Paleotopography and Phosphate Analysis of a Buried Jungle Site in Ecuador

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The Western Pichincha Project, a survey and excavation program on the western flank of Ecuador's northern Andes, has so far comprised the discovery of more than 230 archaeological sites and the preliminary subsurface testing of one multi-component site, Nambillo. The Nambillo site is a very long, narrow, ridgetop site in the rainforest. It contains a series of superimposed buried soils, each of which yields cultural remains and which taken together range in age from 1500 b.c. (radiocarbon years) to the Conquest. The Nambillo site presented particularly difficult conditions for subsurface exploration because of the buried soils and the very dense vegetation. The implementation of a systematic soil-coring strategy and the collection of buried soil samples for phosphate analysis at Nambillo have resulted in a detailed reconstruction of the site stratigraphy, of ancient landforms at the site, and of human activity areas. These reconstructions permit the elaboration of a suitable excavation strategy for future study of the site without recourse to random-search tactics of excavation.

Introduction

The Western Pichincha Project is an ongoing archaeological exploration of the western flank of the Andes in northern Ecuador's Pichincha province. Fieldwork on the project began in 1984, and the first stage comprised nearly two years of pedestrian surveys over the very rugged sub-Andean slopes and subtropical and tropical rainforests that separate the highland basin of Quito from the Pacific coastal lowlands (FIG. 1, inset). More than 230 prehistoric sites were catalogued in this mostly-unexplored region, permitting the construction of archaeological culture areas and tentative regional chronologies. A wide variety of culture-historical topics are being addressed on the basis of this regional survey, including the identification of "lost" protohistoric Indian settlements, the tracing of ancient trading routes, the study of a widespread mound-building complex, and the determination of coastal and highland influence on local ceramics, among other problems (see Lippi 1987 for a summary of this work).

The second stage of the Western Pichincha Project, still in its early phase, involves the subsurface exploration of selected multi-component sites. Fieldwork at the subtropical rainforest site of Nambillo (OPQuMi-7) was carried out over six months from mid-1985 to the beginning of 1986, and the successful utilization at Nambillo of a strategy of systematic coring and phosphate testing is the subject of this article.

The Nambillo Site

The archaeological site of Nambillo is in Mindo parish to the WNW of Quito and the volcanic massif of Pichincha. The San Lorenzo Cordillera, a narrow sub-Andean ridge, leads down from Pichincha Volcano and runs northwesterly to the Valley of Mindo (FIG. 1). A winding dirt road approximately 10 km in length from the village of Mindo was opened a few years ago by local residents, and the existence of this road permitted a survey of a part of the ridge to be carried out in 1984 by project personnel. A nearly continuous distribution of artifacts was encountered along the entire length of the road, with various prehistoric periods represented. This distribution, coupled with the fact that ethnohistoric data indicate a dispersed population rather than nucleated towns, led me to postulate that the 10 km or so of cultural remains represented the vestiges of numerous, relatively isolated farmsteads that tended to overlap somewhat through the millennia. It is worth noting that there are no permanent inhabitants of the ridge today, other than a few transhumant families attempting to carve small pastures out of the mostly untouched (in recent times) rainforest.

In the section of the road farthest from Mindo, we discovered many sherds virtually identical to those from the Cotocollao Phase of the highland area of Quito (approximate age in the Quito area: 1500–500 b.c. [according to Villalba n.d.] and 2000–500 b.c. [according to

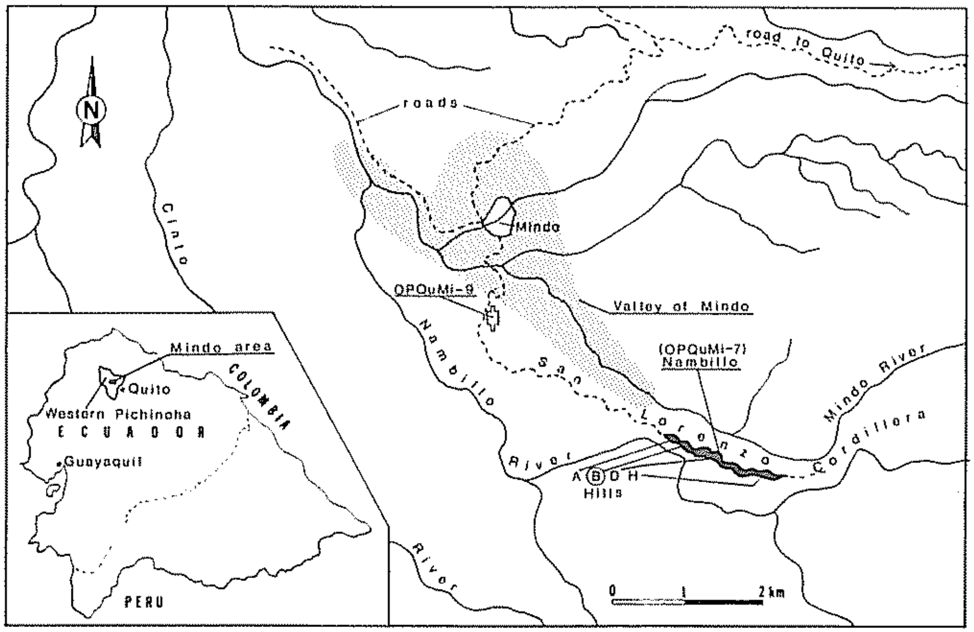


Figure 1. Map of the Mindo area showing the location of the Nambillo site along the San Lorenzo ridge. Inset shows the Western Pichincha research region and the Mindo area within Ecuador.

Porras 1982: 247]). It was possible to observe in the road cuts a series of three discrete, superimposed paleosols, each developed on sediments of volcanic origin and separated by sterile tephra strata. Each paleosol contains archaeological remains of a distinct period and the lowest one (designated Paleosol 3) produced the Cotocollao ceramics, which belong to Ecuador's Formative Period. Paleosol 2 appears to contain an immediately post-Cotocollao occupation that lasted into the first centuries A.C. The uppermost buried soil, Paleosol 1, consists of a series of superimposed cultural deposits spanning several centuries before the Conquest and a post-Conquest occupation no later than the 1660 eruption of Pichincha.

