Chapter 2
Archaeological Approaches to Obsidian Quarries: Investigations at the Quispisisa Source

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Introduction

At a global scale, and spanning human history from the Paleolithic through recent times, the material remnants of mining and quarrying have sustained the interest of a segment of the archaeological community. This volume provides us with an opportunity to reflect on how and why archaeologists have studied the vestiges of mining and quarrying, and to consider a specific Andean context: the extraction of Quispisisa-type obsidian from the Jichja Parco obsidian quarries over a period of 10,000 years of Central Andean prehistory. Preliminary research at the source (Contreras et al. in press; Tripcevich and Contreras 2011) has documented large-scale extraction of obsidian, while regional consumption patterns (Burger and Glascock 2002) demonstrate that the material was used and widely distributed not long after humans arrived in the Central Andes. We use the example of ongoing research at the Quispisisa source to examine what study of mining and quarrying in the Prehispanic Andes can contribute to perspectives on the Andean past. More generally, we reflect on the actual questions that archaeologists hope to address by examining mines and quarries, and consider how we can approach mining and quarrying evidence in such a way as to be able to answer such questions.

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Archaeology of Lithic Procurement

Source areas present particular difficulties to archaeologists but may also provide opportunities for research. As single locations that are linked to sites dispersed throughout a larger region, source areas enable holistic archaeological approaches to regional lithic economies and technical reduction processes. Moreover, in the case of obsidian, the links provided by geochemical source assignment offer definitive connections that are relatively rare in archaeology. At the same time, the challenges of working at sources are many. Theoretically and methodologically, research at quarries is complicated by a material record that is predominantly "shattered, overlapping, sometimes shallow, nondiagnostic, undatable, unattractive, redundant, and at times voluminous" (Ericson 1984: 2). Difficulties in temporal control, as well as the effort involved in differentiating an abundance of naturally fractured raw material from cultural products, present obstacles to the study of quarry use over time.

The priorities of quarry studies, viewed globally, have long included (1) linking production at quarry sites and the transport of material to evidence from lithic consumption at sites in the region, (2) inferring the rates of production, and (3) considering the regional contexts of lithic access and distribution through time. Evidence for technology and manufacturing changes is abundant at quarries and workshops, as these locations are typically rich in primary reduction material. However, a deficiency in later stage lithics (often the exported product) limits the usefulness of typological approaches and methods that focus on the characteristics of finished tools. Opportunities for research in source areas are particularly strong for approaches that take a technical and sequence-based approach to understanding the use of stone material, but as sequences or operational chains explicitly link early and larger stages of production, using a sequence-based approach at a source area forces the analyst to carefully study regional assemblages as well as source area materials. Clearly it is easier to build such links with geochemically or petrographically sourceable stone (among these the "chain" can be better demonstrated), and regional consumption patterns are of course best assessed in regions with published bodies of lithics research.

Studies at lithic sources often seek to address questions concerning the material type, appearance, and morphology of source material, and the degree of reduction performed at the source area. This characterization and quantification enables the investigation of social considerations of broader interest to archaeologists:

- Who procured the raw material and produced the evidence of quarrying that archaeologists may document?
- Were the knappers the same individuals who procured material?
- Were either of these groups specialized or supported? What sort of infrastructure facilitated the quarrying for material (and does architectural or depositional evidence remain)?
- What kind of sociopolitical organization underpinned raw material procurement? Was access to the resource limited to particular communities due to ethnic or political restrictions?

- Who consumed the material (i.e., were miners procuring for their own use, for trade or exchange, or at the behest of others)? Was material consumed locally or widely distributed?
- Were source area visits embedded in other activities or were these special purpose journeys? Were particular social or ceremonial practices associated with access to the source area or procurement, and use of the material?
- Is the source area and, by association, distinctive material from that source, prominent in the ritual or cosmological landscape in the region? This may be evident from activities at the source or in special treatment of the material.

We explore means of addressing such questions in this chapter focusing on obsidian procurement at the Quispisisa source.

Building from a Production System Approach

Procurement at lithic sources represents the first step in a progression conceptualized by frameworks such as the lithic reduction sequence and *chaîne opératoire* (Edmonds 1990; Schiffer 1975; Sellet 1993; Shott 2003; Torrence 1986). These sequences aid researchers in positioning geological source areas within the larger context of lithic tool use life, maintenance, and discard. The prevalence of early-stage reduction material in source areas, however, means that a complete operational chain will probably depend upon incorporating evidence from lithic materials recovered in other contexts elsewhere in the region.

In recent decades, archaeologists have sought to place procurement and lithic production into its regional context by identifying principal indicators of changes in procurement through time. Ericson's (1984: 4) approach to the study of "lithic production systems" is shown in Table 2.1.

These indices depend, upon general artifact-type categories and provide a basis for comparing empirical data from reduction activities between workshops, local sites, and the more distant consumption zone. A discussion of these measures is beyond the scope of this chapter, but Ericson's approach collapses variability, both in time and space, in the interest of comparability between archaeological datasets. This was intended to reflect a production and distribution system with "feedback mechanisms" in the form of regional demand (Ericson 1984: 2). Because it principally relies on metrics that are commonly gathered in laboratory analysis, Ericson's approach provides a means of generating a composite view of particular production zones where consistent data are available (Fig. 2.1).

