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THE CLAY OBJECTS FROM THE MISSISSIPPIAN COOSA MOUND SITE/PLANT HAMMOND SITE (9FL3):

The Nature of Mississippian Pre-Fired Ceramic Paste Preparation

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Abstract

A cache of whole and fragmentary clay objects recovered from the Mississippian Coosa Mound Site/Plant Hammond Site (9FL3) appear to be fully prepared, but unfired ceramic paste. While there is a cursory mention of ceramic paste preparation in the ethnohistoric literature, specifics of paste preparation were not recorded. Unfired prehistoric ceramic paste has not been analyzed for eastern North America. These materials provided a unique opportunity to explore the nature of prehistoric, pre-fire ceramic paste processing.

Particle-density, particle-size, and organic content tests indicated that the paste was prepared from previously separated (possibly levigated) silt-clay, mixed with previously prepared and size-sorted fine and medium sand. Evidence suggests that organics, such as grease, blood, or glue, were added to the paste, presumably to enhance its workability. The paste was kneaded on a surface that had been coated with fine sand and with silt-clay dust. Paste was gathered up in handfuls, rolled into a conical shape, then placed on a mat or cloth covered with silt-clay dust. Evidence suggests that two ceramicists produced the unfired clay objects.

INTRODUCTION

The clay objects recovered from Feature 12 at prehistoric site 9FL3 (originally known as the Coosa Mound Site [Wauchope 1966:219], and now called the Plant Hammond Site [e.g., Hally and Langford 1988:13, 18]) appear to be a cache of unfired ceramic paste that preserves, in a frozen moment, the six pre-firing steps of ceramic manufacture essentially unrecorded for prehistoric eastern North America. Most of that paste appears to have been worked into cone-like objects, which then were set aside and for some reason allowed to dry out. A small portion of the paste appears to have been kneaded, placed with those cone-like objects, and also with them abandoned. Also associated with Feature 12 was a small volume of uniform-sized quartz/orthoquartzite sand grains.

Although there is more than sufficient information about how prehistoric ceramics were constructed then fired (e.g., Sassaman 1991), there is scant ethnohistoric and virtually no reported archaeological information on how the paste was made prior to the fashioning and firing of the vessel. This lack of information on ceramic manufacture, starting with acquisition of the raw material and ending with a finished, suitable paste, was long considered a core issue in prehistoric archaeology of the eastern United States (e.g., Thomas 1894:682; Holmes 1903:48; Swanton 1946:549; Shepard 1956:49). However, the absence of any substantial physical evidence, combined with shifts in research interests, resulted in the entire topic of pre-fired ceramic technology being set to one side (cf. Sassaman 1991).

We want to start by going over what is known, ethnohistorically, about pre-fired ceramic paste technology. This is the best approximation we can have for how things were done before European contact. Some of those paste-preparation steps appear evidenced by the material from Feature 12. Next, the analytical methods will be explained. Following that, the specifics of the collection itself will be given, after which the implications of the cache will be discussed.

PRE-FIRED CERAMIC TECHNOLOGY IN THE EASTERN UNITED STATES

The kind of pottery manufacture done in the eastern United States could involve up to six steps before the vessel assumed any shape:

(1) a suitable "clay" or fine-grained earth was obtained;

(2) that clay was somehow processed or refined, with larger inclusions being removed;

(3) grease, glue, or blood might be added

(4) a tempering agent -- shell, ceramic sherds, sand, steatite, fibers, chert, and so on -- was selected (if, in the potter's opinion, it was warranted) then ground to a uniform consistency;

(5) the "clay" and temper were mixed with water and kneaded until the paste was plastic; then

(6) the paste was allowed to age; that is, it was stored damp for a period to permit the water to distribute more evenly to give the best plasticity.

Any evidence of abandoned, pre-fired ceramic paste will have evidence of some and perhaps all six of those steps. Ethnohistoric accounts of those steps, especially the first three, are essentially lacking, a situation that has been lamented for over a century (see Thomas 1894:682; Holmes 1903:48; Swanton 1946:549; Shepard 1956:49).

Most ethnohistoric accounts of pottery making begin with a statement that a suitable clay was located; those accounts then proceed to discuss tempering, shaping, and firing of the vessel, leaving unaccounted the intervening paste-preparation steps. For example, Butel-Dumont, writing of the Natchez in 1753, stated

> After having collected the earth necessary for this work, and cleaned it well, they take shells and pound them to a fine and delicate powder ... [translated in Thomas 1894:882; the same passage is given also in Holmes 1903:57; Swanton 1911:62; Swanton 1946:550].

Adair (1775:424-425) only noted that the Cherokee used clay for pottery.

A number of questions come to mind. For example: Cleaned the "earth" how? Where were the people getting the "clay" and what were they doing to it before the temper was added? Kneaded the "clay" how? Aged it where? In what form? Where was all of this activity done, anyway? How long was the "clay" or the completed paste set aside and stored before being used? Holmes, who was compiling the first extensive documentation of prehistoric ceramics for the astern United States, was so bothered by those and similar questions and the apparent lack of answered that he asked the ethnographer James

Mooney, when the latter next visited the Cherokee, to find out how the "clay" was processed (Holmes 1903:48, 53-55). Mooney found that the "clays" were taken from a creek, pounded, mixed with water, and then considered ready for working. This was the methods recorded by Du Pratz in 1758 amongst the Natchez, and by Hunter in 1823 amongst the Osage (Holmes 1903:57, 58; see also Swanton 1911, 1946).

Holmes mentioned two other ways of preparing the paste prior to adding temper. The first, reported to Holmes by a Cherokee informant in 1891, mentioned that the "clay" was passed through a sieve *before* it was pounded (Holmes 1903:153; this was not recorded by Harrington [1908] but was by Fewkes [1944] for the Catawba potters living with the Cherokee). The winnowing or dry-sieving of "clay" also was mentioned by Shepard (1956:51) and given a measure of plausibility for the Southeast by Swanton (1911:62) when he discussed sifting, sieving, and winnowing maize with baskets of cane splints.

Isolating a fine-earth component for the paste could also be done through levigation. This actually is a more common and dependable method, but one that is not recorded directly for aboriginal ceramics in the United States. For example, in discussing ceramic manufacture in the Northeast, Holmes remarked:

> Respecting the securing and selecting of the ingredients, and the *levigating*, mixing, and manipulation of the paste, but little can be said [1903:161; emphasis added].

Clearly, Holmes considered levigation to be an expected step in paste preparation. This is the only direct mention of levigation of which we are aware before Fewkes (1944:75, fn. 15; Fewkes simply noted that he looked for levigation but did not find it). Speck (1909:25) did note that Yuchi potters sorted coarse from fine particles by swirling a mixture of water and clay in a shallow pan, and Swanton (1946:551) related a commentary by Bartram in 1792 that one Creek village obtained clay from a large artificial pond just outside of the settlement. It is unclear if the pond was for clay or for the cultivation of angelica, since the latter was grown in such ponds. It is possible that it was for both, and other things besides. (It is notable that uncharred rootlet fragments were scattered throughout the clay material from Feature 12, and that gley inclusions also were present.)

Bartram's would be an exercise in levigation on an very large scale, which would be consistent with what had been a high population-density, stratified society. The only known evidence for levigation in prehistoric North America was a probable levigation spoil identified in Minnesota, associated with a Middle Woodland occupation, prehistoric site 21CA58 (Neumann 1975, 1978). Although preliminary tests yielded data consistent with such a feature, further tests have yet to be done to the matrix.

The ethnohistoric information for the first two steps -- locating then processing or refining the clay -- is vague. It would seem that a natural fluvial deposit was sought if this was available (cf. Harrington 1908:402, "the Indians merely dig down through the surface soil ..."). The material was usually too coarse to be used without first removing large particles and dry-pounding the raw material. Tempering was not always added, presumably because the sand fraction native to the original deposit was sufficient.