Given the accessibility of the site, its clear and deep stratigraphy, the presence of a discrete Formative occupation (the study of which is one of the principal goals of the project), and its proximity to a major protohistoric settlement and trail system,[1] it was decided to make a preliminary subsurface evaluation of the site in the latter part of 1985, during months when the weather is less rainy than usual.

Nambillo is a long, narrow site straddling the high ridge of the San Lorenzo Cordillera between the Mindo and Nambillo Rivers at about 1500–1600 m above sea level and some 300 m above the nearby valley floor. The zone of Mindo is classified as very humid, pre-montane forest, and it is still covered to a large extent by jungle vegetation. The mean annual temperature is between 18° and 22°C and precipitation between 2000 and 3000 mm. The principal products of the zone today are sweet manioc, plantains, lemons, sugar cane, lumber, cattle and—in smaller quantities—maize, guayaba, *Xanthosoma* sp., and tobacco.

Subsurface Testing at Nambillo

Even though archaeological remains occur all along the exposed ridgetop from Mindo at least to the end of the dirt road, a distance of some 10 km, the area of prime interest, due to the visibility of Formative Period remains and the three well-defined paleosols, is 1900 m long and was divided into eight sectors corresponding to the eight hills occurring one after another along the undulating ridgetop. The width of the habitable zone along the top

1. Although the Nambillo area today is uninhabited and difficult to reach, such was certainly not the case in late prehistoric times. A very large earthen pyramidal mound (OPQuMi-9) located on the same San Lorenzo ridge but near the present town of Mindo (FIG. 1) was quite possibly the site of the civic/ceremonial center of the native "town" of Mindo referred to in early colonial documents. This important settlement of Yumbos (the late prehistoric and early historical inhabitants of the region) was connected to the thriving, densely-populated highland region around Quito by a series of trails used by traders. Based on ethnohistoric data and our own archaeological survey, it is very likely that at least three such trails followed the San Lorenzo Cordillera out of Mindo, passed through Nambillo and then divided to reach Quito by different routes.

Figure 2. Hill D at Nambillo showing the author laying out radials prior to soil coring. The clearing in the center foreground corresponds to the 180° line. The vegetation seen here is typical of that over the entire site.

of the ridge varies from about 3 m to about 150 m. On either side of this zone the slope is very steep, and there is very little or no habitable area down to either river. Given these dimensions, the very dense vegetation, a small workforce, and the imperative to evaluate the potential of the site in a single field season, it was necessary to devise a strategy that would permit a subsurface reconnaissance of the site and its three buried soils with a minimum of effort.

Two traditional archaeological methods, the excavation of numerous test pits and controlled surface collecting, were inappropriate in this case. The number of test pits required for a meaningful sample would have been very high, resulting in a minimal amount of information in spite of significant expense in time and energy, and with the destruction of a substantial part of the local archaeological record as well. The modification of this method to one of shovel-testing would not have been an improvement given the deeply-buried cultural horizons. Controlled surface collecting would have been useless since the modern surface is culturally sterile. A solution to the methodological problem was obtained from soil science. Both soil coring and phosphate analysis are pedological methods familiar to most archaeologists. What is unusual about the present study is that these two methods were used systematically and in combination as the primary testing strategy. They proved to be extremely valuable in solving a variety of problems related to the testing of a large, deeply-buried, and heavily-forested site.

Method I: Soil Coring and Stratigraphic Analyses

Soil coring was carried out at Nambillo using a soil probe made to our specifications in Ecuador, with an 8-cm-diameter cylindrical soil collection tube and a series of galvanized pipes that would allow us to obtain cores from as deep as 4 m below the surface. While one person did the coring, a second person maintained a detailed record of soil and sediment horizons, depths, artifacts recovered from the probe, and samples collected for phosphate testing. Since the various hills to be tested were approximately circular or elliptical in plan, a coring strategy was selected using a datum point near the central, high point of each hill with soil probes located at 5-m intervals along radial lines 30° apart (FIG. 2).

In general, the upper boundary of each paleosol is abrupt and well defined, and its depth could be determined with a precision of ± 3 cm. On the other hand, the base of each paleosol presents a gradual transition to the underlying stratum, and it was not possible to measure the base depth so precisely. These two situations are expectable, considering that the paleosols are the result of the gradual development of an organic soil horizon, while the sediments in which the soils form are of volcanic origin and were deposited instantaneously upon firm, compacted surfaces.

This method of soil coring by radial sampling was carried out on the three elevations of Nambillo designated Hills A, B, and D; the same work on Hill H was in progress when increased rainfall and other factors forced the close of the field season. All coring was done manually and proved to be quite arduous because of the clayey texture of the weathered parent material. Four local residents were trained in the coring procedure, and one of these eventually assumed the task of recording the stratigraphic data and collecting soil samples. This freed the project archaeologists to conduct stratigraphic excavations at selected locations on hills that had already been cored.

The soil coring was extremely valuable for five reasons. First, the probes provided efficient access to the deeply-buried paleosols and could be performed by non-archaeologists. Second, the coring permitted a reasonably detailed look at the stratigraphy of the hills prior to their excavation. This in turn allowed subsequent excavations to be carried out stratigraphically without depending on more destructive and less useful test pits. Third, the soil probes were only 8 cm in diameter and did not themselves destroy a significant part of the archaeological record. The method results in a minimal disturbance of the cultural context. Fourth, the 8-cm cores yielded a number of artifacts that were accurately located within the stratigraphic columns. The presence of several artifacts (mostly small sherds and some flaked stone) within a particular paleosol in adjacent cores was taken as indicative of a high concentration of cultural remains in that area. The validity of that assumption can be tested during subsequent excavations.

Finally, the stratigraphic data could be used to make "paleotopographic maps" of each of the paleosols (see Stein 1986). That is to say, one can interpret the subsequent excavation data in relation not to the modern surface but rather to the surface that existed during the prehistoric period in question. The importance of these systematic reconstructions is substantial for an adequate understanding of the nature of the settlement pattern. A series of these paleotopographic reconstructions will be presented, but first it is necessary to summarize briefly the general stratigraphy of the site.

The Stratigraphy of Nambillo

Table 1 presents the generalized stratigraphy for the site. The data come from the soil cores, although the road cuts and the later stratigraphic excavations were utilized to confirm the information provided by the cores and to establish more accurately the base of each paleosol. Radiocarbon dates available from the site are also included.

