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## Chapter 8

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# Spatial and Temporal Variations in Stone Raw Material Provisioning in the Chivay Obsidian Source Area

*Nicholas Tripcevich and Alex Mackay*

Research into the prehistoric procurement of widely circulated raw materials provides an opportunity to investigate changes in the mechanisms of exchange through time and the impact of regional demand on local provisioning systems. Raw material sources are often exploited to meet both local and regional needs, but parsing the effects of local from regional demand at a lithic source can be complex. By focusing on the relationship between the artifacts found at raw material source workshops and at local sites, archaeologists can gain information about exploitation of the lithic source, as well as local and regional provisioning in prehistory. This chapter focuses on lithic artifacts found in the vicinity of the Chivay obsidian source that lies above the Colca Valley of Arequipa and the documented regional consumption of obsidian from this source in prehispanic times. Comparisons of local obsidian consumption with production at the source indicate that quarrying in the principal obsidian source area was not carried out by local residents for local consumption. This suggests the operation of two distinct procurement and distribution systems: (1) embedded procurement for a down-the-line exchange mode of distribution, disseminating relatively small nodules of Chivay obsidian into local and regional consumption zones, and (2) direct procurement by caravans of large nodules at the source, specifically for regional consumption.

The Chivay obsidian source is located at 4900 m above sea level (masl) on the slopes of two adjacent volcanic vents high

above the Colca Valley in southern Peru (Brooks et al. 1997; Burger, Asaro, Salas et al. 1998; Tripcevich 2007, 2010; Tripcevich and Mackay 2011; Tripcevich et al. 2012). The data presented here reveal the operation of both targeted and embedded procurement systems at the Chivay source area (sensu Binford 1979; Gould and Saggars 1985). Data from a workshop at the obsidian source indicate that targeted long-distance procurement of large obsidian nodules for non-local consumption increased during the Terminal Archaic and Early Formative periods. As we discuss below, the regional distribution of Chivay obsidian at this time was at its peak both geographically and in diversity of sites, suggesting that the demand for obsidian was relatively high, and that regional economic integration around the Titicaca Basin had not yet coalesced into a distinctive exchange sphere.

The Chivay/Cotallauli<sup>1</sup> obsidian was formerly known as the “Titicaca Basin Type” (Burger and Asaro 1977) because proveniencing research begun thirty-five years ago showed that over 90% of the obsidian artifacts analyzed from the Titicaca Basin are of this type (Fig. 8.1). In the mid-1990s, the geological source of this type was finally documented in the Colca Valley and the obsidian type was renamed (Brooks et al. 1997; Burger, Asaro, Salas et al. 1998; Burger et al. 2000). The prevalence of non-local obsidian in the Titicaca Basin is noteworthy when one considers that high-quality cherts are available in much of the region, including the Titicaca Basin, and small and often low-quality<sup>2</sup> nodules of obsidian are available in flows and lag

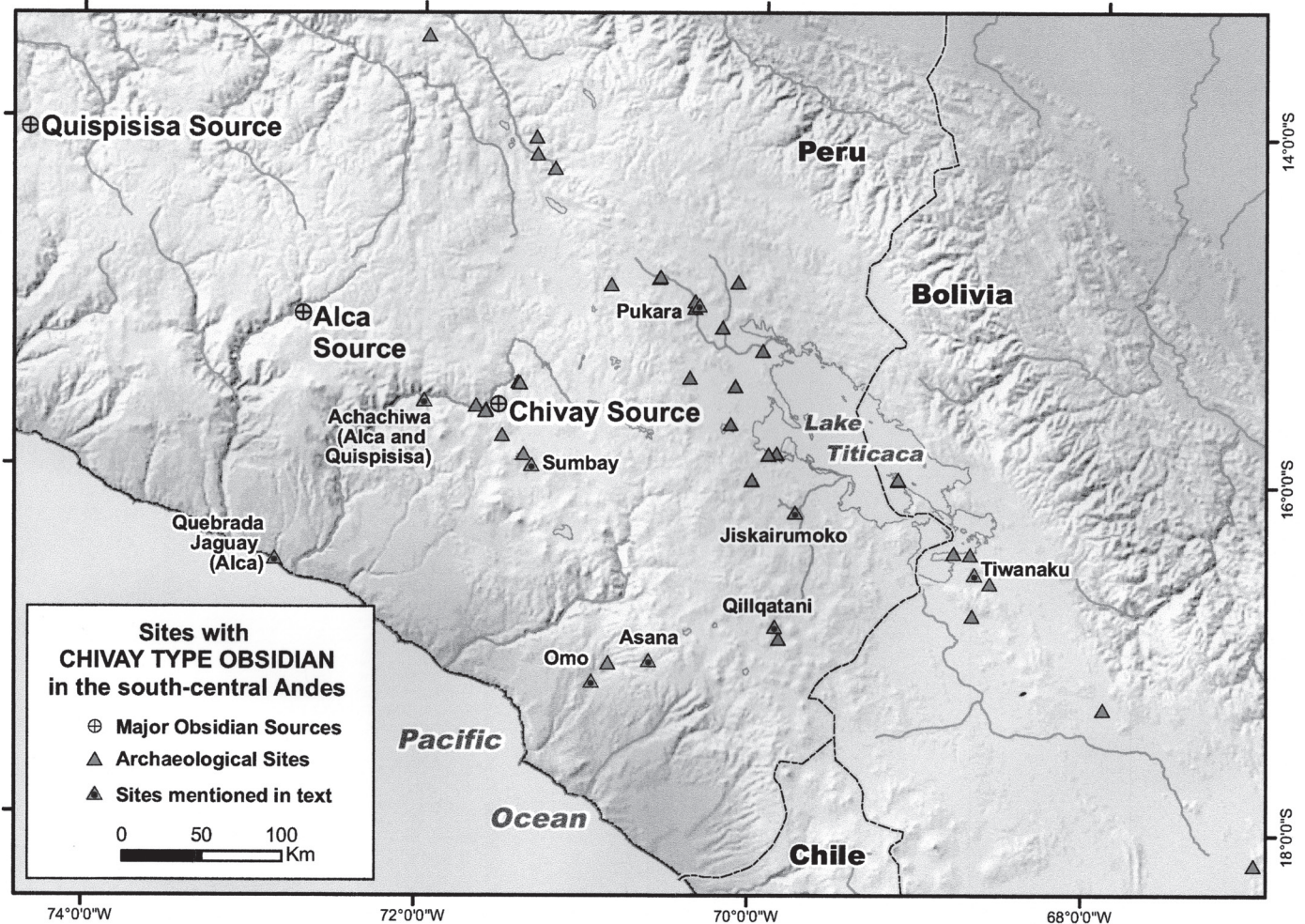


Figure 8.1. Chivay type obsidian in the south-central Andes (from data principally in Burger et al. 2000).

gravels in more easily accessible locations on the slopes of Cerro Hornillo.

The use of Chivay obsidian in the south-central Andes spans a ten-thousand-year time period. As compared with other widely distributed obsidian types in the central Andes, the consumption of Chivay obsidian is almost entirely confined to the high-altitude altiplano of Peru and Bolivia (Fig. 8.2). Obsidian artifacts produced from this source material are known for having the characteristics of a homogeneous and relatively transparent glass (Brooks et al. 1997). As discussed in further detail below, the earliest evidence of human use of the Chivay source area dates to the Early Archaic period (9000–7000 BCE). The obsidian sourcing literature indicates that the distribution of Chivay obsidian increases significantly through time from the Terminal Archaic until the Middle Formative when it reaches its largest geographical extent, and then it occurs exclusively

in the areas occupied by Titicaca Basin polities during the Late Formative and Middle Horizon. There is evidence of reduced use in the Late Intermediate period and the Late Horizon (Burger et al. 2000).

Here, we examine the local and regional importance of the Chivay source in three parts. First, we review both the local and regional obsidian distribution data and explore the changing use of the Chivay source area through time by way of the spatial distributions of temporally diagnostic materials. Next, we investigate the role of obsidian within the local economy by comparing obsidian consumption at local sites (less than one-day's travel from the source) with production at a site identified as the probable source workshop. Finally, we discuss what our data reveal about the contexts of regional demand for obsidian that guided production at the source workshop, and the implications of these changes in regional demand for obsidian through time.

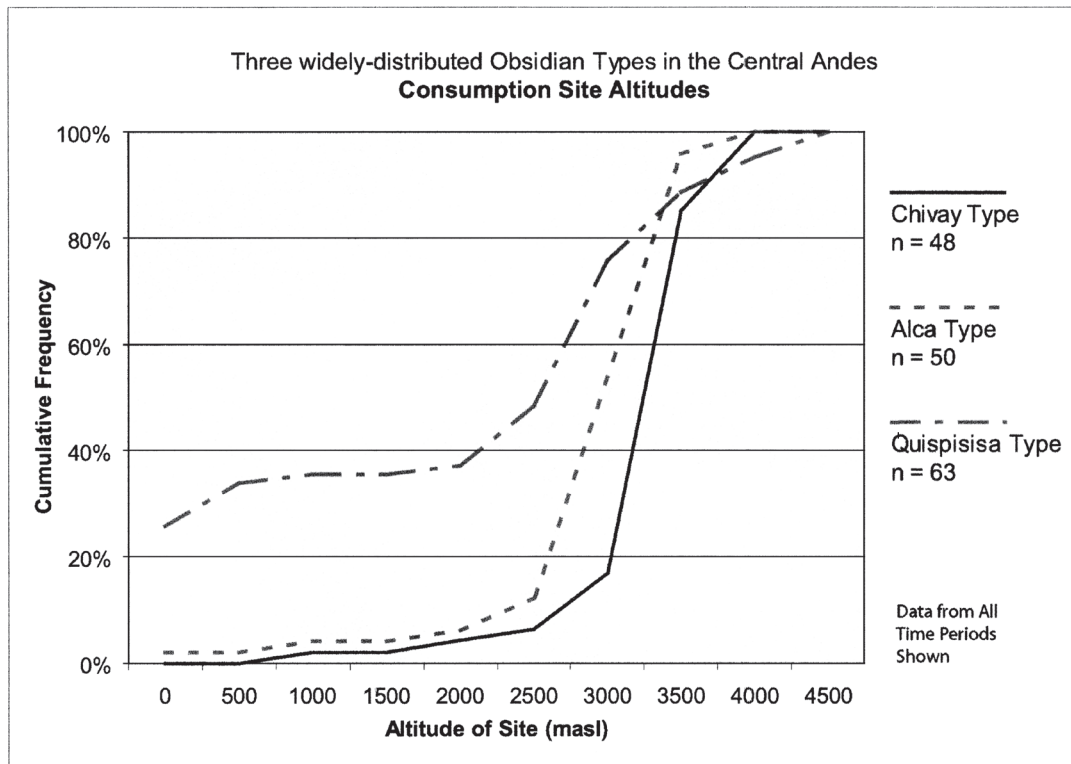


Figure 8.2. Comparison of the consumption site altitudes of three major obsidian types in the Andes (source: Brooks et al. 1997; Burger et al. 2000; Craig 2005; Frye et al. 1998; Stanish et al. 2002).

We discuss the local use of Chivay obsidian in terms of contrasting ecological zones in the Colca area. Agro-pastoral land use patterns that are common in the Andes are apparent in the Colca Valley in both prehispanic and modern subsistence activities (Guillet 1992; Browman 1990). Intensive agriculture in the lower elevation valley grades into a herding economy in the higher altitude puna ecozone, and Colca Valley communities maintain access to products from higher altitude areas either through exchange or by direct access (Casaverde R. 1977; Guillet 1992:133–39; Markowitz 1992:69–76; Shea 1987:81–85). Such systematic local movement created an excellent context for embedded procurement of lithic raw materials in the past. This procurement of obsidian, embedded into local travel between valley and puna, can be contrasted with targeted procurement by regional caravan networks. At least one historically important travel route (“Quebrada Escalera” on Fig. 8.3) passes close to the Chivay obsidian source (Casaverde R. 1977).

For the purposes of field research in 2003 the study region was divided into six blocks, four of which were surveyed intensively (Fig. 8.4), while the more remote Blocks 4 and 5 were inspected

on reconnaissance trips. The nature and distribution of resources in the intensive survey blocks are as follow:

**Block 1** is an oval volcanic depression known as “Maymeja” (Fig. 8.3) by the local herders, and it is where the largest and highest quality obsidian nodules are located. In general, Maymeja is a rocky and barren high-altitude environment but it also contains productive *bofedal* grazing land that currently supports a herder and approximately 200 animals for part of the year. Altitude range of survey: 4070–5160 masl.

