PIRURU: A PRELIMINARY REPORT ON THE ARCHAEOLOGICAL BOTANY OF A HIGHLAND ANDEAN SITE

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As part of a larger archaeological project, we are engaged in the analysis of plant remains from Piruru, a highland Andean site in the Department of Huanuco. Although our investigations include plant remains of all types, the present report discusses only biogenic opals, or phytoliths, since this class of biological microfossil is relatively little known to Andean archaeologists.

The site of Piruru in the Department of Huanuco is located on the right slope of the Rio Tantamayo at 3800 meters mean elevation above sea level. From the present day village of Tantamayo, the site is reached by a 2 to 3 hour climb to the edge of the puna. Piruru is an open site marked at the surface by fortifications of the Late Intermediate Period which cover an area of about 4.5 hectares. The current excavations have been in progress since 1981, particularly in lower levels in which a rectangular platform was discovered by Girault in 1970 (Bonnier et al. 1983). This structure and another like it are composed of a fill of rocks and soil contained by a low wall of 2 courses of standing stones. The original platform probably dates to the Preceramic Period. The Formative Period is also represented at the site . . .

Since 1981 Bonnier and Rozenberg have directed the project. They have designed the excavations to comprise 3 units: Unit I/II, 15 meters square; Unit III, 40 meters square; and Unit IV, 30 meters square. By the end of the 1983 season the excavation of Unit I/II had been completed. A maximum depth of 3.8 meters is recorded. Considerable progress has been made in Units III and IV and the excavations may be completed during the 1985 field season.

A stratigraphic summary as recognized by Bonnier and Rozenberg primarily on the basis of Unit I/II excavations shows a substantial hiatus in occupation between Early Formative and Late Intermediate phases. Table 1 summarizes the occupational sequence.

Because Piruru is an open site the contents of the site are subjected to precipitation moisture which would affect organic materials in a way different from materials protected in a cave or rockshelter site. The influx of plant remains growing at the surface of an open site may be quite different from what might be encountered in the case of a sheltered site. Soil pH at the site ranges from about 5 to above 6, moderately acid to nearly neutral. Animal bones are only rarely encountered, and the

distribution of calcium and other exchangeable ions suggests substantial leaching, but the phosphorus content suggests that bones may have decomposed in the soil.

TABLE 1

PHASES OF OCCUPATION	ARCHITECTURE
PIRURU TANTAMAYO Late Intermediate	FORTIFIED SETTLEMENT
Fill.....	
PIRURU PIRWA Early Formative	CIRCULAR STRUCTURES
PIRURU WAYTA Preceramic	PLATFORMS
PIRURU WAKCHA Preceramic	SUBTERRANIAN CONSTRUCTION

So far, pollen preservation has not been good in those samples which we have extracted. A marshy area a few miles from the site has good pollen preservation but lacks sufficient depth for adequate coring. Extracts from the marsh surface show an overwhelming proportion of grass pollen and palynomorphs from nonseed plants (Kaplan and Bonnier, excerpt from a paper presented at the Society for American Archaeology Annual Meeting, Denver, May 2, 1985).

Grasses are important in the domestic economy of the Andes and are major components of the vegetation, which varies with elevation in its species composition. Because of these interacting factors and the interest of Andean prehistorians in the economic integration of vertically distributed environmental zones, we chose to include a study of phytoliths in our project.

The present vegetation in the vicinity of the site is heavily cropped by domestic animals and probably by small wild herbivores. Thorny shrubs are the most conspicuous aspect of the dry season vegetation, since grasses tend to be closely cropped by domestic animals, especially sheep and a few bovine cattle that belong to the family whose residence is adjacent to the site. Small wild animal species no doubt account for a considerable share of the total herbivore effect. Above the site, the bunch grasses and cushion plants predominate and it is this area that provides much of the **paja** (straw and thatch) that is used for domestic purposes. At this stage of the project, we do not sufficiently understand the pattern of plant exploitation of the area to know how much of the useful grasses are obtained locally and what fraction must be brought in from a distance. The crops grown locally are **oca**, *Oxalis tuberosa*; **ullucu**, *U-*

lucus tuberosa; **mashua**, *Tropaeolum tuberosum*; the Andean potato, *Solanum tuberosum*; and **quinoa**, *Chenopodium quinoa.* Oats are grown at a lower elevation, about 3400 meters.

We have completed or have in process the analysis of over 60 soil samples for phytoliths from the site and several from offsite controls. The latter are taken from a boggy area which receives run-in from surrounding grass-covered hills, from a walled corral which has been used as a sheep pen, and from the soil surface within the confines of the site.

Rovner (1971) introduced phytolith analysis as a method for analysis of archeological sediments. Pearsall (1982) has reviewed the use of the procedure and has employed phytolith analysis in the detection of maize present in coastal Ecuador (1978) and in the botanical analysis of Cotocollao, in the province of Quito (personal communication, 1984). The results of these studies suggests that the method merits wider use in Andean archaeology and vegetation analysis.