The third step -- adding glue, grease, or blood -- was sometimes mentioned (e.g., Densmore 1929; Fewkes 1944; see Shepard 1956:52-53). Densmore (1929:162), for example, wrote that in the past Objibwa pottery was "made of clay and sand, mixed with a little glue." Shepard explained that the addition of such organics improved the working quality of the paste, because the organics acted as protective colloids that dispersed the clay particles. The presence of grease, glue, or blood in the initial paste mixture cannot be documented from fire ceramics. Only if unfired paste is encountered can prehistoric evidence of that third step be documented.

The fourth set -- the preparation of a tempering material -- is obvious from the archaeological record, only because the ceramics often are tempered. Not all ethnohistoric ceramics had tempering agents added to the fine-earth component, since in some cases the proto-paste obtained contained an appropriate mix of sands sufficient to serve as temper.

Tempering agents served a technological function, of course: An overabundance of silt-clay would result in a crazed vessel, even before it was fired. Tempering agents like shell also provided a nutritional adjunct: The shell added calcium to whatever liquid would be cooked then consumed in such a vessel (Neumann 1979). In a high population, stratified Mississippian society where access to calcium -- for hunting-gathering peoples, meat; for pastoral peoples, milk -- would have been limited because of limited access to game, shell-tempered ceramics would have helped build then maintain the skeletons of the children (and the mothers who bore them; adult males have substantially less dietary calcium needs; see Neumann 1997, 1998).

Aside from the above-quoted remarks that tempering agents were selected, processed, then added, little information is known. In some respects, it has always been assumed that all that is needed to be known anyway is that temper *was* added, and of course that is self-evident from the fired ceramics.

The fifth step was the addition of water and kneading of the mixture into a ceramic paste. That, too, seems self-evident, so much so that there is nothing else about it in the ethnohistoric literature. People kneaded the silt-clay and the temper into a paste, then, with the sixth step, stored it someplace to allow the moisture to become evenly distributed throughout the matrix.

The fifth and sixth steps are steps that are so innocent that even the cursory recordation of early European explorers added nothing else. It was invisible, presumably because it was obvious (or because it was something that the other sex did and therefore a specialized step that was not essential for the recorder to know much less worry about, since his concern as observer would be the final product, or the firing of that product).

We think that the material from Feature 12 also documents the fifth and sixth step. The flat objects found in the feature, with their heavy, almost "sugared" sand coating one side, and their palm-heel-print and thumb-impressed marks combined with their shape suggestive of the kneading step; the iron oxide precipitation suggestive of storage.

METHODS AND DATA MANIPULATION

Recovered in 1973, for the last quarter-century the whole and mended items from Feature 12 of prehistoric site 9FL3 had been labeled as "baked clay objects." This material was submitted to the Pocket Park - Wentworth Analytical Facility/Diachronics Division, along with the question of what the items actually were.

The collection from Feature 12 contained material in three forms: (1) individually bagged, entire or partially mended conical clay objects, together in one paper bag; (2) large clay-object fragments, unmended, in another paper bag; and (3) comparatively small, clay-object fragments, quartz/orthoquartzite sand, around three tiny stray pieces of burnt bone, crumbs, and other debris in a small cardboard box.

The collection first was sorted and inventoried. This involved removing all of the fragments or items from their bags, setting them out, and seeing if fragments mended. One result was that pieces from all three sets were found on occasion to mend into one entire object, confirming that all of the material submitted came from the same cultural deposit/event. As many pieces as possible were mended, raising from 10 to a total of 15 complete and nine nearly complete objects within the sample. Mended items representing individual objects each were given a number, measured, then bagged separately.

Each item was measured and weighed, including object height, length of major and minor axes of the elliptical base, and weight. The purpose of these measurements was to assemble just enough dimensional variables that each set would be unique to the object while also allowing a cluster analysis to be done. Unmended fragments were grouped together and weighed as a set. Since many of the bags had small spalls and crumbs at the bottom, and since the cardboard box also had those kinds of fragments, that material was separated out into a series of samples for particle analysis. The cardboard box also had, mixed with the dust, 1973 excavation trash (paper scraps, unused match heads, roots), a lot of quartz/orthoquartzite sand grains. Those sand grains were separated individually from the other material, weighted, and bagged.

Regardless of *what* the clay objects were, they still appeared nearly identical in intended shape but vastly different in overall size. Since, baked or not, they clearly had been modeled, the question of whether more than one set of hands was involved was raised. To help answer this, a cluster analysis was done using numerical classification based upon single-linkage Euclidean distances (Everitt 1974). This is the only numerical classificatory technique that is not considered mathematically dubious (Jardine and Sibson 1968).

The material was examined under a dissecting microscope to get some sense of what it was that was present. Then, four basic physical tests were performed on the clay material:

(1) a slaking test, to assess if indeed the material had ever been baked (it had not, hence the next three tests);

(2) an organic content test, using hydrogen peroxide (H_2O_2), to subjectively gauge if unusually high concentrations of organics were present;

(3) a particle density (specific gravity) test, to provide the average particle density needed to perform a sedimentation particle-size analysis using a hydrometer; and

(4) a hydrometer sedimentation particle-size analysis.

Particle-density and -size analyses followed methods outlined by Bouyoucos (1927, 1936), Blake (1965:371-373), Day (1965:548), and Shackley (1975:38-39, 87-91, 117). For the estimate of particle density (specific gravity), five samples totalling 15.66g were selected from the unmendable crumbs in the bottom of the cardboard box and the two larger paper bags. Each of the five samples was weighed on an Ohaus 310.00 x 0.01g balance. Samples ranging from 3.01 - 3.18g were placed in 10.00 ml of distilled water, in a 15 ml graduated and screw-cap test tube at 25.0°C. Air bubbles were removed using a stiff wire strand. The displaced volume relative to weight was measured.

For the particle size analysis, a collection of spalls and small clay-object fragments were oven-dried at 93.3°C for 15 hours then at 107.2°C for 13 hours. The final oven-dried weight totalled 149.51g. The dried material was divided into five samples, consisting of three from the various small spalls found at the bottom of the bags and in the cardboard box, and two more from unmendable but still large clay-object pieces. One of each was bagged in a zip-lock bag against future analyses (crumbs: 34.89g; fragments: 54.62g). Two samples of the crumbs and one of the fragments, each weighing 20.00g oven-dried, were separated for analysis.

Each of the three 20.00g samples was placed in 125 ml of 40.00g/1000.0 ml sodium hexametaphosphate solution at 25.0°C, and allowed to slake for 16 hours. After 16 hours, two of the three samples (Samples 2 and 3) were transferred to sedimentation vessels; the third sample (Sample 1) was held in reserve. Sample 2 was chosen as one of the crumb samples, since it was not known if the crumbs represented a different sub-sample of the material (for example, because of their susceptibility to spalling off). Sample 3 represented what seemed to be pieces of the actual clay objects that broke -- not spalled -- off of original items.

A standard hydrometer sedimentation measurement was done, following procedures outlined by Bouyoucos (1927, 1936). This process makes use of Stoke's Law:

$$t = 18\eta h/g(\rho_S - \rho_L)\, X^2 \tag{1}$$

where *t* is the time in seconds; η, viscosity of water at the experimental temperature (at 25.0°C, 0.894); *h*, 24.0 cm (for the purposes of the experimental instrumentation); *g*, acceleration of gravity (980 cm/sec^2); ρ_S, specific gravity of the material dropping through the medium (here, 2.884 g/cm^3); ρ_L, 0.997 g/cm^3 at 25.0°C); and *X*, particle size in millimeters. Measurements were taken at half-phi (0.5 Φ, where $\Phi = -\log_2 mm$) intervals, as well as at 0.1000 mm, 0.0500 mm, and 0.0200 mm, with readings beginning at 0.1000 mm (+3.25 Φ).