**Block 2** is a puna environment featuring very large bofedales, and intensive pastoralism. Departing from the Chivay source, this block lies one-day’s travel to the southeast, and it is the first grazing area of significant size that could support large herds in the direction of the Lake Titicaca Basin. Altitude range: 4350–4530 masl.

**Blocks 3 and 6** are primarily in the *suní* zones of the upper Colca River valley close to a river confluence that forms a crossroads in the regional transportation system. There is abundant evidence of former agricultural activity in this area, although

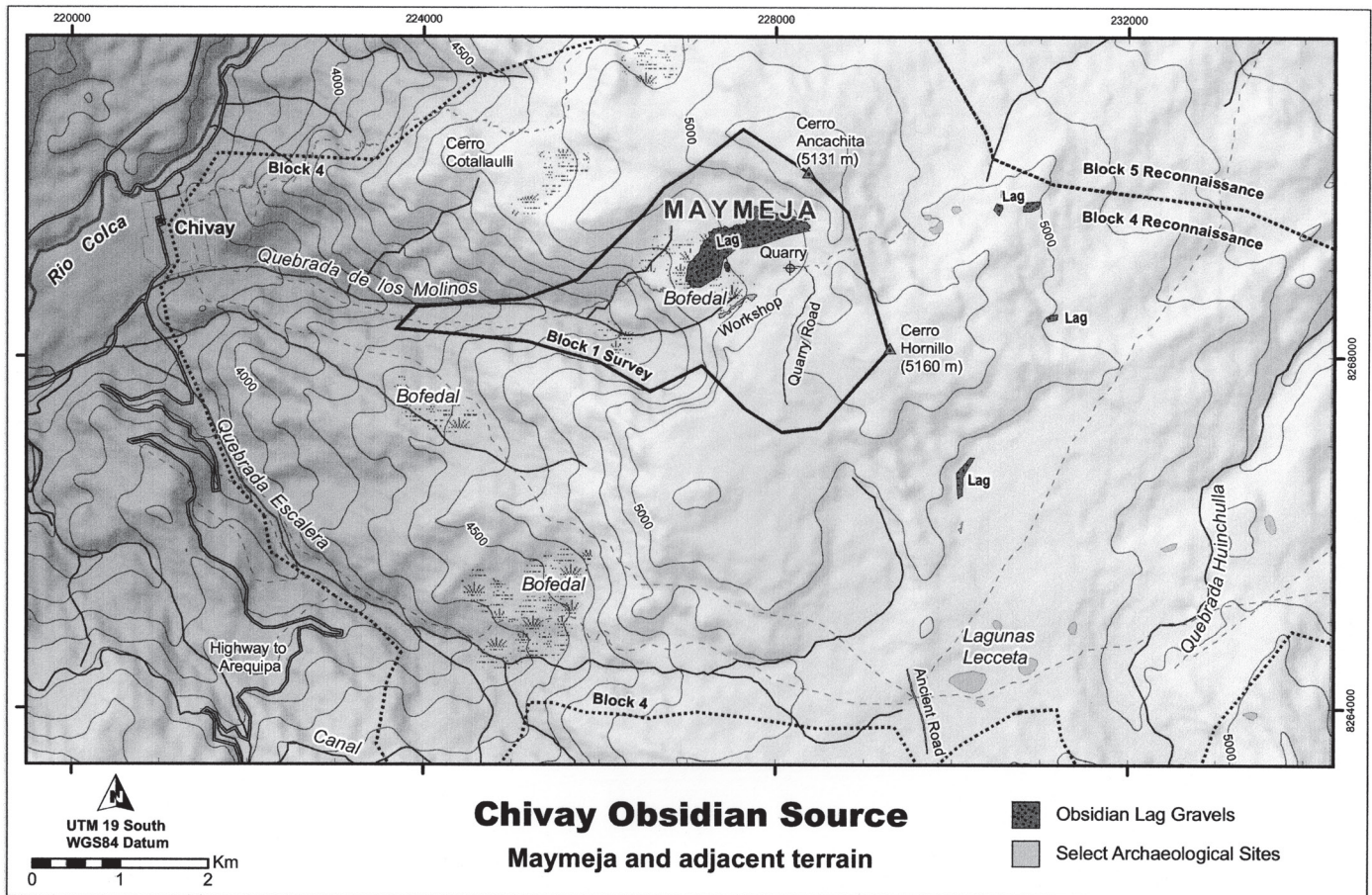


Figure 8.3. Chivay obsidian source showing Maymeja zone and obsidian lag in surrounding terrain.

today the maximum altitude of intensive agricultural activity seems to have shifted another 100 vertical meters down valley to the vicinity of Tuti. Altitude range: 3830–4300 masl.

**Blocks 4 and 5** are extensive zones of lava flows and tephritic soils, with modern pastoral settlements concentrated around water sources. Due to the difficulty of access and the low density of archaeological features in this area, we conducted a prospective rather than a systematic survey in these survey blocks (Banning 2002). Altitude range: 3870–5160 masl.

Our intensive survey areas (Blocks 1, 2, 3, and 6) totaled 33 km<sup>2</sup> with a surveyor interval of 10–15 m, while in our reconnaissance work (Blocks 4 and 5) we targeted areas that were judged from imagery and maps to have a high likelihood of archaeological sites and geological obsidian exposures. During the course of the project we dug eight 1 × 1 m test units in three of the survey blocks. Using a mobile GIS system based on ESRI Arcpad 6 customized for archaeological feature recording (Tripcevich 2004), 1100 separate archaeological loci were located and mapped during the survey and reconnaissance work.

A quarry pit and a nearby workshop were identified in the course of the survey of the Maymeja area of Block 1, in the obsidian source zone (Fig. 8.3). The quarry pit was found in association with the largest, high-quality obsidian nodules, and was at an altitude of 4950 masl. The quarry pit is now mostly filled in, but remains 2 m deep and 4 m × 5 m across (Fig. 8.5). The quarry is exposed on a ridge and is a difficult place to work. A workshop site was found 600 m downslope in a warmer, sheltered location and close to the only perennial water source in Maymeja as well as to a bofedal. In this discussion of raw material procurement, it is important to note that the quarry pit is not the only source of obsidian in the area. Smaller nodules of variable quality obsidian also occur as marekanites or surface lag gravels (Fig. 8.6) throughout Maymeja as well as just below 5000 masl around the shoulders of the rhyolitic southern dome, Cerro Hornillo. No high-quality obsidian was available in either Block 2 or Block 3, though chert, chalcedony, quartzite and aphanitic, fine-grained volcanic stone (andesite and basalt) did occur locally.

Departing from the quarry was a prehispanic road that is 3–4 m wide and cleared of most rocks (see Fig. 8.3 map). This

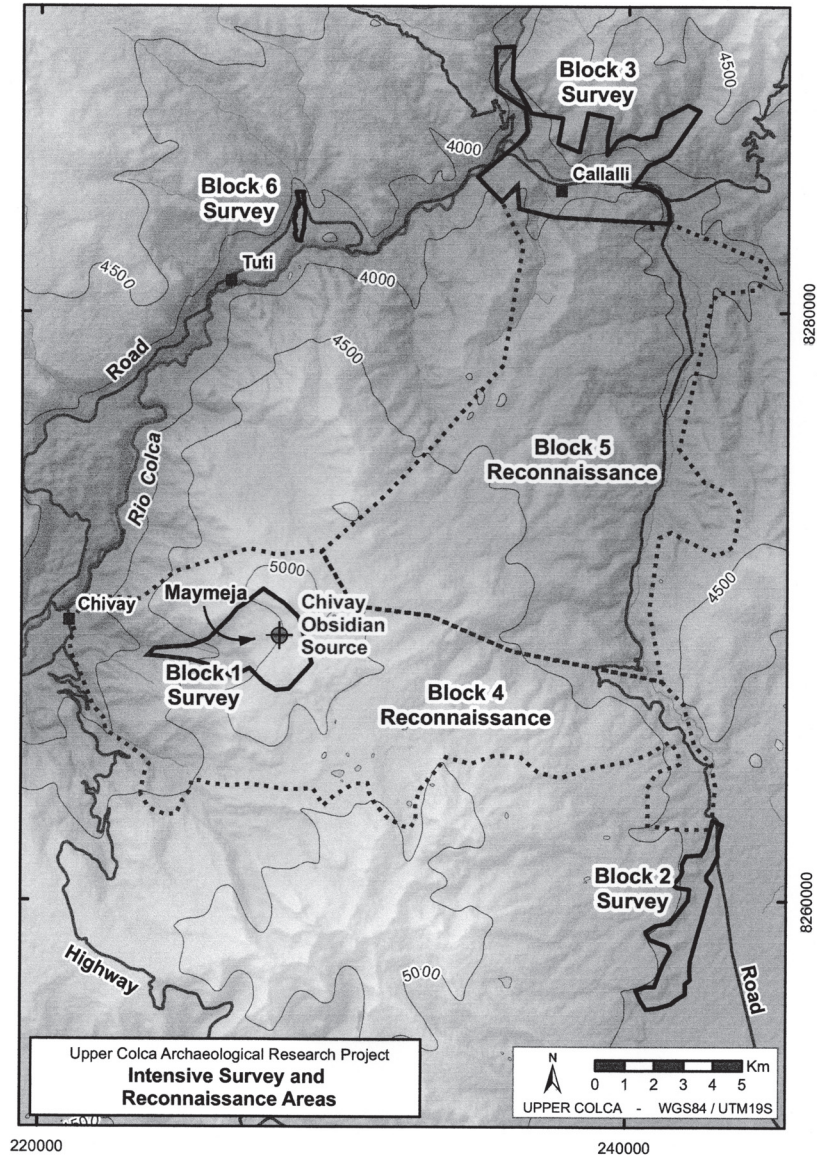


Figure 8.4. Upper Colca Project Area: 2003 intensive survey and reconnaissance blocks.

road departs the Maymeja area toward the south, following the route with the lowest gradient out of the volcanic depression and avoiding difficult talus areas. We were able to follow two sections of this road for a total of 3 km, and it can be described as of the “*Cleared Road type*: . . . systematically cleared of all stones or other debris” (Beck 1991:75–76). At 4 km from the quarry pit this trail joins “Escalera,” a major thoroughfare climbing steeply out of the Colca Valley to the puna and off toward the east-south-east (the direction of Lake Titicaca). Today, the route of the modern Chivay-Arequipa highway has shifted traffic to Patapampa and around the south side of Cerro Huarancante and so currently these more ancient travel routes see little use.

### I. Surface Survey: Temporal Distributions Around the Obsidian Source

General patterns in the prehistoric use of the obsidian source region can be explored by examining the spatial distributions of temporally diagnostic archaeological features that we documented in the course of our survey work. Temporal control was difficult to achieve with our surface survey data: the rugged volcanic terrain and infrequent water sources of the Upper Colca Project survey area present few suitable residential locations, leading to a high percentage of reoccupation sites.

