INCA VOLCANIC STONE PROVENANCE IN THE CUZCO PROVINCE, PERU

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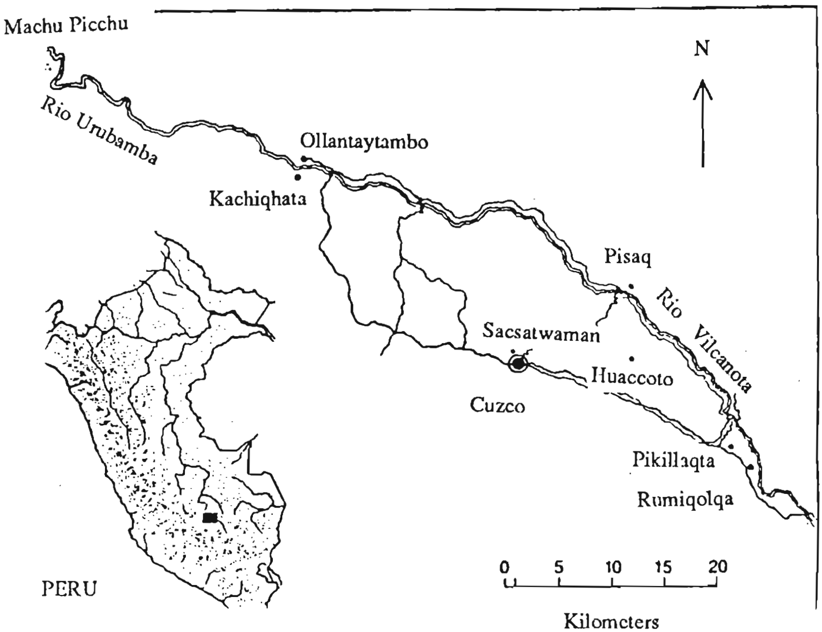
Introduction

The use of andesite and basalt as architectural ashlars by Inca stonemasons has been widely discussed throughout the literature (Rowe, 1946; Kendall, 1985; Vargas, 1970; Gasparini and Margolies, 1980; Protzen, 1985; Protzen 1986; Agurto Calvo, 1987). Most of these archaeological or architectural studies are in agreement that the primary Inca quarrying centers in the Cuzco area are in the Rio Huatanay valley at Rumiqolqa and Huaccoto, both to the southeast of Cuzco (Fig.1). Rumiqolqa is approximately 35 km distant at an elevation of 3330 m (11,000 ft). Huaccoto is approximately 19 km from Cuzco at an elevation just below 4100 m (13,500 ft).



Adapted from Protzen, 1986

Fig. 1 **Map of Cuzco province, Peru**

Prior research to date on volcanic stone provenance determination of Inca contexts in the Cuzco province has been limited to early petrographic work (Gregory, 1916) which did not have archaeological study as a primary focus. While Gregory's geological services were supplied to the Bingham expedition beginning in 1912, his surveys of the Cuzco area still stand as a much-quoted model of initial scientific interest in Inca quarrying.

Geological investigations in the Cuzco province include those surveys with tectonic, petrogenetic, or metallogenic aims (Gregory, 1916; Kalafatovich, 1957; Gabelman, 1964). Some of these investigations also cover the Anta plateau and the Rio Vilcanota-Urubamba watershed as far downstream as Machu Picchu but are notably incomplete or on a scale inconclusive for detailed help in provenance determination.

In addition to Rumiqolqa and Huaccoto the other major extrusive deposition mentioned in these studies for the Rio Huatanay valley is found at the cuesta of Mt. Ichchu-Orcco between Huaccoto and Rumiqolqa, nearly 28 km distant from Cuzco. Although Mt. Ichchu-Orcco has been surveyed (Gregory, 1916, 93ff) as part of south Cerro Pachatusan, it has not yet been connected in the available literature with Inca quarrying. This may be due to its higher altitude at 4450 m (14,700 ft), a scoria texture "devoid of cleavage or flow structure" (Gregory,1916,93), and its size of deposit (too small for extensive quarrying) in comparison to the nearer, lower, and larger quarries at Huaccoto which have ideal quarrying features.