The humus of Stratum I is of recent formation and is culturally sterile on the hills that were tested. The sediments of Stratum II almost certainly were deposited by the 1660 eruption of the active caldera of the Pichincha massif, known as Guagua Pichincha. This powerful explosion in historical times deposited tremendous quantities of ash and pumice on the western flanks of the volcano, including the area of Nambillo. Stratum III, with properties of both II and IV, is the result of the natural mixing of those two strata over time.

Paleosol 1 (Stratum IV) developed in the ash of Stratum V with the accumulation of forest detritus and the breakdown of ash, resulting in a black, clayey horizon. This was the ground surface before 1660 and it supported a series of human occupations through time. That these occupations belong to the late prehistoric and to the early colonial periods is suggested by four kinds of evidence: their position immediately beneath the sediments deposited in 1660; the similarity of the ceramics with those associated with earthen platform-mound construction in the Northern Sierra of Ecuador (estimated to date between a.c. 1250–1525 [Athens 1980: 126]); the presence in an intermediate level of the tibia of a horse or ass (*Equus* sp.), animals introduced by the Spanish; and by the series of radiocarbon dates, mostly between 800–1000 b.p.[2]

Strata V–VII are absent from several cores. This is almost certainly due to the effects of differential erosion of pyroclastic deposits. Strata V and VII are sterile volcanic sediments and VI (Paleosol 2) is an organic horizon developed within the VII sediments. In general, the ash and pumice were eroded from the higher elevations and finally settled in the low areas of the site. This differential accumulation of sediments following each of the volcanic episodes, which resulted in a partial or complete blanketing of the area and disruption of human habitation, has re-shaped the local relief very markedly. It is necessary to reconstruct the previous relief in order to approach an understanding of the local settlement system. This was accomplished, as will be shown, using the coring data.

2. The tibia was discovered in level 5 of Paleosol 1, beneath levels 3 and 4 with ^{14}C dates, respectively, of 820 ± 75 b.p. and 895 ± 75 b.p. The occurrence of a post-Conquest animal in this pre-Conquest context can most easily be explained by positing that the bone was within an aboriginal pit that went unrecognized due to the homogeneous blackness of the entire paleosol. Such a pit would have been dug during an occupation associated with levels 1 or 2, which are undated but necessarily fall between 820 b.p. and A.C. 1660. The possibility that the tibia intruded into level 5 of the paleosol after 1660 can be confidently ruled out since any disturbance through the yellow, sandy volcanic sediments would have been very conspicuous.

Table 1. Generalized stratigraphy for the site of Nambillo. Available dates (in radiocarbon years) are included for each paleosol.

Stratum	Description	Thickness (cm)
I	Humus, sandy silt with decaying organic matter, Munsell 10YR2/2 (very dark brown)	15
II	Volcanic sediments, ash, coarse pumice sand and fine pumice gravel, 2.5Y5/4 (light olive brown)	20–30
III	Transition between Strata II and IV, sand and clay, 10YR3/3 (dark brown)	15
IV	Paleosol 1 (buried anthropic epipedon), clay, 10YR2/1 (black) ^{14}C: 820 ± 75 b.p. (GX-12475), 895 ± 75 b.p. (GX-12476), 905 ± 130 b.p. (GX-12478), 995 ± 70 b.p. (GX-12477), 1015 ± 130 b.p. (GX-12474), 1665 ± 75 b.p. (GX-12479)	70–80
V	Volcanic sediments, ash, coarse pumice sand and pumice gravel, variegated	0–20
VI	Paleosol 2 (buried anthropic epipedon), clayey silt, 10YR3/2 (very dark grayish-brown) ^{14}C: 1665 ± 200 b.p. (GX-12467), 1775 ± 75 b.p. (GX-12466), 2095 ± 80 b.p. (GX-12465), 2515 ± 85 b.p. (GX-12468)	0–50
VII	Volcanic sediments, several indistinct bands of ash and pumice sand of varying coarseness and color	0–140
VIII	Paleosol 3 (buried anthropic epipedon), clay, 10YR2/1 (black) ^{14}C: 2315 ± 260 b.p. (GX-12472), 3225 ± 260 b.p. (GX-12469), 3330 ± 80 b.p. (GX-12473), 4540 ± 80 b.p.* (GX-12470), 5325 ± 110 b.p.* (GX-12471)	25–55
IX	Weathered ash C horizon, clay with cementation, 5YR5/8 (yellowish red)	
	Total depth:	145–405

*These dates are too old for the Cotocollao Phase and may pertain to wood charred by an earlier volcanic eruption.

Paleosol 2, where it does exist as a discrete horizon, is thinner and contains less organic material and less clay than either of the other paleosols. The presence of ceramics that seem to derive from late Cotocollao types and radiocarbon dates that nearly overlap with Cotocollao suggest that Nambillo was re-occupied after a relatively short hiatus following the volcanic activity that deposited the very thick Stratum VII.

Paleosol 3 (Stratum VIII) is macroscopically similar to Paleosol 1, although 3 is thinner and much more ancient. Near the base of Paleosol 3, the sediments are more cemented and more reddish-yellow, as the organic horizon gradually blends into the underlying parent material. The presence of cultural material in this transitional zone suggests that the first human occupation of the site occurred almost directly over the parent material, in which a soil was just beginning to develop, although mixing and trampling probably resulted in the downward movement of some artifacts.

Stratum IX, which corresponds to the weathered and somewhat cemented parent material, belongs to the Silante Formation deposited mostly in the Upper Cretaceous and consists of volcanic sediments with intermittent lava and rocky materials. One can observe this formation to a depth of 10 m or more in various road cuts in the zone of the San Lorenzo Cordillera, and there is no evidence of pre-Formative Period occupations overlying it.

The Paleotopography of Nambillo

Having described the general stratigraphy of Nambillo, it is possible to return to the matter of the ancient surfaces of the site. Hill B has been chosen to illustrate the methods and results for the remainder of this report; it is here where the most dramatic changes in the shape and size of the hill occurred through time.