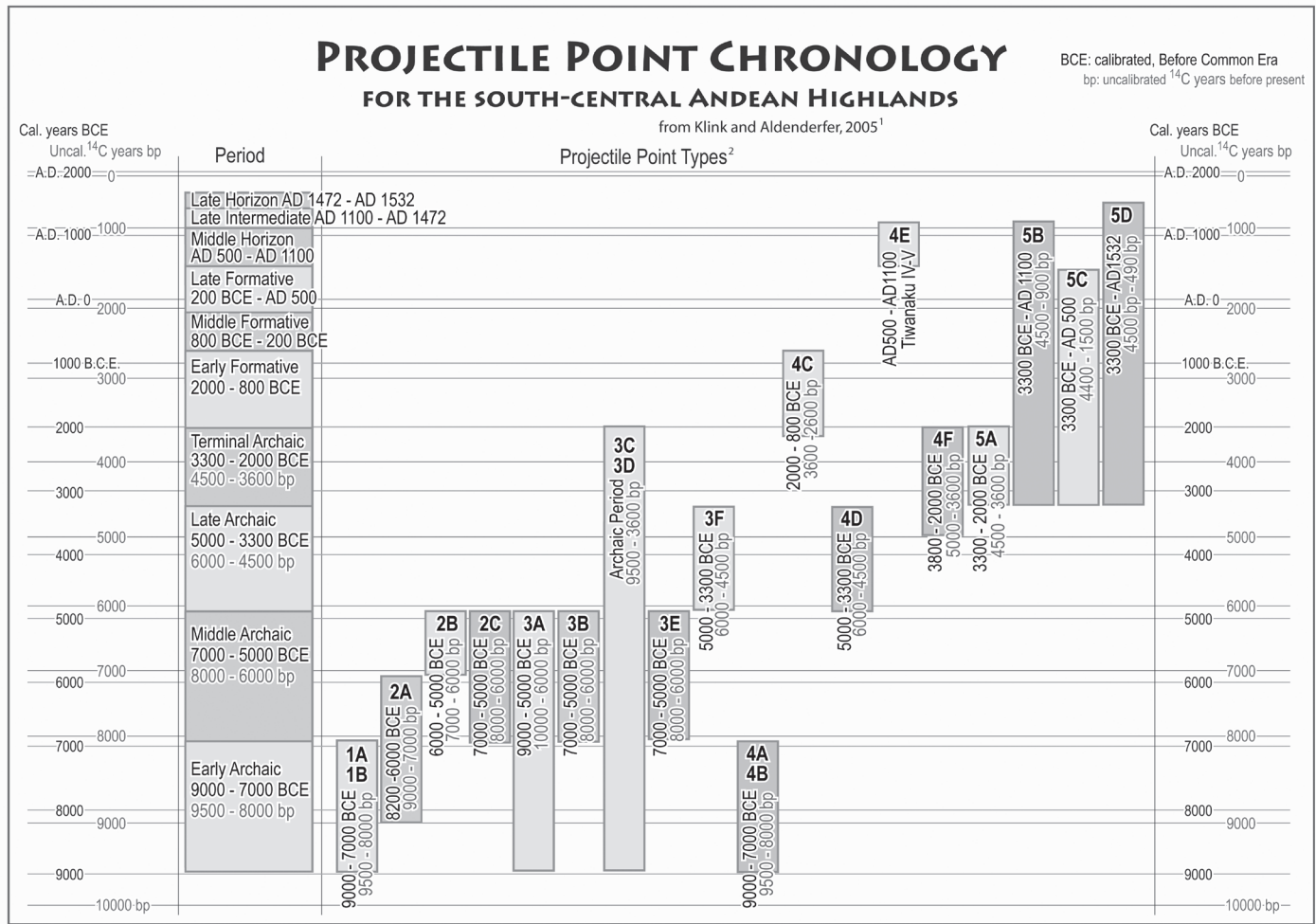
We have the benefit of recently published time-sensitive chronologies for both projectile points and pottery styles appli-



Figure 8.5. Test excavations in the debris pile at the Maymeja quarry pit with the workshop and bofedal 600 m downslope on the left side of the photo.



Figure 8.6. Obsidian surface lag gravels or marekanites east of Cerro Hornillo. These deposits are accessible but consisted of smaller nodules with bubbles and ash inclusions, and lacked an adjacent bofedal.



<sup>1</sup> Klink, C. and M. Aldenderfer, 2005. A Projectile Point Chronology for the South-Central Andean Highlands. In *Advances in Titicaca Basin Archaeology-1*, edited by C. Stanish, A. Cohen and M. Aldenderfer, pp. 25-54. Cotsen Institute of Archaeology, Los Angeles, California.

<sup>2</sup> Date ranges of projectile point types are from the uncalibrated before present dates reported by Klink and Aldenderfer. They were calibrated using Oxcal v3.9 (C. Bronk Ramsey, 2003), and then the mean of the 2 $\sigma$  BCE range was rounded to the nearest 100. The point types are plotted on two reference scales that were derived from dates calibrated in 500 year increments. Errors of  $\pm 50$  years were used for dates <5000 bp and errors of  $\pm 100$  years were used for dates  $\geq 5000$  bp. These dates and period definitions are not precise; they are meant only for convenient reference.

Figure 8.7. Calibrated and uncalibrated temporal charts with projectile point typology data from “Projectile Point Chronology for the South-Central Andean Highlands” (Klink and Aldenderfer 2005; Bronk Ramsey 2003; Stuiver et al. 1998).

cable to the Colca region (Klink and Aldenderfer 2005; Wernke 2003:447–537). The south-central Andean projectile point chronology was published by Klink and Aldenderfer (2005) in the first volume of this book series using uncalibrated Before Present dates. In Figure 8.7 shown here, the uncalibrated date ranges for each projectile point type were calibrated in Oxcal v3.9 (Bronk Ramsey 2003) and the mean was rounded to no more than 100 years to arrive at a general reference for projectile point types against calibrated Before Common Era dates.

The limitations of typological approaches notwithstanding (Mackay 2005), the chronological pattern in our survey data shows relatively steady occupation through the Archaic and then a marked increase in frequency of finds associated with the Terminal Archaic and onward (Fig. 8.8). We found consistent occupation of the Block 2 puna area in all time periods, and relatively few diagnostic artifacts near the Chivay obsidian source as compared with those found in Block 2.



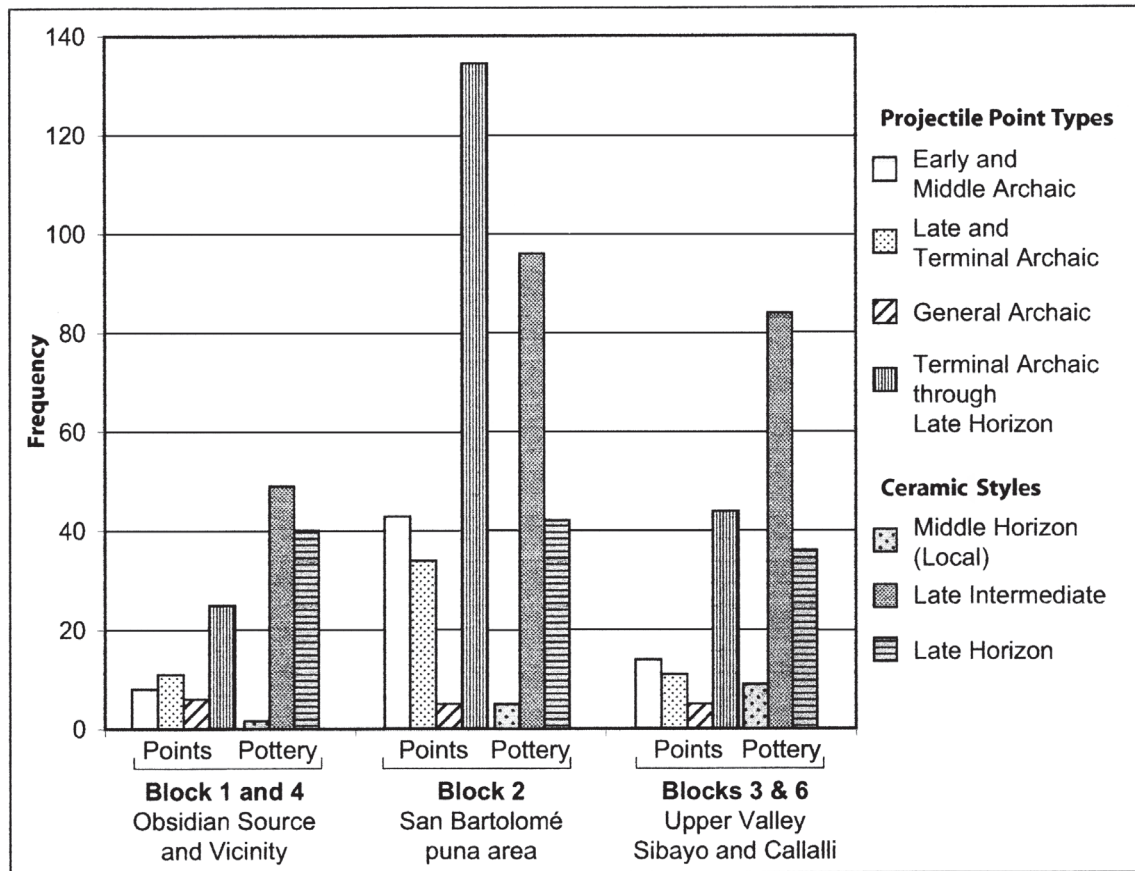


Figure 8.8. Temporally diagnostic artifacts by block from the Upper Colca 2003 survey.

### Early Use of the Chivay Source

#### Regional Use during the Early and Middle Archaic

The earliest documented use of Chivay obsidian falls during the Early Archaic. During this period human groups in the south-central Andes have been characterized as living in small foraging groups with high mobility and relatively egalitarian social structure (Aldenderfer 1989, 1999). Obsidian exchange between neighboring groups may have been in the context of both maintaining access to resources and risk reduction (e.g., Wiessner 1982). From a subsistence perspective, Spielmann (1986:281) describes these as *buffering*, a means of alleviating periodic food shortages by physically accessing them directly in neighboring areas, and *mutualism*, where complementary foods and other goods that are procured or produced are exchanged on a regular basis. Finished obsidian tools may have served as tokens representing mutual access to territory, or as markers of intergroup or interindividual relationships (Brown 1985:223). Another likely context for obsidian distribution in the Archaic period is at periodic aggregations. Seasonal aggregations have been well documented among foragers living in low population densities, where gatherings are the occasion for trade and consumption of surplus food as well as for maintaining social ties and

for ceremonial obligations (Birdsell 1970:120; Steward 1938). If analogous gatherings were occurring among foragers in the south-central Andes, it would have created an excellent context for the distribution of a highly visible material like obsidian that was irregularly available in the landscape.

#### Evidence from Obsidian Procurement

In our survey we recovered sixteen Early Archaic type obsidian points in the vicinity of the Chivay source, but all of them were found outside the Maymeja source area, either in the lower reaches of Block 1, or in Block 2 to the east, so there is no Early Archaic evidence from the quarry area itself. At the site of Asana in Moquegua, more than 200 km to the southeast, Aldenderfer (1998:157, 163) recovered Chivay obsidian flakes in levels belonging to the Asana II/Khitsuña phase, or Early Archaic levels. One flake was found stratigraphically above a  $^{14}\text{C}$  sample dated to  $9820 \pm 150$  BP (Beta-40063) 10,000–8700 cal BCE. Eleven other flakes were found in a level dating to  $8720 \pm 120$  BP (Beta-35599) 8250–7550 cal BCE. At the rockshelter of Qillqatani, obsidian from a still unidentified source was found in levels dating to around  $7100 \pm 130$  BP (Beta-18926) 6230–5720 cal BCE. Chivay obsidian is not found at Qillqatani until approximately 1500 years later. What is interesting about

Temporal Period Projectile Point Type	Survey Blocks 1 & 4 Chivay Source and vicinity (B4)	Survey Block 2 San Bartolomé	Survey Block 3 & 6 Callalli area and Upper Valley (B6)	Total
<b>Middle Horizon</b> Type: 4E		Obsidian: 1		1
<b>Term. Archaic - Late Horizon</b> Types: Series 5, 5D	Volcanics: 1  Obsidian: 32	Volcanics: 1 Chalcedony: 1 Chert: 2 Obsidian: 117	Obsidian: 1	155
<b>Term. Archaic - Middle Horizon</b> Type: 5B	Obsidian: 2	Volcanics: 1 Obsidian: 11		14
<b>Term. Archaic - Late Formative</b> Type: 5C		Obsidian: 1		1
<b>Archaic Period (general)</b> Type: 3D	Volcanics: 2  Obsidian: 2	Volcanics: 2 Chert: 1 Obsidian: 2	Chalcedony: 1 Chert: 1	11
<b>Terminal Archaic</b> Type: 5A	Obsidian: 2	Obsidian: 2	Chert: 1	5
<b>Later Late Archaic and Term. Archaic</b> Type: 4F	Obsidian: 2	Volcanics: 2 Chalcedony: 1 Obsidian: 7	Obsidian: 1	13
<b>Late Archaic</b> Types: 3B, 3F, 4D	Volcanics: 1  Obsidian: 3	Volcanics: 12 Chalcedony: 1 Chert: 2 Obsidian: 7	Volcanics: 1 Chalcedony: 1 Chert: 2 Obsidian: 1	31
<b>Later Middle Archaic</b> Type: 2B	Obsidian: 1			1
<b>Middle Archaic</b> Types: 2C, 3A, 3B, 3E	Volcanics: 1 Chert: 1  Obsidian: 7	Volcanics: 5 Chert: 3 Obsidian: 12 Quartzite: 1	Volcanics: 1 Chert: 2 Obsidian: 1	34
<b>Early - Middle Archaic</b> Type: 2A		Obsidian: 2		2
<b>Early Archaic</b> Types: 1A, 1B		Volcanics: 3 Chalcedony: 1 Chert: 2 Obsidian: 14		20
<b>Total</b>	57	217	14	288

Figure 8.9. Diagnostic projectile points by survey block from the Upper Colca 2003 survey.

the use of obsidian at Asana and at Qillqatani is that an obsidian source (the Aconcagua source [Frye et al. 1998]) of material of lower knapping quality is nearby—but that source is used only briefly by pastoralists at Asana, and much later in the sequence. Evidently, the quality of Chivay material was preferred even at these early dates.