Ericson presents the spatial distribution of lithic production in terms of stages of production and zones of geographic proximity to the source area. In principle, this regional approach provides a clear set of expectations about reduction patterns against which to examine actual archaeological data. In practice, however, the intermingling of artifacts from different episodes of quarrying and variable quarrying strategies often undermines the value of such generalizations. Furthermore, developing indices at a regional scale depends upon consistently implemented and

Table 2.1 Measurement indices for lithic production analysis (after Ericson 1984: 5)

Name	Variable (numerator)	Normalizer (denominator)	Unit(s)	Relevance
Exchange index	Single source	Total lithic material	Count, weight, %	Regional exchange
Debitage index	Debitage	Total tools and debitage	Count, weight, size, %	General production index[a]
Cortex index	Primary and secondary reduction flakes	Total debitage	Count, %	Indicative of the import of raw materials on site[a]
Core index	Spent cores	Total cores and tools	Count, %	Use if cores were transported or a medium of exchange
Biface index	Bifacial thinning flakes	Total debitage	Count, %	Biface production

[a]Excluding retouch/sharpening flakes

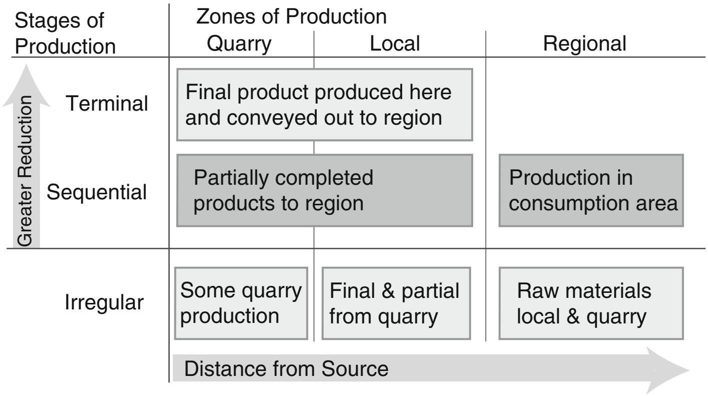

Fig. 2.1 Production system diagram based on table by Ericson (1984: 5)

comparable methods in lithics research, thus broadly applying such an approach to published data in the Central Andes is still difficult. Moreover, Ericson's approach provides a composite view of particular production zones by documenting the predominant production strategy at a given source area, but at the cost of characterizing variability within a production context.

It may take many years of work to decipher the complex record of activities at a large quarry zone over past millennia. For example, the Tosawihi opalite quarries in the US Great Basin (Elston and Raven 1992) have been examined in detail over some years using an energetics and ecology approach. In recent decades, a greater number of archaeologists are considering the ritual significance and meaning of quarrying in the past, often using empirical evidence that includes ceremonial structures at quarries and links to stone objects from that source found in ritual contexts (Bradley 2000: 81–96; Bradley and Edmonds 1993; Cooney 1998; Edmonds 1995; O'Connor et al. 2009; Skeates 1995; Topping 2010). In the Andes, the evidence for the symbolic and ceremonial importance of quarries is strongest at architectural stone sources used during later periods of the Prehispanic period (Chaps. 3 and 4). The systems-based approaches to production provide comparative information about broader patterns of regional interaction and prompt investigators to make explicit many of their assumptions. However, a focus on broad systems may lead to reduced attention to detail and less documentation of variability, as well as eliding any changes in contexts of consumption.

Obsidian Quarrying in the Central Andes

The breadth of chapters in this volume suggests that the evidence of mining and quarrying behavior in the Central Andes reveals a range of ways to manage (and perhaps even conceptualize) resources. Compare, for example, the patterns of access

