Phytolith Research in Manitoba

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By Matthew Wiecek for ANTH 3980

Botanical evidence, such as macroremains and pollen, have long been used as archaeological evidence. In the late seventies, however, phytoliths were added to the repertoire. Phytoliths have been making major contributions to archaeology all over the world. Previously, paleoethnobotanical research was simply not possible in the Amazon, because all organic remains decay there. Phytoliths are essentially rocks (opal, which is hydrated silica), and as rocks they survive where organic matter does not. Phytoliths provided a window into the past that didn't exist before, providing information on Amazonian agriculture that wasn't possible to find before. The origins of agriculture there were pushed back thousands of years when phytolith evidence appeared in areas where evidence did not previously exist (Leigh Syms, personal communication). In addition to the New World, phytolith research is also done in the Old World; a study of phytoliths from African plantains traced the origin of that plant to Melanesia through Asia (Vrydaghs 2007:10). It is therefore clear that the introduction of phytoliths to archaeology has made massive leaps forward in that discipline, bring in new knowledge of the past that wasn't possible before. In addition to the Amazon and other places, phytoliths have contributed greatly to our understanding of precontact foodways in Manitoba. In this essay I am going to write in great detail on the contributions of phytoliths to our understanding of Manitoba prehistory, using three case studies. The first of these studies will be on anthropogenic burning of the landscape, and the next two will be on the role of maize in prehistoric foodways in southern Manitoba.

Each case study will include phytoliths in a major role, but phytoliths do not exist in isolation. No one ever just collects phytoliths alone and records the plants they represent, never to do anything with that data. Phytoliths are always part of a larger context, in two ways. In the first way, phytoliths are often used in combination with starch granules, pollen and macroremains. Each line of evidence fills in gaps in the others, and reinforces them. Any conclusion supported by multiple lines of evidence is always stronger than a conclusion supported by only one line of evidence, and the picture is always more detailed and complete. Multiproxy approaches can combine some or all forms of botanical evidence, or they can go beyond botanical evidence. The case studies to come combine phytoliths with carbonized food residues, starch granules, stable isotopes, trace element analysis and more. Phytoliths exist as parts of a larger whole, and this essay is written accordingly. In addition to multiproxy evidence, there is a second way in which phytoliths exist as part of a larger whole. In the second way, the information gained by studying phytoliths is used to reconstruct either past ecology or past culture. Paleoecologists use phytolith data as a means to the end of reconstructing past ecology. Here inferences are made about all aspects of the past ecology and environment based on phytolith assemblages. Archaeologists use phytolith data to figure out what plants people used where, and in turn use that information to reconstruct past culture, foodways and lifeways. For those reasons, the following case studies will not look at phytoliths alone, but will instead look at phytoliths within a larger context. The next case study uses phytoliths (alone) to learn more about one aspect of the lifeways of precontact peoples of southern Manitoba. The next two case studies will use phytoliths to expand our knowledge of the foodways of the precontact peoples of southern Manitoba.

Now, having done a thorough introduction, the case studies. First, we will look at the archaeology of people who set stuff on fire. There are many historical accounts of the native peoples of the Prairie deliberately starting grass fires. These fires were used “as a signal, as an offensive strategy in warfare, and as a means of attracting bison to or away from a certain locale” (Boyd 2002:474). Lewis and Clark, when they were at a Mandan-Hidatsa village, reported that a fire was started to obtain an early crop of grass. A fire can actually encourage the growth of grass by removing litter from the ground. This grass would have fed the native’s horses, and attracted huntable bison to the area. In late July 1858 H. Y. Hind reported that natives of Saskatchewan deliberately started a fire for the purpose of altering the course of a bison herd. Hind saw this as a common and old activity, and believed that these fires extended the open parkland into the woodlands (Boyd 2002:474). The context of Boyd’s study is on the Souris river near Hartney, between the towns of Souris and Melita, in the glacial Lake Hind basin (Boyd 2002:472). The topography is quite diverse, with grasslands, forest, sandhills and wetlands. The sandhill area has lots of desert features, including a wide variety of dunes. The stratigraphy of the area includes a lake bed (early Holocene), sand dunes and sheets (later Holocene) and paleosols. Phytolith samples were taken only from the paleosols.