RESULTS

Metrics and Basic Sample

Table 1 summarizes the material associated with Feature 12. Approximately 9384.14g of material was analyzed; another 50g or so of material, present as dust, granules, and crumbs in paper bags, was not measured. Also present was 69.2g of uniform-sized quartz/orthoquartzite sand grains, representing a volume of about 118 ml.

The sample consisted of 15 complete clay objects (Table 2a). Each was conical or sub-conoidal, around 85 - 95 mm high, with a flattened elliptical base around 60 - 65 mm along the major axis and 45 - 50 mm along the minor axis. Most weighed between 190 - 400g (Figures 1, 2). It is telling to note that, when set upright on their flattened bases, most of the clay objects listed to one side. Some of those objects, by the way, clearly had fallen over while still damp: Their sides not only were flattened,they had bits of dirt adhering to them. Actually, nearly all of the objects had patches of silt-clay stuck to their sides.

Fragments in the collection allowed another nine objects to be put back together (Table 2b), sufficiently so that dimensions and weights could be estimated with reasonable confidence (the objects had nearly identical surface curvatures, so that when a small piece was missing, it was easy to estimate the size and scale of the missing part).

Ten fragments consisted of flattened clay objects (Figure 3). These were of irregular shape, often flatter on one side than the other (approaching a plano-convex cross-section). Some pieces had large-grained albeit uniform-sized sand adhering to the flattened side, as if it had been placed on something that had had sand sprinkled on it beforehand.

The collection also contained pieces with hand-heel/palm imprints, as well as thumb impressions (Figures 3, 4). These will be considered later when the overall collection and its implications are discussed.

Visual Examination

With the unaided eye, the three characteristics that stood out about the clay objects were:

(1) their rust-orange color;

(2) the "scale" of dirt adhering to object exteriors; and

(3) the fracture patterns amongst most of the objects.

The rust-orange color appears to have been the product of iron oxide precipitation at the surface of the object (Figures 5, 6). The obvious interpretation is that water, rich in iron, seeped to the surface of the object then evaporated, leaving the iron oxide (Fe_2O_3) behind. It probably was the rust-orange color that led to the erroneous interpretation of the objects having been fired. While it is not known if the water itself or the silt-clay fraction was rich in iron oxide, the amount precipitated at the surface of the objects suggests that the latter is the better guess.

Between five - 80 percent of the exterior of the 24 entire or nearly entire objects had dirt adhering to them. "Dirt" is the best word: It is as if a moist, formed object had somehow fallen over onto dusty earth, then was uprighted with the earth still clinging. This suggests several things: That the objects were damp when set aside, that they were set aside in a dusty, dirty environment, and that the dirt clinging to them did not change their worth in the eyes of the people messing with them.

The fracture pattern -- and its lack -- were most telling. Nearly every object, whether still in one piece or in several, had deep cracks through the mass the object, *but did not in any case have any surface crazing.* The cracks almost always were longitudinal, and tended to bisect the object (e.g., Figures 7, 8). In many cases, those lengthwise halves were themselves split into three parts: There were cases, like Item 16, where five of the six pieces were present in the collection, and all that was missing was half of the tip of the conical object (see Table 2b; hence the remark "missing half of tip"). Very often, the faces of the cracked pieces presented surfaces that suggested that separate masses of ceramic paste had been pressed together (e.g., Figure 11, Figure 9 --> Figure 10, Figure 7 --> Figure 8, Figure 12).

While through-mass cracks were present, surface crazing was not. That is, a clearly moist and molded clay object had dried and, eventually, broken (often along molding surfaces), but the drying process in no way resulted in deformation of the material. The absence of surface crazing -- or of any crazing -- indicated that the clay objects were perfectly tempered. Without tempering, the objects would have crazed as well as cracked apart.

The material also was examined with a dissecting microscope (10x - 20x) and a brightfield-darkfield metallurgical microscope (50x - 200x). Examination revealed that the matrix was tempered with very fine sand, occasional larger (about 0.5 mm diameter) rounded quartz/orthoquartzite sand grains, and muscovite (mica) (Figure 5, 13). Also contained within the fabric were very small (0.1 mm) flecks of charcoal. These flecks were rare, and were found later to occur on the order of one or two per gram of material. The microscopic examination also confirmed that the iron-oxide exterior of the objects was a product of iron-oxide precipitation at the surface of a drying object: The iron oxide was banded and concentrated at the exterior of the clay object volume (Figure 5).

Slaking Test

A slaking test is nothing more than taking a putatively baked or fired object and placing it in water. Baked objects, and fired ceramics, will hold together; unbaked objects will crumble apart. This is the first and basic test performed to see if something has been fired or not.

Two unmendable crumbs from the bags, each around 2.0g in size (although not weighed) were dropped into 100 ml of distilled water. Within 30 seconds, each had fallen completely apart. The objects clearly had never been fired. Subsequent work with the material demonstrated beyond doubt that none of the objects had ever been baked or fired.

Organic Content Test

Five unmendable crumbs from the bags, each around 1 - 2g in size (although not weighed) were placed on aluminum foil. One milliliter of H_2O_2 was placed on each. In four of the five cases, vigorous and enveloping effervescence was observed. Observation with a hand lens (5x) revealed that small bubbles were forming around each of the observable particle grains (as the liquid hit the crumb, the crumb would collapse into its individual grains, as had happened with the slaking test), suggesting that the organic content of the material surround and coating the grains was high.

Particle Density (Specific Gravity) Test

The five specific gravity samples had an average specific gravity of 2.884 g/cm^3, both as individual samples (n=5) as well as an aggregate (displacement of 5.43 ml by 15.66g). The range was 2.864 - 2.917 g/cm^3. The average 2.884 g/cm^3 was taken as the experimental figure for the particle size analyses.

Particle Size Analyses

The results of the preliminary particle analyses are displayed in Figures 10 and 11. Particle analyses are presented with at least one of five scales: Wentworth (preferred by Griffiths 1967 as well as by us), ASTM/AASHO, USDA, ISSS and Φ (= $-\log_2$mm). Generally, anything over 0.1 mm in diameter (Φ = +3.25) cannot be caught using a hydrometer technique. Stoke's Law, in fact, is felt by many to be inapplicable to particles greater than 0.05 mm (Φ = +4.25) in diameter. For that reason, the particle analyses here a preliminary.

Figure 14 shows the basic histogram spread of particles in both samples from the collection. The coarser sand fraction is estimated in both cases. Notable in each case is that there was a definite fine-grained (silt-clay) portion to the material, comprising around 38.36 percent (Sample 3) to 38.86 percent (Sample 2), then a separate and large sand-sized fraction for each sample. In a naturally deposited sediment, the particles would exhibit a normal distribution, skewed perhaps, but still normal in the sense of a gradual rise to a peak, then a drop. Neither sample showed that.

The results of the particle analyses are given in Figures 15 and 16. Figure 15 presents the data from the two samples in the more tradition cumulative-percent, log-normal manner. Again, in a normally distributed population, the distribution would show as an S-shaped curve, beginning with particles larger than 0.001 mm and continuing, as the S-form curved back, into the 2.0 mm and beyond range.

The shapes of the two curves in Figure 15 here suggest multiple sedimentation events. Phrased another way, the curve suggests that fine-grained material was separated out in some manner, and that another particle size was added to that material. The "other" material would be the tempering agent in the paste. Here, it may only have augmented a sand fraction already present; or, again, there may have been modification of the proportion of the fine-grained, silt-clay component. In any case, the profiles shown in Figure 15 suggest artificial manipulation of the particle size distribution.

