APPENDIX C

STARCH AND PHYTOLITH ANALYSIS OF STONE TOOLS
INTRODUCTION

Nine stone tools, mostly groundstone, were submitted for starch analysis from the Siren Site, 41WM1126, Texas. Because the extraction method produced phytoliths along with the starch, the phytoliths were also examined. The starch grains and phytoliths recovered from the use surfaces of these tools may provide subsistence and tool function information.

METHODS

The extraction of starch grains from the surfaces of these tools was based primarily on a phytolith extraction method, with exposure to oxidizing chemicals kept to an absolute minimum to preserve the starch. First, a sonicating toothbrush and a mild detergent (5% Triton X-100) was used to facilitate release of microscopic residue particles adhering to the groundstone surface. Each sample was rinsed thoroughly and centrifuged using short-duration spins (10 seconds at 3000 rpm) to remove clay particles. Next, the samples were frozen and dried under vacuum. The dried samples were then mixed with potassium cadmium iodide (density 2.3 g/ml) and centrifuged to separate the microfossils, which will float, from most of the inorganic silica fraction, which will not. Because a significant portion of microscopic organic matter was recovered that hindered microfossil observation, nitric acid was added to each sample. After one hour, the samples were rinsed to neutral with water and then a final alcohol rinse. Next, the samples were mounted in optical immersion oil for counting with a light microscope at a magnification of 400x. The entirety of the slide was scanned for starch grains as well as for phytoliths of economic significance. Diatoms and sponge spicules, organisms with silica shells, were also noted. A diagram was produced indicating the total number of potentially significant microfossils observed.

ETHNOBOTANIC REVIEW

It is a commonly accepted practice in archaeological studies to reference ethnographically documented plant uses as indicators of possible or even probable plant uses in prehistoric times. The ethnobotanic literature provides evidence for the exploitation of numerous plants in historic times, both by broad categories and by specific example. Evidence for exploitation from numerous sources can suggest widespread utilization and strengthens the possibility that the same or similar resources were used in prehistoric times. Ethnographic sources outside the study area have been consulted to permit a more exhaustive review of potential uses for each plant. Ethnographic sources document that with some plants, the historic use was developed and carried from the past. A plant with medicinal qualities very likely was discovered in prehistoric times and the usage persisted into historic times. There is, however, likely to have been a loss of knowledge concerning the utilization of plant resources as cultures moved from subsistence to agricultural economies and/or were introduced to European foods during the historic period. The ethnobotanic literature serves only as a guide indicating that the potential for utilization existed in prehistoric times, not as conclusive evidence that the resources were used. Phytolith and starch remains, when compared with the material culture (artifacts and features) recovered by the archaeologists, can become indicators of use. Plants represented by phytolith and starch remains will be discussed in the following paragraphs in order to provide an ethnobotanic background for discussing the remains.
**Native Plants**

_Cyperaceae (Sedge Family)_

The Cyperaceae (sedge) family contains grasslike or rushlike herbaceous plants that are commonly found in riparian habitats. Only a few members of this family are noted to be of economic importance. The nutlike tubers of _Cyperus esculentus_ (chufa, yellow nutgrass) can be eaten raw, boiled, or dried and ground into a flour (Peterson 1977:230). The seeds of _Cyperus odoratus_, as reported by E. Palmer, are reported to have been eaten by the Cocopah Indians, while the Apache are noted to have eaten the underground parts of _Cyperus Fendlerianus_ (Kearney and Peebles 1960:149-150). The Pima are reported to have eaten the small tubers of _Cyperus ferax_, and to have chewed fresh or dried tubers of _Cyperus esculentus_ for coughs (Curtin 1984:98-99). _Cyperus esculentus_ and _Cyperus rotundus_ (nutgrass) can be common weeds in cultivated fields and pastures (Kearney and Peebles 1960:150). The young shoots and bases of older shoots of _Scirpus validus_ and _Scirpus acutus_ (great bulrush, tule) can be eaten raw or cooked. The pollen and ground seeds can be used as a flour, and the rootstalks, which are rich in sugar and starch, can be roasted for several hours and eaten like potatoes or dried and ground into a flour (Peterson 1977:230). The Hopi Indians are reported to have eaten the raw stem bases of _Scirpus acutus_. _Scirpus_ stems also were used for weaving (Kearney and Peebles 1960:151).

