PHYTOLITH STUDIES AT BIG HIDATSA, NORTH DAKOTA: PRELIMINARY RESULTS

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Abstract. The objective of this study is to evaluate phytolith analysis as a means of reconstructing subsistence patterns at archaeological sites. Phytoliths are microscopic deposits of opaline silica that form in plants, particularly grasses. Subsequent deposition in archaeological sediments preserves evidence of the original plant after all organic remains have decomposed. Several studies have attempted to identify corn phytoliths from early archaeological contexts. Methodology consisted of three steps: examination of modern corn material, comparison to native grasses with similarly shaped phytoliths (identification of characteristic corn phytoliths), and examination of archaeological sediments. Presence of characteristic phytoliths was taken to indicate presence of corn.

To evaluate the accuracy of phytolith analysis a study was conducted at Big Hidatsa, a Plains Village site in North Dakota where corn was a dietary staple. Examination of Mandan corn varieties indicates leaf and husk material produce cross-shaped phytoliths. Preliminary examination of sediments indicates cross phytoliths are rare; distribution is neither abundant nor ubiquitous. Cob chaff yielded short trapezoids, a type abundant in many wild grasses. More research is necessary to characterize corn short trapezoids. Sediment provenience, cultural patterns of plant use and discard, and natural processes must be considered in any interpretation of phytoliths from sediments.

INTRODUCTION

Phytoliths are microscopic mineral deposits that form within and between plant cells. Although the term can refer to any mineral deposit (for example, calcium oxalate crystals in oak leaves), deposits of opaline silica are usually indicated (Rovner 1983). In this paper “phytolith” will refer only to silica deposits.

Three general types of silica deposits have been reported (Sangster and Parry 1981): deposits associated with cell walls, deposits between cells, and deposits that fill cells completely. Families rich in silica include the Gramineae (grasses), Cyperaceae (sedges), Juncaceae (rushes), and Equisetaceae (horsetails).

Several functions have been proposed for phytoliths. Parry and Smithson (1958) proposed that some phytoliths are deposits of excess silica or, alternatively, that silica may act as structural support for plant cells. Kaufman et al. (1981) suggested a function as “windows” to transmit light to inner, photosynthetic tissue. Jones and Handreck (1967) indicated that rice varieties high in silica content are more resistant to fungus attack than those low in silica. Whatever the function, it is known that silica (although not an essential nutrient element) is necessary for the growth of grasses, particularly rice.

Phytoliths are deposited in sediments after decomposition of the organic structure in which they form. Since phytoliths are mineral in nature, preservation often occurs under conditions that can destroy macrobotanical remains. In addition, phytolith analysis can yield data not obtainable from other types of botanical remains. Although many families produce distinctive phytoliths, the most abundant and morphologically varied forms occur in the grass family. Grasses contain specialized cells that accumulate silica, in addition to other cells that may become silicified. Subfamily and tribe may be identifiable by phytolith content, although the task is more complex than it first appeared to be (Twiss et al., 1969, Mulholland and Rapp 1985). Grass pollen grains, on the other hand, all have the same morphology. The only taxon identifiable below the family level is corn, due to larger size. Thus, phytoliths represent a new microfossil with potential applications in paleoecology and paleoethnobotany. However, many variables require further research before phytolith analysis can be used to its full potential.

Phytolith research has been applied to various archaeological and environmental problems. Several studies centered on identification of food plants at archaeological sites. Pearsall (1978) identified corn (or maize) phytoliths at the Real Alto Site in Ecuador. The sediments, associated with hearths, pits, and floors, were dated at 2450 B.C. Piperno (1984) identified corn phytoliths in sediments from several sites in Panama. Two rockshelters, Cueva de los Ladrones and Aduagulce, lacked macrobotanical remains but yielded corn phytoliths from early ceramic contexts. Ladrones also had significant amounts of corn phytoliths in a preceramic context (dated 4910 B.C.). Both Pearsall and Piperno used three general steps. First, native varieties of corn were analyzed for phytolith content. Comparison to native grasses revealed characteristics that distinguished corn from other grass phytoliths. Finally, sediment samples were analyzed for phytoliths; distinctive shapes and/or abundance of shapes were taken as evidence of corn use at that site. In addition, Piperno examined sediments from Sitio Sierra, a late ceramic site where corn cobs and seeds were recovered (Piperno 1984, p. 375). The phytolith assemblage there resembled those from the two rockshelters.