Figure 3 is a topographic map of the modern surface of Hill B based on elevation data from the soil core lo-

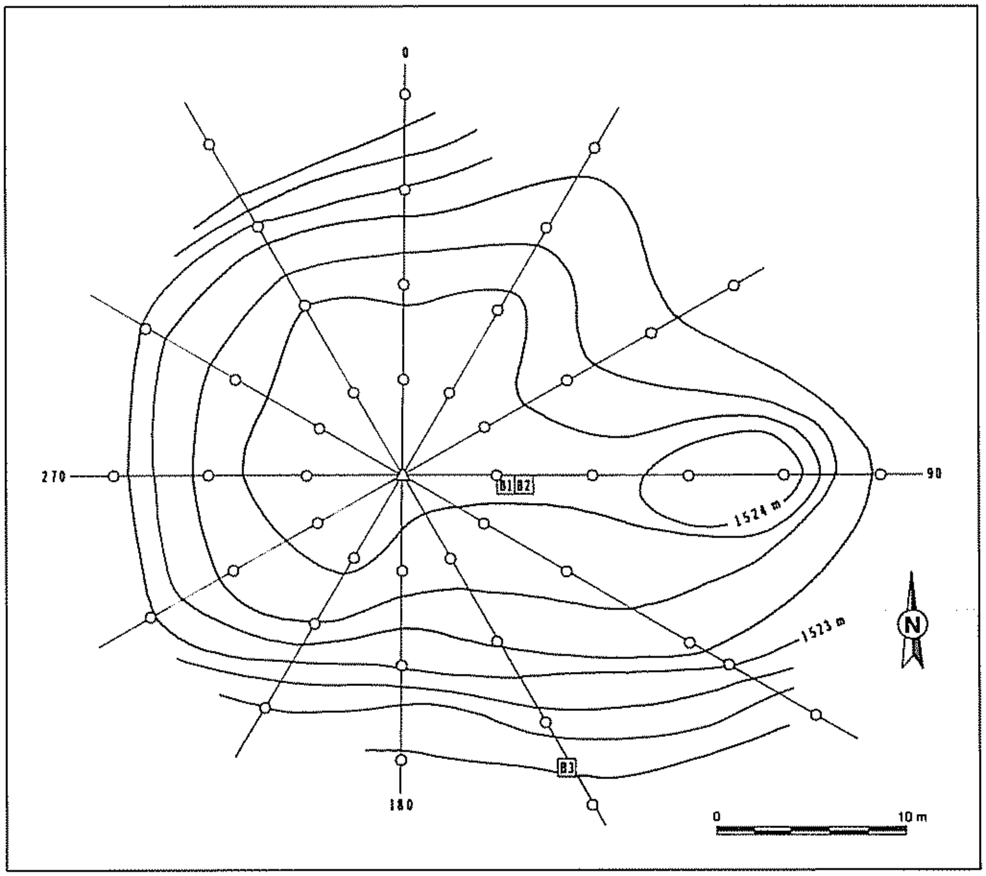


Figure 3. Topographic map of Hill B (modern surface) with soil cores indicated. Infrequent deviations from 5-m intervals between cores were necessary to avoid large trees. Triangle = datum point; square = 1 × 1 m excavation unit (B1—B3); and a circle = soil core. The contour intervals are 25 cm.

cations. Figure 4 shows the same hill during the final occupation of the site (which corresponds to the surface of Paleosol 1) just before the 1660 eruption. This landform, designated "Paleo-Hill B1," is quite similar to modern Hill B except that the paleo-hill has a slightly larger and flatter central summit.

Paleosol 2 was present in so few cores on Hill B that it is not possible to map Paleo-Hill B2. Nonetheless, given the thinness of Stratum V where it occurs at all, it is reasonable to suppose that Paleo-Hill B2 would not have varied notably in form or size from Paleo-Hill B1.

On the other hand, Paleo-Hill B3 (FIG. 5), the surface of the lowest paleosol, is markedly different from the other landforms. In this early period, the hill was much smaller, with a steep slope towards the SE. The small elevation to the east of the datum point in the later hills did not exist in this early period. It is important to mention that Paleosol 3 did not appear as a discrete horizon in several cores beween 270° and 60°, due to the absence of intermediate tephra deposits in that zone. In order to reconstruct the surface of Paleo-Hill B3, it was necessary to interpolate depth values in this area of a single paleosol. Although the map in Figure 5 is only partially interpolated, the reliability of the interpolated segment could be evaluated by comparing it with the map of Paleo-Hill B4 (the surface of the underlying C horizon, Stratum IX). Since Paleosol 3 occurs almost directly upon the C horizon and since there are no intermediate unweathered, uncemented volcanic sediments to change the paleo-hill's contour, it was inferred that Paleo-Hills B3 and B4 should be nearly identical in form and size. Such was indeed the case, implying that the interpolation of Paleo-Hill B3 is reasonably accurate. (In order to avoid unnecessary duplication of illustrations Paleo-Hill B4 is not shown here.)

To better visualize the landform changes through time, a series of cross-sections of Hill B was prepared, four of which are shown in Figures 6–7. On the basis of the horizontal and transverse images, one can formulate a

