ANALYSIS OF ORGANIC REMAINS FROM HUAMACHUCO QOLLQAS

Coreen E. Chiswell
University of California, Los Angeles

The Huamachuco Archaeological Project is a long term study being carried out in the north highlands of Peru. Although the project itself has a number of aims and interests, the work reported here was devised to address the identification of storage in architectural remains (Chiswell 1984).

Storage facilities have been identified in a number of locations in the Huamachuco region. The majority of the facilities are related to the Inca occupation of the area, but facilities dating to earlier times have also been found. However, there are also large sites in the area where storage has yet to be identified or is seemingly not present at all. Most notable in this category is the area's largest site, Marcahuamachuco, which was occupied and politically important for over six hundred years.

The absence of storage facilities at Marcahuamachuco is curious. Thè site itself is physically removed from any agricultural land and it does not seem unreasonable that food storage must have been undertaken, if for no other reason than to support the large population estimated for the city. Therefore, it seems likely that stockpiling at Marcahuamachuco occurred in facilities that have yet to be positively identified. Thus, the project was interested in considering methods of addressing this problem.

For a number of reasons, the choice of analytical technique fell to phytolith analysis. The study of botanical silica was originated by botanists and soil scientists, but has been applied to archaeological questions with increasing frequency in the past decade. However, there had been no previous application of the phytolith analysis for the purpose described here and it was necessary to "test" the technique under conditions permitting greater control over the variables involved. The application chosen was to consider the question of storage in more obvious facilities, the Late Horizon **qollqas** (storage structures) which were identified in the area in 1981 (Topic and Topic 1982:10).

To confirm the results of the phytolith work, it was necessary to draw on independent sources of information, and the qollqas were also submitted to more "traditional" methods of analysis--excavation and flotation. This research will be described first and then compared with the results of the phytolith study.

In terms of location, Huamachuco's storage complex seems to be most similar to the facilities associated with the site of Hatun Xauxa in the Mantaro Valley (Earle et al. 1980:30-35)--both are dispersed groups of storerooms arranged on the hills in the immediate vicinity of the Inca settlement (which, in our case, is thought to underlie the present day town of Huamachuco).

The Huamachuco storage facilities consist of five groups of qollqas on three hills southwest of town: Cerro Santa Barbara, Cerro Mamorco, and Cerro Cacañan. Cerro Santa Barbara is the largest of the groups and has 72 qollqas arranged on four terraces. However, preservation is not good and this count is a minimum, reflecting only the buildings which are still physically represented.

The size of the terrace system suggests that the original count may have been considerably larger. Cerro Mamorco has three rows of qollqas physically isolated from each other. Cerro Cacañan has the fewest storerooms, but also has a number of larger associated buildings, which are thought to have served administrative purposes.

The minimum number of Inca qollqas at Huamachuco is therefore 144. The storage facility is thus not a large one, particularly when compared with the figures available from Inca sites further south. A number of other differences from other known Inca storage complexes can also be identified.

Unlike the pattern reported elsewhere (for example, Morris 1967), both circular and rectangular building forms are not represented in the Inca facilities of Huamachuco. Rather, all five complexes consist exclusively of rectangular buildings of relatively uniform architectural characteristics. However, despite this difference, Huamachuco's structures are consistent enough with the general pattern of Inca storage (Morris 1971:137-138) to support their identification as qollqas. Built of stone, they are situated along the contours of the hills on which they are located. They average between 5 and 7 meters in length and 2.5 to 4 meters in width. Doors are rarely preserved, indicating that they were probably elevated; the door of one example at Cerro Mamorco was raised 35 centimeters above present ground level.

Excavations conducted at qollqas on each of the three hills have revealed interesting differences in structural detail between the three groups.[1] The Cerro Santa Barbara qollqas have three low parallel walls on which a raised floor was likely supported. The floor treatment of the Cerro Mamorco and Cerro Cacañan qollqas was somewhat different. The excavated examples on these hills are transected by three parallel subfloor canals, in all but one example. Where preservation is good, the canals proved to open through both the up- and downslope sides of the qollqa walls. Thus, excavation has revealed two very different approaches to floor construction that seem to occur in separate parts of the storage complex.