Figure 16 provides more specific information on particle-size characteristics. Depending upon the sample, between 38.86 - 38.36 percent of the paste consisted of clay- and silt-sized particles (particles under 0.06 - 0.05 mm in diameter, depending upon the particle-size scale used). In Sample 2, clay-sized particles (particles of 0.002 mm or less diameter) made up around 14.86 percent of the total sample; in Sample 3, clay-sized particles made up 7.99 percent of the total sample. The remaining 61.64 - 61.14 percent of the material consisted of sand, all of which definitely was smaller than 1.0 mm in diameter, and quite likely less than 0.71 mm in diameter. That is, the sand probably would be classified as "medium" in the Wentworth and the USDA particle scale systems. The proportional distribution between silt - clay and sand can be appreciated in Figure 17, where approximately 4.1 mm (58.6 percent) of the 7.0 mm of sediment accumulated along the center axis at the bottom of the sedimentation vessel represents sand.

The particle distribution in the paste is consistent with a previously processed fine-grained material having been mixed with a coarser tempering material (Figure 14, 15). Both samples showed a tendency toward a bimodal particle-size distribution. That is, there appeared to be a somewhat normally distributed array of silt-clay sized particles along with a normally distributed (albeit with a high kurtosis) array of fine and medium sand.

Numerical Taxonomy and Related Statistical Analyses

Given the analysis of the matrix -- unfired, made of two parts silt-clay to three of sand -- an assessment of the overall shape of the objects has meaning. A numerical analysis was done on the 24 whole or essentially whole clay objects. The main purpose was to see how many "hands" or individuals may have been involved in the production of the collection, since as modeled objects -- fired or not -- their size may well have been related to the hand-size as well as construction habits of the makers. The results are presented graphically in Figure 16.

Four measurements were used: Height of the object, the major and the minor axes of the elliptical-cross-section base, and the weight. It is notable that those four dimensions all had very strong correlations for the total collection, ranging from +0.555 for the height compared to the length of the minor axis (df:23, $p < 0.001$ that the two did not correlate) through +0.738 for the major axis compared to the minor axis (df:23, $p \ll 0.001$ that the two did not correlate) to +0.824 - +0.858 for the weight compared to all linear dimensions (df:23, $p \ll 0.001$ that the two did not correlate). Individual comparison of different objects were consistent with the correlations of the dimensional measurements. For example, the two objects shown in the cluster analysis to be most similar in form -- Items 11 and 23 with a Euclidean distance of 3.35 -- had shapes that were virtually identical given the dimensions used ($\chi^2 = 0.017$, df: 3; $p \gg 0.995$ that the two forms are not independent). The two objects that linked Cluster 1 with Cluster 2 (Items 12 and 16 with a Euclidean distance of 36.29), also appear to have been drawn from the same mental template in terms of form ($\chi^2 = 1.801$, df: 3; $0.75 > p > 0.50$ that the two forms are not independent). Only Item 1, with a Euclidean distance of 100.16 from the next nearest object (Item 2), was arguably different in the proportional distribution of the four physical dimensions ($\chi^2 = 8.489$, df: 3; $0.025 > p > 0.010$ that the two forms are not independent).

Ignoring Item 1, which was clearly smaller than all of the other objects in the collection, and which may well have been the forming of the last hand-full of paste, there are two basic clusters (Table 3). The statistical differences in these clusters are best illustrated using object weight, which correlated strongly with the other dimensions and of course would be a function of volume given similarity in overall form (Cluster 1 vs Cluster 2: $t = 9.67$, df:18; $p = 0.0000$ that the two sets are from the same population). Cluster 1 consisted of 11 objects. These were the larger of the clay objects in the collection.

Cluster 1 contained three sub-clusters, varying in overall size and in weight (Table 3). Average height and length of the minor axis did not differ; average length of the major axis differ up to 9.67 mm. Average weight differed up to 65.38g. Statistical tests using average weight indicated that all three subsets represented distinct clusters (Table 4).

Cluster 2 also contained three distinguishable sub-clusters (Table 3). These showed much smaller differences in linear dimensions (a maximum range of around 8.56 mm in height), but greater differences in weight (88.33 g difference in average weight between Cluster 2.1 and Cluster 2.3). Again, using weight as a criterion, statistical tests indicated that all three subsets represented distinct clusters (Table 4).

The objects in Cluster 2 tended to have much greater variability in length than those in Cluster 1, and of course were smaller in all four dimensions. However, while the proportional distribution of the four recorded dimensions were essentially the same amongst the two linking objects (Items 12 and 16), they were essentially different in terms of the average dimensions for the two clusters ($\chi^2 = 6.348$, df: 3; $0.25 > p > 0.10$ that the two forms are not independent). How the proportional distribution of the four dimensions compared amongst the six sub-clusters is given in Table 5.

Table 5 indicates that all of the sub-clusters in Cluster 1 were essentially the same in terms of how the objects were shaped, or at least the figures are consistent with such an interpretation. Further, each of the sub-clusters in Cluster 1 is rather different -- again in terms of the proportional distribution of those dimensions -- than found for most of the sub-clusters in Cluster 2 (the only exception being Cluster 1.2 and Cluster 2.2; not surprisingly, Item 8 in Cluster 2.2 proved the nearest link to the items in Cluster 1: Item 17 in fact).

Cluster 2.1 is rather different not only from anything in Cluster 1, but also from the two other sub-clusters in Cluster 2. While Clusters 2.2 and 2.3 display the same kind of association found amongst the three sub-clusters in Cluster 1, that is not really true for Cluster 2.1.

Taking all of the results together -- the cluster analysis along with the various statistical tests -- it would appear that there may well have been two sets of hands involved in making the clay objects. One apparently was capable of producing nearly identical items, represented by the items in Cluster 1. The second was less capable of generating as tightly clustered a series of forms, although those forms were reasonably similar amongst themselves, and that set would be represented by the items in Cluster 2.

DISCUSSION

Although probably encountered any number of times, we are not aware of any analysis of prehistoric unfired ceramic paste from the eastern United States. That such material has been encountered is certain: Dr. Roger Moeller (telephone conversation, 30 May 1998) remarked that he had recovered "bocce-ball-sized" unfired clay objects during a data recovery observation along the Delaware River in Pennsylvania. However, such material is extremely rare, since it falls apart in extreme moisture.

The clay objects and associated pieces from Feature 12 represent tempered, kneaded, and prepared ceramic paste that was never fired. The material gives insights into two aspects of Mississippian ceramic technology: The nature of the pre-fired paste, and the pre-vessel-formation manufacturing steps.

Nature of the Pre-Fired Paste

At one level, the fine sand and mica tempering of Middle Mississippian paste has long been known. Wauchope (1966:219), in writing of the ceramics recovered from the vicinity of prehistoric site 9FL3, noted that the *Savannah Stamped* sherds were tempered with medium to coarse sand as well as mica. Wauchope (1966:74) found such tempering amongst Etowah Smooth as well; Hally and Langford (1988:61) noted that Middle Mississippi Period (A.D. 1200 - 1350) Etowah ceramics were usually grit tempered, although "grit" is not described. A decline in shell tempering appears characteristic of Middle Mississippian ceramics in northwestern Georgia, and that change in temper preference is part of a general question on ceramic technology included in the region's overall research plan (Hally and Langford 1988:88).

The material from Feature 12 expands the understanding of what constituted the ceramic paste and how it was prepared. Assuming that the tested samples apply to the entire collection, the paste was composed of approximately 61 percent fine to medium sand, with the balance made up of silt and clay. Clay-sized particles could range from eight to 15 percent of the paste volume.