Outside the tributary Rio Huatanay and in the watershed (into which it feeds) of the Rio Vilcanota-Urubamba can be found several other extrusive deposits. These known deposits are discussed in the following paragraphs.

Of note is the Pachatusan formation (north Cerro Pachatusan) on the Vilcanota side of the range between Cuzco and Pisac, discussed in several studies (summarized by Gabelman, p. 22ff). It is approximately 10 km from Cuzco at an elevation near 4000 m (13,400 ft) but nearly inaccessible from the direction of Cuzco. While it may have served other sites as yet undetermined, the Pachatusan formation is extremely unlikely to have served Cuzco (due to lack of access approach via a known pass) even though it would appear to be closer than either Huaccoto or Rumiqolqa. Another part of this formation may possibly be found high above the Vilcanota opposite Calca, although its elevation and mineralogy are unknown to this author (pers. comm. J.P. Protzen, 1988). It has not been suggested by any prior study that this geological deposit has ever been used for Inca quarrying.

Although most of the known extrusive deposits in the Cuzco province appear to be roughly in the triangle of the Huatanay-Vilcanota-Urubamba watershed convergence (Fig.1) with intrusive granitic rock dominant downstream of the town of Urubamba, another volcanic deposit can be found outside this area above colonial Pisac at approximately 3310 m (10,920 ft) on the northeastern ridge over the Rio Vilcanota.

These extrusive deposits are the only known loci to date. Unfortunately, as mentioned previously, geological mapping of the Cuzco province is incomplete, therefore additional major deposits (and by extension potential quarries) of extrusive material may yet be found. The preliminary nature of this discussion is nonetheless accurate for the locales covered; as with other studies of provenance it is always much easier to determine where sources of material cannot be fixed than to pinpoint a firm source. Given the necessity of further scientific exploration of the rigorously steep Andean highland, it is expected that the present study will be superseded by future investigation. The following discussion examines each of the known Inca volcanic stone quarrying contexts in detail, noting where this study has provided new information.

Rumiqolqa

Rumiqolqa has been known as an Inca quarry for centuries through local tradition (Squier, 1877); indeed, its very name in the Quechua language means "stone storehouse" (rumi="stone"; qolqa="storehouse"). Being roughly 100 m below Cuzco in elevation, and in reality downstream from it 35 km as stated earlier, the transport of stones to the Inca capital would have been difficult against the gravity gradient slightly uphill. Extant illustrations from the 16th c. chronicler Guaman Poma are considered fairly accurate in depicting mode of transport as bringing worked stones up ramps which are still much in evidence (Guaman Poma, [1616] 1956; Protzen, 1985, 164ff, 1986,81ff; and this researcher's experience in 1988), although Protzen's cogent arguments against a mita workforce (Inca corvée or forced labour) dragging the stones are to be taken seriously (Protzen, 1986, 88).

Protzen has the most reliable accounts of Inca stoneworking to date and has provided much personal assistance in the present research both in the fieldwork in Peru as well as in California. The primary quarry identified by Squier and Protzen is named the Llama Pit (Protzen, 1986, 82). At least 250 abandoned Inca ashlar blocks in various stages of stonedressing can be found there made from the andesite (Protzen, 1986: 83).

In hand examination, the Rumiqolqa stone often exhibits conchoidal fracture. Although it is often flow-banded and sometimes glassy, the Rumiqolqa stone is generally a darker grey than the Huaccoto stone and is also generally slightly harder.

Petrography

The initial petrographic analysis made by Gregory in 1916 identified the Rumiqoloqa quarry material as hypersthene basalt (Gregory, 1916, 100). However, it should be categorized as hornblende andesite by present standards. The primary phenocrysts in the Rumiqolqa quarry material in order of total volume are plagioclase feldspar, basaltic hornblende, and biotite (Fig. 2). Very little pyroxene was found in any of the Rumiqolqa samples, making up less than 1% of the volume, however, there were found occasional xenoliths of apatite and opaque ilmenite.

Gregory identified the plagioclase as bytownite, which is unlikely as it is rarely found in basalt or andesite (especially unlikely to crystallize in a magma with biotite). Thus, it is more likely to be oligoclase or andesine (Keith, 1989). The plagioclase laths are found in a moderately-aligned textural direction.