Now, to study the fire history of an area, the most important part of the study is differentiating between burnt and unburnt phytoliths. Boyd used plant ashing in a laboratory kiln (300-500 degrees Celsius) to get comparative material. This comparative material is known to be burnt, so it shows the archaeologist what to look for. Phytoliths found in the field can be compared with the known burnt phytoliths to determine whether or not they were burnt by ancient fires. For each sample he calculated a Burnt Phytolith Index (BPI), the ratio of burnt to unburnt phytoliths expressed at a percentage (Boyd 2002:478). It is not known whether or not phytoliths in different plant species absorb carbon inclusions at different rates, so only grass phytoliths were used, to control for that possible variable. The method of separation in the lab was deflocculation, then wet sieving, then gravity separation (Boyd 2002:475). Carbonates were removed with hydrochloric acid, which was in turn removed by washing with water. First, a sample was taken from modern soil, 1 cm down, right beneath the leaf litter. It had a very low BPI (mean of 8.2%), and the last known fire in the area was in the late 1940s (Boyd 2002:478). Here we have a low BPI in a place and time with few to no fires. Samples taken from 880+-80 BP had a BPI of 73%, and were associated with a large amount of charcoal and burnt bone. Charcoal and burnt bone are evidence alone of fires, so it has been independently confirmed that the fire frequency has quite high at that time. The phytoliths have a high BPI in an area with evidence for many large fires, which shows that phy. This lends support to the use of BPI as a measure of the amount of burning in an area. It is cautioned, though, that fires in grasslands and forests, due to differences in fuel, may have different intensities and durations. Therefore BPI should be used to measure fire history through time but not space.

So what did he find? For one thing, all the phytoliths found were grass phytoliths with no arboreal phytoliths. This indicates that the area was predominantly grassland (Boyd 2002:479). Here we see an example of paleoenvironment reconstruction. Phytoliths have contributed to our knowledge of past ecology and environment in Manitoba, thus it is a "contribution to our understanding of Manitoba prehistory" (the thesis of this essay). There is a dune blowout/fill-in sequence in the stratigraphy at the site. From the top to the bottom of this sequence he found a change in phytoliths that indicates a shift from cool dry conditions to warm moist conditions. Boyd suggests that the basin this stratigraphic sequence represents may have collected moisture, allowing tall grass species (which favour moist conditions) to predominate where there otherwise would have been short grass species (which thrive in dry conditions) (Boyd 2002:479). Now for the purpose of this study: the fire history of the Lauder Sandhills in southern Manitoba. To do that we are tracking the BPI (Burnt Phytolith Index) through time to determine the frequency of fires. It is assumed that frequency is variable and intensity is constant, because there is no change in fuel (such as a transition from grass mats to forest litter that was never observed).

Boyd's exact words are: "However, given potential differences in fire intensity and/or duration produced by different types of fuel (e.g. grass vs forest litter), this index should probably only be used as a relative measure of change through time, at a single sample location that is homogenous with respect to vegetation/soil type" (Boyd 2002:478). One thing I would like to add is that vegetation density can change, even when the vegetation type (grass vs forest) does not. It is already known from historic and ethnographic evidence that fires alter the landscape. This prehistoric landscaping would change the amount of fuel available for fires. There is potential for further research here. The Burnt Phytolith Index can be expanded to take into account the quantity and type of vegetation present. Not only would the ratio of burnt to unburnt phytoliths be measured, but the value of the BPI would be adjusted based on the types and quantity of phytoliths present in the assemblage. This would allow this measure to be used in a wider variety of locations.