The high particle density of the paste -- 2.884 g/cm^3 -- is consistent with a micaceous material and with mineral-rich soils. Both are visually obvious in the sample. The iron-rich nature of the paste was so great that, on drying out completely, iron oxide was deposited throughout near-exterior 1.0 - 10.0 mm of the objects. It is possible that the concentration of iron oxide around the exterior surface of the objects helped to keep them together.

(The primary reason that the objects remained intact was due to the binding together of matrix with the ionic forces of the clay particles. The working of the clay within the paste would have helped the particles to stack themselves, as plates, which would have been held together by exchanged cations. This is how adobe bricks maintain their form, while a block of sand will crumble when it dries out. The addition of water is usually sufficient to disperse the particles of a clay-held matrix, and that of course is the slaking test used here.)

The fine-earth component of the paste may well have been obtained through levigation, either levigation done directly to obtain the fine-earth component, or levigation associated with the kind of angelica ponds reported by Bartram. This is consistent with the occasional presence of gley inclusions in the objects (e.g., Figures 7, 8). The existence of a silt - clay mass independent of the sand is suggested by the apparent sharp division between the two particle-size classes. The sand appears to have been added, not to have been a natural part of the paste. Knowing this forces consideration of the uniform-sized quartz/orthoquartzite sand grains in the feature as either potential temper, or as large-grained residues of the finer sand actually used to temper the paste.

The high-mineral content along with the probable separate addition of sand would be consistent also with Harrington's (1908:402) description of Catawba potters simply digging down into the subsoil to obtain basic raw material.

Analysis of the unfired paste suggests that the organic content was comparatively high. This assessment was based upon the observed reaction of bits of the paste to the addition of hydrogen peroxide. Workability of aboriginal ceramic paste at times was improved by the intentional addition of organics like blood or grease. The addition of such organics may also have helped hold the objects together.

Various microorganisms feed on soil organics and convert those organics into water-insoluble gums (primarily polysaccharides). These linear organic polymers link particles together primarily by bonds formed with the surfaces of the clay particles (Allison 1968). Under normal soil conditions, those polymers disappear. The microorganisms feed on organics from the A horizon, synthesizing polysaccharide gums, while other micro-organisms enter cavities in the newly formed soil aggregates and decompose those gums. A balance is maintained. That balance is removed under anaerobic conditions (since the polysaccarides cannot then be oxidized) and under conditions of high organic input. In a series of experiments, Avnimelech and Nevo (1964) found that only rapidly decomposed organics -- carbohydrates, proteins, fats and the like -- would produce that kind of polymer-based soil aggregation. Materials like sewage and sawdust would not.

If a body of processed paste, enriched with organics like grease or blood, were processed then allowed to sit, forgotten, microorganisms in the paste would feed on those organics. Organic polymers would being to coat particles in the paste, forming most rapidly in those portions of the paste body that dried first: The exposed surface. Particle aggregation would start, and possibly even a surface curst would form (see Soulides and Allison 1961). If such a body of paste had been processed from a sediment low in nitrogen (for example, a pond sediment), the activity of those organisms responsible for decomposing the linking gums would be impeded (Harris et al. 1963:544; Avnimelech and Nevo 1964:225). With a body of paste resting on the surface, the only source of food for the microbial population synthesizing the gums would be the organics present in the paste matrix. Once those were consumed, the organisms would starve. Once dry, those gums also would decompose.

It seems likely that the reason the paste reacted strongly to hydrogen peroxide was because it was reacting to a widely dispersed polysaccharide coating the paste particles. While the paste crumbs fell apart in minutes when placed in distilled water, they fell apart in seconds when a couple drops of hydrogen peroxide was placed on them. The most likely cause of the accompanying effervescence as well an the sudden mechanical failure of the crumb would be a high concentration of microbial gums. And the most likely explanation for such a high concentration of microbial gums would be a paste drawn from pond sediment and to which grease, blood, or glue had been added.

Steps in Processing

The first four possible steps in the aboriginal production of a suitable ceramic paste was the obtaining a suitable fine-earth (silt-clay) component, the refining or processing that fine-earth material to remove larger inclusions, the addition of some kind of tempering agent, then the possible addition glue, grease, or blood to improve workability. Where in the sequence any organics actually would be added is unclear; presumably it would have been after the initial addition of temper and water, at some point near the start of the kneading process.

The next series of steps involved working the paste then setting it aside damp to "age," so the water within the paste would be more uniformly distributed. The material from Feature 12 documents those steps as well.

The paste clearly was kneaded, and some of the remnants of that kneading were present in the collection (Figure 3, 4). Swanton (1946:549), quoting Du Pratz, wrote that the kneading was done "on a flat board." If such were the case for prehistoric site 9FL3, then is also is possible that dust or fine sand was sprinkled about on the surface of that board, to avoid possible sticking. that is done with the preparation of bread dough for the same reason. It may have been done for the objects from Feature 12 as well, since many of the flat, unrolled pieces have a higher incidence of sand attached to one side of their exteriors than to the other.

That there was a dusty involvement is also seen in the common presence of fine-grained material adhering to the clay objects (e.g., Figure 7).

Apparently after kneading the material, the equivalent of a handful was taken and rolled. Based on the average weight and the known particle density of the material, a mass ranging from 80 cm^3 (Cluster 2) - 126 cm^3 (Cluster 1) was taken or at least gathered into the hands. This was surprisingly standard in size: A ball of 80 cm^3 would be about 5.7 cm in diameter; a ball of 126 cm^3, about 6.2 cm in diameter. This would be approximately the size of the globular end of a 100-watt light bulb (for comparison, a baseball is around 7.2 cm in diameter). Presumably the amount was what felt comfortable in the potter's hand; since the average diameter of such a ball would have been about the same, and since there were considerable differences in the final products, one might argue that two different people of approximately similar hand size were present (One, by the way, probably was an adult: The finger impressions in Figure 3 are the size of an adult thumb, and given the flatness of the object and the nature of the impressions, probably also were made with a pair of thumbs). The volume of that hypothetical ball of paste is interesting: Recall that the volume of uniform-size quartz/orthoquartzite sand in the feature was about 118 cm^3. One wonders if that represented a handful of sand tossed in with the other items in Feature 12.

It is useful to remember that, on average, an adult west African woman produces 10 pottery vessels a year throughout her life (Neumann 1997). After a decade or two messing around with ceramic paste and hand-building ceramic vessels, differences that to a non-ceramicist might appear subtle in all likelihood would be sensed by someone with experience, an observation that holds for all manual skills.

That in most cases the paste was accumulated until the appropriate size was present is shown by the physical composition of the clay objects. In many cases, the objects were made up of smaller pieces all melded together (e.g., Figures 9 --> 10; see also Figure 7). The material was not so much being rolled out into coils, which was the process seen by Dumont amongst the Natchez in 1753 (quoted in Swanton 1946:550: "...they knead it with the hands and feet, forming a dough of which they make rolls 6 or 7 feet long and of whatever thickness is desired."), as it was set up into pre-coils.

As each mass was taken, it was rolled, some more thoroughly or at least from more thoroughly kneaded paste than others. The rolling is evidenced in the cross-sections of several of the clay objects (e.g., Figures 16, 17).

After rolling into a roughly conical form, the clay object was plopped down on a dusty surface. The potter probably merely reached to one side in doing that, which is why the clay objects, while mostly able to stand upright, still list to one side; it probably is the reason why they are flattened at one end.

The surface onto which the clay objects were unceremoniously plopped appears to have been cloth or matting, based upon impressions on a few of the objects (e.g., Figure 18). That mat was covered with dust, which is evidenced by the bits of non-paste material sticking to the flattened sides or bottoms of the clay objects. Presumably that dust or dirt was put on the mat to prevent the clay objects from sticking. It evidently did not always work: A number of the clay objects showed irregular loss of their bases, as if the object, while still damp, had stuck to something and the base gave away when the object was lifted up.