Gregory referred to the hornblende phenocrysts with "All the hornblende present is the brown variety common in basalts and is much corroded." (Gregory, 1916). This should be referred to as basaltic hornblende (or oxyhornblende).

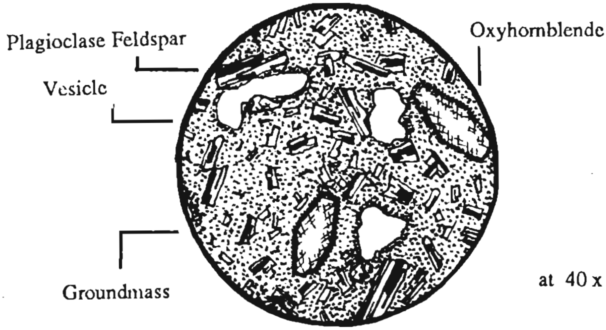


Fig. 2 Rumiqolqa petrographic thin-section

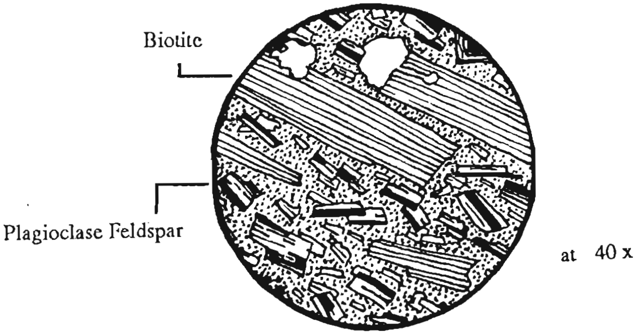


Fig. 3 Huaccoto petrographic thin-section

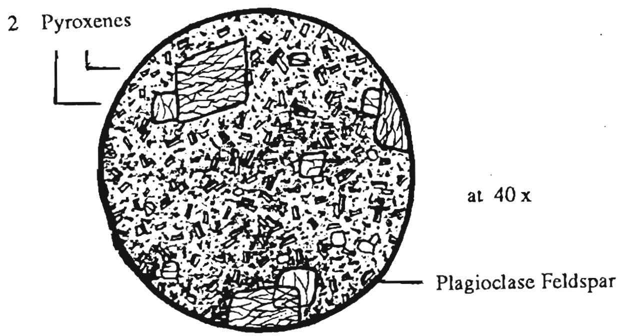


Fig. 4 Pisaq petrographic thin-section

In some cases inclusions of pyroxene are found in the hornblende phenocrysts. Biotite is also found in the Rumiqolqa material, although with considerably less frequency than hornblende.

This textural analysis is summarized in Table 1. As stated, there is some preferential direction of alignment indicated in the use of "hyalopilitic" by Gregory (1916, 100), wherein the feldspar phenocrysts and other phenocrysts are parallel or subparallel with the alignment of the groundmass. Actually, this is apparent mostly for the hornblende and perhaps the biotite, not so much for the feldspars. Certainly in comparison to the Huaccoto quarry material, the texture of Rumiqolqa material is relatively "felty" or random in direction.

The typical Rumiqolqa groundmass is made up of approximately the same constituents as in the phenocrysts, with perhaps a few opaque grains of ilmenite or titanomagnetites. While not as porous as many basalts, also characteristic is the slight vesicularity of this lava.

Table .1 TEXTURAL ANALYSIS BY VOLUME

RUMIQOLQA		HUACCOTO		PISAQ INTIWATANA & RIACHUELO KITAMAYO QUARRY	
1. Groundmass	41%	Groundmass	32%	Groundmass	27%
2. Vesicles	6%	Vesicles	3%	Vesicles	0-1%
3. Phenyocrysts	(53%)	Phenyocrysts	(65%)	Phenyocrysts	(65%)
a. Plagioclase feldspar	31%	a. Plagioclase feldspar 3	9%	a. Plagioclase feldspar	4%
b. Oxyhornblende	16%	b. Biotite Mica	24%	b. Two Pyroxene	19%
c. Biotite Mica	5%	e. Oxyhornblende (resorbed)	2%	- Clinoyproxene ((Augite)	13%
d. Pyroxene	1%			- Orthopyroxene	6%

The Inca archaeological contexts in which Rumiqolqa quarry material can be found follows after the discussion of Huaccoto quarries and petrographic data.