A consideration of the facilities with respect to the differing storage requirements of different products helps provide a tentative interpretation for the structural differences observed between qollqas (see also, Morris 1981). Of the two types of construction, the one that resulted in a raised floor (Cerro Santa Barbara) would probably have been the most effective means of minimizing humidity. The qollqas with canals would probably have been more humid inside because of the more direct contact with the soil below. In addition, humidity inside the qollqas could have been further raised by using the canals to channel water under the structures. From what is known of the storage requirements of maize and tubers, it might be hypothesized that maize and possibly other dry goods were being stored at Cerro Santa Barbara and tubers at the other two sites.

The analysis of the minimal amounts of non-modern plant material recovered by flotation tends to confirm this interpretation. Soil samples from the two qollqas excavated at Cerro Cacañan produced only modern botanical material with the exception of a very small amount of fragmentary wood charcoal. The Cerro Mamorco samples yielded slightly more material, including carbonized seed fragments of two unidentified, presumably non-food, species from the first qollqa, a few burned maize fragments from the third qollqa, and small amounts

of fragmentary wood charcoal from all three. The best recovery of botanical material was from the Cerro Santa Barbara samples, which produced much larger quantities of burned maize and wood charcoal. Thus, the storage facilities which were thought to be devoted to dry storage on the basis of their raised floors produced the most maize. The anomalous example in terms of this interpretation is the recovery of maize at Cerro Mamorco. However, it should be noted that while the structure involved did not have a raised floor, it also did not seem to have the sub-floor canals which were observed in the other buildings at the site and so is anomalous in terms of its structure as well as its contents. Thus, the general correlation of raised floors with maize and dry storage and of sub-floor canals and tubers would seem to hold.

Before turning to the work done with phytoliths, one other example of storage facilities in the Huamachuco area should be mentioned. These facilities, at the site of Cerro Amaru, are of interest because they present an interesting comparison to the facilities already described.

In addition to other architecture, Cerro Amaru has a group of structures arranged in four rows along the contour of the hill. The structures are made of unmodified stone and have a circular form approximately 6 meters in diameter. Despite all the features which would lead to their identification as another portion of the Inca storage facility, the ceramics recovered from excavation have led to a Middle Horizon assignment. This interpretation is supported by radiocarbon ages which are in marked contrast to those from the Cerro Santa Barbara qollqas:

Cerro Amaru	1270±80; A.D.	680 (UGa 4870)
	1550±60; A.D.	400 (UGa 4871)
Cerro Santa Barbara	395±75; A.D.	1550 (UGa 4661)
	475±65; A.D.	1475 (UGa 4662).

Notwithstanding the early date of the structures, excavation of two of the buildings identified a number of features that indicate they may have been constructed as storehouses. The inner wall of each example was ringed by a low bench and the floor bisected by a low wall. The upper- and lowermost points of the outer wall were perforated by holes which may have enhanced ventilation. Thus, it seems that the storage concerns were similar to those identified on Cerro Santa Barbara. A floor resting on the bench and medial wall and provided with ventilation would probably have served to create an environment of low humidity, favoring grains over tubers.

To summarize, the present picture of storage in the Huamachuco region is of a complex of structurally different rectangular qollqas dating to the Late Horizon and of a series of circular qollqas which date earlier. The former facility appears to have been devoted to both maize and tuber storage, whereas there is only evidence to suggest maize storage at the latter. It remains to discuss the attempt to use phytolith analysis to confirm or augment these conclusions.

The analysis of phytoliths has only recently been applied extensively in archaeological research. Numerous archaeological problems have been addressed by studies of phytoliths, ranging from paleo-environmental reconstruction to analysis of diet (Pearsall 1982; Rovner 1983). However, one of the most significant contributions has been made in the field of identifying cultivated species,

such as the work done towards identifying maize at Real Alto, Ecuador (Pearsall 1979:135-150). The success of studies such as these in identifying specific plants was one of the reasons for the decision to test phytolith analysis in the study of storage facilities. However, other reasons can be cited concerning the properties of phytoliths themselves and the shortcomings of alternative techniques.

Despite the fact that it has been used in other types of archaeological research, a number of reasons argued against the use of pollen analysis. Large amounts of pollen would not be expected in qollqa soils because of factors of preservation as well as the fact that the pollen-producing parts of plants are unlikely to have been stored. Such factors as contamination from airborne sources would further complicate the interpretation of any results obtained. In contrast, the properties of phytoliths make their presence in qollqa soils much more likely. Phytoliths are composed of a silica compound that is highly resistant to alteration. Unlike pollen, phytoliths are deposited into the soil at the site of plant decay and are less subject to wind transportation. Furthermore, studies have indicated that relatively little movement of phytoliths occurs within undisturbed soils once deposition occurs (for example, Beavers and Stephen 1958). Thus, one can expect to find concentrations of phytoliths in the immediate location of their deposition.