**Asteraceae (Sunflower Family)**

The Asteraceae (sunflower or aster family) is the largest family of dicots worldwide. Members of the Asteraceae family were used in a variety of ways, including as construction materials, tools, crafts, medicines, and as food. Seeds were exploited from several members of this group. Most Asteraceae seeds ripen in the late summer and fall. Young leaves were eaten raw or cooked as greens. Roots were eaten raw or cooked. Several plants were used as chewing gum including _Antennaria_ (pussytoes), _Lactuca_, _Lygodesmia_ (skeletonweed), and _Hieracium_ (hawkweed). Members of this family also were important medicinal resources (Chamberlin 1964:362-363)(Kirk 1975:132-157; Moore 1989:22-23, 55-56, 128-129)(Tilford 1997:16, 38, 66, 144, 166, 180). Woody members of the sunflower family noted in west Texas include ragweed (_Ambrosia_ spp.), sagebrush (_Artemisia_ spp.), baccharis (_Baccharis_ spp.), rush bebbia (_Bebbia juncea_), Texas greeneyes (_Berlandiera betonicifolia_), brickellbush (_Brickellia_ spp.), spiny chloracantha (_Chloracantha spinosa_), damianita (_Chrysactinia mexicana_), rabbitbrush (_Chrysothamnus_ spp. and _Eriocameria_ spp.), fleshyleaf clappia (_Clappia suadaeolina_), onehead brittlebush (_Encelia scaposa_), terpentine bush (_Eriocameria iaricifolia_), tarbush (_Flourensia cernua_), nakeweed (_Gutierrezia_ spp.), false broomweed (_Haploesthes greggii_), burrobush (_Hymenoclea monogyna_), southern goldenbush/jimmyweed (_Isocoma plurifolia_), shortleaf jefea (_Jefea brevifolia_), pricklyleaf (_Thymophylla_ spp.), cinchweed (_Pectis_ spp.), rockdaisy (_Perityle_ spp.), sweetscent (_Pluchea odorata_), arrowweed (_Pluchea sericea_), trans-Pecos false claptadisy (_Pseudoclappia arenaria_), resinbush (_Viguiera stenoloba_), and species of goldeneye (_Viguiera_ spp.).

**Poaceae (Grass Family)**

Members of the Poaceae (grass) family have been widely used as a food resource. Grass grains were normally parched and ground into a meal to make various mushes and cakes.
Young shoots and leaves were cooked as greens. Grass also is reported to have been used as a floor covering. Some species of grass were used medicinally. *Andropogon glomeratus* (bushy bluestem) was used by the Catawba Indians to treat backache. *Hordeum jubatum* (foxtail barley) is used as an eye medicine. A decoction of *Oryza sativa* (rice) is used in fevers and inflammatory infections of the stomach, lungs, and kidneys. Paiute Indians gave sugar from *Phragmites communis* (common reed) to people with pneumonia. This plant also has been used as a diuretic, depurient, and an emetic. Grass seeds ripen from spring to fall, depending on the species, providing a long-term available resource (Burlage 1968:81-85; Chamberlin 1964:372; Harrington 1967:322).

**DISCUSSION**

Nine groundstone samples were submitted primarily for starch analysis from the Siren Site (41WM1126) located in Williamson County, Texas (Table 1). The site is on the eastern edge of the Edwards Plateau, along the south bank of South Fork of the San Gabriel River. Both the Blackland Prairie and Edwards Plateau Physiographic Regions fall within the project area boundaries. The Blackland Prairie is characterized by tall grass prairie taxa and microhabitats that support oak (*Quercus*), mesquite (*Prosopis*), Eastern red cedar (*Juniperus virginiana*), pecan and hickory (*Carya*), elm (*Ulmus*), and hackberry (*Celtis*). The Edwards Plateau has similar grass, tree, and shrub components.

Of the nine artifacts submitted for analysis, only one sample (506) was directly associated with a feature (47). Feature 47 is a cluster of FCR that has a Transitional Archaic cultural affiliation. Discussion of the results will start with sample 507 from Feature 47, followed by the remaining tools.

**Feature 47 (East Block, NW Quad, Level 9)**

Feature 47 was encountered in the western unit of the Eastern Block. The feature was a layered cluster of tabular fire-cracked limestone rocks. Thermally altered sediment and charcoal flecking defined the margins of this feature. The rocks composing the feature were a mixture of burned and fractured *in situ* specimens. Temporally diagnostic artifacts associated with the feature include a Castroville dart point. Feature 47 has a Transitional Archaic cultural affiliation.