We were beginning to discuss the variation of the BPI through time in the Lauder Sandhills. Boyd found no correlation between fire frequency and moisture. Boyd identifies four samples that show moist conditions but do not have a change in BPI (Boyd 2002:479). One last observation is that the upper two stratigraphic levels have a very low BPI, indicating a sharp decrease in fire frequency. This confirms his suspicion that after European contact grass fires on the Prairies were suppressed (Boyd 2002:479). Here we have more evidence confirming the validity of BPI as a measure of the fire history of an area.

Now phytolith research is not just about collecting microscopic pieces of opal for a rock collection that no one can actually see without a high-powered microscope that most people could never afford. An archaeologist uses phytoliths to identify plants. Those plants are used to identify human activities and those human activities to identify culture.

This chain of inferences from material remains to lifeways, foodways and culture is how all archaeological research works. So far we have seen these phytoliths used to identify plants, and those plants have been used to identify past climate and ecology. But what about going from plants to human activities? Boyd argues that climate change alone does not provide a complete explanation of the fire history of the Lauder Sandhills in southern Manitoba. He argues that climate change is only one factor in the paleoecology and fire history, and that human agency plays a part in a complex interaction (Boyd 2002:484). Because of this, the Prairie landscape is not entirely natural but is partially artificial – a mix of natural and human influences. There are some specific instances of correlation between climate change and fire frequency but many instances were there is no correlation. Instead, Boyd argues that anthropogenic fires played a part, based on: 1) an increase in Sonota-Besant remains 2) the known connections between Sonota-Besant and coeval eastern Woodland cultures and 3) it has already been proven that eastern Woodland peoples used deliberately set fires (Boyd 2002:481). The paleoecological record shows that pollen from fire resistant plants (oak, chestnut and pine) and charcoal remains both peak at the same time (Boyd 2002:483). Recent archaeological evidence shows that human use of the land intensified in the Lake Hind basin (which contains the Laurel Sandhills), and this trend corresponds with the fire frequency maximum. Historic evidence shows that a part of native land use is burning the land to make it more productive or to control the movement of bison, and so it is reasonable to assume that an increase in land use would cause an increase in anthropogenic burning (Boyd 2002:483). This increase in burning may have led to an increase in population density as the productivity of the land increased, something Boyd regards as speculative but interesting (Boyd 2002:483). That speculation about population density could be explored through demographic research into the changes in population of the people of that period. All of this information, and speculation potentially leading to further research, is ultimately based on phytolith assemblages. Here we have more "contributions of phytoliths to our understanding of Manitoba prehistory".

What we just saw was one application of phytolith studies to archaeology: reconstructing the fire record in an area where there is great evidence for anthropogenic burning. Phytoliths were therefore successfully used to expand our knowledge of past human activities. For my next case study I am going to turn to the application of phytolith studies to the archaeology of agriculture and precontact foodways. These next two case studies are going to be about maize consumption in southern Manitoba. The first of the two, which will be considered next, is based on a combination of phytoliths, starch granules and macrofossils. The previous section, on anthropogenic burning, was primarily about phytoliths but included some other archaeological evidence as well. This section will be about a wide range of botanical remains.

There will be two closely related case studies in this section. The first one is Boyd 2006. It is already well known that the native cultures of the Middle Missouri were horticulturalists who grew a maize-beans-squash complex that has its origins in the American Southwest. It is also well known that there are strong connections between southern Manitoba and the Middle Missouri cultures. It is known that the Middle Missouri cultures grew maize because of historical and ethnographic evidence (that historical-ethnographic evidence made possible because they continued to be horticulturalists into the contact period). In southern Manitoba, though, contact period native cultures were primarily bison hunters. Archaeological evidence of kill sites has confirmed that bison hunting is an ancient tradition among these people. There has, however, been much work done on hunting through such highly visible evidence as animal bones. However, there had previously been little research into the archaeobotanical record of the area (Boyd 2006:1), even though plants are an important part of the diet of nearly every culture around the world (Boyd 2006:10). This is a problem, among other reasons because it skews our knowledge of foodways in southern Manitoba in favour of hunting. Since plants are so important to the diet worldwide, it seems like a no-brainer to study plant remains for that side of a culture's foodways. At the very least, we will find out what plant foods they gathered to complement and/or supplement the bison hunt. There is also the possibility that we will discover practises and traditions that did not persist into the contact period. Boyd's research into maize consumption is a step forward in addressing the deficiency described above.