Huaccoto

Huaccoto has also been known as a quarry for centuries, although sources suggest it was most active in the later period after imperial Inca expansion under Pachacuti (mid-15th c.) with which Rumiqolqa is associated (Gregory, 1916, 92) and most-closely associated with a Post-Conquest or Inca-Colonial chronology (Rowe, 1946; Gasparini & Margolies, 1980, 302; Protzen, pers. comms. 1988-89).

As stated earlier, Huaccoto is closer to Cuzco than Rumiqolqa at a distance of 19 km as opposed to 35 km. Also much higher in elevation at approximately just below 4100 m (13,500 ft), Huaccoto is on the plateau high above the Rio Huatanay valley. As such, a gravity gradient would help in transport of quarry material to Cuzco, especially considering it is almost half the distance of Rumiqolqa. At this point it is unknown why Rumiqolqa was abandoned, considering the high number of extant ashlars mostly dressed and ready for transport. Whether or not the death of Pachacuti coincides with Rumiqolqa's waning use or whether civil war and the subsequent Spanish conquest ended the Rumiqolqa quarries as the major source of andesite is a question for the historians. Since Rumiqolqa was never depleted (indeed has been worked sporadically ever since up to the present time), either hypothesis is possible. However, it is equally possible in the colonial period that Huaccoto's proximity and gravity gradient made it more ideal in that considerably less manpower is required for transport. In conjunction with this, the loss of mita workforce and the lower volume of building in the colonial period may evidence just such a situation.

Huaccoto stone quarries are also still worked on a minor scale. Its flow structure "favors separation into slabs suitable for [road] paving, curbstones, and door facings . . ." (Gregory, 1916, 92). In hand specimen, the Huaccoto material appears most often in thin flat cleavages of a lighter colour than Rumiqolqa stone, ideal for surface cover as roadbeds and stone floors. Because of a general lighter colour, its phenocrysts are more visible to the naked eye.

Petrography

The initial petrographic analysis of Huaccoto quarries, identified the material as hypersthene andesite (Gregory, 1916, 92). However, by present standards it should be categorized as biotite andesite (Table.1). The primary phenocrysts in Huaccoto quarry material in order of total volume are plagioclase feldspar and biotite. Additionally, a small volume of resorbed hornblende and occasional xenoliths of apatite are found as well (Fig.3).

Gregory identified the feldspar as ranging from andesine to labradorite (Gregory, 1916, 92), which is accurate, and they occur in greater quantity and longer laths than in the Rumiqolqa lava. Additionally, as in Gregory's use again of "hyalopilitic" (1916, 92) they depict a strong textural alignment (much more so than Rumiqolqa lava, as stated previously).

The characteristic Huaccoto phenocryst is biotite, which occurs in long, almost acicular laths up to 2 mm in length, easily double the size of Rumiqolqa biotite. Occasional glomerocrysts or clusters of biotite are found in the Huaccoto lava as well.

The hornblende in Huaccoto material is infrequent and is in a heavily-altered or resorbed state. It is possible that Gregory, who doesn't mention hornblende in his petrographic description for Huaccoto, considered the few characteristic resorbed amphibole traces as pseudomorphs of hornblende.

The typical Huaccoto groundmass appears to be made up of the same constituents found as phenocrysts. Gregory described this groundmass as "cryptocrystalline" (1916, 92), which fits Huaccoto material more than Rumiqolqa material.

This textural analysis is summarized in Table 1. A distinct flow structure can be seen in Huaccoto lava, justifying Gregory's use again of "hyalopilitic" (1916,.92), with definite phenocryst alignment compared to Rumiqolqa lava. Another distinctive feature is the relative freshness and clarity of Huaccoto lava, although Gabelman maintains nearly simultaneous formation, probably in the Miocene period (Gabelman, 1964, 31 & 33). Nevertheless, the hydrothermal alteration of some Rumiqolqa material could account for partial difference in that portions of the Rumiqolqa lava are of a reddish hue even when freshly fractured, indicating a subsurface volcanic vent, whereas the Huaccoto lava appears fresher at the time of fracture although its lighter grey colour after half a millenium is often weathered to a red-brown hue (Gregory, 1916, 92-3).