**Sample 506**

Sample 506 is a piece of groundstone from a layered cluster of tabular fire-cracked rock, found with bone fragments. A portion of the use surface was washed for starch and other microfossil remains. No starch grains were observed; however, the recovery of several phytoliths associated with seeds, specifically the material that surrounds them, were observed. A silicified cone cell from the material that surrounds the achene (seed) of a sedge (Cyperaceae) was recovered (Figures 1 and 2 A). This particular type of cone cell is similar to those produced by the genus *Cyperus*. Three opaque perforated plate phytoliths were recovered (Figure 2 B). These phytoliths are similar to those produced by large seeded sunflower family (Asteraceae) members such as sunflowers (*Helianthus*) and marshelder (*Iva*).
Also, a single dendriform phytolith was observed (Figure 2 C). Dendriforms originate in the bract material (lemmas, paleas and glumes) that surrounds the seed (caryopsis) of some wild and domesticated grasses. They are very common in the bract material of Pooidae grasses, especially domesticated cereal grain and related wild taxa. Dendriforms can be indicators of grass seed processing at archaeological sites. This is because the dendriform-bearing plant material that encapsulates the grass seed is never entirely removed from all of the grains during parching, winnowing, and grinding steps. These dendriforms can then be cooked, digested, and incorporated into the archaeological/geological record. Lastly, three diatoms from the genus *Aulacoseria* were observed. Although pennate diatoms and sponge spicules can be found in moist soils, filamentous diatoms from the genus *Aulacoseria* are planktonic and typically associated with lakes and large rivers. In some archaeological contexts, the presence of diatoms can be an indication that water from a lake or river was used to process or cook various foods.

Thus, the phytolith evidence suggests that seeds from various plants growing in the vicinity of this site were gathered and processed using this groundstone. Plants likely to have been utilized by the site occupants include sedges, sunflowers and/or marshelder, and grasses. Again, no starch was observed from the surface of this groundstone.

**East Block, NE Quad, Level 6**

**Sample 311.2**

Sample 311.2 represents a wash of the surface of a very small fragment of groundstone. Approximately 9 cm² of the use surface was washed. No starch was recovered; however, this sample did yield eight opaque perforated plate fragments from the seed hull of a member of the Asteraceae family. As explained for sample 506, these phytoliths were likely derived from sunflower or marshelder processing. With the recovery of eight of these fragments (the highest amount from all of the artifacts analyzed) from such a small piece of groundstone, there is a high likelihood that this tool was used to processes Asteraceae seeds. Also recovered was a single dendriform phytolith most likely derived from grass seed processing.

**Sample 311.1**

Sample 311.1 represents a wash of the surface of another very small groundstone fragment. Approximately 3 cm² of the use surface was washed. No starch was recovered, and no phytolith indicators of food or food processing were observed. This result is likely due to the small amount of surface area available for analysis.

**Sample 316**

Sample 316 represents a wash of another small fragment of groundstone. Approximately 17 cm² of use surface was washed. As for sample 311.1, no starch or phytolith evidence of food processing was observed.
Sample 1141

Sample 1141 represents a wash of mano recovered from Level 2. When washed, this mano discharged a large amount of “red ochre”-stained clay-sized particles. No x-ray fluorescence or x-ray diffraction studies were done on this material to identify the specific constituents. Recovery of these colored mineral particles suggests that this mano may have been used to process mineral pigments. The high reactivity of this stone when tested with hydrochloric acid suggests that it is limestone. The prominent finger holds would have formed easily because of the acidic nature of human hands (approximately pH 5.5). No phytolith indicators of plant processing were observed; however, a single starch grain was recovered (Figure 2 E). This grain is rather large and somewhat angular in nature. This starch particle actually comprises two grains (see red arrows), and exhibits damage from either cooking or dessication over time, making observation of its birefringence and extinction cross under polarized light almost impossible (Figure 2 F). Similar starches are noted in the roots of lotus (*Nelumbo*), although the difficulty in observing the identifying characteristics of this small group of starches makes this identification problematic. Thus, identifying the origin of this starch cluster is rather difficult, but it may be derived from a root or tuber. Thus, this mano may have functioned early on as a root or tuber processing tool, and later as a mineral processing tool.

Sample 861

Sample 861 represents a wash of a small, almost egg-shaped, mano or grinding stone recovered from Level 4. When washed, this tool discharged a large amount of yellow ochre-stained clay-sized particles. This suggests that it may have been used to process mineral pigments. The high reactivity of this stone when tested with hydrochloric acid suggests that it is also of limestone origin. The surface of this tool is very gritty, resembling sandpaper. It also displays very slight ridges bilaterally along the long axis. This is possibly due to its use in the palm of the hand (gently rolling the tool against the object to be ground using the palm of the hand to control the rolling motion). It is also very likely that the micro-pits and resulting surface roughness represent areas that were easily dissolved from hand-derived acids. This tool yielded fairly strong evidence that is was used to process plant material, as well. A silicified cone cell from the material that surrounds the achene (seed) of a sedge (Cyperaceae) was recovered (Figure 2 A). This particular type of cone cell is similar to those produced by the genus *Cyperus*. Five opaque perforated plate phytoliths were recovered, suggesting that large seeded sunflower family (Asteraceae) members such as sunflowers (*Helianthus*) or marshelder (*Iva*) were processed with this tool. Three dendriform phytoliths were observed, suggesting that grass seeds were processed with this tool. A dendritic long cell with fragments of a thinly silicified epidermal sheet element attached to its margins also was recovered (Figure 2 D). This particular type of phytolith is similar to those produced by members of the cool-season grass subfamily Pooideae, and may be derived from wildrye (*Elymus* sp.) And last, an *Aulacoseria* sp. diatom was observed, suggesting that water may have been used with this tool to process materials. Thus, this mano may have functioned early on as a seed processing tool, and later as a mineral processing tool.
Sample 1562.3