In some cases, the conical clay objects tipped over. This was shown by the flattened sides, a couple of which seemed to have matting or cloth impressions as well (no attempt was made to do a plasticine impression, since the clay objects are very dusty and talc-like, and there was a concern that the object stuck to the plasticine would pull apart). Those objects, too, picked up dust or dirt, reinforcing an image of a mat covered with "flour" to prevent the damp paste pieces of sticking.

The material from Feature 12 appears to have been set up to be used, and for one reason or another was set aside. It is possible that the material was molded into the cones to facilitate aging, allowing the moisture in the object to escape more quickly and therefore be ready to use sooner. That is was forgotten but allowed to dry completely is indicated not only by its existence, but also by the precipitation of iron oxide around the exteriors of all of the objects. That iron oxide deposit, which is what led to the idea that the objects had been fired, appears to have been left as iron-rich water -- either originally such or as a consequence of dissolving the iron originally within the paste itself -- was drawn to the surface and evaporated. This is illustrated by the cross-section in Figure 5; an extreme case is shown by the thick iron-rich exterior band on Item 22 in Figure 6.

At some point, the exercise ended. It is possible that the material was being partially prepared then set aside to age. It would take a skilled, habitual ceramicist to be so confident of the distribution of moisture in the paste that breaking the larger mass out into smaller pieces to age could be done in a way that would yield dependable working material. It is just as likely that the entire exercise was interrupted for one reason or another, and the paste was set aside to be dealt with later. Even if it dried out, it would only require the addition of some water to again make it sufficiently plastic to work.

CONCLUSION

The clay objects recovered from Feature 12 at prehistoric site 9FL3 represent processed, tempered, but unfired ceramic paste. The material permitted preliminary particle-size and organic-content analyses. Results of those analyses were consistent with a ceramic paste in which the silt-clay component was obtained from a medium lacking any sand -- possibly through levigation or from a ponding feature. That silt-clay component may also have been obtained from the native subsoil, since when the paste dried a high concentration of iron oxide was left on the surface of the formed clay objects. That suggested the presence of high concentrations of iron oxide, either in the water used or in the silt-clay of the paste. The second option is more likely.

Fine to medium sand was isolated as a tempering agent. That tempering agent was added to the fine-earth component, roughly in a ration of three parts sand to two parts fine earth. Evidence suggests that at some point in the preparation of the paste, some kind of organic material -- glue, blood, grease -- was added, presumably to increase workability.

The material from Feature 12 includes objects that appear to reflect kneading. The kneading was done on a surface over which medium-sized sand and silt - clay had been lightly sprinkled. Most of the material, though, was taken in handfuls then partially rolled into conical objects, that were then set to one side on a dust-covered mat or cloth.

Statistical results suggest that two individuals may have been responsible for production of the clay objects. One definitely was an adult, and one definitely had more experience than the other, based upon variation in final forms of the clay objects.

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END NOTES

1. The rolling out into a conical form then the half-conscious, half-throwing motion placing the object to one side was witnessed during experimental work performed by Ms. Maorn Nasser at the University of Georgia Archaeology Laboratory. This was a fortuitous observation. The clay objects were picked up from the Laboratory, and while waiting for them to be boxed and placed in the car, we wandered around the lab. In the outside room, Nasser was doing experimental pottery work. Sitting on the table was one of the conical-shaped objects like the clay objects. Up until that point, no one had the slightest notion of what the clay objects might be, although many different ideas had been collected. Asking about the object, Nasser again picked it up, gave it a demonstration cursory roll in the hand, and again plopped it down. Her clay object had all of the features of those from Feature 12: The rounded edges of the cone, the canted, listing nature of the objects, and even the size. She was taking handfuls of paste, rolling it into such cones preparatory to making coils. Something like that could not be staged again if we had to. We saved the item.

REFERENCES CITED

Adair, James
1775 *The History of the american Indians.* Edward and Charles Dilly, London.

Allison, Franklin E.
1968 Soil aggregation -- some facts and fallacies as seen by a microbiologist. *Soil Science* 106:136-143.

Avnimelech, Y., and Z. Nevo
1964 Biological clogging of sands. *Soil Science* 98:222-226.

Blake, G.R.
1965 Particle density. Pp. 371-373 in *Methods in Soil Analysis. Part 1. Physical and Mineralogical Properties, Including Statistics of Measurement and Sampling,* edited by C.A. Black, D.D. Evans, J.L. White, L.E. Ensminger, and F.E. Clark. American Association of Agronomy, Madison.

Bouyoucos
1927

1936

Day, Paul R.
1965 Particle fractionation and particle-size analysis. Pp. 545-567 in *Methods in Soil Analysis. Part 1. Physical and Mineralogical Properties, Including Statistics of Measurement and Sampling,* edited by C.A. Black, D.D. Evans, J.L. White, L.E. Ensminger, and F.E. Clark. American Association of Agronomy, Madison.

Densmore, Frances
1929 *Chippewa Customs.* Bureau of American Ethnology Bulletin 86.

Everitt, Brian
1974 *Cluster Analysis.* Halstad, New York.

Fewkes, Vladimir J.
1944 Catawba pottery-making, with notes on Pamunkey pottery-making, Cherokee pottery-making, and coiling. *Proceedings of the American Philosophical Society* 88:69-125.

Griffiths, John C.
1967 *Scientific Method in Analysis of Sediments.* McGraw-Hill, New York.

Hally, David J., and James B. Langford, Jr.
1988 *Mississippi Period Archaeology of the Georgia Valley and Ridge Province.* Georgia Archaeological Research Design Paper No. 4/University of Georgia Laboratory of Archaeology Series Report Number 25.

Harrington, M.R.
1908 Catawba potters and their work. *American Anthropologist* 10:399-407.

Harris, R.F., O.N. Allen, G. Chesters, and O.J. Attoe
1963 Evaluation of microbial activity in soil aggregate stabilization and degradation by the use of artificial aggregates. *Soil Science Society of America Proceedings* 27:542-545.

Holmes, W.H.
1903 Aboriginal pottery of the eastern United States. *Twentieth Annual Report of the Bureau of American Ethnology 1898-99*:1-237.

Jardine, N., and R. Sibson
1968 The construction of hierarchic and non-hierarchic classifications. *Computer Journal* 11:117-184.

Neumann, Thomas W.
1975 *A Study of 21 CA 58: An Analysis of a Multi-Component Middle Woodland Site on the Shores of Prehistoric Lake Gayashi.* Master's Thesis, University of Minnesota.

1978 A model for the vertical distribution of flotation-size particles. *Plains Anthropologist* 23:85-101.

1979 *Culture, Energy, Subsistence: A Model for Prehistoric Subsistence.* Ph.D. dissertation, University of Minnesota. University Microfilms International, Ann Arbor.

1997 Prehistoric Human Impact on the Ecology of the Eastern United States and Implications for Management Practices. Invited address for combined conference thematic session *The Role of Native Peoples in Shaping Ecosystems*, coordinated by Steven Simms. Annual meeting of the Ecological Society of American, Albuquerque, New Mexico.

1998 The Role of Native Peoples in Shaping Ecosystems in the Eastern United States: Management Implications. Presented as part of the lecture series: Wilderness and Political Ecology. Utah State University, Logan, Utah.

Sassaman, Kenneth, Jr.
1991 *Economic and Social Contexts Of Early Ceramic Vessel Technology in the American Southeast.* Ph.D. dissertation, University of Massachusetts - Amherst. University Microfilms International, Ann Arbor.