Sandweiss et al. (1998:1832) observe that the Chivay source may have been covered by a glacial readvance during the Younger Dryas (ca. 10,800–9800 cal BCE) and they propose that this is why the earliest confirmed site in coastal Peru, Quebrada Jaguay (Fig. 8.1), had obsidian only from the Alca source despite being nearly equidistant from the Chivay source. At the Chivay source,

the Maymeja area was perhaps glaciated during the Early Archaic while the eastern and southern flanks of the Cerro Hornillo were exposed, but contained smaller obsidian nodules. The Early Archaic obsidian points recovered from Block 2 (Fig. 8.9) were relatively small (length for 13 complete points = 34.96 mm +/- 6.72 mm) and it appears that the material could have been obtained from lag deposits of smaller obsidian nodules around the east side of Cerro Hornillo (Fig. 8.6) or from secondary deposits in glacial moraines. The earliest points found in the Maymeja source area were three Middle Archaic points, which leaves open the possibility that the Maymeja sector of the Chivay source area was glaciated as late as 7000 BCE.

*Late Archaic and Terminal Archaic Periods*

In the Late and Terminal Archaic periods, obsidian continues to be used in flake form, for projectile point production, and occasionally for other bifacial tool types. Although obsidian has many functional applications, especially among pastoralists, it is also visually unusual and may have served as a marker of ethnic affiliation or had symbolic significance in some cases, particularly in zones where it does not occur naturally (Tripcevich 2010:69). In the context of sociopolitical change and early social ranking that begins in the Late and Terminal Archaic, obsidian was perhaps one of a number of materials of limited availability that served as status indicators.

*Regional Use at the End of the Archaic*

In the Late Archaic period, obsidian continues to be used as flakes and as bifacially flaked tools, especially projectile points, both locally and regionally. The regional database is somewhat limited for the Late Archaic because many of the samples that are potentially from the Late Archaic contexts described in Burger et al. (2000) are surface collected from multicomponent rockshelter sites. A few samples were gathered from diagnostic Late Archaic projectile point types, providing a stronger temporal affiliation. Interestingly, the obsidian types Tumuku and Chumbivilcas, chemical types with less extensive circulation in the past (the geological sources are still unlocated), are relatively abundant in the Late Archaic.

Chivay obsidian continues to be found throughout the Titicaca Basin but regional evidence indicates that obsidian circulated slightly less during the Late Archaic. This situation is reversed in the Terminal Archaic when Chivay obsidian returns and is found in relative abundance in the south-central Andes.

Buffering and mutualism strategies (described above) likely continued to serve as a means for the exchange of goods between foragers, and these strategies continued to be relevant with early pastoralists. On a subsistence level, hunters benefit from the fracture predictability and the penetration and cutting capacity of obsidian tools. Obsidian has advantages and disadvantages over other available lithic materials like chert or andesite for both hunters and herders performing their subsistence tasks. With the advent of pastoralism around 3500 BCE, obsidian distribution and use expanded significantly in the south-central Andes. These changes are probably the result of some combination of the following phenomena: population growth, increased regional interaction and exchange by pastoralists, the functional properties of obsidian tools for herders, or the social and symbolic value of obsidian in a time of emerging social hierarchy. Among herders, obsidian functions as a practical cutting tool for both shearing wool and butchering (Gilmore 1950:446). The best caravan llamas are castrated males and obsidian or broken bottle glass continue to serve pastoralists as a sharp implement for this procedure because glass or stone remain non-oxidized and are less likely to cause infection than castrating with a metal knife

(Timoteo Valdevia, pers. comm., 5 Sept 2003). With expanding herds, the demand for obsidian for all of the above pastoral procedures would have increased during this time. Simultaneously, obsidian was heavily used for series 5 type projectile points. Increased regional interaction from the Terminal Archaic period and onward is further suggested from the wider distribution of projectile point types in this time period. Less pronounced differences in regional projectile point forms has been observed as Type 5B and 5D projectile points were circulated widely within the pastoral zone of highland south-central Andes in the Terminal Archaic and onward (Klink and Aldenderfer 2005:47–53).

In the consumption zone far from the source area, the possession of Chivay obsidian—a visible and often transparent non-local product—may have served as a means of differentiating oneself for the local context or indicating affiliation or trade with distant groups (Tripcevich 2010:69). Exotic materials like gold pendants and non-local sodalite beads are found in the Chivay obsidian consumption zone (Aldenderfer et al. 2008). Such objects, along with obsidian in some cases, belong to a class of artifact used to demarcate commonplace from supernatural referents, or were at least part of a constellation of practices associated with the use of objects that signal status difference.

Further evidence of obsidian from secure contexts is needed to gain a better understanding of how non-local items figured into ritual and ceremonial practices in the Late and Terminal Archaic. Some researchers describing ranked societies have assigned long-distance traders great importance, as Helms (1992:159) argues that “we should consider long-distance travelers or contact agents as political-religious specialists, and include them in the company of shamans, priests, and priestly chiefs and kings as political-ideological experts or ‘heroes’ who contact cosmically distant realms and obtain politically and ideologically useful materials therefrom.” However, in the south-central Andean highlands—where many households own cargo llamas starting perhaps during the Terminal Archaic, and where debt relationships or barter (non-market exchange) is argued to have been widespread in prehistory (Browman 1990; Nuñez and Dillehay [1979] 1995)—the actual kilometers implied by “long-distance” may need adjustment in this discussion. Traversing social boundaries and the risks of travel from changing political configurations probably represented greater obstacles to long-distance exchange than the physical distance across the puna once cargo-bearing camelids were available.

The degree to which this concept of ritual power accruing with distance is applicable in the south-central Andean highland would probably return to the articulation between the economy of exclusive, status-conferring goods and economies of other non-exclusive, reciprocity-based means of circulating goods. For sacredness or exotic power to be conferred through possession of non-local goods like obsidian, those goods cannot be widely available or mutable in economic circles accessible to just anyone (Clark and Blake 1994; Goldstein 2000).

Availability of materials often changed diachronically in the past, be it obsidian in the prehispanic Andes or glass drinking

vessels in ancient Rome, and availability is a principal factor in ascribing value to its consumption (Appadurai 1986:38; Smith 1999:113–14). If this was the case in the Colca Valley, we should expect fewer ritual or ceremonial contexts for obsidian in the vicinity of the source area than has been observed in the consumption zone that includes the Titicaca Basin. Obsidian accessibility was linked to technological changes such as camelid domestication, allowing for cargo transport by llamas, and ultimately the emergence of sustained long-distance contact through caravan transport. Obsidian may have become relatively obtainable to everyone in the north Titicaca Basin from the Middle Formative onward as one of a number of items circulating among people sharing common ideological and economic bases.

#### *Late and Terminal Archaic Evidence from the Chivay Source Area*

In our Chivay source survey work we found that Late Archaic projectile point distributions are notable for the increased use of fine-grained volcanic rocks (andesite and basalt), particularly in the Block 2 puna area. There was perhaps a functional basis for this heavy use of fine-grained volcanics, as 56% of the large and stemmed 4D type points (Klink and Aldenderfer 2005:44–45) in our study are made of fine-grained volcanics while only 10% of the overall projectile points are made from fine-grained volcanics. Furthermore, projectile points made from the volcanics are consistently large and heavy ( $= 6.3 \text{ g} \pm 2.88$ ) while projectile points of other material types are much more variable, perhaps because the reduction constraints on volcanics result in larger points. The adoption of obsidian for small point production during the Terminal Archaic could therefore be linked to technological changes like the adoption of bow and arrow (Klink and Aldenderfer 2005:54). Additional support for the introduction of the bow at this time comes from Chinchorro burials in coastal northern Chile dating to circa 3700–1100 cal BCE, or the Terminal Archaic and Early Formative (Bittmann and Munizaga 1979).

The most pronounced temporal pattern observed in the vicinity of the Chivay source is the abundance of obsidian projectile points in the unstemmed, unshouldered triangular forms referred to as series 5 types (Klink and Aldenderfer 2005:47–53). The point chronology is not very time sensitive for these later periods with our data because over 90% of the series 5 points that we recovered were type 5D (Fig. 8.9), spanning the time period from the Terminal Archaic through the Inka period. In the Upper Colca Project area these points are most prevalent in the Block 2 puna area of our survey area where it appears that the points were being manufactured (Fig. 8.4). In the Block 2 area, the 130 projectile points we recovered belonging to series 5 were associated with quantities of advanced stage reduction debris, while in Block 3 the 22 obsidian series 5 points we identified were frequently isolates and, in general, obsidian tools were rarely associated with obsidian chipping debris.

#### *Ceramic Period Distributions from Survey*

The marked changes that occurred in the south-central Andes in the Formative period (ca. 2000 BCE) are summarized here with respect to lithic provisioning in the Colca Valley. Throughout the Formative and Middle Horizon the regional demand for obsidian is sustained, and then during the Late Intermediate period and Late Horizon the production and circulation of Chivay obsidian appear to diminish. Here we summarize the regional distributions and then discuss the ceramic period use of the Chivay source.

#### *Regional Context*

Early and Middle Formative distributions were larger in quantity and also geographically more extensive than during earlier times; however, distributions did not expand evenly in every direction. Chivay obsidian use was confined to the highland area (Figs. 8.1, 8.2). By the Early Formative period, distributions of Chivay obsidian have been found in excavations from at least six different sites ranging from the Cuzco Valley to southern Lake Titicaca Basin and the Island of the Sun, and also westward to Qillqatani on the headwaters of the Osmore River (Aldenderfer, in press; Burger et al. 2000:288–89; Shackley 2005; Stanish et al. 2002).

During the Middle and Late Formative, and the Middle Horizon, the relationships between obsidian distributions, stylistic traits, and accelerating political changes in the Lake Titicaca Basin have been explored elsewhere (Burger, Asaro, Salas et al. 1998; Burger et al. 2000). First emerging during the Late Formative period, Titicaca Basin regional centers appear to have commanded increasing influence over regional exchange. Investigations in the Titicaca Basin, including excavated obsidian samples collected predominantly from regional centers (Burger et al. 2000:322–23; Giesso 2003:323), have led investigators to propose that regional exchange with neighboring areas was controlled in some form by the Titicaca Basin centers, though the nature of this regional control is indistinct (Bandy 2005; Stanish 2003:156–64). If ethnography can serve as an example for the developing herder-agriculturalist relationship, modern pastoralists of the western Lake Titicaca Basin have long-standing mutualistic ties with the warm, productive farming areas of the western slope, such as the Colca Valley (Flores Ochoa 1968:129–37). Such accounts show that exchange between such areas was mediated by social ties between communities or individuals, and that even in modern circumstances, the transactions took place in private patios using barter medium where exchange values are typically fixed through tradition (Browman 1990; Nielsen 2001). During the subsequent Middle Horizon, obsidian in the Titicaca Basin continues to originate in the Colca Valley (Burger et al. 2000:324–43; Giesso 2003). Given the well-demonstrated pattern of Tiwanaku exercising control over distant resource areas such as Moquegua and Cochabamba, one might expect Tiwanaku materials in the vicinity of the Chivay source. Instead, we find no Tiwanaku affiliation, but rather Wari influence in the main

Colca Valley. Finally, during the Late Intermediate period and Late Horizon, the circulation of obsidian declined. Despite the evidence for conflict during the Late Intermediate period (Arkush 2005), and the close ethnohistoric ties between the Colla and the Aymara-speaking Collagua ethnic group in the upper Colca Valley (Julien 1983; Lumbreras 1974), demand for Chivay obsidian appears to have declined on a regional scale.

#### *Ceramic Period Evidence from the Colca*

The Formative through Late Horizon economy activities in the area of the Chivay source and adjacent suni and puna zones were principally devoted to pastoralism that complemented agricultural intensification projects occurring in the main Colca Valley. A principal question about raw material procurement in complex societies is the issue of circumscribed access to resources (Torrence 1984, 1986:98–110). At the Chivay source, we found no evidence of significant walls or major sites along access routes; however, there were natural barriers in the form of steep walls that ring this glaciated volcanic depression and that effectively limit access to the Maymeja area to six entry points. Furthermore, there is no evidence for there ever having been a supply and demand-based market economy in the south-central Andes (La Lone 1982; Stanish 2003:20–21, 69), precluding the commercial profit incentive for monopolizing access.