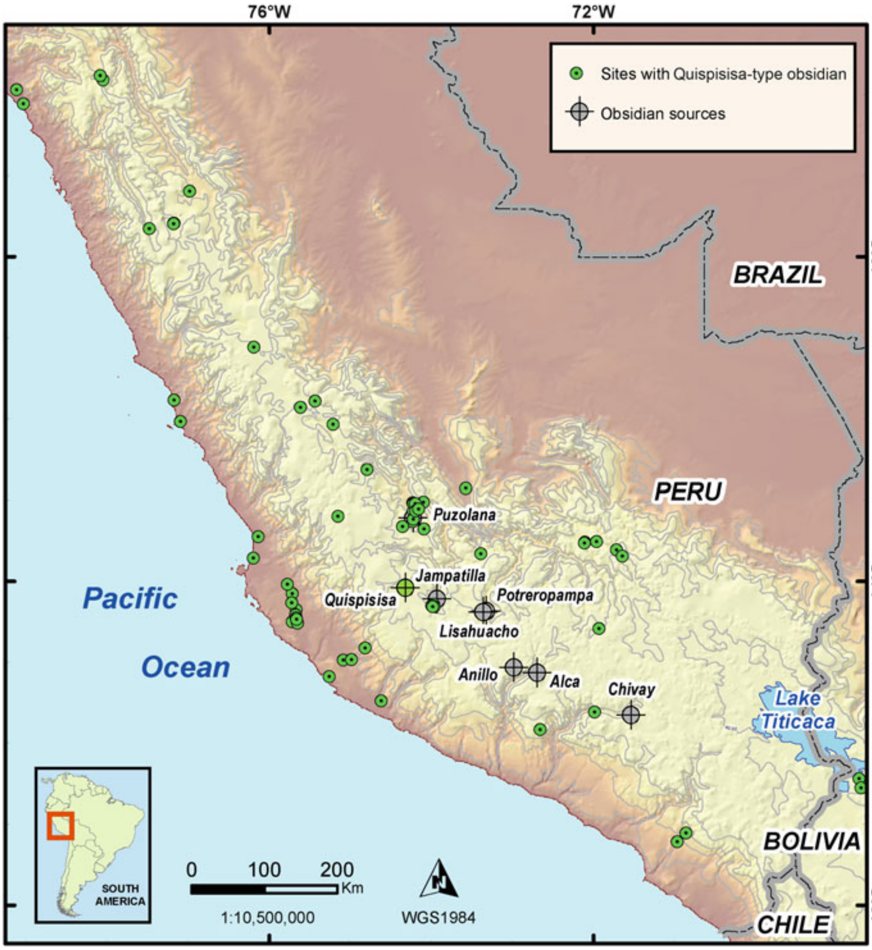

Fig. 2.2 Map of central Andes showing major obsidian sources (labeled) and the location of archaeological sites containing artifacts made from Quispisisa-type obsidian

described by Jennings et al. at Cotahuasi and Inca period mining by Salazar et al. at Atacama. What can obsidian contribute to this discussion? That is, what do we know about the way(s) in which obsidian was procured, distributed, and circulated in the Prehispanic past of the Central Andes?

We examine these issues of lithic procurement and production using the case study of the source of Quispisisa-type obsidian in southern Ayacucho, Peru (Fig. 2.2). As a reflective natural glass with conchoidal fracture producing extremely sharp edges, obsidian has been employed by humans since the earliest tool-making periods in world prehistory. Obsidian is of great utility to present day archaeologists as well due to its high visibility, distinctive material characteristics, and analytical potential (Shackley 2005). Even prior to the advent of geochemical analysis methods, obsidian procurement was emphasized by archaeologists studying ancient mining (Holmes 1900, 1919: 214–227). Over the past 50 years, research interest in obsidian has increased around the world, largely as a consequence of the discovery that chemical composition of obsidian artifacts and source areas could be used to link artifacts to geological sources (Burger and Asaro 1977; Cann and Renfrew 1964; Glascock et al. 2007; Shackley 2011). Obsidian also provides a means of direct chronological control through estimates derived from the rate of absorption of water on culturally modified materials (Eerkens et al. 2008; Liritzis and Laskarisa 2011; Tripcevich et al. 2012). While there are limitations to the obsidian hydration dating method in some circumstances, it has proven to be of broad utility for improving chronological sequences. Hydration dating can be particularly useful at quarry sites where supporting evidence from culturally diagnostic artifacts or datable organic material is frequently unavailable (Tripcevich et al. 2012).

Early archaeological attention to obsidian in the Central Andes focused not on procurement but rather on its appearance in archaeological contexts. The material has been the subject of archaeological attention for at least a century—Max Uhle described dart foreshafts with obsidian points from the Nazca cemetery at Chaviña as early as 1909 (Uhle 1909) and also collected obsidian from sites such as Marcahuamachuco (Fig. 2.3) in the early years of the twentieth century (Burger and Glascock 2009; McCown 1945). Uhle and his successors were primarily interested in obsidian *cum* artifact, and in using those artifacts to infer the behavior of their makers and users. By the 1970s, when it had become analytically possible to separate Central Andean obsidians into geochemical groups (Burger and Asaro 1977; Burger et al. 2000: 271–272), the obsidian sources became foci of interest as a first step to permit subsequent research into regional procurement. The immediate goal was to identify geological source areas in order to tie geochemical groupings of obsidian to specific origin points.

Geochemical links between artifacts and obsidian types enabled discussion not just of tool use, but also of the circulation of specific obsidians. In the Andes, systematic research into obsidian sourcing that had begun in the 1970s was delayed by the remoteness of many of the sources and by dangerous political conditions during the 1980s (Burger and Glascock 2002; Burger et al. 2000; Glascock et al. 2007). Obsidian sources in the Central Andes are confined to the South-Central Andes; the next sources to the north are in the highlands of Ecuador (Burger et al. 1984; Burger and Glascock 2009), and while material from Ecuadorian sources has been found transported 450 km south in Tumbes, Peru (Moore 2010: 406), the region forms a sphere of circulation separate from the sources of southern Peru (Burger 1984). Similarly, there are regionally significant obsidian sources in southern Bolivia, Argentina, and Chile (Barberena et al. 2011; Yacobaccio et al. 2004), but material from those sources circulated in a distinctive sphere from that of the central Andean obsidian sources.