Shackley, Myra L.
1975 *Archaeological Sediments: A Survey of Analytical Methods.* John Wiley and Sons, New York.

Shepard, Anna O.
1956 *Ceramics for the Archaeologist.* Carnegie Institution of Washington Publication 609.

Soulides, D.A., and F.E. Allison
1961 Effect of drying and freezing soils on carbon dioxide production, available mineral nutrients, aggregation, and bacterial population. *Soil Science* 91:291-298.

Speck, Rank G.
1909 *Ethnology of the Yuchi Indians.* Anthropological Publication of the University Museum, University of Pennsylvania 1 (1).

Swanton, John R.
1911 *Indian Tribes of the Lower Mississippi Valley and Adjacent Coast of the Gulf of Mexico.* Bureau of American Ethnology Bulletin 43.

1946 *The Indians of the Southeastern United States.* Bureau of American Ethnology Bulletin 137.

Thomas, Cyrus
1894 Report on the mound explorations of the Bureau of Ethnology. *Twelfth Annual Report of the Bureau of Ethnology 1890-1891*:17-742.

Wauchope, Robert W.
1966 *Archaeological Survey of Northern Georgia with a Test of Some Cultural Hypotheses.* Society for American Archaeology Memoir 21.

Table 1. Clay Objects and Other Material Associated with Feature 12, 9FL3.

Description	*n*	*g*	*Comment*
Complete clay objects	15	4224.9g	Items 1 - 15
Nearly complete objects	9	2456.4g	Items 16 - 24; estimated original weight: 2652.1g
Partially mended objects	4	695.7g	Items 25 - 28, each missing about half of original form
Unmended fragments	15	546.9g	do not mend with any other items in collection; represent at least eight other objects; together labeled Item 29
Flat, unformed fragments	10	808.8g	flattened clay objects, mostly fragments; together labeled Item 30
Miscellaneous fragments	34	315.7g	various pieces, either from the conical or the flattened clay objects; together labeled Item 31
Piece retaining palm print	1	103.6g	Item 32
Piece retaining palm print	1	34.5g	Item 33
Base fragment showing either fabric marking or cord-cutting	1	29.5g	Item 34
Small fragments, spalls	---	168.14g	loose pieces and crumbs from bottom of bags or box; 75.66g used in particle-size and -density analyses
Uniform-sized quartz and orthoquartzite sand grains	---	69.2g	sand grains, each about 1.0 mm in diameter

Table 2. Whole and Nearly Whole Clay Objects: Feature 12, 9FL3.

a. Whole Objects

Item #	height mm	basal dimensions major axis mm	basal dimensions minor axis mm	weight g
1	70.9	36.7	31.3	88.5
2	84.2	60.3	40.4	184.5
3	94.5	63.0	59.3	333.5
4	98.0	74.1	61.0	400.7
5	93.4	56.5	41.5	231.5
6	93.2	56.8	50.9	286.5
7	93.4	66.7	65.1	363.6
8	100.2	66.1	50.8	296.5
9	91.6	63.2	44.4	208.6
10	108.1	63.9	52.0	342.8
11	98.6	62.9	56.0	355.0
12	108.4	71.2	53.6	402.4
13	82.2	63.4	51.2	254.3
14	88.7	59.3	50.4	201.1
15	90.8	69.0	51.2	275.4

Table 2. Whole and Nearly Whole Clay Objects: Feature 12, 9FL3 (con'd).

b. Nearly Whole Objects (Only a small piece missing, as noted; estimated dimensions, based upon approximate mends, presented in parentheses)

Item #	height mm	basal dimensions major axis mm	basal dimensions minor axis mm	weight g	Comment
16	109.8	69.0	52.8	352.2 (378.2g)	Missing half of tip and half of lateral base
17	98.3	61.6	46.5	306.0 (332.2g)	Missing half of base
18	83.0 (86.5mm)	56.3	39.4	186.6 (194.2g)	Missing center of base and scuff-loss of tip
19	96.6	61.2 (67.5mm)	60.6	351.0 (374.4g)	A little loss mid-side
20	93.4	59.8	51.8	230.7 (254.4g)	Most of base"shat-tered" away
21	85.3	55.5	46.2	205.3 (212.9g)	Missing half of tip
22	79.5	51.4	50.1	172.1 (185.5g)	Missing half of tip
23	98.6 (98.8mm)	64.8	56.5	312.9 (357.7g)	Missing base
24	90.9 (99.4mm)	65.0	53.4	339.6 (362.6g)	Missing tip

Table 3. Metrics on Clay Objects in Clusters of Figure 16: 9FL3.

Cluster 1

Item #	*height* *mm*	*basal dimensions* *major axis* *mm*	*minor axis* *mm*	*weight* *g*
Overall (n=11):	100.35	66.34	56.07	363.92
Cluster 1.1 (n=6) Items 11, 23, 24, 7, 19, 6	99.43	65.98	57.40	365.25
Cluster 1.2 (n=3) Items 3, 17, 10	100.30	62.83	52.60	336.17
Cluster 1.3 (n=2) Items 4, 12	103.20	72.65	57.30	401.55

Cluster 2

Item #	*height* *mm*	*basal dimensions* *major axis* *mm*	*minor axis* *mm*	*weight* *g*
Overall (n=12)	89.08	59.80	47.36	232.12
Cluster 2.1 (n=6) Items 9, 14, 21, 2, 18, 22	85.97	57.56	45.15	197.80
Cluster 2.2 (n=3) Items 6, 8, 15	94.73	63.97	50.97	286.13
Cluster 2.3 (n=2) Items 13, 20	87.80	61.60	51.50	254.35

Table 4. **Summary of t-Test Results of Weights for Clusters in Figure 16: 9FL3.** Numbers of the associated objects given in parentheses; see also Table 2. Probabilities are likelihood at a 95 percent confidence level that the two sets belong in the same population.

	Cluster 1.1 (11, 23, 24, 7, 19, 16)	*Cluster 1.2* (3, 17, 10)	*Cluster 1.3* (4, 12)	*Cluster 2.1* (9, 14, 21, 2, 18, 22)	*Cluster 2.2* (6, 8, 15)
Cluster 1.2 (3, 17, 10)	t = 5.79 p = 0.0020 df: 6				
Cluster 1.3 (4, 12)	t = -9.43 p = 0.0002 df: 5	t = -18.98 p = 0.0028 df: 2			
Cluster 2.1 (9, 14, 21, 2, 18, 22)	t = 19.24 p = 0.0000 df: 14	t = 23.60 p = 0.0000 df: 6	t = -41.64 p = 0.0000 df: 5		
Cluster 2.2 (6, 8, 15)	t = 11.05 p = 0.0016 df: 3	t = 7.20 p = 0.0055 df: 3	t = 18.76 p = 0.0028 df: 2	t = -11.37 p = 0.0003 df: 4	
Cluster 2.3 (13, 20)	t = 29.52 p = 0.0000 df: 5	t = 24.51 p = 0.0017 df: 2	t = 172.88 p = 0.0037 df: 1	t = -11.73 p = 0.0001 df: 5	t = 5.22 p = 0.0350 df: 2

Table 5. **Summary of χ^2-Test Results Comparing Average Dimensions for Clusters in Table 3: 9FL3.** Probabilities are that the proportional distribution of the four dimensions measured are not independent. Degrees of freedom = 3.