In addition to these factors, other arguments can be made to support the decision to use phytolith analysis in the storage situation outlined earlier. Evidence from other Inca studies indicates that different types of plants were stored separately, for no other reason than differing storage requirements (Morris 1981). Because of this separation, it is reasonable to expect that a limited variety of plants would be represented in any one qollqa. Thus, the phytolith sample from a qollqa should be simplified in terms of the number of forms recovered.

The amount of plant material present in a qollqa is also likely to be greater than in non-storage contexts. Although there is record of looting of stores by the Spanish, other evidence indicates that it is not unlikely that some stores were never removed from the qollqas. The chronicler Polo describes additions being made annually to qollqas even though some materials deteriorated before their use (Murra 1980:133). The recovery of macrobotanical remains from other highland storage situations (D'Altroy and Hastorf 1984:345-346) also suggests that at least some plants remained in the qollqas long enough to decompose and contribute their phytoliths to the qollqa soils.

The project undertaken involved two different types of analysis. Because phytolith work is a relatively young field, there are still large numbers of species which have yet to be studied in terms of their silica content. Predictions can be made on the basis of generalities--grass species tend to contain much more silica than non-grass species--but the discipline is far from the time when descriptive taxonomic guides will be available for even limited numbers of species. Complicating this issue is the fact that phytolith quantities and kinds vary between parts of plants as well as between species. For a study concerned with the identification of specific parts of specific plants, the necessary first step was to analyze these parts in order to characterize their silica content. Having accomplished this, the second step of the study was to extract the silica from soil samples taken from the qollqas and to analyze it with respect to the conclusions drawn from the first part of the study.

On the basis of ethnohistoric accounts and archaeological work elsewhere, a total of 35 plants or parts of plants were identified as storage possibilities. These samples included the edible portion of a variety of both highland and non-highland crops, as well as related items such as maize cobs and peanut shells. Also included were a number of plants which, although inedible, were also thought likely to have been present in storage situations. Included in this category are a number of grass species which may have been used in the packing of stored foods, particularly tubers.

The samples selected were submitted to acid digestion in order to liberate the silica from the surrounding plant tissue. The digestion process produces a dried sample which is mounted for microscopic analysis using Canada balsam (See Kaplan and Bonnier, Appendix, this volume). Biogenic silica assumes a number of forms depending on where it is deposited in the plant's cells. The first observation made was a note of whether silica was present and the relative amounts of each kind of silica. A more detailed analysis was then made of the plants which contained short cells, the type of phytoliths which have proved to be most profitably studied in previous research.

Four of the samples tested--peanut, peanut shell, pumpkin seed, and potato flesh--had either no silica or such small quantities as to be discounted from further analysis. The remaining samples had varying amounts of the various kinds. The majority of the samples had quantities of the kinds of silica which are considered to be relatively undiagnostic, but no short cells. However, seven samples were found to contain large enough numbers of short cells to be considered significant.

The seven samples with short cells in abundance were all, not surprisingly, members of the grass family: four varieties of maize cob,[2] **ichu** grass, caña brava, and an unidentified species of grass collected in the market from a **chipa**, a framework bundle stuffed with leaves used for carrying produce. Each of these samples was submitted to closer analysis and counts of the occurrences of the various short cell forms were made.

When phytoliths are mounted on slides, they become aligned in a number of different positions. It has traditionally been the case when analyzing such slides to ignore all phytoliths which are in a "rotated" position (Twiss, et al. 1969). However, recent studies have demonstrated that useful information can be obtained from the three-dimensional morphology of a short cell and increasing emphasis has thus been placed on trying to observe the shape of a short cell in all positions (Piperno 1984).

The approach adopted for this study is something of a compromise between the two extremes. The samples were mounted in a permanent medium in order to prevent sampling duplication and could not be rotated in order to observe all dimensions. However, observations were made of as many of the characteristics as possible for each short cell encountered. Three separate traits--shape-of-top, shape-of-side, and shape-of-bottom--were observed and classified in terms of a key that was devised on the basis of the forms observed in the plant samples. Approximately 240 short cells were recorded for each of the samples studied.