More important as a textural feature is the size and distribution of phenocrysts in Huaccoto lava as compared to Rumiqolqa lava.,

The archaeological contexts in which Huaccoto material is found appears following the discussion of Rumiqolqa source-determinations. Both of these will appear on a site-by-site basis.

Stylistic analysis

After petrographic analyses, a second provenance characterization could be suggested in the stylistic conformity of the actual Inca ashlars. This is the weakest correspondence of the three because it makes two assumptions: that stones were often dressed at the quarry source; and that the shape of the stone would determine its placement instead of vice versa.

In response to the first assumption, Protzen states "stones from Rumiqolqa were generally finished, or nearly finished, on five of their six surfaces while they were still in the quarry" (Protzen, 1986, 85). This may not always be the case, coming as it does from observations at the primary extant Rumiqolqa Inca Llama Pit quarry, but finished ashlars at Rumiqolqa on ramps spread out over several kilometers on various ramps clearly bear out Protzen's accuracy.

In response to the second assumption, it follows naturally in stone courses that uniformity of shape can be an asset. This is especially true for the many perfect stone courses in Cuzco from Pachacuti's building programs. If shape and dimensions were pre-determined at the quarry as inferred from Protzen, then this indicator could be useful as a possible provenance evidence.

At least one other study has suggested some correspondences in the deliberate Inca stoneworking or dressing of the material along certain sought-for patterns. Agurto Calvo distinguishes about twenty-four different stone course patterns (Agurto Calvo, 1987, 154-62, 170-75).

The period identified with Pachacuti rarely uses ashlars without rectangular or squarish shapes in medium to large sizes for most andesite contexts in Cuzco. On the other hand, the contrast in the colonial period is seen with much less rigorously-shaped andesite ashlars, and thus less perfect stone courses, and these are generally smaller in size than their predecessors, often approximately 25 by 25 by 30 cm or less (as opposed to Pachacuti's larger ashlars).

Thus a stylistic feature (e.g. linearity, size, and uniformity of ashlar) may also be used to render some evidence for the source of the material, but is intended here only in a simple corroboration of the petrographic characterizations.

Introduction to other contexts

Analysis of Rumiqolqa material in Cuzco will focus on the archaeological context of Koricancha, the Temple of the Sun, with some suggestions about other contexts. The discussion on Huaccoto material in colonial Cuzco will focus on a sector of streets near Koricancha, specifically the calle diagonal to Santo Domingo which is early Post Conquest. Several contexts outside Cuzco are also associated with Huaccoto material as well. Finally, an altogether different source and site context will follow in discussion, the context of Pisaq and its determination of provenance. As suggested, the three separate lines of evidence which will be used to make determinations of provenance are petrographic and stylistic conformity to the other contexts.

Koricancha

The 16th c. chronicler Guaman Poma de Ayala describes the building of Koricancha by Inca Pachacuti (Guaman Poma, [1616] 1958, 189). This is during the period of imperial expansion in which Rumiqolqa quarries are exploited (Protzen, 1986:80), and the Temple of the Sun is an important focus of imperial energy in rebuilding the Inca capital. Discussions of the fabulous and legendary elements of Koricancha such as Inca Garcilaso's 1616 account are not in order here, whereas the Instituto Nacional de Cultura (Peru) survey in 1978 for restoration and conservation is succinctly summarized in an account with interest in scientific detail (Agurto Calvo, 1987, 146-50). As would be expected, the dark grey andesite extant in the Koricancha complex is from Rumiqolqa, based on petrographic and stylistic analysis.

Petrography

Based on samples provided by the British Museum of Natural History from the collection of the Pentland Expedition in 1837 and samples collected in 1988, petrographic analysis shows the internal Koricancha complex (partially within the colonial Iglesia Santo Domingo) to be hornblende andesite. The textural match, including percentages of volume, size and distribution of phenocrysts, flow structures, and groundmass features fall within the Rumiqolqa lava range as demonstrated by the Llama Pit and adjacent Rumiqolqa quarries. The petrographic match is fairly conclusive.