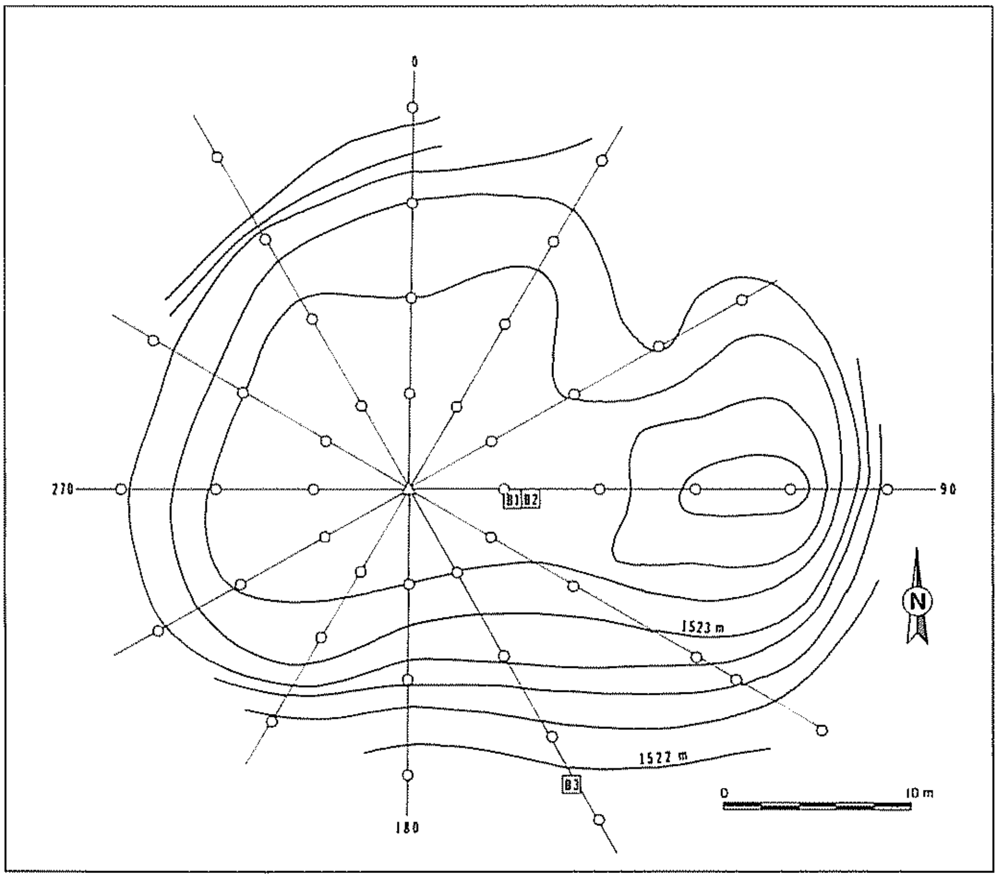


Figure 4. Topographic map of Paleo-Hill B1 (surface of Paleosol 1).

number of hypotheses that will be of great utility in guiding future excavations at the site.

First, Paleo-Hill B3 is considerably smaller than Paleo-Hills B1 and B2. The small flat area on top of the earliest of those three hills implies a greatly-restricted household area (household activities are inferred from the cultural remains identified) or more intensive use of the hillsides in the Formative Period. (Phosphate analyses presented below favor the first possibility.)

Second, the small elliptical elevation to the east of the datum point in Figures 3, 4, and 6b is absent from Paleo-Hills B3 and B4. The observation that this landform appeared later and has no obvious natural origin leads me to postulate that it may be a small rectangular platform mound, which became more elliptical in shape following its burial by volcanic sediments. While rectangular mounds of such small proportions are not previously reported for the mound-building complex of northern Ecuador, I observed just such a feature at the Las Tolas de Curipoguio site (OPQuNl-26) in the north central portion of my research region.

Third, a few aboriginal pits belonging to the Formative Period were identified through soil coring. During the laboratory review of the depths to the surface of Stratum IX, cases were found in which readings were much greater than those from adjacent probes. For example, in the core designated B-90°-5m (5 m east of datum on Hill B), Paleosol 3 had an apparent thickness of 130 cm (from its surface to that of Stratum IX), while the same paleosol in the surrounding cores measured from 25–55 cm in thickness. Indeed, based on that isolated reading, as well as the phosphate results and without regard for the neighboring depth values, I made the decision prematurely in the field to perform the first stratigraphic excavation (Unit B1) right next to the B-90°-5m core. I expected that Paleosol 3 would be very thick there. It was not Paleosol 3 that was so thick, however, but rather a deep aboriginal pit that appeared in the corner of the unit, just where the core had penetrated (FIG. 6B). The placement of the excavation unit turned out to be unfortunate since only a small portion of the pit was uncovered, making it very difficult to determine its size or nature. A careful perusal of the stra-

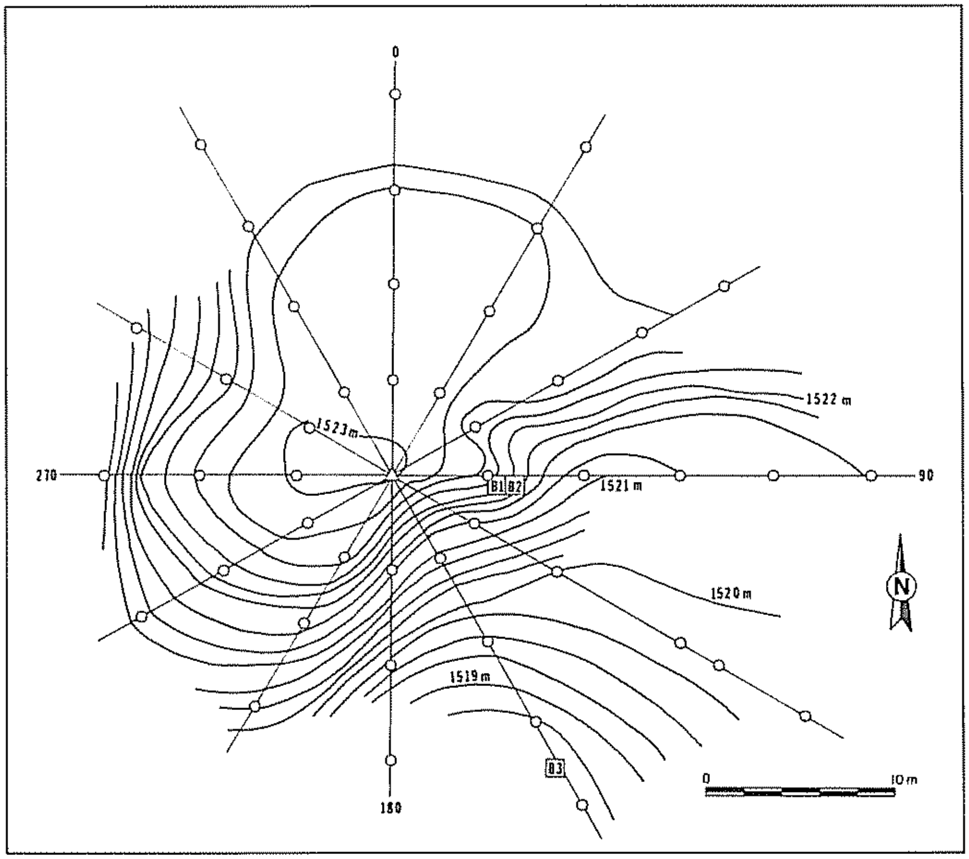
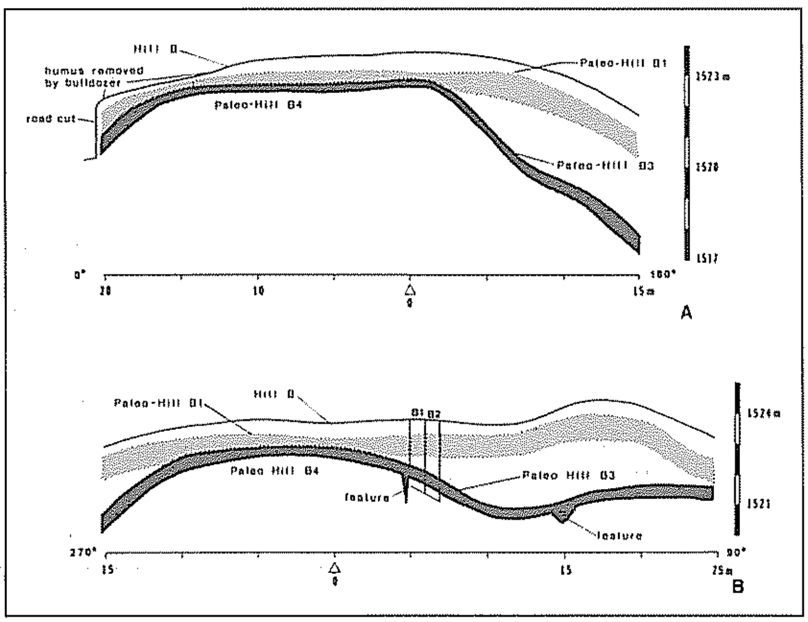