The plant analysis identified four plants--caña brava, "chipa", ichu, and maize--which could be distinguished from each other on the basis of their short

cells. This conclusion permits several suggestions to be made concerning the interpretation of the soil samples. Given that tubers are thought to have been stored in layers of vegetation, the recovery of a sample with a short cell distribution which resembles that of ichu or chipa might indicate the remains of tuber storage. On the other hand, a distribution which more closely resembles that of maize would lead to a different interpretation. Similarly a sample which strongly resembled that of caña brava would lead to a third interpretation based on the fact that caña brava has been recovered as part of fallen thatched roofs from other Huamachuco sites.

Obviously, these predictions are based on the assumption that the phytolith contribution from the plants involved in storage situations will be so high as to completely mask any other source of silica. Unfortunately, the results which have been obtained from the analysis of soil samples to date tend to prove this assumption to be overly optimistic.

Phytoliths are extracted from soil samples using the principle of flotation--because they have a lighter specific gravity than the matrix in which they are contained, phytoliths can be separated by floating the sample in a liquid with a specific gravity of approximately 2.6.

Extractions were carried out for a total of 25 soil samples representing 8 structures, as well as for control samples collected at each of the three locations where excavations were conducted in 1983 (Cerro Cacañan, Cerro Mamorco, and Cerro Amaru).[3] The samples were submitted to exactly the same analytical procedure as the plants--for each sample approximately 240 short cells were observed and characterized according to the classification key developed for the plant samples. The resulting data were then submitted to two different kinds of comparisons.

The first comparison was between all the soil samples from a single building and the corresponding control sample for the site involved. The purpose was to identify those samples which could not be distinguished from the controls and which could therefore be considered as contaminated or indicative of nothing more than the soil naturally present at the site. Then the soil samples were compared to the plant samples to see if any specific plants could be identified.

The result of the first part of the analysis was the identification of two structures in which none of the soil samples could be distinguished from the control sample. These two structures at Cerro Cacañan were thus not included in the remaining analysis because there was nothing to differentiate their soil from that of the rest of the hill.

When compared with the information collected from the plant samples, five of the six remaining qollqas yielded at least one positive result. All of the positive identifications except one were with the species of ichu grass. On the basis of these results it would seem that ichu was present in both of the Cerro Amaru storerooms tested, as well as in all three of the excavated Cerro Mamorco qollqas. The sole remaining positive identification was of blanco maize cob at one of the Cerro Amaru storerooms.

Interpretation of these results is somewhat equivocal. One of the Cerro Amaru storerooms produced evidence of maize, the crop predicted to be stored at that site. The Cerro Mamorco qollqas produced indications of ichu, which

may represent the packing material that would be expected in conjunction with tuber storage (again the crop predicted for the site). However, the evidence of ichu at Cerro Amaru confuses the whole picture. This grass may represent fallen roofing material, in which case the interpretation of the Cerro Mamorco qollqas must also be called into question. Therefore, the results of the phytolith work with respect to the question of storage must be considered somewhat conditional.

In conclusion, it should be emphasized that there exist a number of possibilities for the refinement of the techniques adopted here. An analysis of all forms of silica, and not just the short cells, may augment the information available from analysis. An increase in the number of samples collected and processed from storage sites might identify sources of variation that have been masked in this study. And the analysis of more plants native to the Huamachuco region, particularly the grasses, may help to clarify some of the external sources of contamination. Thus, the analysis of phytoliths in storage situations has yet to reach the stage of refinement at which it could be usefully applied to the situation at Marcahuamachuco described in opening. However, with continued research the technique would still seem to hold considerable promise.

Acknowledgments

I would like to thank Drs. John and Theresa Topic of Trent University for the opportunity to conduct this research and for all their assistance during its course.

Notes

1. Three qollqas on Cerro Mamorco, two on Cerro Cacañan, and an associated structure on Cerro Cacañan were excavated in the 1983 field season. This information was augmented by the excavation of parts of four qollqas on Cerro Santa Barbara in 1982. Unfortunately, no soil samples from the Cerro Santa Barbara qollqas were available for phytolith analysis.

2. Short cells were present in the maize kernel samples, but only in relatively small numbers. The forms of the short cells were identical to those observed for the cob samples and it is likely they are the result of pieces of cob adhering to the kernels after shelling takes place.

3. Control samples were taken in the vicinity of each group of qollqas (but removed from the actual architectural remains) in order to assess the nature of the phytoliths contributed by the naturally occurring vegetation in each area.

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