Geochemical sourcing thus added a vital dimension to our understanding of the procurement and circulation of obsidian in the Central Andes (summarized in Glascock et al. 2007). However, geochemical sourcing is not in itself sufficient to approach questions about the organization of procurement and manufacture, its

Fig. 2.3 Obsidian biface measuring 53.4 mm with grey banding and an opaque red tip. Photo courtesy of the Phoebe A. Hearst Museum of Anthropology and the Regents of the University of California. Photography by Nicholas Tripcevich (Catalogue No. 4-3531)

links to consumption, and to further interpretive work concerning, for example, the conceptualization of resource ownership and access through prehistory. Andean obsidian source research thus parallels the history of work in Mesoamerica where there was a "contagious enthusiasm for obsidian sourcing" (see Clark 2003: 19) in the late 1960s and 1970s. In the case of the Andes, however, it was somewhat less contagious being largely the result of efforts of one person: Richard L. Burger. In the Andes, we thus saw an initial focus on distribution patterns as a means of reconstructing networks of trade and exchange, and presently, with all the major sources identified, a shift to emphasizing obsidian sources themselves as resources, to be exploited or conserved, controlled, or communally maintained.

Richard Burger's collaborative studies (Burger et al. 1994, 1998a, 1998b, 1998c, 2000, 2006; Burger and Glascock 2000, 2001, 2002; Glascock et al. 2007) have now located and sampled at seven of the principal obsidian sources in the Central Andes (Fig. 2.2): Alca, Chivay, Jampatilla, Lisahuacho, Potreropampa Puzolana, and Quispisisa, while the Acarí type has recently been linked to the Anillo source in northern Arequipa. However, survey and excavation characterizing Prehispanic procurement at these sources remain scarce, represented in print only by Tripcevich's work at Chivay (Tripcevich 2007; Tripcevich and Mackay 2011). Ongoing geoarchaeological survey and geochemical analysis at the Alca obsidian source (Burger et al. 1998b; Jennings and Glascock 2002; Rademaker

2006, 2012) have documented a few quarry pits and limited tunneling into tuff for obsidian procurement, as well as identifying distinct geochemical signatures for particular flows at Alca that may provide analytical possibilities (Eerkens and Rosenthal 2004). For example, Rademaker (2012) is able to explore patterns in the use of particular sectors of the Alca source, such as an apparent shift during the later Holocene towards greater use of one particular subsource that lies along a travel corridor.

This research notwithstanding, the long-term widespread use of obsidian in the Central Andes suggests that quarries have been underused as research foci. In particular, Quispisisa-type obsidian has a remarkably long history of use, and eventually was transported great distances, reaching nearly 1,000 km from the source to the site of Pacopampa by the first millennium B.C.E. (Burger and Glascock 2009: 25). While Peru's other two major sources—Alca and Chivay—display relatively little evidence of quarrying, the project that we have begun at the source of Quispisisa-type obsidian in southern Ayacucho, which we describe here and in (Contreras et al. in press; Tripcevich and Contreras 2011) focuses on an obsidian source that contains the most large-scale evidence of obsidian quarrying found in the Central Andes to date.

Quarrying of Quispisisa-type Obsidian

Our preliminary work at the Quispisisa source (Tripcevich and Contreras 2011: 125) has demonstrated that the area features an array of quarrying evidence unique in the Central Andes. In our initial visit to the source area, we used Burger and Glascock's (2000, 2002) description of the two-hour hike to the source area, and we were guided by a local resident Jesus Vilchez who described large pits across the Urabamba river from the obsidian exposure encountered by Burger's team. Over the ensuing 4 years, we conducted numerous reconnaissance visits to the source area, and have thus far documented 34 quarry pits on a hill known as Jichja Parco. The pits themselves are mainly ellipsoidal, ranging in size from about 10 m on their long axes and 1 m deep to 45 m across and 3 m deep. The pits documented thus far are spread over an area of 90 ha, comprising in total a mined surface of at least 13,000 m^2 and an estimated excavated volume of at least 32,000 m^3. We have also observed but not yet documented other pits, both comparable in size and shallower, meaning that these figures are minimal counts.

The pits occur in clusters across the hillslope, often adjacent to one another. They are virtually carpeted with obsidian, primarily small discarded nodules, and surface scatters also include flake debris from the initial stages of reduction. Spoils piles were apparently routinely heaped downslope, forming a berm following the circumference of at least part of each pit; these berms are similar in composition (judging by surface inspection) to the bottoms of the pits in most cases (Fig. 2.4). They give the pits the appearance of the "Doughnut quarries" described at the Ucareo-Zinapécuaro obsidian source in West Mexico (Healan 1997).

Fig. 2.4 Photograph showing quarry pits aligned along a contour (pits 7005 and 7006 are visible) with a downslope berm on the *left*

Approaching the quarry pit area on foot takes several hours by trail from the road, and one passes a few locations where obsidian is exposed through erosion on the sides of the Urabamba drainage (Fig. 2.5). Crossing the river, one encounters a considerable density of obsidian nodules up to 30 cm across eroding out in the headcuts of quebradas, alluvially transported in quebrada channels, or colluvially transported on slopes. The availability of large nodules in these contexts brings up a question: why excavate large pits to acquire obsidian when it is readily available in these erosion contexts? The extensive evidence of quarrying also prompts a more general question about the exploitation of Quispisisa-type obsidian: do big pits imply organized labor? More generally, such evidence focuses our attention on an issue particularly germane to this volume: how are we to interpret quarrying evidence?