A more extensive test of the accuracy of phytolith analysis is proposed here using samples from Big Hidatsa, North Dakota. Big Hidatsa is a protohistoric/historic Plains Village site located in the Knife River Indian Villages National Historic Site near Stanton. The Hidatsa Indians occupied the site from the 1700’s to 1845 (Ahler and Swenson 1985). Corn was a staple food, as recorded by both explorers and ethnographers (Wilson 1917). In addition, corn cobs and kernels were recovered during excavations at the village in 1980 (Ahler, pers. comm.). Therefore, corn phytoliths should be abundant at Big Hidatsa. If absent, the assumptions underlying phytolith analysis must be re-examined.

METHODS AND MATERIALS

Modern plant reference material consisted of native corn plants grown from seed obtained from the Regional Plant Introduction Station at Ames, Iowa. This seed was donated by Oscar Will of Bismarck, North Dakota and is believed to have come from the

FIG. 1. Cross phytolith from corn (Zea mays L.), leaf.
Mandan Indians. Two varieties, Mandan Clay Red (P.I. 213807) and Mandan Yellow Flour (P.I. 213794), were examined in this initial study. The plants were grown in Duluth, Minnesota. In addition, a collection of wild grasses was made in 1980 from the site area. All plant specimens were digested in a mixture of nitric acid and potassium chlorate (a modification of Rovner 1971, 1972). Sediment samples were collected in 1980 from test pit profiles. Separation of phytoliths was done using a zinc bromide heavy liquid flotation procedure (a modification of Rovner 1971). The preparations were examined using both a Zeiss research microscope equipped for Nomarski differential interference contrast microscopy and a scanning electron microscope (AMR-1000A). Detailed counts of 400 phytoliths each were made at 400x magnification on 7 slides of the corn preparations. All cross and dumbbell phytoliths were measured. Sediment examination consisted of a preliminary scan for crosses followed by a detailed count of 100 phytoliths.

RESULTS

Phytoliths from corn leaves and husks have recently been the subject of detailed research. Pearsall (1978) examined nine races of corn from Ecuador. She established that corn generally had a higher percentage of phytoliths with a cross-shaped outline than did native grasses (Fig. 1 - bar is 10 micrometers in length). ['Cross' was defined as having at least 3 indentations and a length no more than 9.16 micrometers greater than the width.] In addition, corn crosses tended to be larger than those of native grasses. Specimens of the large and extra-large categories (16.03 to 25.19 micrometers on the shorter side) were found only in corn, although these categories represent less than half of the crosses present in most varieties. Later research by Piperno (1984) indicated that some wild grasses (Oplismenus hirtellus and a bamboo) do produce large and/or extra-large crosses in quantities similar to corn. However, Piperno determined that corn crosses can be distinguished from those of other grasses by three-dimensional shape morphology. Study of twenty races of corn from Panama showed that corn crosses are mostly symmetrical from top to bottom; that is, both top and bottom are cross-shaped in outline. A few have a rectangle or arch on one side and a cross-shape on the other. Most wild grasses do not produce large quantities of symmetrical crosses. All three factors - percentage of crosses, size categories, and three-dimensional morphology - must be considered when identifying corn phytoliths.

Examination of leaves from two Mandan corn varieties indicated that two of the above factors characterize these varieties. Crosses (Fig. 1) were the dominant phytolith shape observed, followed by dumbbell-shaped phytoliths in much smaller amounts (Fig. 2 illustrates dumbbells from another species). Most of the crosses were symmetrical; both top and bottom faces were cross-shaped. A few possessed a rectangle or arch on one side. Size ranges of the crosses, however, were smaller than those reported for most of the South American varieties. Extra-large crosses were extremely rare (only 2 of more than 700 crosses examined) and large crosses were scarce (46). The vast majority were medium and small in size. Piperno and Pearsall both reported corn varieties with few-to-no large and extra-large crosses, although their research focused on varieties with large crosses. The two Mandan varieties examined thus fit into one end of the range of published phytolith data for corn.