Our survey data are based largely on distributions of ceramic types. The Formative and Middle Horizon pottery styles for the Colca Valley are still being refined, but the Late Intermediate period (LIP) and Late Horizon (LH) pottery are well documented (Brooks 1998; De la Vera Cruz 1987; Malpass 1987; Wernke 2003). In our 2003 survey work we found sherds from grit-tempered, unslipped, neckless ollas in abundance, particularly in the Block 2 puna area. Despite the frequent use of Chivay obsidian in the Titicaca Basin, ceramics in styles belonging to the Titicaca Basin are few in the Colca Valley prior to the Late Intermediate period. In the course of our survey we located three sherds that resembled Qaluyu and Pukara styles in Block 3; however, sherds of Colla ( $n = 26$ ) and Chucuito-Inka ( $n = 8$ ) styles were identified in the course of our survey. While conducting an extensive survey in the main Colca Valley, Wernke (2003:135–39) located one sherd of diagnostic Pukara design.

During our survey work in 2003, the Middle Horizon evidence was even more enigmatic than the Formative. No Tiwanaku or Wari sherds were found during our survey despite the Colca region having spatial associations with both Middle Horizon states. In the case of the Tiwanaku polity, obsidian from the Chivay source was widely used both in the urban core of Tiwanaku and at affiliated sites throughout the south-central Andes. Colca Valley obsidian accounts for 90% of the obsidian artifacts ( $n = 29/32$ ) that have been analyzed from Tiwanaku's civic-ceremonial area, and microdebitage of obsidian predominates in the fill of a number of ceremonial mounds in the Tiwanaku heartland (Brooks et al. 1997; Giesso 2003:367–70). To date, the only sample of Chivay obsidian collected from a site below 2000 masl is at the Tiwanaku colony of Omo (Goldstein 1989)

at 1250 masl in Moquegua (Figs. 8.1, 8.2), and, interestingly, it was mixed in roughly equal portions with all the major Peruvian obsidian types: Alca, Quispisisa, and Andahuaylas A type obsidian (Burger et al. 2000:332, 338). In the Colca Valley, there are Wari-influenced settlements but in the Wari sphere people appear to have not used obsidian from the Chivay source, even when those people were residing in the Colca Valley. Large, Wari-influenced settlements have been identified at Charasuta (Doutriaux 2004:212–23) near Lari about 25 km down valley from the Chivay source, and at the site of Achachiwa (Doutriaux 2004:202–7; Vera Cruz 1987, 1988), 46 km down valley near Cabanaconde (Fig. 8.1). At Achachiwa, a predominantly Middle Horizon site with Wari architectural features, Brooks (1998:447) reports that she collected seven obsidian flakes for analysis and, surprisingly, none of the flakes were of Chivay type obsidian. Six of the flakes were from the Alca source (96 linear km away) and one was from the Quispisisa source (300 linear km away). Regional relationships during the Middle Horizon at the Chivay source are unresolved because no Tiwanaku or Wari ceramics were found at the source, yet the obsidian was being transported to the Titicaca Basin at the same time that the adjacent Colca Valley itself exhibited strong Wari influences, if not outright Wari control. This paradox might illuminate aspects of the relationship of Tiwanaku with its peripheral resource areas, complementing the emphasis on direct control through vertical complementarity that dominated regional research on the Middle Horizon.

Our survey results show that during the Late Intermediate period and Late Horizon, the Block 1 terrain around the obsidian source reflects a relatively high density of use as compared with earlier periods, but the emphasis appears to have been on pastoral grazing opportunities and water control projects rather than on obsidian procurement. The Block 2 puna was intensively occupied in the late prehispanic period, and again the spatial associations of Late Intermediate period and Late Horizon ceramics in Block 2 are predominantly with pastoral activities.

#### *Summary of Our Survey Evidence*

Our survey data indicate that the area surrounding the Chivay source was integrated into local economic subsistence throughout prehistory. Obsidian procurement was probably embedded in hunting forays into the mountainous terrain of the source area from the earliest human use of the region and through the most recent prehispanic periods. Our evidence from survey and excavation indicates that an emphasis on obsidian procurement, primarily in the form of nodules and blanks, appears to have peaked during the Terminal Archaic, Formative, and Middle Horizon. Procurement through direct access to the Chivay source—either embedded in foraging behavior or associated with caravan travel through intentional quarrying and production—appears to have been a dominant means of Chivay obsidian distribution. A second principal form of distribution is through down-the-line or local, reciprocity-based exchange networks, a process supported by regional evidence of obsidian appearing

in diminishing numbers and smaller sizes with distance from the Chivay source. Differentiating these forms of production from obsidian production in the area of the Chivay source is the subject of the remainder of this chapter.

## II. A Comparison of Local Obsidian Consumption and Workshop Production

In the course of our 2003 fieldwork, test units were excavated at sites in each of the three survey blocks. The workshop pit returned Terminal Archaic and Early Formative dates, those from the puna were Late Formative, while those from the valley were Middle Horizon (Fig. 8.10).

Obsidian made up a large part of the stone artifact assemblages throughout the survey region. In Block 2, the puna of San Bartolomé, obsidian artifacts represented over 80% of collected artifacts, while in the Block 3 Callalli area obsidian was 35% of the artifacts (Table 8.1).

In Blocks 2 and 3, the nearest source of obsidian was over 15 km away. Obsidian appears to have served an important role in local raw material consumption, particularly in the pastoralist zone of Block 2 (San Bartolomé). Obsidian was being reduced throughout the survey region, though in Block 3, as mentioned above, obsidian reduction sites are few. The consumption pattern in Block 3 appears more akin to the distant consumption areas in the Titicaca Basin where obsidian has been found predominantly in the form of retouched tools and, especially, projectile points.

Given the density of obsidian in the local consumption zone, we may ask: Did the Block 2 and Block 3 obsidian come from the Maymeja quarry area, or from the more easily accessible cobbles occurring as surface lag around the east side of the Hornillo vent? This question connects to the issue of attempting to determine who invested the labor in excavating the quarry at Maymeja and reducing obsidian at the nearby workshop. If sufficient chemical variability were present at the Chivay source, then chemical analysis could aid in identifying more precisely the subsource origin of individual obsidian artifacts (Eerkens and Rosenthal 2004). Fourteen geological obsidian samples from throughout the Chivay source area were sent to the Missouri University Research Reactor for analysis and it was confirmed that, unlike the neighboring Alca source, there is little chemical variability at the Chivay obsidian source (M. D. Glascock, pers. comm., 2005; Burger, Asaro, Trawick et al. 1998; Jennings and Glascock 2002). The Chivay obsidian, known for its clarity, is aphyric throughout the source region but the surface lags observed on the east and south-east flanks of Cerro Hornillo had two apparent limitations. First, the nodules were smaller, with nodule sizes not exceeding 15 cm. Second, the material contained inclusions of gas bubbles or ash particles around which crystals would form as the magma was quenched. These inclusions rendered the glass either cloudy or occluded with very small inconsistencies that appeared to impact the visual quality and, in some cases, the fracture mechanics of the glass. Thus we were able to address the issue of subsource

provenience by comparing the morphology and visual characteristics of complete obsidian flakes from the Maymeja workshop with those from Block 2 and those from Block 3.

The length and mean thickness of cortical and non-cortical complete flakes are shown in Figure 8.11. Early stage reduction flakes, taken here to be those with more than 20% cortex, made up 5% of all obsidian flakes in Blocks 2 and 3. The presence alone of such flakes indicates that some obsidian cobbles were being transported from the source region and reduced in Blocks 2 and 3. We note that there is a relatively clear distinction between the upper size limits of these early stage reduction flakes from Maymeja, and those appearing in Block 3, and, more strikingly, in Block 2 (Fig. 8.11, dashed line). Cortical flakes over 40 mm in length were common at the source workshop, but no cortical flakes at Block 2 were this length, and few cortical flakes in Block 3 exceeded 40 mm in length. These data do not support the reduction of large cobbles, such as those available in the Maymeja quarry, in the puna (Block 2) and in the upper valley (Block 3).

We can extend this analysis to all complete obsidian flakes, in case initial reduction (and decortication) of larger cobbles was occurring elsewhere with only later processing present in Blocks 2 and 3. With all complete flakes included, we find that these limits on flake size are reinforced, again most markedly in Block 2. Thus, there are no flakes discarded in Blocks 2 or 3 that approach the flake size potential offered by the quarry source, even after initial decortication. We preclude distance decay as an explanation of this pattern for two reasons. First, the early stages of cobble reduction, as represented by cortical flakes, are present on site. Thus, complete or near-complete cobbles were being reduced locally, but the maximum size of flakes attainable from these cobbles had an upper limit (an absolute upper limit in the case of Block 2) of 40 mm, substantially smaller than those produced in Block 1. Second, in our reconnaissance of Blocks 4 and 5, we found that there was a lack of significant intermediary consumption zones between the source and our puna and valley consumption zones.

The second piece of evidence for the use of these more accessible deposits is the visual characteristics of obsidian artifacts. Looking at the spatial distribution of obsidian with and without inclusions across all obsidian artifacts in our collections (primarily flakes) shows that those with inclusions are present in all parts of the survey. Obsidian artifacts containing inclusions are especially prevalent in Block 3, where they make up approximately one-half of the obsidian artifacts (Table 8.2).

These results have implications for comprehending the relationship between the quarried source and the local consumption of obsidian. If large cobbles of obsidian from the Maymeja quarry were being distributed to the region through down-the-line exchange, we would expect pieces from the quarry in the flaked artifacts from adjacent Colca Valley settlements. The data seem to preclude local consumption of the larger obsidian cobbles available in Maymeja. Such nodules appear to have played a minimal role in the local raw material consumption economy. This suggests to us that the extraction at the quarry was being carried out by non-locals specifically for the purposes of export.

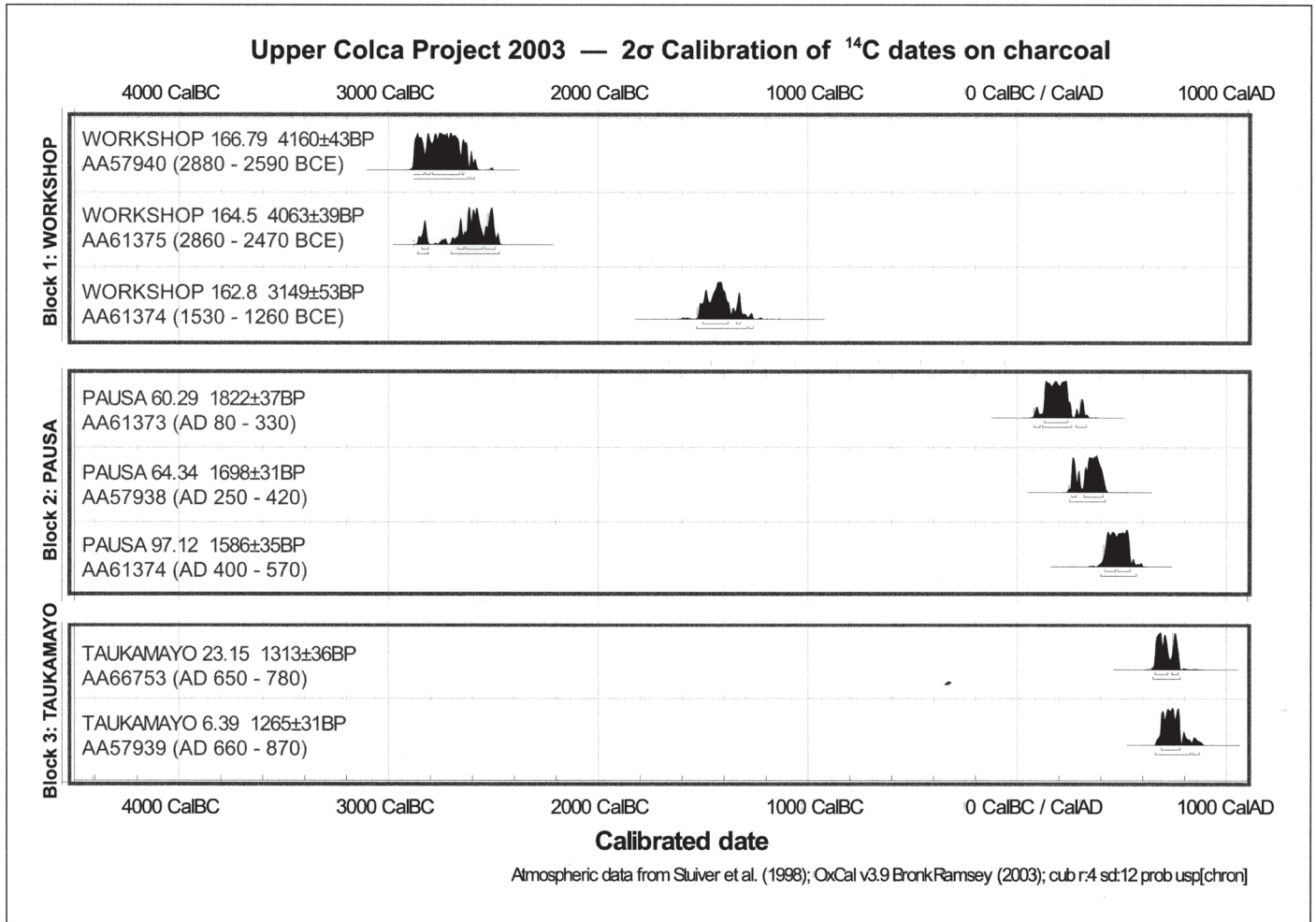


Figure 8.10. Radiocarbon dates from Upper Colca 2003 test excavations.