Sample 1562.3 represents a wash of a very small fragment of groundstone. Approximately 8 cm² of the surface was washed for starch and phytolith microfossils. When washed, this groundstone fragment discharged a relatively large amount of red ochre-stained clay-sized particles. This suggests that it may have also been used to process mineral pigments. Four opaque perforated plate phytoliths were recovered, suggesting that large seeded sunflower family (Asteraceae) members such as sunflowers (Helianthus) or marshelder (Iva) were processed with this tool. And finally, a single sponge spicule was observed, suggesting that water may have been used with this tool to process materials. Thus, this groundstone may have functioned early on as a seed processing tool, and later as a mineral processing tool. Alternatively, seeds may have been ground along with minerals as an easily acquirable source of oil for making a pigment. (Oily pigments apply more easily to skin.) It should be noted that Asteraceae seeds such as sunflower and marshelder have a relatively high oil content.

Sample 1712 from Level 1

Sample 1712 represents a wash of a somewhat circular hammerstone with a 24-to-26-inch circumference. No starch or phytolith indicators of food or food processing were observed. If this tool was used to crack open nuts such as pecan or walnut, it is possible that it would have had limited contact with the starchy nut meat inside. Detecting the oils present on this type of tool with FTIR analysis would be the best way to identify nut processing.

Sample 2102 from Level 5

Sample 2102 represents a wash of a relatively flat piece of groundstone with long striations clearly visible on its surface. No starch was observed, and only one opaque perforated plate phytolith was recovered, suggesting that large seeded sunflower family (Asteraceae) members such as sunflower (Helianthus) or marshelder (Iva) were processed with this tool. A single Aulacoseria sp. diatom was observed, suggesting that water may have been used with this tool to process materials.

SUMMARY AND CONCLUSIONS

Nine groundstone tools and one hammerstone were submitted for starch analysis. However, the extraction method used also recovered phytoliths. Although formal phytolith counts were not made, since this was a starch analysis, their presence was noted when phytoliths of economical significance were observed. The only sample that yielded a starch grain was sample 1141, a mano that may also have been used to process pigment minerals, such as red ochre. Groundstone sample 1562.3 also yielded evidence of possible red ochre mineral processing. Mano sample 861 may have been used to process yellow ochre. Five of
the tools (311.2, 506, 861, 1562.3 and 2102) yielded evidence of seed processing that included members of the sunflower family (Asteraceae), sedge family (Cyperaceae), and grass family (Poaceae). Three tools (311.1, 316, and 1712) yielded no evidence of plant material processing. Finally, the combination of evidence for both microscopic seed remains and mineral pigments on two of the same tools suggests that the seeds may have been intentionally ground along with the mineral pigments, perhaps to add an oily base to them. Oily pigments would be particularly suited for application to the skin.
### TABLE 1
PROVENIENCE DATA FOR SAMPLES FROM THE SIREN SITE (41WM1126), TEXAS

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FTIR = Fourier Transform Infrared Spectroscopy
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FIGURE 2. SELECTED PHYTOLITHS AND A STARCH GRAIN RECOVERED FROM GROUNDSTONE TOOLS, THE SIREN SITE (41WM1126).

All micrographs taken at approximately 400x magnification. The white scale bar in A equals 10 µm in length.

A) Silicified cone cell from the material that surrounds the achene (seed) of a sedge (Cyperaceae) recovered from mano sample 1141. This particular type of cone cell is similar to those produced by the genus *Cyperus*.

B) Opaque perforated plate phytolith recovered groundstone sample 311.2. These phytoliths are similar to those produced by large seeded sunflower family (Asteraceae) members such as sunflower (*Helianthus*) and marshelder (*Iva*).

C) Dendriform phytolith recovered from groundstone sample 311.2. Dendriforms originate in the bract material (lemmas, paleas and glumes) that surrounds the seed (caryopsis) of some wild and domesticated grasses.

D) Dendritic long cell with fragments of a thinly silicified epidermal sheet element attached to its margins, recovered from mano sample 861. This particular type of phytolith is similar to those produced by members of the cool season grass subfamily Pooideae, and may be derived from wildrye (*Elymus* sp.).

E) Large angular starch grain cluster comprised of two grains (see red arrows). The starch grain on the left exhibits damage from either cooking or dessication over time, making observation of its birefringence and extinction cross under polarized light (F) almost impossible to see. The starch grain on the right may have burst open. This starch grain cluster may be derived from a root or tuber.
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