Examination of the grass reference collection indicated dumbbell and crosses are produced by at least some species of all subfamilies represented (Mulholland and Rapp 1985). Before detailed analysis was initiated, selected sediment samples were examined for phytolith content. Sediment samples were chosen from one test unit (Fig. 3) for this preliminary study. The unit, 224 NE 206, is in a midden from the core area of the site. Samples were examined ranging from the top soil layer to a paleosol, including an ash lens and a cave or bell pit. Crosses were very rare, occurring in low quantities in a few samples. Most were small to medium in size. The single exception (Fig. 4) measures 16 1/3 micrometers (21 micrometers in length) and is a large cross. The sample, from a light brown laminar silt containing charcoal, bone, and pottery, is located 13-19 centimeters below the modern soil surface.

It was noted that these samples from the bell pit (Feature 97) had differing amounts of phytoliths. Sample 115, from the center of the pit, had few recognizable grass phytoliths. Phytolith density was low, consisting mostly of nonspecific forms. Sample 116, at greater depth and in a different sediment unit, had frequent grass phytoliths; Sample 117, from the same sediment at the pit base, had abundant grass phytoliths. All three major categories of grass phytoliths (as described in Twiss et al. 1969) were observed in these two samples. Again, crosses were extremely rare and were small or medium in size. Samples 116 and 117 also had nonspecific forms (plant hairs and epidermal cells). If the phytoliths indicate in situ decomposition of plants, the sediment unit at the base of the pit may have had a concentration of grass material. This would confirm one of Wilson's (1917) observations, the lining of bell pits with grass.

DISCUSSION

A goal of many archaeological phytolith studies is identification of plant use at a site. Phytoliths characteristic of corn leaves and husks have been recovered from archaeological sediments, indicating use of corn at those sites (Pearsall 1978, Piperno 1984). This study, designed to check the accuracy of the phytolith record, indicates that not all situations are so straightforward. Although corn was used extensively at Big Hidatsa, characteristic corn phytoliths from
leaves were rare in the sediments. However, sediments from different contexts did contain different amounts and types of phytoliths. It should be possible to relate phytolith assemblages, sediment context, and possible plant use.

The scarcity of cross phytoliths in sediments at Big Hidatsa was disappointing at first. A single large cross cannot be taken as conclusive evidence of corn use at this site, especially since the depth below surface is not great. Although this site was never cultivated (hence no plow zone formed), the possibility cannot be ruled out that this phytolith is a modern contamination from the surface. However, discard patterns of different plant parts may explain this seemingly anomalous situation (Wilson 1917). Corn husking took place in the garden. Most of the husks and all other vegetative material, including leaves, were left there. Phytoliths from these plant parts may therefore help to locate native corn fields. Ears were carried into the village itself, for drying, threshing, and winnowing. Only phytoliths from reproductive material should be expected in any abundance in villages of this period.

Corn kernels, cobs, and chaff were subsequently digested and examined. Phytoliths are not produced by the cob or kernel but are abundant in the chaff. However, chaff phytoliths are not cross-shaped bodies like those found in both leaves and husks. The chaff produces bodies with a circular base and a ridge or rectangular-to-oval raised portion on top (short trapezoids -Fig. 5). Similarly-shaped bodies are abundant in most of the sediments examined. However, this type of phytolith also occurs in many native grasses and much morphological work remains before those from corn can be identified accurately.

This study shows that additional factors must be considered as part of any phytolith study. Cultural patterns of plant use and

FIG. 3. Soil profile, north wall, Unit 224 NE 206, Big Hidatsa.
include careful comparison of artifact content and microstratigraphy of the two levels.

Other factors should also be considered. Post-depositional sediment processes may affect phytoliths. Sampling and laboratory procedures must be checked to eliminate bias in the samples. The characteristics that distinguish corn phytoliths from those of other grasses must be tested, until all grasses have been examined, to establish the degree to which corn is distinct. Modern sediments must also be examined to determine the natural "background" phytolith deposition. Comparison of cultural sediments to modern A horizons should show differences due to cultural activity.

Phytolith analysis is not a simple procedure nor are most variables understood to a sufficient degree. Much basic research needs to be done. In this study, the next step is clear - short trapezoids must be examined in detail to see if those from corn chaff are distinguishable from those of native grasses. The complex nature of phytolith analysis has already been indicated by the work to date.

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