Table 8.1. Obsidian is prevalent in surface collections from all three survey blocks.

	Block 1		Block 2		Block 3	
	number	percent	number	percent	number	percent
obsidian						
unretouched flakes	4180	93.2	4810	93.8	1928	95.1
retouched	172	3.8	267	5.2	81	4.0
cores	132	2.9	52	1.0	18	0.9
total	4484	100.0	5129	100.0	2027	100.0
non-obsidian						
unretouched flakes	90	84.1	958	86.9	3571	95.2
retouched	13	12.1	91	8.3	74	2.0
cores	4	3.7	54	4.9	105	2.8
total	107	100.0	1103	100.0	3750	100.0
percentage obsidian	97.7		82.3		35.1	

Table 8.2. Obsidian: clear and with inclusions, by survey block.

Block	Obsidian Clear	Obsidian Inclusions	Total
1	1922	99	2021
2	698	116	814
3	213	228	441
4	163	50	213
5	172	63	235
6	17	5	22
total	3185	561	3746

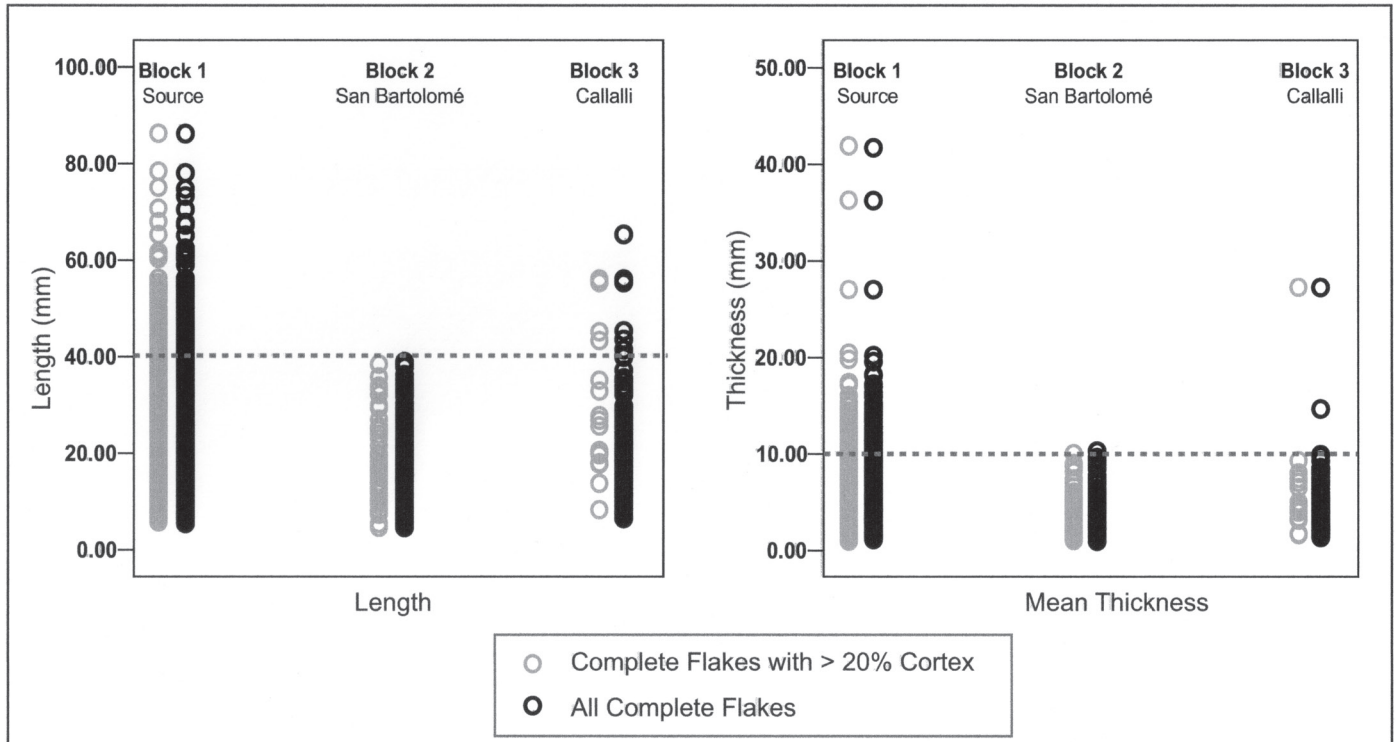


Figure 8.11. Flake metrics for obsidian from the quarry area, and consumption zones (Blocks 2 and 3).

### III. What Were the Contexts of Demand That Guided Production at the Source Workshop through Time?

To explore the contexts of consumption and demand for obsidian, we turn to the excavated data from the Maymeja workshop site (for further details on workshop and quarry stratigraphy see Tripcevich and Mackay 2011 and Tripcevich et al. 2012). At the workshop site (Q02002u3) we excavated a  $1 \times 1$  m test unit to a depth of 70 cm in the center of a low mound of obsidian flaking debris that measured  $3 \text{ m} \times 4 \text{ m}$ . This test unit was clearly in a production context as it contained 339 cores (all with no positive percussive features) and overall we excavated over 750 kg of cultural material from this unit.

The analysis of a sample of flakes and cores from each level of this test unit revealed three important patterns.

1. *Mode of production.* Broken bifaces and bifacial thinning flakes are a relatively consistent feature of all levels. Combined, they account for about 5% of artifacts examined in each level. This indicates both that non-local consumers were commonly being provisioned with artifacts in biface form, and that this system was relatively consistent through time.

2. *Number of cores per level.* The basal level of the pit, dating to the middle of the Terminal Archaic (Fig. 8.10, Lot 166.79), contains relatively few artifacts in general and few cores specifically, as does the level that supersedes it, level 6 (Fig. 8.12). From level 5 the number of cores increases considerably, reaching a peak in level 4 and subsequently tailing off, albeit in a stochastic fashion. The peak in level 4 is important because it dates to circa 1400 BCE—and is thus contemporaneous with a known peak in Chivay obsidian frequency in at least one non-local consumption site: the rock shelter of Qillqatani (Aldenderfer 2005:22). This gives us reason to believe that this particular workshop site is in fact one source of the Chivay obsidian manufactured for use in distant locations. A second conclusion we can draw from this is that subsequent fluctuations in core prevalence per level may be indicative of changing demand for obsidian in other non-local consumption areas.

3. *Reduction sequence at the workshop test unit.* A notable pattern occurs in level 4 of the workshop test unit (Fig. 8.13) where a peak in core prevalence correlates with an increase in size of early stage reduction flakes. The error-bar figures present size data on flakes with more than 20% cortex from the last 5 levels



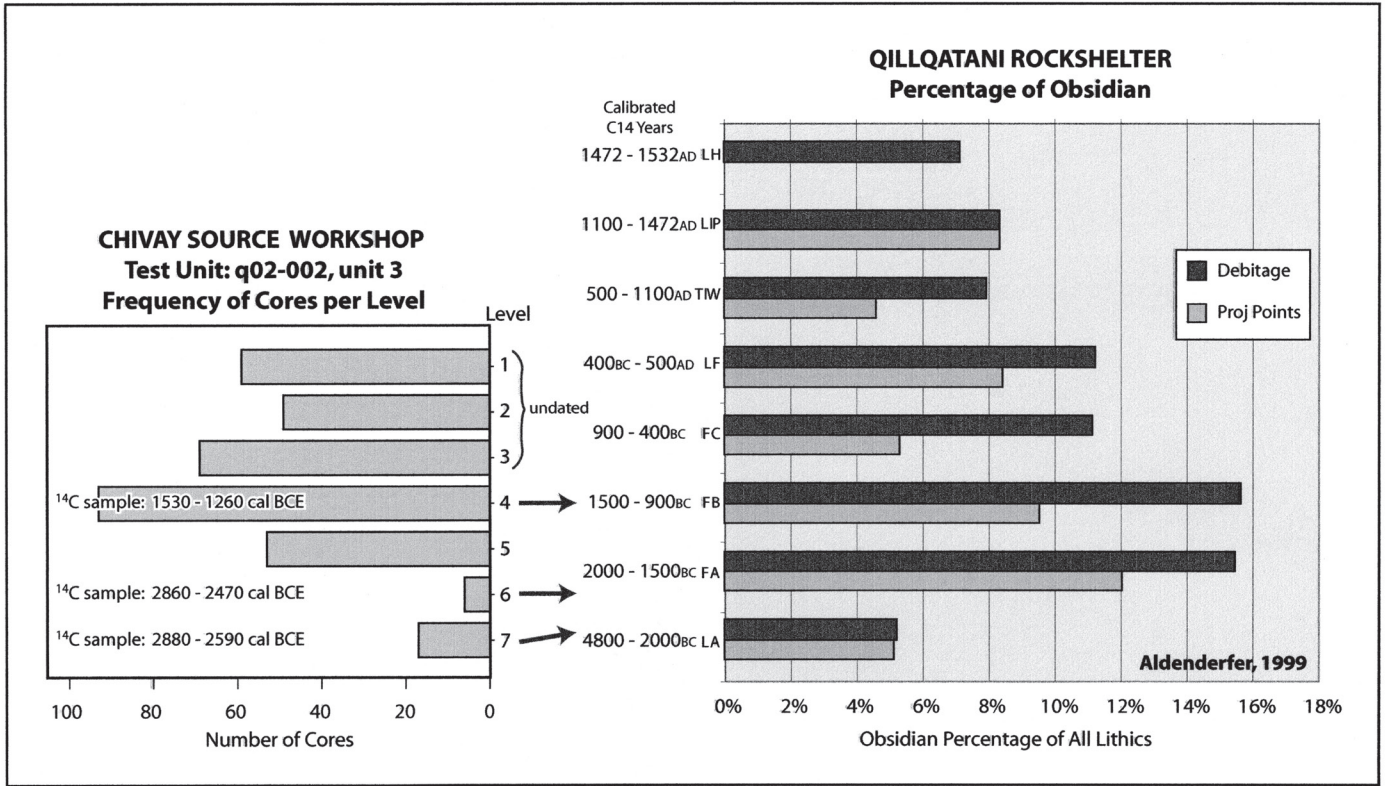


Figure 8.12. Cores from the Chivay source workshop and obsidian artifacts from Qillqatani (Aldenderfer 2005:22; Frye et al. 1998).