Although phytoliths have been shown to be abundant in nongrass plants (Piperno and others, personal communications), they are particularly well known in grasses and for this reason can be expected to be particularly abundant in the **puna** and **suni** vegetation zones. The taxa of grasses that are best represented in the puna climatic zone are those belonging to the subfamily pooideae (= festuceae) which carry on C3 photosynthesis. C3 grasses (the Calvin-Benson photosynthetic cycle) are characteristic of grasslands having growing season temperatures of 60 - 78 degrees F (15 - 25 C) (Gould and Shaw 1983:50). C4 photosynthesis typically carried on by many grasses of the paniceae subfamily is most efficient at high growing season temperatures above 80 degrees F (30-40 C) (Gould and Shaw, 1983: 50). This, of course, is much higher than the temperature typical of the puna climate during the growing season. Certain phytolith types, particularly a dumbell-shaped or bilobate type, are so specific to the paniceae that their presence and relative frequency can be used as an indicator to differentiate paleoclimates in some geographic areas. Contemporary ecological correlations of temperature, elevation, and photosynthetic carbon cycle in East Africa (Livingstone and Clayton 1980) are sufficiently regular so as to permit paleoclimatic reconstruction based on fossil grass cuticles in that area. Such correlations have not yet been established in the Andes.

At Piruru we are in the process of collecting and analyzing soil samples for both pollen and phytolith remains. Relatively little pollen is present or well-preserved. We, therefore, place greater emphasis in our microfossil studies on phytolith analysis. Soil samples are collected along with flotation samples so that when the analysis of seed and wood flotation materials has been completed, comparisons of macro- and microfossil remains may be made.

Extracted phytoliths suspended in 100% ethanol are dropped onto a glass microscope slide. The ethanol is evaporated, canada balsam, cedar oil, or another high refractive index medium is added, the phytoliths are stirred into the mounting medium with a wooden applicator stick, and a cover glass is added (See Appendix). The phytoliths may then be examined by optical microscopy. A series of reference slides has been assembled by processing herbarium materials collected in the vicinity of the site.

Our classification of phytolith types is based on that of Twiss, Smith, and Suess (1969) as modified by various workers especially Brown (1984) and Mullholand (personal communication). The term "panicoid" in general use by phytolith analysts for the bilobate or dumbell form suggests that this type is characteristic of the Paniceae subfamily of grasses. This usage is appropriate in midcontinental North America, where almost all of the phytoliths of this type do indeed derive from species of this subfamily. However, the term cannot be usefully applied in the puna where the bilobate "panicoid" phytolith form is abundant but where there are probably no species of this subfamily represented. The importance of this circumstance has become apparent in the current study and is presented here to serve as a caution to other workers and to avoid misunderstanding.

In some of our counts, bilobate phytoliths reached 9-10%. This count is unexpectedly high at a mean elevation of 3800 meters in the Andes if the source of bilobates are grass species within the paniceae. This initial assumption in our study was based on North American (Twiss et al. 1969) and East African (Livingstone and Clayton 1980) findings concerning the distribution of panicoid and festucoid grass species. We speculated that the bilobates in our site samples might have been derived from woody panicoid grasses brought up from low elevations on the eastern slopes of the Andes. A study of our marsh sample and recently received plant collections showed that the bilobates were present in offsite control sediments and in a festucoid grass *Stipa* sp.. Gould and Shaw (1983) record the presence of bilobates in this genus in North America, but the abundance of these phytolith types in some of our samples was unexpected.

As far as we have gone in the analysis, it appears that phytoliths are well preserved in these soils, that differences between surface control samples and prehistoric sediments may be discerned, and that differences occur in the percentage composition of phytolith types in different parts of the site. With respect to the significance of the panicoid (bilobate) phytolith type occurring in these prehistoric sediments, we emphasize that even the most general application of a north temperate (or East African) model to a highland Andean system may be completely wrong. We are continuing our analysis in an attempt to utilize phytolith evidence to recognize activity areas within the site, to distinguish sterile fill from culturally derived matrix components, and to detect any evidence for vegetation change.

Our phytolith study will complement our study of other botanical remains at Piruru, but it is too early to know whether phytolith analysis will provide results which are independently significant. It may be that the ubiquity of grasses in the puna and the extensive utilization of the genus *Stipa* results in a uniformity of deposition, a blending of the natural vegetation with culturally derived sources, that will make interpretation difficult. Whether or not independent significance becomes apparent, it is clear that to achieve any usable results at all, a well developed set of reference materials is absolutely necessary and offsite controls are essential.

We hope to extend our site-related studies to a larger examination of phytolith types, their distributions in highland Andean soils, and their relationship to the vegetation and its changes.

References

Bonnier, Elisabeth, R. Howard, L. Kaplan, and C. Rozenberg
1983. Recherches Archeologiques, Paleobotaniques et Etnolinguistiques Dans Une Vallee Du Haut Marañon (Perou): Le Projet Tantamayo Piruru. *Bulletin de l'Institut Français d'Etudes Andins* XII(1-2):103-133.

