diverse obsidian exploitation in the Arequipa region, and focused procurement efforts on just two sources, Alca-1 and Alca-4. Judging by Fig. 5, a similar process likely developed in the Nasca region, but focused on Quispisisa obsidian instead, across the Chavín period, and the Wari and Inka Empires.

The people of La Puntilla evidently enjoyed a privileged and seemingly exclusive supply of obsidian nodules from Quispisisa. Considering the pervasive regional relationships of conflict at this time, it may be surprising that many of their regional contemporaries also did obtain Quispisisa obsidian in overwhelming proportions. That source may have had a special status at the time, as suggested by its growing importance at Chavín the Huantar, or it may simply be a factor of accessibility, either because of its shorter distance or because of economies of scale associated with mining and movement in llama caravans (Burger and Glascock, 2000b; Matsumoto et al., 2018; Tripcevich and Contreras, 2011). A slight uptick in source diversity during the EIP is almost certainly related to the interregional events taking place at and near Cahuachi, bringing people from different regions to participate in ceremonies and social events (Kantner and Vaughn, 2012). Attendees may have had their own and independent supply structures for materials such as ceramics, foodstuffs, and lithics, and exchanged them as part of trading or other redistributive activities.

6. Conclusions

A sample of 88 obsidian artifacts from the Early Horizon site of La Puntilla in the SNR shows homogeneity in the source profile. All artifacts derive from the Quispisisa source, despite our sampling across a variety of artifact types, including finished tools (projectile points, bifaces) and waste material (flakes, including flakes with cortex). While Quispisisa is the closest source of obsidian to the SNR at about 85 km, and dominates source profiles for all time periods in the region, other sources, such as Jampatilla are only 20% further in distance. The homogeneity in source profile suggests regulated obsidian distribution networks during the Early Horizon.

More broadly, our analysis of diachronic trends in the SNR shows that source diversity changes in a predictable manner. During Horizons, including the Early, Middle, and Late Horizons, geochemical diversity contracts, focusing just on Quispisisa. By contrast, during the Archaic, and Intermediate Periods (Early and Late), source diversity increases. Such changes speak to varying degrees of control and/or organization in long-distance exchange networks. During periods of greater sociopolitical integration and organization (Horizons), obsidian seems to have moved through more controlled networks. During periods of sociopolitical fragmentation (Intermediate Periods), exchange networks seem to have been less regulated and more geographically open.

CRediT authorship contribution statement

Jelmer W. Eerkens: Writing – review & editing, Writing – original draft, Visualization, Investigation, Formal analysis, Conceptualization. **Hendrik Van Gijseghem:** Writing – review & editing, Writing – original draft, Funding acquisition, Conceptualization. **Jeffrey R. Ferguson:** Writing – review & editing, Writing – original draft, Visualization, Formal analysis, Data curation.

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Data availability

All of the data for this article appear within the text

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