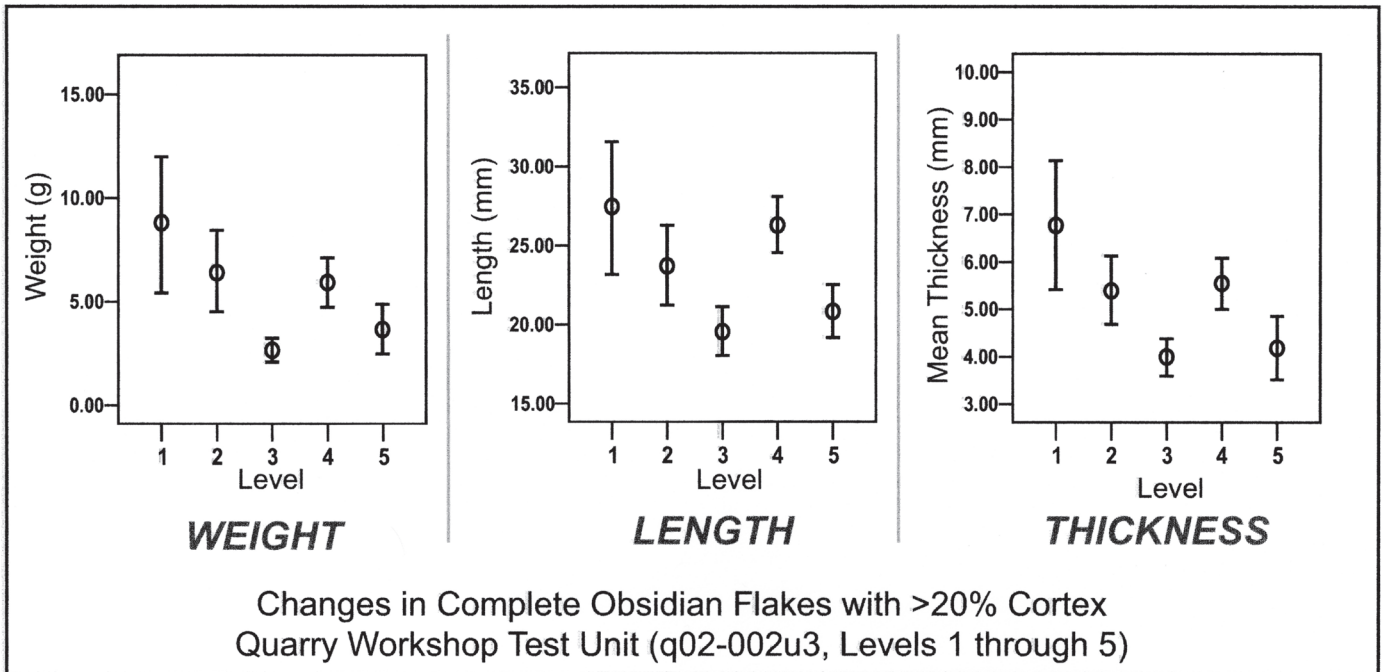


Figure 8.13. The changing morphology of complete obsidian flakes from the workshop test unit.

of the pit. Again, we take such flakes to be a reasonable indicator of initial cobble size. We see clear peaks in the size of early stage reduction flakes in levels 4, 2 and 1. In all instances, early stage reduction flakes from these three levels are significantly larger, statistically speaking, than those in levels 5 and 3. These data indicate that at certain times either demand or quarrying techniques led to the acquisition and reduction of larger cobbles. These interpretations are preliminary as few comparable datasets are available in the consumption zone against which to test our model of local versus regional consumption.

### Discussion and Conclusion

The regional demand for obsidian from Chivay throughout the prehispanic period resulted in distinctive archaeological patterns in both the Chivay source area and the larger consumption zone. Viewed diachronically, geographical changes in Chivay obsidian distributions provide some insight into the development of economic and social linkages across distance in the region. Obsidian use in the area adjacent to the source shows that, through most of preceramic time, obsidian, along with chert and fine-grained volcanic stone, was used for projectile point production and in the form of simple flakes.

#### *Obsidian Procurement*

During the Early and Middle Archaic, during times of high residential mobility and in a context of relative social equality, obsidian procurement and exchange probably took place through direct access by mobile foragers or through down-the-line exchange. Beginning in the Terminal Archaic several changes occur in concert that influenced the production and regional consumption of obsidian at the Chivay source. First, the costs associated with regional exchange were lowered in a formal sense with the availability of cargo animals. The increased circulation of obsidian during the Terminal Archaic and through the Formative period serves as a measurable proxy of an overall reduction in the cost of moving products, from exotic or ceremonial goods, to perishable consumables like coca or *ají* pepper that were perhaps more widely available and more relevant to the non-elite segment of the altiplano population (Browman 1981). Using obsidian as a surrogate for inferring larger exchange patterns in perishable goods introduces its own problems, particularly given that (1) demand for the specific lithic properties of obsidian changed in prehistory, and (2) there were only a few geographical origin places of obsidian relative to the dispersed sources of perishable agricultural goods (Clark 2003:23). A pattern observed by ethnographers in the Andes is for altiplano residents to descend to adjacent agricultural regions in neighboring lowland valleys on the east or west sides to acquire products not available in the highlands (Custred 1974; Lecoq 1987; Nielsen 2001; West 1983), much as the pastoralists of Paratía acquire goods predominantly from the Colca (Flores Ochoa 1968:129–37). In the case of the

north Titicaca Basin, a symmetrical relationship existed between herders and sierra agriculturalists in Arequipa. Herders would provide animal products, salt, and other goods circulating on the altiplano and they would acquire corn, peppers and other mid-altitude products in exchange. With obsidian available on a short detour from the Escalera caravan route climbing out of the Colca (Fig. 8.3), a caravan leaving the area with less than the anticipated load of sierra products (due to low crop yields or some other contingency) could recover some of the loss from the journey by transporting obsidian to the pastoral communities where it is widely used. Such an embedded mechanism, as a secondary and reliable Colca product in demand regionally, could account for a substantial proportion of obsidian circulation since caravan transport became established.

#### *Variability at the Chivay Source*

In the course of our research in the environs of the Chivay obsidian source, we established that procurement and production of most obsidian for local use was sufficiently distinct to distinguish it from regional production activities at the obsidian source. Local needs for obsidian appear to have been satisfied with relatively small, easily available nodules. Therefore, material entering down-the-line trade networks from local communities were relatively small pieces of obsidian unless the social distance of exchange systems were sufficiently intimate to reciprocate regional demands for specific characteristics, such as larger, more homogeneous, or visually transparent nodules (Ericson 1984:6; Sahlins 1972:191).

On a practical level, flakes produced from small obsidian nodules easily available on the surface throughout the Chivay source region are probably adequate to meet the majority of requisite tasks (such as shearing and butchering). Relatively small projectile points can also be produced from such nodules. In contrast, a directed effort to obtain large, homogenous nodules was undertaken at the Maymeja quarry area, and the artifactual evidence of this production is not apparent in the local economy. If this quarrying activity were stimulated by down-the-line exchange, we would expect some portion of Blocks 2 and 3 obsidian flakes to exhibit traits of having come from the Maymeja quarry area. Instead, we see evidence that intensified production at the workshop associated with the Maymeja quarry commenced just as evidence for expanded consumption appears in faraway parts of the south-central Andean highlands.

Simultaneously, evidence for the Late and Terminal Archaic beginnings of political dynamism in the Titicaca Basin appears in the form of ritual structures, differential status in burials, precious metals, and other “transegalitarian” traits of incipient social ranking. The benefits of such material to individuals in the Titicaca Basin could be modeled in terms of improved relative social position, or increased reproductive success. The importance of regional interaction in the preceramic can be difficult for archaeologists to appraise because stylistic indicators of interaction are relatively few. We believe that camelid herds

were expanding, caravan transport was probably flourishing, and the maintenance of regional social relationships was as relevant as ever to people in the Titicaca Basin. Prior to the sedentism and seed-plant agriculture that characterized early village life at the beginnings of the Formative period, access to semi-exotic obsidian may have visible and symbolic value because it was associated with exchange relationships and alliances between the Titicaca Basin and the western slope of the Andes. Demonstrating and maintaining these regional social relationships through possession of Chivay obsidian may have presented opportunities to aggrandizers in the Titicaca Basin. Our conclusions regarding the influence of obsidian exchange remains tempered with the recognition that in addition to being a remarkable, natural glass, obsidian has basic utility to pastoralists that would guarantee some degree of regional distribution regardless of its social or political significance.

### Notes

1. Brooks et al. (1997) refer to this obsidian source as “Cotallaulli,” while Burger, Asaro, Salas et al. (1998) refer to it as “Chivay.”
2. We use the term “low-quality” lithic material to refer to what we perceive as poor or unpredictable knapping characteristics caused by the presence of ash or gas inclusions, phenocrysts, microfissures or joints in the stone.

### References Cited

- Aldenderfer, Mark S.  
1989 The Archaic period in the south-central Andes. *Journal of World Prehistory* 3(2):117–58.  
1998 *Montane Foragers: Asana and the South-Central Andean Archaic*. University of Iowa Press, Iowa City.  
1999 The Pleistocene/Holocene transition in Peru and its effects upon human use of the landscape. *Quaternary International* 53(4):11–19.  
2005 Preludes to power in the highland Late Preceramic period. In *Foundations of Power in the Prehispanic Andes*, edited by Kevin J. Vaughn, Dennis Ogburn, and Christina A. Conlee, pp. 13–35. American Anthropological Association, Arlington, VA.  
in press *Winaypach aka markan Jaqipxtwa: Qillqatani and the Evolution of Andean Pastoralism*. University of Arizona Press, Tucson, Arizona.
- Aldenderfer, Mark, Nathan M. Craig, R. Jeffrey Speakman, and Rachel Popelka-Filcoff  
2008 Four-thousand-year-old gold artifacts from the Lake Titicaca Basin, southern Peru. *Proceedings of the National Academy of Sciences* 105(13):5002–5.
- Appadurai, Arjun  
1986 Commodities and the politics of value. In *The Social Life of Things: Commodities in Cultural Perspective*, edited by Arjun Appadurai, pp. 3–63. Cambridge University Press, Cambridge.
- Arkush, Elizabeth  
2005 *Colla Fortified Sites: Warfare and Regional Power*. PhD dissertation, University of California, Los Angeles.
- Bandy, Matthew S.  
2001 Population and History in the Ancient Titicaca Basin. PhD dissertation, University of California, Berkeley.  
2005 Trade and social power in the Titicaca Basin Formative. In *Foundations of Power in the Prehispanic Andes*, edited by Kevin J. Vaughn, Dennis Ogburn, and Christina A. Conlee, pp. 91–111. American Anthropological Association, Arlington, Virginia.
- Banning, E. B.  
2002 *Archaeological Survey*. Manuals in Archaeological Method and Theory. Plenum, New York.
- Beck, Colleen  
1991 Cross-cutting relationships: The relative dating of ancient roads on the north coast of Peru. In *Ancient Road Networks and Settlement Hierarchies in the New World*, edited by Charles D. Trombold, pp. 66–79. Cambridge University Press, Cambridge, England.
- Binford, Lewis R.  
1979 Organization and formation processes: Looking at curated technologies. *Journal of Anthropological Research* 35(3):255–73.
- Birdsell, J. B.  
1970 Local group composition among the Australian aborigines: A critique of the evidence from fieldwork conducted since 1930. *Current Anthropology* 11(2):115–42.
- Bittmann, B., and J. R. Munizaga  
1979 El arco en América: Evidencia temprana y directa. *Indiana* 5:229–51.
- Bronk Ramsey, Christopher  
2003 Oxcal radiocarbon calibration program, version 3.9. <http://www.rlaha.ox.ac.uk/O/oxcal.php>.
- Brooks, Sarah O.  
1998 Prehistoric Agricultural Terraces in the Rio Japo Basin, Colca Valley, Peru. PhD dissertation, University of Wisconsin, Madison.
- Brooks, Sarah O., Michael D. Glascock, and Martín Giesso  
1997 Source of volcanic glass for ancient Andean tools. *Nature* 376:449–50.
- Browman, David L.  
1981 New light on Andean Tiwanaku. *American Scientist* 69(4):408–19.  
1990 Camelid pastoralism in the Andes: Llama caravan fleteros, and their importance in production and distribution. In *Nomads in a Changing World*, edited by Philip Carl Salzman and John G. Galaty, pp. 395–438. Istituto Universitario Orientale, Naples.