Brown, Dwight A.
1984. Prospects and Limits of a Phytolith Key for Grasses in the Central United States. *Journal of Archaeological Science* 11:345-368.

Gould, Frank W. and R.B. Shaw
1983. *Grass Systematics*, 2nd ed. Texas A & M University.

Livingstone, D.A. and W.D. Clayton
1980. An Altitudinal Cline in Tropical African Grass Floras and its Paleoecological Significance. *Quaternary Research* 13:392-402.

Pearsall, D.M.
1978. Phytolith Analysis of Archaeological Soils: Evidence for Maize Cultivation in Formative Ecuador. *Science* 199:177-178.
1982. Phytolith Analysis: Applications of a New Paleoecological Technique in Archeology. *American Anthropologist* 84:862-871.

Piperno, D R.
1984. A comparison and differentiation of Phytoliths from maize and wild grasses: use of morphological criteria. *American Antiquity* 49:361-383.

Rovner, I.
1971. Potential of opal phytoliths for use in paleoecological reconstruction. *Quaternary Research* 1:343-359.

Twiss, P.C., E. Suess, and R.M. Smith
1969. Morphology and Classification of Grass Phytoliths. *Soil Science Society of America, Proceedings* 33(1):109-115.

APPENDIX
Phytolith Procedures

Soil Extraction Procedure adapted from various sources for use with highland Andean soils.

If soil sample is devoid of clay, omit 1 - 6. For acid soils delete 7.

(1) Put soil sample (about 100 gm) in 500 ml beaker.
(2) Add distilled H_20 to fill beaker.
(3) Add 10 g Calgon and stir well.
(4) Let settle overnight, and decant off liquid.
(5) Repeat steps 2-4 about 5 times.
(6) Wash sample w/DH_2O and let settle overnight, decant liquid through a fine brass or stainless steel screen. Discard the large particles in the screen.
(7) Test the sample which has passed through the screen for presence of carbonates by adding 2 ml of 10% HCl to sample--if no bubbling proceed to next step--if there is a reaction, add 10% HCl to sample and let stand overnight, or until reaction ceases. Decant liquid.
(8) Place 5 - 10 ml of wet sample into watch glass and dry in oven.
(9) When sample is dry, transfer to 50 ml beaker or flask.
(10) Add 30 ml chromic/sulfuric commercial glass cleaning solution and let stand overnight. If solution is very thick, add more chromic/sulfuric and allow to digest for at least 4 hours more, longer if necessary.
(11) In hood, add carefully DH_2O to beakers of sample to 50 ml to double volume in beaker. Contents of beaker will heat.
(12) When cool, pour sample into a large centrifuge tube (polypropylene 50 ml).
(13) Centrifuge for 5 minutes at #3 in a bench top clinical centrifuge, decant, and wash 2X.
(14) Transfer pellet to a 15 ml tapered glass centrifuge tube and wash (dehydrate) with 100% ethanol 2X, agitating w/vortex agitator and stirring w/wooden applicator stick before centrifugation.

Continue extraction with tribromomethane (bromoform) according to the method of Rovner (1971) or with zinc chloride as follows.

(15) Add $ZnCl_2$ solution (adjusted to specific gravity of 2.4 at which point a glass microscope slide will remain suspended in the solution). Mix well with applicator stick and centrifuge at #3 for 1/2 hour.
(16) Decant supernatant into 2nd 15 ml centrifuge tube (tapered glass). There will be about 6 ml supernatant in tube.
(17) To 2nd centrifuge tube containing supernatant, add water to 12 ml (mix well, centrifuge, and decant). Water should have lowered specific gravity so that phytoliths sink into pellet.
(18) To the 1st pellet add more zinc chloride as in step 15. Repeat steps 15-17 2X each time adding supernatant from heavy liquid centrifugation to 2nd centrifuge tube.

(19) Discard remaining sample from 1st centrifuge tube. Wash sample in 2nd tube w/distilled water 3X (centrifuge at #3 for 5 minutes) with thorough mixing between.
(20) Wash sample w/95% ETOH 2X as in (19).
(21) Transfer pellet to small vial, rinsing centrifuge tube w/95% ETOH.

(22) To make permanent slide:

a) Place 3 drops of sample suspension (phytos in ETOH) onto a microscope slide.

b) Place on slide warming tray and allow ETOH to evaporate.

c) Add 3 drops of dilute Canada balsam in xylene (about the consistency of vegetable oil). Other high refractive index mounting media suitable for diatoms may be used.

d) Add coverslip immediately.

e) Allow slide to remain on slide warmer to evaporate xylene and harden Canada balsam.

f) A nonhardening high contrast mounting medium such as cedar oil may used in place of a hardening medium in order to facilitate the rolling over of phytoliths during examination.