Boyd chose as the location of his study the Tiger Hills and Oak Lake Sandhills, both of which have seen extensive archaeological fieldwork. That work has established strong cultural connections between southern Manitoba and the cultures of the Missouri

River (Boyd 2006:2). Tiger Hills is a forested area, and Oak Lake Sandhills consists of dune fields. Six sites were chosen. Five are the sites of taxa closely connected to Middle Missouri cultures (sites are Lovstrom, Lowton, Duthie, Vera, Hollow B, Schuddemat, taxa are Vickers focus, Mortlach phase, Northeastern Plains Village complex). The sixth one is Twins Fawns of the Late Woodland. This site was chosen randomly, and has no connection with Middle Missouri cultures (Boyd 2006:2).

Four lines of evidence were investigated in this study: phytoliths and starch granules, carbonized food residue, and plant macrofossils.

There is strong multiproxy evidence of maize consumption at the sites studied, as well as possible evidence of beans (Boyd 2006:9). Phytoliths and starch granules were found in hearths, indicating that they were consumed when the sites were occupied. At Lockport maize macrofossils were found in storage pits that also contained a variety of gardening implements, including bison scapula hoes. Boyd then goes on to note that only wild species were found among the charred hearth remains, and these were all species locally available that were consumed by natives during the historic period (Boyd 2006:9). He also notes that those gardening implements are quite rare.

Now how did that maize get into Manitoba? Boyd explores three possibilities for the origins of the maize found (all are described in detail in Boyd 2006:9-10). The first one is trade. In this hypothesis, southern Manitoba cultures traded their bison meat for maize from the Middle Missouri. If this is the case, then the archaeological record would show evidence of the presence of maize but not the production of maize. The second one is village dispersal. Ethnographic research of the Mandan and Hidatsa indicates that during the summer and fall they would disperse from their villages to scattered campsites to hunt bison for extended periods of time. If this was practised in Manitoba, then we would need to determine what the function of a site was, that is to say, take and process soil samples from every site. Finding no evidence of maize production at a hunting camp would not disprove the hypothesis that maize was grown locally. The gardens would be found at a main village. The third hypothesis is that horticulture was practised locally. It would have been irregular, though, based on the scant evidence of gardening implements across southern Manitoba.

In addition to that, Boyd did another study of maize consumption in southern Manitoba (Boyd 2008). This time he used microfossils, trace element analysis and stable isotopes to determine the northern limit of maize consumption in North America. This time he expanded his study beyond components with clear connections to Middle Missouri cultures. He added components from the Late Woodland, and went beyond the prairie into the boreal forest and Canadian Shield (Boyd 2008:2550). In this study, Boyd included Tiger Hills and Oak Lake Sandhills, the sites of the previous study. He added Lockport and the Winnipeg River (in the Canadian Shield boreal forest) to his sample of southern Manitoba sites (Boyd 2008:2546). The sites and artifacts found come from a wide variety of cultures, including Northeastern Plains Village Complex, Vickers Focus, Blackduck Complex, Sandy Lake Complex, and Rainy River Composite (Boyd 2008:2546).

This study uses three lines of evidence: microfossils (starch granules and phytoliths), trace element analysis and stable isotopes (carbon and nitrogen). One issue with determining the presence of maize from phytoliths is that maize produces a number of phytolith shapes that are found in other plant taxa. Boyd solved this problem by restricting his study to "'wavy-top' rondels with entire bases" (Boyd 2008:2548). That shape is found only in *Zea Mays*, and has already been used as evidence of the presence of maize from South America to eastern North America (Boyd 2008:2548). Starch is discussed, but Boyd argues that starch cannot be used alone as evidence of maize. This is because the lack of research on starch granules in southern Manitoba has resulted in a poor understanding of starch assemblages found here (Boyd 2008:2548).