- Brown, James A.  
1985 Long term trends to sedentism and the emergence of cultural complexity in the American Midwest. In *Prehistoric Hunter-Gatherers: The Emergence of Cultural Complexity*, edited by T. Douglas Price and James Allison Brown, pp. 201–34. Academic Press, Orlando.
- Burger, Richard L., and Frank Asaro  
1977 *Trace Element Analysis of Obsidian Artifacts from the Andes: New Perspectives on Pre-Hispanic Economic Interaction in Peru and Bolivia LBL6343*. Lawrence Berkeley Laboratory, University of California.
- Burger, Richard L., Frank Asaro, Guido Salas, and Fred Stross  
1998 The Chivay obsidian source and the geological origin of Titi-caca Basin type obsidian artifacts. *Andean Past* 5:203–23.
- Burger, Richard L., Frank Asaro, Paul Trawick, and Fred Stross  
1998 The Alca obsidian source: The origin of raw material for Cuzco type obsidian artifacts. *Andean Past* 5:185–202.
- Burger, Richard L., and Michael D. Glascock  
2000 Locating the Quispisisa obsidian source in the Department of Ayacucho, Peru. *Latin American Antiquity* 11(3):258–68.
- Burger, Richard L., Karen L. Mohr Chávez, and Sergio J. Chávez  
2000 Through the glass darkly: Prehispanic obsidian procurement and exchange in southern Peru and northern Bolivia. *Journal of World Prehistory* 14(3):267–362.
- Casaverde R., J.  
1977 El trueque en la economía pastoril. In *Pastores de puna: Uywamichiq punarunakuna*, 1st ed., edited by Jorge A. Flores Ochoa, pp. 168–91. Estudios de la sociedad rural, vol. 5. Instituto de Estudios Peruanos, Lima.
- Clark, John E.  
2003 A review of twentieth-century Mesoamerican obsidian studies. In *Mesoamerican Lithic Technology: Experimentation and Interpretation*, edited by Kenneth G. Hirth, pp. 15–54. University of Utah Press, Salt Lake City.
- Clark, John E., and Michael Blake  
1994 Power of prestige: Competitive generosity and the emergence of risk in lowland Mesoamerica. In *Factional Competition and Political Development in the New World*, edited by Elizabeth M. Brumfiel and John W. Fox, pp. 17–30. Cambridge University Press, Cambridge, England.
- Craig, Nathan M.  
2005 The Formation of Early Settled Villages and the Emergence of Leadership: A Test of Three Theoretical Models in the Rio Ilave, Lake Titicaca Basin, Southern Peru. PhD dissertation, University of California, Santa Barbara.
- Custred, H. Glynn  
1974 Llameros y comercio interregional. In *Reciprocidad e intercambio en los Andes Peruanos*, vol. 10, edited by G. Alberti and E. Mayer. Instituto de Estudio Peruanos, Lima.
- De la Vera Cruz, Pablo A.  
1987 Cambios en los patrones de asentamiento y el uso y abandono de los andenes en Cabanaconde, Valle del Colca, Perú. In *Pre-Hispanic Agricultural Fields in the Andean Region*, edited by William M. Denevan, Kent Mathewson, and Gregory W. Knapp, pp. 89–128. British Archaeological Reports, International Series, Oxford, U.K.
- 1988 Estudio Arqueológico en el Valle de Cabanaconde, Arequipa. Bachelor thesis, Universidad Católica Santa María.
- Doutriaux, Miriam  
2004 Imperial Conquest in a Multiethnic Setting: The Inka Occupation of the Colca Valley, Peru. PhD dissertation, University of California, Berkeley.
- Eerkens, Jelmer W., and J. S. Rosenthal  
2004 Are obsidian subsources meaningful units of analysis? Temporal and spatial patterning of subsources in the Coso volcanic field, southeastern California. *Journal of Archaeological Science* 31(1):21–29.
- Ericson, Jon E.  
1984 Towards the analysis of lithic production systems. In *Prehistoric Quarries and Lithic Production*, edited by Jonathon E. Ericson and Barbara A. Purdy, pp. 1–10. Cambridge University Press, Cambridge, England.
- Flores Ochoa, Jorge A.  
1968 *Los pastores de Paratía: Una introducción a su estudio*, 1st ed. Instituto Indigenista Interamericano, México.
- Frye, Kirk L., Mark Aldenderfer, and Michael D. Glascock  
1998 The Aconahua Obsidian Source and Its Relation to South-Central Andean Exchange Systems. Paper presented at the Institute of Andean Studies conference, Berkeley, CA.
- Giesso, Martín  
2003 Stone tool production in the Tiwanaku heartland. In *Tiwanaku and Its Hinterland: Archaeology and Paleoecology of an Andean Civilization, Vol. 2*, edited by Alan L. Kolata, pp. 363–83. 2 vols. Smithsonian Institution Press, Washington, D.C.
- Gilmore, R. M.  
1950 Fauna and ethnozoology of South America. In *Handbook of South American Indians*, edited by Julian H. Steward, pp. 345–464, vol. 6. Smithsonian Institution, Bureau of Ethnology, Washington, D.C.
- Goldstein, Paul S.  
1989 Tiwanaku occupation of Moquegua. In *Ecology, Settlement, and History in the Osmore Drainage, Peru*, edited by Don Stephen Rice, Charles Stanish, and Phillip R. Scarr, pp. 219–56. British Archaeological Reports, International Series, vol. 545(i), Oxford, U.K.
- 2000 Exotic goods and everyday chiefs: Long-distance exchange and indigenous sociopolitical development in the south central Andes. *Latin American Antiquity* 11(4):335–61.
- Gould, Richard A., and S. Saggars  
1985 Lithic procurement in central Australia: A closer look at Binford's idea of embeddedness in archaeology. *American Antiquity* 50(1):117–36.

- Guillet, David W.  
1992 *Covering Ground: Communal Water Management and the State in the Peruvian Highlands. (Linking Levels of Analysis)*. University of Michigan Press, Ann Arbor.
- Helms, Mary W.  
1992 Long-distance contacts, elite aspirations, and the Age of Discovery in cosmological context. In *Resources, Power, and Interregional Interaction*, edited by Edward M. Schortman and Patricia A. Urban, pp. 157–74. Plenum Press, New York.
- Jennings, Justin, and Michael D. Glascock  
2002 Description and method of exploitation of the Alca obsidian source, Peru. *Latin American Antiquity* 13(1):107–18.
- Julien, Catherine J.  
1983 *Hatunqolla: A View of Inca Rule from the Lake Titicaca Region*. University of California Publications in Anthropology, vol. 15. University of California Press, Berkeley.
- Klink, Cindy, and Mark S. Aldenderfer  
2005 A projectile point chronology for the south-central Andean highlands. In *Advances in Titicaca Basin Archaeology—1*, edited by C. Stanish, A. Cohen, and M. Aldenderfer, pp. 25–54. Cotsen Institute of Archaeology, Los Angeles, California.
- La Lone, D. E.  
1982 The Inca as a nonmarket economy: Supply on command versus supply and demand. In *Contexts for Prehistoric Exchange*, edited by Jonathon E. Ericson and Timothy K. Earle, pp. 292–316. Academic Press, New York.
- Lecoq, Patrice  
1987 Caravanes de lamas, sel et échanges dans une communauté de Potosi, en Bolivie. *Bulletin de l'Institut Français d'Etudes Andines* 16(3/4):1–38.
- Lumbreras, L. G.  
1974 *The Peoples and Cultures of Ancient Peru*, translated by Betty J. Meggers. Smithsonian Institution Press, Washington, D.C.
- Mackay, Alex  
2005 Informal movements: Changing mobility patterns at Ngarrabullgan, Cape York, Australia. In *Lithics 'Down Under': Australian Perspectives on Lithic Reduction, Use and Classification*, edited by Christopher Clarkson and Laura Lamb. British Archaeological Reports, vol. 1408. Archaeopress, Oxford.
- Malpass, Michael  
1987 Prehistoric agricultural terracing at Chijra in the Colca Valley, Peru: Preliminary report II. In *Pre-Hispanic Agricultural Fields in the Andean Region*, edited by William M. Denevan, Kent Mathewson, and Gregory W. Knapp, pp. 45–66. British Archaeological Reports, International Series, vol. 359(i), Oxford, U.K.
- Markowitz, Lisa B.  
1992 Pastoral Production and Its Discontents: Alpaca and Sheep Herding in Caylloma, Peru. PhD dissertation, University of Massachusetts.
- Nielsen, Axel E.  
2001 Ethnoarchaeological perspectives on caravan trade in the south-central Andes. In *Ethnoarchaeology of Andean South America: Contributions to Archaeological Method and Theory*, edited by L. A. Kuznar, pp. 163–201. Ethnoarchaeological series, vol. 4. International Monographs in Prehistory, Ann Arbor, Michigan.
- Núñez, Lautaro, and Tom D. Dillehay  
1995 [1979] *Movilidad giratoria, armonía social y desarrollo en los Andes meridionales: Patronos de tráfico e interacción económica*. Universidad de Chile, Antofagasta.
- Sahlins, Marshall  
1972 *Stone Age Economics*. Aldine Publishers, New York.
- Sandweiss, D. H., H. McInnis, R. L. Burger, A. Cano, B. Ojeda, R. Paredes, M. del Carmen Sandweiss, and M. D. Glascock  
1998 Quebrada Jaguay: Early South American maritime adaptation. *Science* 281:1830–32.
- Shackley, M. Steven  
2005 Source provenance of obsidian artifacts—Jiskairumoko (189), Peru. University of California Berkeley Archaeological XRF Laboratory. In *The Formation of Early Settled Villages and the Emergence of Leadership: A Test of Three Theoretical Models in the Rio Ilave, Lake Titicaca Basin, Southern Peru*, by Nathan M. Craig, pp. 908–16. PhD dissertation, University of California, Santa Barbara.
- Shea, D.  
1987 Preliminary discussion of prehistoric settlement and terracing at Achoma in the Colca Valley, Peru. In *Pre-Hispanic Agricultural Fields in the Andean Region*, edited by William M. Denevan, Kent Mathewson, and Gregory W. Knapp, pp. 67–88. British Archaeological Reports, International Series, vol. 359(i), Oxford, U.K.
- Smith, Monica L.  
1999 The role of ordinary goods in premodern exchange. *Journal of Archaeological Method and Theory* 6(2):109–35.
- Spielmann, Katherine A.  
1986 Interdependence among egalitarian societies. *Journal of Anthropological Archaeology* 5:279–312.
- Stanish, Charles  
2003 *Ancient Titicaca: The Evolution of Complex Society in Southern Peru and Northern Bolivia*. University of California Press, Berkeley.
- Stanish, Charles, Richard L. Burger, Lisa M. Cipolla, Michael D. Glascock, and E. Quelimá  
2002 Evidence for early long-distance obsidian exchange and watercraft use from the southern Lake Titicaca Basin of Bolivia and Peru. *Latin American Antiquity* 13(4):444–54.
- Steward, Julian  
1938 *Basin-Plateau Aboriginal Sociopolitical Groups*. U.S. Government Printing Office, Washington, D.C.

- Stuiver, M., P. J. Reimer, and T. F. Braziunas  
 1998 High-precision radiocarbon calibration for terrestrial and marine samples. *Radiocarbon* 40(3):1127–51.
- Torrence, Robin  
 1984 Monopoly or direct access? Industrial organization at the Melos obsidian quarries. In *Prehistoric Quarries and Lithic Production*, edited by Jonathon E. Ericson and Barbara A. Purdy, pp. 49–64. New Directions in Archaeology. Cambridge University Press, Cambridge.  
 1986 *Production and Exchange of Stone Tools Prehistoric Obsidian in the Aegean*. Cambridge University Press, Cambridge.
- Tripcevich, Nicholas  
 2004 Interfaces: Mobile GIS in archaeological survey. *The SAA Archaeological Record* 4(3):17–22.  
 2007 Quarries, Caravans, and Routes to Complexity: Prehispanic Obsidian in the South-Central Andes. PhD dissertation, University of California, Santa Barbara.  
 2010 Exotic goods, Chivay obsidian, and sociopolitical change in the south-central Andes. In *Trade and Exchange: Archaeological Studies from History and Prehistory*, edited by Carolyn Dillian and Carolyn White, pp. 59–73. Springer, New York.
- Tripcevich, Nicholas, and Daniel A. Contreras  
 2011 Quarrying evidence at the Quispisisa obsidian source, Aya-cucho, Peru. *Latin American Antiquity* 22(1):121–36.
- Tripcevich, Nicholas, J. W. Eerkens, and Tim R. Carpenter  
 2012 Obsidian hydration at high elevation: Archaic quarrying at the Chivay source, southern Peru. *Journal of Archaeological Science* 39(5):1360–7.
- Tripcevich, Nicholas, and Alex Mackay  
 2011 Procurement at the Chivay obsidian source, Arequipa, Peru. *World Archaeology* 43(2):271–97.
- Wernke, Steven  
 2003 An Archaeo-History of Andean Community and Landscape: The Late Prehispanic and Early Colonial Colca Valley, Peru. PhD dissertation, University of Wisconsin.
- West, Terry L.  
 1983 Suffering we go: A llama caravan in Bolivia. *Llama World* Spring:10–15.
- Wiessner, Polly  
 1982 Risk, reciprocity and social influences on !Kung San economics. In *Politics and History in Band Societies*, edited by E. Leacock and R. B. Lee, pp. 61–84. Cambridge University Press, Cambridge.