The quarrying evidence at the Quispisisa source may be the product of a long history of exploitation: regional archaeological evidence demonstrates that the source was exploited as early as the Archaic Period by mobile foragers. Later, in the first millennium BCE, Quispisisa-type obsidian was widely distributed in the interaction network associated with the Chavín phenomenon, and during the Middle Horizon the Wari Empire made extensive use of obsidian from this source. In other words, we may presume that the source area has been subject to extraction under divergent sociopolitical formations. Whether the extraction activity itself changed as the consuming populations changed remains an open question; this drives the issue of how distinct Central Andean sociopolitical forms organized the production of lithics and the exploitation of raw materials more generally.

We suggest three (overlapping rather than mutually exclusive) factors at play in quarrying behavior, and elaborate below (Table 2.2) specific models of differing

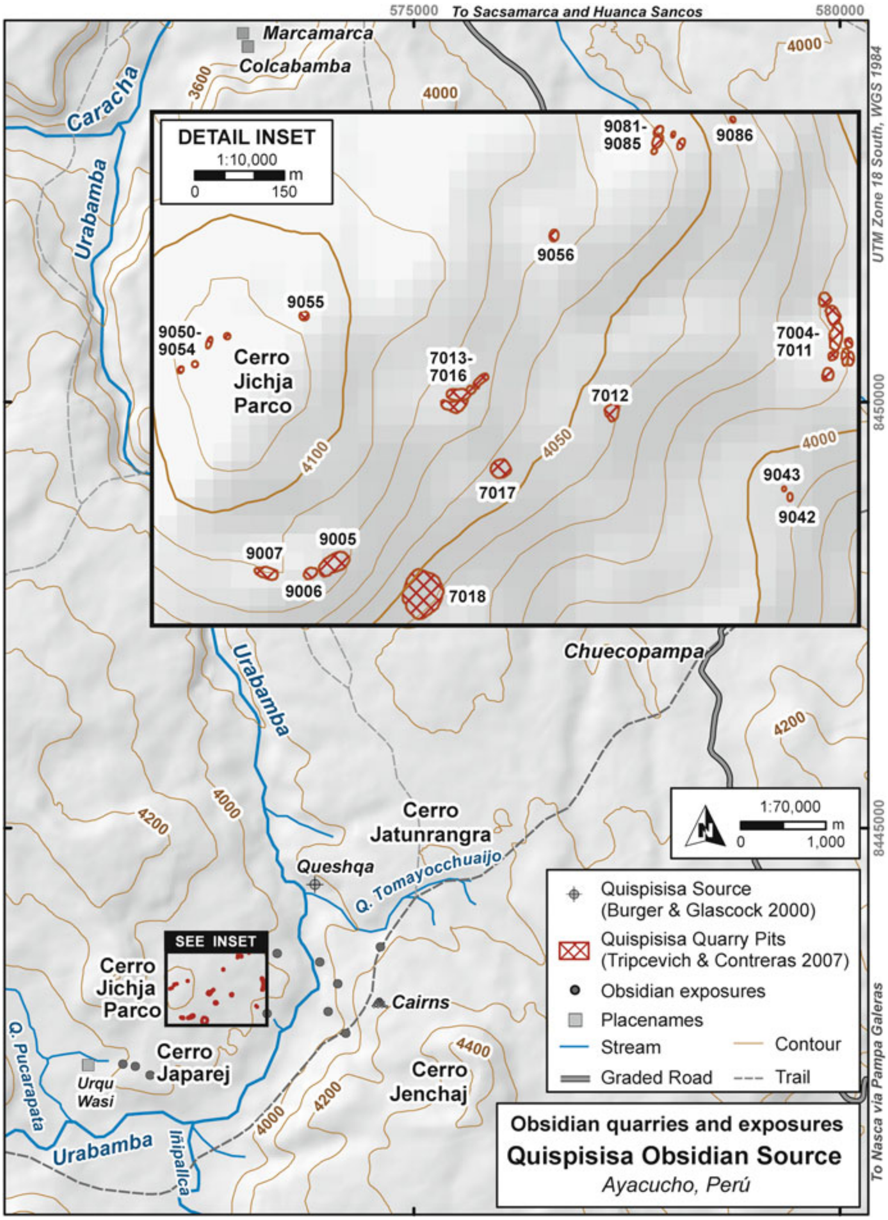

Fig. 2.5 Map of Jichja Parco quarry area at the Quispisisa Source

modes of exploitation and their material correlates for two extremes: unmanaged and low-intensity extraction by foragers (or pastoralists, or even nearby agriculturalists) on one end of the spectrum, and coordinated, perhaps state-run, access/extraction/production on the other.