Stylistic and other features

The andesite ashlars of Koricancha easily fit into the Rumiqolqa range, being highly-finished and regular and in nearly perfect linear courses. In Agurto Calvo's terminology, they are all "mediano" to "grande" in size, "sedimentario" in type, "recto" or "rectangular" in shape, "lisa" in finished texture, "pulida" in joints, and "plana llana" in worked courses, showing uniform "labrado" dressing throughout (Agurto Calvo, 1987, 147-50).

Furthermore, the colour and weathering of the andesite in the Koricancha context is consistent with Rumiqolqa material, being normally of a dark grey hue and sometimes with traces of reddish stain from weathering in highly-exposed locations.

Other suggested Rumiqolqa source contexts in Cuzco would be too numerous to discuss here, but a few are worthy of note, including many of the buildings around the relict Huacaypata and Cusipata squares (especially the Cassana, Pachacuti's palace on the former square), the Aguajpinta, the Calle Maruri, and the Acllawasi, to name but a few. These are suggested on a visual basis only (colour, weathering, and stylistic features) and could be verified by petrographic and chemical analyses, which would entail the systematic collection of samples. Such petrological research could not be undertaken without official encouragement from the Peruvian Instituto Nacional de Cultura, but would yield much archaeological information and advance scientific understanding of Inca stoneworking.

Colonial Cuzco

In the warren of narrow Cuzco streets just northwest of Korikancha and southeast of the Huacaypata are several streets whose walls conform to the colonial style of "ashlar" construction with uneven stone courses of low height with small stones. One such facade is the southwest side of the Intikijllu or Calleon del Sol (not the northeast side, which is Inca). Another is the northeast corner of the plaza of the Iglesia Santo Domingo and its street bearing immediately north out of the plaza back toward the town square (Huacaypata). This narrow street facade is highly weathered reddish to brown and its rough andesite is flaking off the wall.

Gregory states "During the Spanish building epoch in particular the Huaccoto lava was extensively used" (1916, 92). Elsewhere he states "the basalt [sic] from Huaccoto weathers rapidly in the Cuzco climate and where found in ancient buildings it is chipped, broken, and pitted, and fragments may be pried from columns and lintels with a penknife. Disfiguration from weathering is however partly compensated with increased attractiveness of color" (1916, 92-3). This facade section conforms to Gregory's description of Huaccoto material used in building. Note that Gregory has now referred to the "Huaccoto basalt" which in the preceding paragraph he identified as "hypersthene andesite", showing the early overlapping of geological terminology regarding basalt and andesite in which andesite was often considered a subcategory of basalt. The following discussions present petrographic analyses of samples obtained in 1988.

As would be expected from Gregory's suggestions and the stylistic and weathering match already mentioned, this colonial Cuzco material is from Huaccoto, based on petrographic evidence.

Petrography

Petrographic examination shows the Cuzco colonial material to be biotite andesite. The textural match, including percentages of volume, size and distribution of phenocrysts, flow structures, and groundmass features fall within the Huaccoto range of biotite andesite. The petrographic match is fairly conclusive.

As mentioned, numerous other colonial Cuzco contexts could be considered as well, including the Callejon del Sol or Intikijllu, possibly the Calle San Agustin, and, according to Gregory but undetermined at present, the "facades of the churches at San Geronimo and San Sebastian and of the Jesuit monastery now used by the University of Cuzco were probably built of stone from this locality [Huaccoto]" (1916, 92), and many others. San Geronimo and San Sebastian are to the east along the approach from Huaccoto in the Cuzco environs. Again, such analyses would entail official encouragement from the Peruvian Instituto Nacional de Cultura.

Ollantaytambo

Another context which, lacking other known quarry sources, is tentatively identified in small part with Huaccoto in this analysis is a small collection of stones at Ollantaytambo. This is at best a perplexing situation, and has been briefly discussed with Protzen, Rowe, Kendall, and Bray, among others.