Figure 5. Topographic map of Paleo-Hill B3 (surface of Paleosol 3).

Figure 6. Cross-sections of Hill B showing changes through time in the landform: A) N-S section (0°–180°); B) W-E (270°–90°). The shapes of the two pits are conjectural.



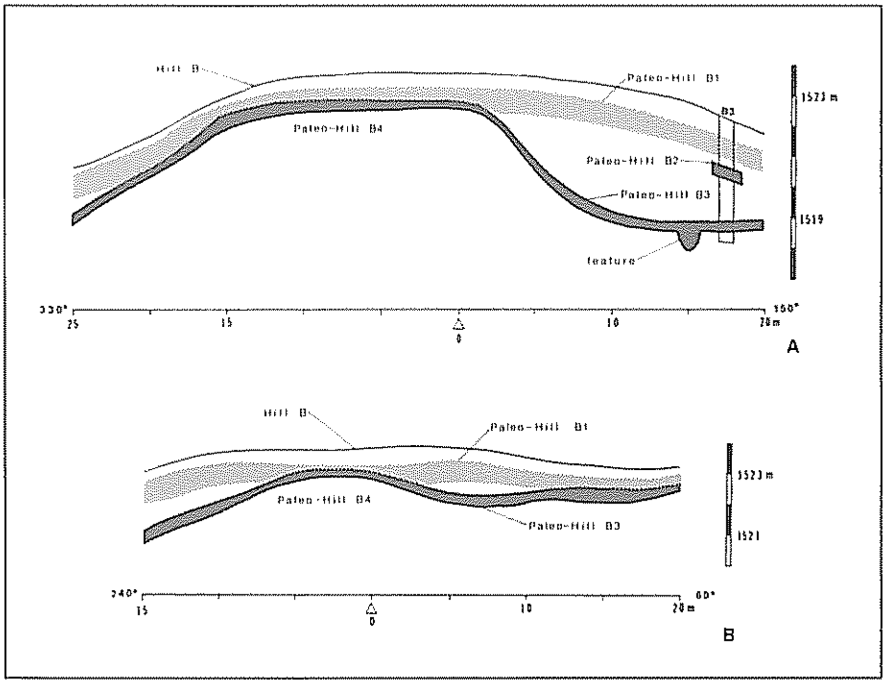


Figure 7. Cross-sections of Hill B showing changes through time in the landform: A) 330°–150°; B) 240°–60°. The shape of the pit is conjectural.

tigraphic data prior to the excavation would have obviated this error. Two other pits have been identified in Paleo-Hill B3 on the basis of the soil probes, at B-90°-15m (FIG. 6B) and B-150°-15m (FIG. 7A). The presence of these features reinforces my opinion that domestic activity occurred in the zone during the Formative Period and will serve to guide the placement of future excavation units.

Fourth, the paleotopographic reconstruction permits a more informed interpretation of the nature of particular zones of the site. Take as an example the stratigraphic excavation, Unit B3. While this cut focused on a relatively high, if marginal, zone of Paleo-Hill B1, it was most likely not a habitable zone of Paleo-Hill B3. In fact, it is quite probable that the area of Unit B3 during the Formative Period was a low, wet zone between two elevated landforms.

Fifth, on the basis of the soil cores, it is clear that the rather elusive Paleosol 2 is fairly well represented in the vicinity of Unit B3, and future attempts to determine the nature of that intermediate occupation should focus on the SE area of Hill B.

Method II: Phosphate Analysis

Anthrosols are soils that have been chemically modified by human activity. The principal elements which such activity contributes to the soil are nitrogen, phosphorus, and potassium. With the exception of phosphorus, these elements are easily leached from the pedon (three-dimensional soil profile). In nature phosphorus occurs most frequently as inorganic phosphate, which combines with hydrogen, calcium, iron, or aluminum in the soil and remains practically immobile indefinitely. The incorrect belief that phosphates disappear easily from the soil by leaching, especially in tropical acid soils, can be attributed to the marked tendency of phosphates to form insoluble molecules. This makes the phosphate unavailable for uptake by vegetation, but it is still present in the position where it was originally deposited (Limbrey 1975: 69–72; Eidt 1984: 26–27).