Table 2.2 Expected material correlates in different scenarios of obsidian exploitation

	Unmanaged access	Coordinated/managed extraction
Knapping choices	More diverse; forms consistent with hunter-gatherer toolkits	More standardized knapping but greater variability of target forms
Intensity of use	Lower intensity; use spread out over time	Higher intensity, use more concentrated in time and potentially involving more coordinated labor
Symbolic/social significance	More variability	Less variability; higher investment

1. Knapping choices—the subsurface material was more suitable for knapping the desired forms because surface nodules were not large enough or were otherwise somehow functionally unsuitable.
2. Intensity of use—the naturally eroding sources became depleted due to concentrated exploitation to meet demand during a specific time period (i.e., the rate of exploitation outstripped the rate of exposure by erosion).
3. Symbolic and/or social significance—there were social or ideological reasons to retrieve stone directly from quarried subsurface contexts rather than surface materials or eroded material in gullies.

Knapping Choices

Understanding procurement and production depends upon a consideration of consumption factors such as target forms for transport and for eventual use, anticipated degree of curation, and reduction strategies practiced. Reduction activities at the obsidian source area reflected demand throughout the region and target artifact size, as well as the ability to transport bulkier material with pack animals and through established routes (e.g., Close 1996).

Preceramic foliate projectile points were often made from durable stone like andesite or quartzite but some proportion of the points are made from obsidian, particularly in the vicinity of obsidian sources. On the whole, the most common formal obsidian tool in the central and south-central Andes is a small triangular point between 1 and 2 cm long and generally corresponds to later, ceramic-using periods of prehistory (Klink and Aldenderfer 2005). A principal exception to the trend towards small, triangular points in the south-central Highlands are the large Wari bifacial knives that are up to 5 cm long, found sometimes far from the geological obsidian source (Bencic 2000; Burger and Glascock 2009; McCown 1945; Nash 2002; Owen and Goldstein 2001; Williams et al. in press). These are commonly made from Quispisisa-type obsidian, the obsidian source used heavily by Wari during the Middle Horizon.

Examples of advanced reduction obsidian artifacts from sites throughout the region thus inform our approach to analysis of materials at the source, as later stage and discarded obsidian artifacts provide insights into the trajectory for artifacts transported from the source area. In upcoming work at the Quispisisa source, our analysis of flaked stone from the source and nearby workshops will focus on changes in blank production and core reduction over time. For example, variation in core to flake ratios may indicate whether producers sought cores or blanks and patterns in the size and shape of late flake removals may indicate preferred blank form. At workshops further from the source, changes in core size at discard may reflect changes in the relative cost of material acquisition. The significance of linking these changes to larger patterns in regional production/consumption highlights the importance of locating datable stratified deposits at production areas and dumps, or in their absence the value of being able to chronologically relate distinct quarrying areas through radiocarbon dating of associated organic material or through examining the evidence of locally-calibrated obsidian hydration rates.

Documenting intra-quarry variability—e.g., color or knapping properties—may be examined in tandem with spatial variability in extraction, assessment, and reduction strategies, offering the possibility of examining chronological changes. Combined with the ongoing study of lithic collections at a regional scale, this approach can draw out patterns in standardization and continuity in lithic production practices that may aid in addressing questions such as whether procurement was practiced to fill local needs or to create products for exchange, as well as addressing questions of potential control of access and/or coordination of production by local or regional authority. As other chapters in this volume demonstrate (Chaps. 6 and 12), there are Prehispanic Andean examples of mineral resources being treated as communal, open-access resources (e.g., rock salt) *and* state-owned and controlled resources (metal ores).

Intensity of Exploitation

We suggest two models to account for the formation of "doughnut quarries" as observed at Jichja Parco. The first posits the gradual formation of pits over the long-term due to continual low-intensity quarrying, while in the second model quarrying is the result of coordinated, intensive exploitation during a specific time period that exceeded the supply of materials available on the surface. Both models may have been in effect simultaneously at certain times during the site's history.

Ad Hoc Quarry Activity

This model suggests two possibilities (1) a preference for subsurface material, and (2) excavation of quarry pits as a process incidental to material acquisition. In the first case, subsurface material might be superior, perhaps better insulated from erosion and thermal fluctuations, or might be preferred for other reasons. In the second case, target nodules might be recovered from the surface resulting in the gradual formation of a pit in that location. As such pits become deeper and labor required to remove material from them increases, new quarries might be started nearby. A small amount of maintenance may have been required for such pits, but on the whole the process need not imply large-scale organization. Exploitation might be by individuals or small groups, with use-rights either unrestricted or perhaps structured by kinship. Quarrying that results from such a system would produce pits spanning a wide period of time and with general heterogeneity in factors such as nodule selection and reduction strategies.

Coordinated Extraction with Intensified Use

The second model posits that the effects of growing regional demand might exceed the obsidian available naturally due to pronounced need during a particular time period. While it is evident that in modern circumstances where erosion on slope surfaces, along riverbanks, and in incised gullies exposes large nodules, it is possible that during specific times extraction outstripped this supply. If obsidian available in surface and erosional contexts was not sufficient to meet demand, excavation for additional material would have become necessary. This might occur in case of moderately intensified extraction in a relatively short (multi-decadal or centennial) span of time, even without extra-local coordination, or in case of significantly intensified momentary (decadal or annual) demand, for instance imposed by a regional polity like Wari. In either case coordination of labor and/or use-rights would lead to many contemporary pits and more homogeneity in material selection and reduction strategies.