Ollantaytambo has been amply discussed in the literature (Gasparini & Margolies, 1980; Agurto Calvo, 1987) and especially Prötzen, whose architectural and quarrying studies are most germane here (Protzen, 1985 & 86). About 20 m north of the Inkamisana religious sector on the ridge of Ollantataytambo, several blocks of andesite were brought to the attention of this researcher by Protzen, who described them as being in a "fountain" context. Andesite is unusual here because the local geological material is mostly meta-arkosic and arkosic greywacke on the north side of the Urubamba valley, of which much of the Inca complex is constructed (Protzen, 1986, 81), and porphyritic granite on the south side of the valley, which the Kachiqhata quarries supplied for the megalithic monuments at Ollantaytambo (Protzen, 1986, 80). Both of these geologic materials and some of the Kachiqhata quarries have been examined by this researcher. Additionally, the arkosic and granitoid materials have been examined in petrographic thin sections along with the andesite from the Ollantaytambo context. The following petrographic analyses provide details of the petrologic conclusions.

Petrography

Petrographic examination shows the Ollantaytambo context material to be biotite andesite.The textural match, including percentages of volume, size and distribution of phenocrysts, flow structures, and groundmass features fall within the Huaccoto range of biotite andesite. The petrographic match, while problematic, is fairly conclusive.,

Provenance caveats

One difficulty with a Huaccoto source is the chronology of either the major Huaccoto stoneworking as known and the assumed age of this section of Ollantaytambo. Since the Huaccoto material is usually associated with colonial quarrying and building, the Ollantaytambo use would predate such quarrying, particularly if the period in question of building Ollantaytambo is identified with Pachacuti, as most historians suggest.

However, one possible resolution is provided here, requiring that some Huaccoto andesite is used prior to the known quarrying exploitation of Rumiqolqa but not in the Cuzco area. It also appears that the Wari site of Pikillaqta (between Rumiqolqa and Huaccoto but far closer to Rumiqolqa) has also employed Huaccoto material, as determined in this researcher's petrographic analysis. It is easily possible that Huaccoto moraine or talus could be deposited by the Rio Huatanay below Pikillaqta which the Wari culture used in their walls. One question raised concerning this is why the Wari might use Huaccoto andesite with the Rumiqolqa material being so near at hand (less than 7 km distant). The logical suggestion is that the Rumiqolqa quarries would not have yet been developed. It is possible that Huaccoto material was used first at an late Wari-early Inca date, then Rumiqolqa material was used by Pachacuti, and finally Huaccoto material was again used in the colonial period. It is well known that Pachacuti's predecessors extensively used porphyritic augite diorite from the plateau on and above El Rodadero (Gregory,1916, 91-2; Rowe, 1946, 1988 pers. comm.; Agurto Calvo, 1987, 120-21), and Pachacuti appears to have been the first Inca to exploit the Rumiqolqa andesite for quarrying. If, accounting for a diversity of styles, much of the Ollantaytambo complex is conflated and portions such as the Inkamisana with Tiwanaku style granitoid stoneworking far precede Pachacuti's later arkosic phase at Ollantaytambo, then it could be suggested that early Inca (or even late Wari) stonemasons knew of the Huaccoto source of andesite and were responsible for its emplacement there in a minor way. Or a predecessor of Pachacuti who followed the initial building phase at Ollantaytambo set a tradition of using andesite which Pachacuti continued by developing Rumiqolqa quarries. This appears far-fetched, requiring as it does a whole string of speculative contingencies, but should be examined more closely.

Perhaps the primary difficulty with this provenance suggestion is the question of transport over a distance of more than 55 km between Huaccoto and Ollantaytambo, and the formidable wall of mountains between them without any obvious transport route. One suggestion is transport down the mountain followed by water transport down the Rio Huatanay to the Rio Vilcanota-Urubamba in the wet season, with portage where necessary. It remains to be seen how much the Incas used rivers as highways as the best routes through mountains. Certainly Inca engineering involved channeling, canalization, agricultural irrigation, aqueducts and other riverine modifications. Perhaps Inca engineers and mita workforce would find this no greater challenge than the others they mastered. For lack of evidence to support this idea, however, perhaps a source should be sought closer to Ollantaytambo.

In any case, the closeness of this Ollantaytambo context in terms of petrographic analyses to Huaccoto material cannot be overlooked. A better explanation is warranted than the suggestions tendered above for this archaeological and geological anomaly.