Sources of phosphorus in the soil are varied—the soil parent material, animals, plants, and humans—but the quantity deposited by humans is much greater than that from nature. Eidt (1984: 30) illustrates this difference in magnitude by the following example. While 100 head of cattle increase by 4.2 mg/sq m/day the phosphorus in a pasture of 100 ha, and the cultivation of one crop per year on 100 ha produces a net loss of 0.04 mg/sq m/day, a residential settlement of 50 persons occupying an area of 0.1 ha results in an increase of phosphorus of 187.6 mg/sq m/day. Most of the phosphorus contributed by human

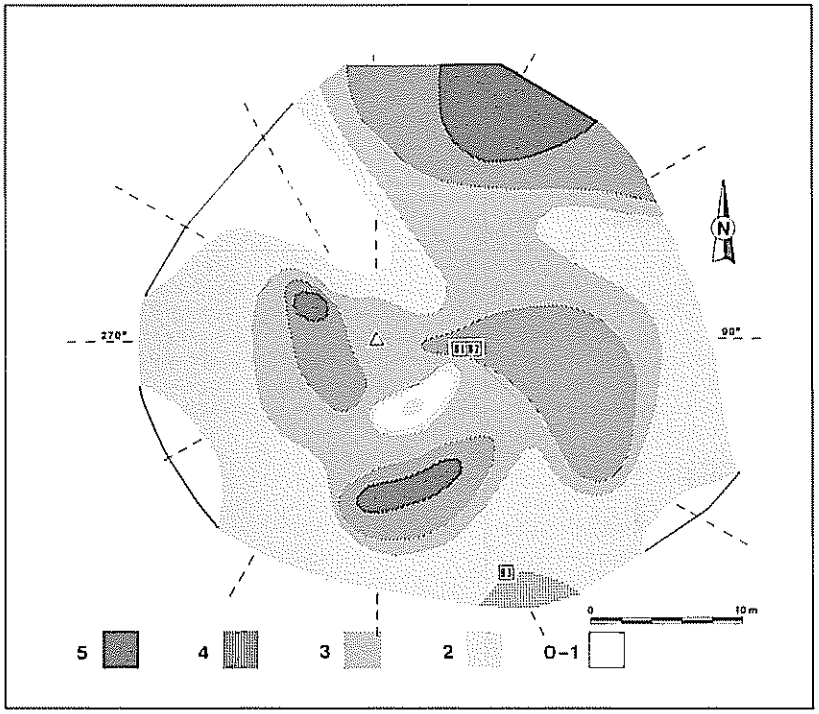


Figure 8. Map of phosphate concentrations 10 cm below the surface of Paleo-Hill B1. "0" = no phosphate, "5" = high phosphate.

activity comes from urine, feces, cadavers, food, and general refuse. Therefore, elevated values of phosphorus are associated with living areas, butchering sites, refuse middens, cemeteries, adequately fertilized cropland, and so on.

The correlation between phosphates and archaeological ruins or artifacts was discovered in 1920, and the chemical analysis of abandoned sites has been performed by geographers since the 1940s (see Eidt 1984: 18–19, 33–35 for a brief history of such studies). Since the analysis in 1948 of phosphates in a funerary mound (Solecki 1951), the use of phosphate analysis in archaeology has propagated slowly and with varied degrees of enthusiasm. This may be the result in part of a past tendency in some cases to utilize phosphate analysis in situations where the results merely served to confirm what was already obvious by visual inspection (Limbrey 1975: 72, and my own previous experience).

Recent advances in the method by Eidt (1984), particularly in the series of reagents used and in the comparability of the results and encouraging results of systematic subsurface phosphate surveying in Colombia (Eidt 1984) stimulated me to implement the method at the site of Nambillo to augment the results of the paleotopographic analysis. Soil samples were collected from each paleosol, approximately 10 cm below its upper boundary, during the soil-coring phase of work. Each soil sample was removed from the carefully-washed cylindrical probe and placed in a plastic bag, taking care to avoid contamination from soaps and hands. Initial phosphate testing was performed in Mindo in the field laboratory using a commercial set of reagents designed for agricultural applications. The quantity of available phosphorus in each sample was determined by comparing the color of the soil-reagent solution to chips of various tones of indigo, and the result was expressed in "pounds of phosphorus per acre" (roughly equivalent to kg/ha). These results were used in addition to the paleotopographic data to position a few stratigraphic excavations on Hills A, B, and D.

Unfortunately, this analysis lacked the precision needed to outline the areas of human activity, and it extracted only available phosphorus from the soil, so an additional series of phosphate tests was run in a chemical laboratory in Quito using the "ring test" described by Eidt (1984: 35–38). The ring test produces results on a scale from 0 (no measurable phosphates) to 5 (5-cm-thick ring, heavy concentration of phosphates). While this test is more appropriate than the agricultural one for abandoned settlement analysis, there remains the problem of unequal extraction of phosphate types.

Eidt (1984: 41–44) describes a more sophisticated test using phosphate fractionation to overcome this problem by distinguishing available from tightly-bound phosphates. He claims rather spectacular results for such an analysis; namely, the ability to determine the relative age of samples, prehistoric soil use, and even the prehistoric crops that were under cultivation! While Knapp (1985: 371–372) and others have questioned Eidt's published conclusions, Eidt (personal communication) continues to increase his already large, mostly unpublished, data base providing empirical support for his experimental method. With this in mind, I continued with the ring-test procedure for the first field season since it provides a satisfactory preliminary survey of the abandoned settlement. Such results are particularly worth having for the allophane-rich soils of Nambillo because soils derived from weathered ash tend to have excellent phosphate retention qualities (Buol, Hole, and McCracken 1973: 113). Future work at Nambillo probably will include phosphate fractionation in an effort to enhance the variety and accuracy of the phosphate data.

Figure 8 is a graphic representation of the distribution of phosphates 10 cm below the surface of Paleo-Hill B1 based on the ring-test results. Contour lines in this case are phosphate isolines with areas of heavier concentration being darker. Figure 8 has a scale and orientation similar to the paleotopographic maps to facilitate comparisons.

There are four zones in Paleo-Hill B1 with high concentrations of phosphates (readings of 4–5), and only one of these is entirely on top of the paleo-hill. The others are partially or completely outside the central level area. Although it is possible that these four zones coincide with four discrete households, it is perhaps more prudent to consider that not all concentrations denote habitations, especially given the differences in size of the four zones and of location with respect to the hilltop. For example, the dark oval area on the moderately steep slope south of the datum point could be a refuse area associated with a house denoted by the dark area immediately west of the datum. On the other hand, the small light zone just south of the datum point was clean (free of organic residues) and could have been, for instance, a stone-flaking area.