At a regional scale, the density and spatial extent of the consumption zone provide some clues about the demand during particular time periods, although consistent quantification of obsidian at many sites is lacking and the sampling of obsidian for sourcing from archaeological contexts in the Central Andes, while improving steadily, remains inconsistent. There is little correlation between the extent of obsidian distribution and size or number of quarry pits: Alca material was as widely geographically distributed as Quispisisa-type obsidian, but the primary source area has only a few modest pits (Rademaker 2012), while Chivay only has one pit (Tripcevich 2007). Such comparisons are further complicated by differences in the accessibility at obsidian at the sources and in the irregular distribution of consumer sites sampled for obsidian sourcing, largely a reflection of the history of archaeological research in the region (Burger 2000). The intensity of extraction is presumably more directly correlated with the intensity of use, but due to the difficulties of sampling we are not yet able to compare the scale of consumption of Quispisisa obsidian to other types.

These two models may be considered as poles on a spectrum of mining behavior. Distinguishing where on this spectrum given evidence of mining activity may fall requires assessing the chronology of extraction. At the Quispisisa source, we approach this from two perspectives. First, cultural evidence from archaeological sites and lithic workshops at both local and regional scales may provide datable samples with which to address the intensity of use over time. Second, directly dating quarry activity through stratigraphic evidence in mining debris and/or through obsidian hydration analysis of flaked obsidian from a broad sample of pit features will provide, at a minimum, a relative chronological evidence for the exploitation of obsidian from these pits.

Symbolic and Social Aspects of Obsidian

> "Of all the things that the Spanish showed him [Atahualpa], there was none he liked more than glass, and he said to Pizarro that he was very surprised that, having things of such beauty in Spain, he would travel to distant and foreign lands looking for metals as common as gold and silver" (Benzoni and Smyth 1857 [1565]).

Ethnohistoric sources and contemporary ethnography in the Andes are rich with accounts of ritual practices associated with mines and mining, and these accounts inform current studies of mining in the Andes, include many of the chapters in this volume. As observed by Bernabé Cobo (1652) and other chroniclers, those who worked the mines also worshiped the ore-rich hills and the mines as shrines. Cobo specifically mentions rituals surrounding silver and gold sources, as well as rituals involved with the procurement of pyrite, sulfur, and cinnabar. We have few details about obsidian mining, however, as it was of little interest to the Spanish chroniclers, and the Inca seem to have made less use of obsidian, apparently focusing on other materials (Burger et al. 2000: 344–346).

These sources suggest that ancient Andean peoples mined and quarried in an animated landscape (sensu Ingold 2006, 2011). Here social and symbolic relationships between human communities and the entities or essence that reside in certain natural features, including particular mountains and the minerals that lay within them, were as significant as economic and political imperatives. Moreover, ethnohistoric and ethnographic evidence of connections between communities and geological landscape features is widespread in the Andes. Thus, while in some contexts it seems that an obsidian source is simply a source of sharp, functional stone, in others obsidian may be charged with social, political, and ideological associations, and the source may be correspondingly prominent in the landscape. The challenge for archaeological approaches to Andean mining is to consider what kind of material evidence would support these assertions of emotive or symbolic attachment to particular places and materials derived from those places. Spatial association with ritually important locations, for example, or a pattern of interment together with other unusual materials believed to have been high value may imply that a source location had ritual significance. Andean ethnohistoric sources do not specify whether obsidian was considered a ritually significant material or if its mining was associated with ritual activity. There are examples of ritual structures at obsidian sources, such as a cluster of Inca period chullpa mortuary structures at the Chivay obsidian source (Tripcevich and Mackay 2011) and a relatively high density of saylluas (cairns) marking the location where a major trail overlooks the Quispisisa obsidian source (Tripcevich and Contreras 2011: 125). However, chullpa and cairn structures are not uncommon in the central Andes, underscoring the difficulty in finding straightforward material indicators of the ritual significance at mining sites.

Archaeological evidence from the Central Andes suggests that obsidian may have been valued as a functionally important and/or exotic material in some times and places, while valued for symbolic and ritual reasons in others. Obsidian generally is found in mundane contexts such as household middens, but it also is sometimes found in ritual contexts (discussed below). Obsidian sometimes appears to be a valued exotic material—for example it has been found included in burials where the material is scarce—but it also is sometimes found in contexts that span intrasite status differences, such as at Pukara (Klarich 2005: 255–256) or at Chavín de Huántar (Contreras and Nado in press).

In addition to focusing on commoner versus elite distinctions in use of this material, it is useful to consider social practices and further details about the use of obsidian at a distance from the geological source area. Obsidian may have been both commonplace and symbolically rich as a marker of group identity or as an "ordinary good" (Smith 1999) incorporated into household practices but communicating social meaning. For example, where it is familiar and known to come from adjacent volcanic regions obsidian might be interpreted as a marker of ethnic affiliation or exchange with communities associated with volcanic, obsidian producing areas. This may have been the case with Chivay obsidian in the Titicaca region where it is available only from the lands well to the west of Titicaca (Tripcevich 2010); it is commonly found at rockshelters and herder sites, and yet it is also found in burials and ritual mounds (Couture 2003; Giesso 2003).