76% of the sites in Boyd's sample showed multiproxy phytolith/starch evidence of maize. He then goes on to note that absolute numbers of wavy-top rondels, found only in the inedible cob, were low (Boyd 2008:2549). One potential area for further research is to search for middens. If maize was grown locally, the middens should be loaded with cobs and have lots of that phytolith. A lack of that phytolith may indicate that maize was processed elsewhere and imported. Not only has phytolith research given archaeologists new knowledge of Manitoba prehistory, it is also opening up possibilities for more research that will lead to more knowledge.

Stable isotopes (nitrogen-15 and carbon-13) were used in the study. However, they present problems for the archaeologist attempting to use their data to reconstruct past foodways and lifeways. Bison meat is 90% protein and maize is 11% protein, so isotopically the bison meat will mask the maize. This makes it very hard to use stable isotopes as evidence of maize consumption (Boyd 2008:2549). However, he then notes that nitrogen-15 can provide information about the predominance of terrestrial vs aquatic foodstuffs in the diet, even if it can't identify the exact animal or plant. Carbon-13 can provide information about predominate foodstuffs (Boyd 2008:2549). Stable isotope analysis found that there were two groups quite separate from one another. The first group was Tiger Hills and Oak Lake Sandhills, and the second group was Lockport and Winnipeg River (Boyd 2008:2550). The Lockport-Winnipeg River samples had a much wider range of variation than Tiger Hills-Oak Lake Sandhills. Trace element analysis was done to determine the geographic origin of maize found at each site. Food residues from the same area would cluster together; food residues from different areas would not cluster (Boyd 2008:2549). It was found that all samples clustered, with one exception: a loop-handled pot of a style normally found in the Dakotas (Boyd 2008:2550).

What we see in this study is a perfect example of multiproxy evidence. It consisted of phytoliths in combination with both botanical and non-botanical evidence. All of these lines of evidence provide different information. The microfossils (phytoliths and starch) were evidence of the presence of maize. The stable isotopes indicated whether terrestrial or aquatic foodstuffs predominated in their diet. The trace element analysis gives information on the geographic origin of remains.

We just saw three studies where phytoliths played a key role in pushing forward the archaeology of southern Manitoba, in combination with other evidence. It was already known through historical ethnographic accounts that native peoples practised anthropogenic burning to make the environment more productive and to control the bison herds. Phytoliths provided the evidence that established the strong possibility that anthropogenic burning was practised by pre-contact natives as well. In addition, phytoliths in combination with many other lines of evidence have caused a revolution in our understanding of pre-contact foodways, with a strong emphasis on the role of maize in southern Manitoba. As Boyd notes, "Using this approach [microfossils, stable isotopes, and trace elements], we conclude that maize was more widely consumed in North America than previously thought" (Boyd 2008:2545). We now have a much more complete picture of pre-contact foodways than ever before. Previously the picture was heavily skewed toward the role of bison meat in the diet. That has always been well understood. The role of maize was almost completely unknown, until now. Thus, my original point in the introduction to this essay: phytolith research has revolutionized our understanding of the precontact peoples of Manitoba. I will now finish this essay with some possibilities for further research.

Phytolith research in Manitoba is still very much a work in progress, though. There is still much work to be done. One important line of research that needs to be pursued is determining the origin(s) of the maize found in southern Manitoba. We have established that it was there, but now we need to find out where it came from. If horticulture was practiced locally, then phytoliths could be used to identify garden plots where maize was grown (or disprove that hyptothesis).

Another potential use of phytoliths goes beyond maize. The Middle Missouri cultures also grew beans and squash, as part of the maize-beans-squash complex that goes all the way to the American Southwest. Phytolith research would therefore expand beyond maize to include those two food plants. My establishing their presence or absence, archaeologists would know that the whole complex spread to southern Manitoba or that only one member spread. Phytolith studies as part of archaeological research have already revolutionized the archaeology of Manitoba, and they have the potential to revolutionize it further.

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