Pisaq

Another important Inca use of andesite for ashlars can be found at Pisaq, approximately 20 km overland from Cuzco on the Rio Vilcanota. Because it is downstream, Inca Pisaq is at an approximate elevation of 3310 m (10,920), with an archaeological complex covering at least 4 sq. km (not counting andene terraces) spread over the north bank ridge above the Vilcanota river. Pisaq has been widely discussed in the literature, including archaeological, architectural, and other discussions (Cook, 1916; Gasparini & Margolies, 1980; Agurto Calvo, 1987) with perhaps the most definitive as yet being that of Victor Vargas in his *P'isaq: Metropoli Inka* (Vargas, 1970).

The primary andesite context at Pisaq is the main structure, the Intiwatana or sun temple, which is itself built around and incorporated with a dark natural volcanic breccia bedrock forming the base and gnomon of the sun temple. The andesite ashlars here are finely worked in extant courses up to 2.5 m and have mostly weathered to a light pinkish hue. Samples were collected from fragments around the Intiwatana in 1988.

One of the most important questions to be resolved by the expedition undertaken with J.P. Protzen and D.R. Griffiths at that time was the location of the andesite source. No mention in the available literature suggested a likely source, other than unfortunately vague information about a local andesite source (Vargas, 1970,98ff.) without a geographic fix. The geological literature suggests some thin volcanic flows in the Pisac [sic] Formation but these appear to be west rather than north of the colonial Pisaq town and away from the ridge (Gabelman, 1964, 22).

One possible scree-filled canyon below the main ridge on which Intiwatana is built was suggested by Protzen as a possible Inca quarry. Northwest and approximately 0.3 km below Intiwatana on the west side of the stream Riachuelo Kitamayu and below Kalla Qasa was a widely-scattered scree area in which Griffiths found nearly-finished ashlars and in which Protzen found numerous hammerstones for working the material. Additionally, ramps and working platforms were identified by Protzen, Griffiths and Hunt. By all indications it was indeed an Inca quarry for some of the Pisaq complex, and both the size and weathering (pinkish hue) of the quarry ashlars approximated those features of the Pisaq Intiwatana above. This is the first suggestion that this is the andesite quarry for Pisaq.

Petrography

Petrographic analysis showed the material for both Intiwatana and quarry to be texturally and mineralogically identical within a 1-2% range of difference. Thin section examination showed two pyroxenes in a fine-grained matrix of mostly plagioclase feldspar. The plagioclase was almost microcrystalline whereas the pyroxene phenocrysts were phanerocrystalline. Any accessory minerals are probably too microlitic to identify. The groundmass is too fine-grained to identify constituent minerals, but it is likely that it is mostly made up of plagioclase and pyroxene. Vesicularity was almost nonexistent in this groundmass (Fig. 4).

This material from both the Intiwatana and the quarry can be considered as (two) pyroxene andesite, and based on the petrographic examination it is strongly suggested that determination of provenance is secure for this Riachuelo Kitamayu andesite quarry to be the Intiwatana source. Some discussion is necessary regarding this Pisaq andesite in its differences when compared to other known Cuzco province volcanics. In mineralogy this andesite would be common; pyroxene andesite being perhaps the most common worldwide. However, in the Cuzco province this is the only pyroxene andesite known to this researcher, others being known near Huaraz far north in some of the Western and Central Andean Cordilleras in the Calipuy Volcanics (Cobbing *et al.*, 1981). This singularity reinforces the match of Pisaq material and quarry. In texture this pyroxene andesite is distinctive: its tiny plagioclase laths in contrast to the phaneritic pyroxene phenocrysts aid in the determination of provenance which matches this quarry with the Intiwatana.

Conclusions

Based on petrographic and external examination (including stylistic features and weathering) which are available for the first time in integrated analyses, certain Inca contexts at Koricancha-Cuzco are matched in determination of provenance to the Rumiqolqa quarries; certain Inca and colonial contexts in Cuzco, and possibly Ollantaytambo and the Wari site of Pikillaqta (petrographic only) are matched in determination of provenance to the Huaccoto quarries; and the Inca context of Pisaq is matched in determination of provenance to the Riachuelo Kitamayu-Pisaq quarry newly identified in 1988. Chemical analyses are being done and thus far have confirmed the petrographic analyses but are not yet available for this report. These determinations are expected to be refined with additional analyses (e.g. electron probe microanalysis) as new and wider ranges of Inca material become available for examination in the Cuzco province and as better geological surveys and mapping add to geological understanding of volcanic material in this region.

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