Bradley (2000: 81–90) describes attachment to the character of flint sources in Neolithic Britain where material from unusual or sometimes dangerous locations on mountain sides appears to be found at greater distances and collected in ceremonial contexts. He links these materials to an affinity for qualities of the source areas that may have led to artifacts made from these materials being placed in the ground with some formality in graves and hoards as "Pieces of place." Stone artifacts from these sources circulated despite the presence of accessible and suitable alternative materials, suggesting to Bradley that these artifacts served perhaps as a reminder or a "piece of" the culturally significant source area in the Neolithic landscape. In some cases, flints from particular sources are visually distinguishable, in other cases it has been argued that a small portion of cortex may be left to aid in identifying sources (Rudebeck 1998). A key feature of these interpretations, then, is that knappers were concerned with more than knapping characteristics and easy availability.

In the Andes, ethnohistoric accounts describe social links, in particular ethnic affiliation and identity, incorporated in the movement of stone from the ethnic place of origin or *pacarisca* as discussed by Ogburn (Chap. 3). While no such accounts have come to light for obsidian, its characteristic appearance and limited number of sources suggest that research on obsidian in the Central Andes should consider such models. Among ethnographies from stone tool-using groups, such as in Australia (Brumm 2010; Gould 1980; McBryde 1997; Taçon 2004), people would endeavor to obtain stone from outcrops associated with their totemic ancestors or otherwise acquire stone over great distances despite many functional alternatives. Objects may accrue meaning by virtue of cultural biographies (Gosden and Marshall 1999), and possession of particular objects could have been bound to social ties resulting from such objects being traded and transported across the landscape (Lechtman 1984; Saunders, 2004). Thus, while it is difficult to determine if ancient peoples retained knowledge about geological origin of particular materials, we may look for patterns in the distribution and/or consumption of stone artifacts from sources that are visually indistinguishable but assignable to sources today (e.g., using obsidian geochemistry). We may investigate whether provenance information may have been communicated in association with artifacts as they were traded, or whether materials from particular sources were directly procured or used and treated in distinctive ways. Phenomena such as direct transport from the source area by displaced populations during the Inca period may explain, for instance, a collection of 29 small, unmodified obsidian nodules from the Chivay source found by Bingham in a ritual context over 300 km distant at the gateway to Machu Picchu (Burger et al. 2000: 347; Burger and Salazar 2004: 103, 161). This possible evidence of ritual use of obsidian at Machu Picchu is complemented back at the Chivay source by an Inca-style cutstone masonry structure (possibly a square *chullpa*) and pottery adjacent the principal obsidian workshop (Tripcevich and Mackay 2011).

While ethnohistoric, ethnographic, and archaeological evidence suggests that geological source areas of visually significant materials were prominent in the landscapes of communities throughout the Central Andean region, Andean peoples used these materials in eminently practical activities for which sharp, workable materials are desirable, and also engaged with them also through ritual practices and ceremonial display, potentially signaling social identity, and/or status. Artifacts may have been imbued with essential power derived from associations with the procurement zone, and may have communicated obligations and relationships between individuals, communities, and sacred entities manifested in various ways in an animated landscape—but in the end, these relationships must be demonstrated in particular cases using specific evidence. Compelling arguments along these lines have been made for other sourceable stones in the Central Andes for Inca stones (Ogburn 2004 and Chap. 3), Tiwanaku stones (Chap. 4), and possibly exotic granite and limestone at Chavín (Turner et al. 1999). This raises an intriguing comparative possibility: did Andean peoples consider obsidian, basalt, and andesite equivalent materials, or was structural stone perhaps distinct from tool stone? Again, considerations of both procurement and consumption evidence may be mobilized to consider this question.

Conclusion

The scale and relatively undisturbed state of the Quispisisa source provide an opportunity to examine Prehispanic organization of production and extraction. The absence of large workshop areas in the immediate area of the source, while initially puzzling, may be resolved with further survey in the region and could ultimately benefit archaeological analyses because workshops from different time periods may have more spatial separation. Even when reduction areas are identified, temporal control over these deposits will be difficult, but in lieu of temporally diagnostic materials like pottery, obsidian hydration dates guided by ^{14}C dates on organic materials may be the best method of parsing the changing use of the source area thorough time. Various aspects of quarrying behavior discussed here—including intensity and character of use—will require chronological control to address.

As source-area research is integrated with evidence of regional production and consumption, a systematic approach to these research topics becomes possible. The varied importance of obsidian from the mundane to the socially significant suggests that source-area research can shed light not just on the contribution of obsidian to subsistence activities, but also on highland people's relationship with this stone source, and its meaning in their broader social and ceremonial milieu.

Ultimately, quarries are of interest for what they can tell us about the ways in which mineral resources were accessed, exploited, controlled, and understood in the Prehispanic Central Andes. Obsidian quarries are particularly well suited for examining diachronic changes in resource use in that they offer the possibility of links to consumption zones via geochemical sourcing and direct chronological control via hydration dating. In the case of Quispisisa-type obsidian, the timespan in question includes the development of agropastoral economies and the florescence and demise of regional polities, offering the possibility of a long-term study of Central Andean approaches to mineral resources.

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