Naturally, these conjectures must be evaluated through excavations. Nevertheless, with the phosphate map and the appropriate paleotopographic map, one can judiciously plan a future series of excavations leaving little to chance. The research problem is reduced basically to the determination of the *type* of human activity carried out in each phosphate zone.

Referring again to Figure 8, the dark zone NE of the datum point and outside the central plain area, a zone which is cut by the modern dirt road, merits additional study, as does the zone in the extreme SE of the diagram. This latter zone could be the margin of another habitation site on an adjacent hill. The fact that the possible platform mound east of the datum point is not characterized by a distinct phosphate zone is not significant, since the feature—whether an artificial mound or not—was formed prior to the existence of Paleo-Hill B1.

Figure 9 shows the distribution of phosphates 10 cm below the surface of Paleo-Hill B3. Unfortunately, the union of the paleosols over nearly half the surveyed area of Hill B results in an incomplete map. Despite this large unknown area, one can perceive a substantial correlation between phosphate concentrations and slope (compare FIG. 5, 9). The absence of measurable phosphates on the steep slope and low area between the two excavated areas (between Units B1–B2 and Unit B3) suggests that material recovered from Unit B3 may belong to a different residential complex separated from the central map area by a gully. It seems unlikely that the immediate area of Unit B3 would have been appropriate either for a house or a garden since it was probably too wet. Perhaps it was the refuse area of an unidentified household outside the surveyed portion of the site. Again, this is speculative and ought to be considered a working hypothesis rather than a conclusion.

Summary and Conclusions

Systematic coring of a quite large, deeply-buried, multicomponent site with dense rainforest vegetation has provided considerable information about the nature of that site with relatively little time and effort. The series of soil probes gave easy access to the buried cultural horizons, provided a panoramic view of the complex stratigraphy, and produced this information without seriously disturbing the depositional context of the cultural remains. Furthermore, the bulk of the work was done by non-archaeologists. In addition to the stratigraphic data from the coring, artifacts with precisely-known provenience were recovered and even aboriginal pits were identified some 4 m below the modern surface. Accurate reconstructions of the various ancient land-forms have been particularly valuable in providing an inferential guide for determining different types of human activity carried out at the site during the different periods of occupation. Since Hill B changed considerably in size and shape through time, knowledge of its geomorphological history is a vital prerequisite to a rational interpretation of the local settlement pattern and function of activity areas.

A preliminary phosphate profile of Paleo-Hills B1 and B3 complemented the paleotopographic reconstructions

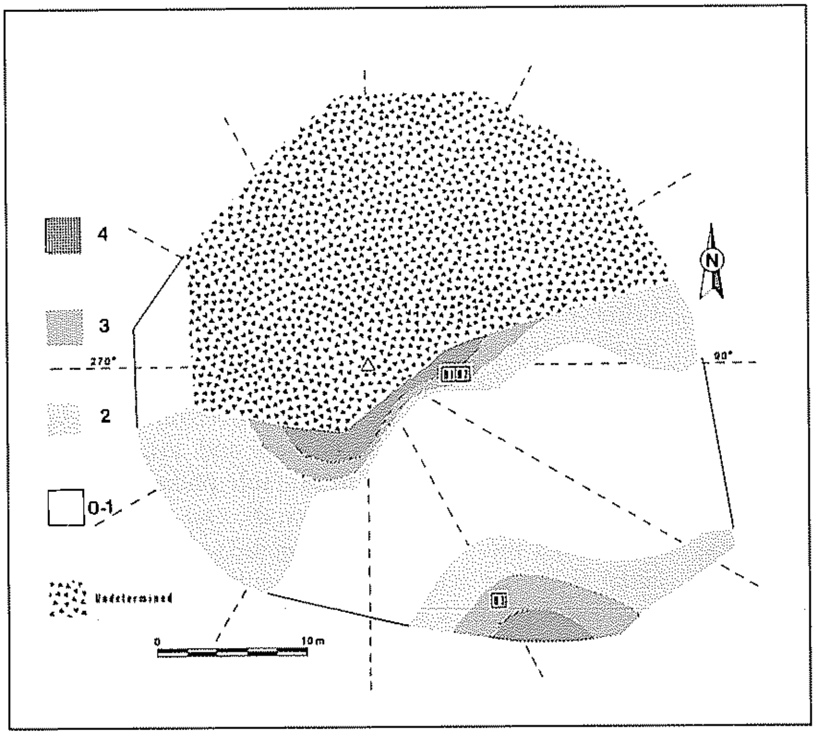


Figure 9. Map of phosphate concentrations 10 cm below the surface of Paleo-Hill B3. "0" = no phosphate, "4" = high phosphate.

by indicating the approximate size, location, and intensity of human activity areas on the ancient landforms ("intensity" here refers to the relative amount of organic refuse deposited). While it is readily acknowledged that the ring test utilized for identifying activity areas does not extract all tightly-bound phosphorus from the soil and is keyed more toward available phosphates, the test is nonetheless useful for a rough phosphate configuration of the buried site.

Combined data on paleotopography and activity areas, then, allow the formulation of a rational strategy for subsequent investigation of the Nambillo site. Several examples of the kinds of hypotheses that can be made have been presented. Since the objective of this article is the description of two mutually-reinforcing methods with a wide range of potential applications rather than the construction of a specific excavation strategy for the site of Nambillo, no effort has been made here to elaborate on or to tie together the various sample hypotheses into a coherent plan. It is sufficient to stress that the two methods have provided a detailed picture of two occupations from the distant past, occupations that are of such difficult access by conventional methods of exploration that the site probably would have been written off as "not amenable to further study."

Whereas random sampling might otherwise have been used to select test pits for excavation in an effort to locate significant activity areas, the coring and subsequent topographic and phosphate reconstructions have resulted in a quick and relatively easy, non-destructive identification of activity areas and even provided a basis for inferring possible types of activity. The remaining problem, to be resolved through "directed" (as opposed to exploratory) excavations and perhaps also through more sophisticated (and still experimental) phosphate fractionation, is to confirm the types of activities carried out at the several identified locations.

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