	Cluster 1.1	*Cluster 1.2*	*Cluster 1.3*	*Cluster 2.1*	*Cluster 2.2*
Cluster 1.2	$\chi^2 = 0.349$ $p = 0.9051$				
Cluster 1.3	$\chi^2 = 0.331$ $p = 0.9541$	$\chi^2 = 0.975$ $p = 0.8073$			
Cluster 2.1	$\chi^2 = 11.615$ $p = 0.0088$	$\chi^2 = 8.872$ $p = 0.0310$	$\chi^2 = 14.549$ $p = 0.0022$		
Cluster 2.2	$\chi^2 = 2.300$ $p = 0.5125$	$\chi^2 = 1.218$ $p = 0.7487$	$\chi^2 = 3.645$ $p = 0.3024$	$\chi^2 = 3.750$ $p = 0.2989$	
Cluster 2.3	$\chi^2 = 4.204$ $p = 0.2403$	$\chi^2 = 2.943$ $p = 0.4005$	$\chi^2 = 6.117$ $p = 0.1061$	$\chi^2 = 2.041$ $p = 0.5639$	$\chi^2 = 0.451$ $p = 0.9295$

Figure 1 [Negative 1, Frame 7]. Examples of Conical Clay Objects from Feature 12, Site 9FL3. (l-r) Items 3, 4, 7. See also Table 2a and Figure 16 (Cluster 1).

Figure 2 [Negative 1, Frame 9]. Examples of Conical Clay Objects from Feature 12, Site 9FL3. (l-r) Items 5, 6, 12, 14. See also Table 2a and Figure 16 (Item 12 is in Cluster 1; the others are in Cluster 2).

Figure 3 [Negative 1, Frame 12]. **Examples of Flattened Clay Objects.** Note finger (thumb?) impressions on piece at right.

Figure 4 [Negative 1, Frame 15]. Example of Item 32 Showing Palm Print.

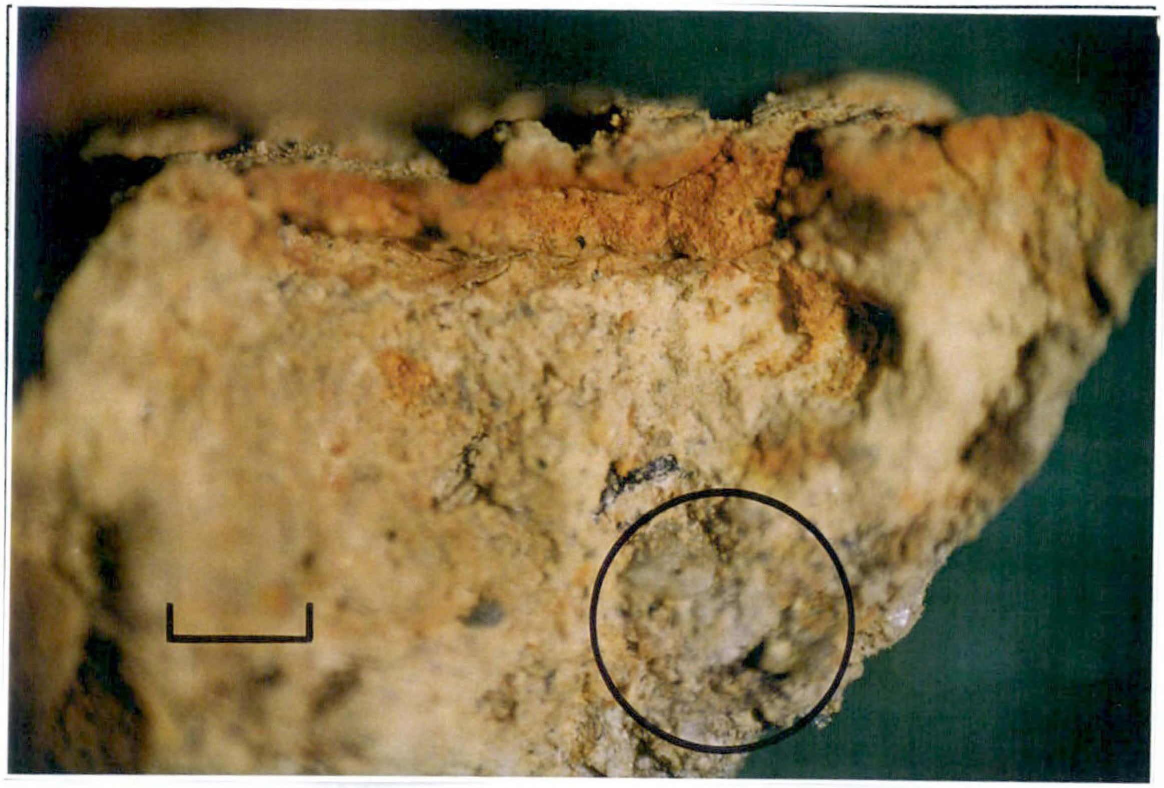


Figure 5 [Negative 2, Frame 9]. Detail of Paste Cross-Section Showing Sand Temper (circled), Charcoal Flecks, and Iron Oxide Precipitation. Magnification 20x; scale = 0.1 mm.

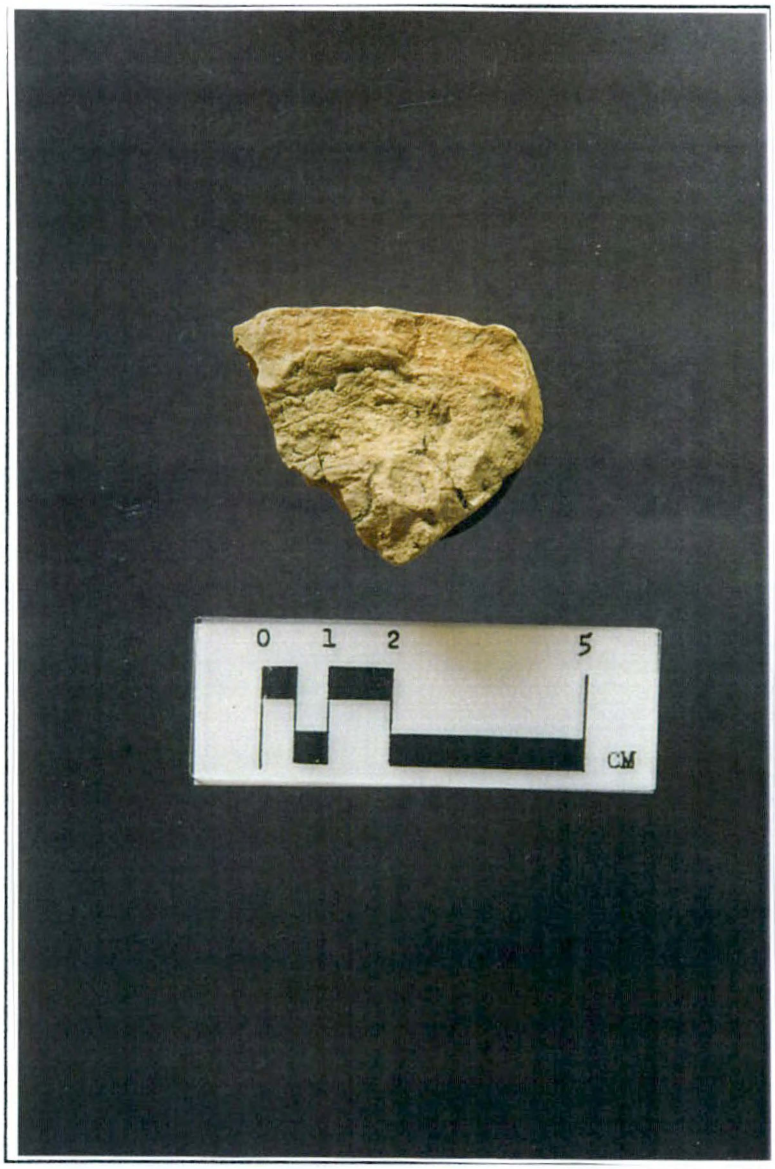


Figure 6 [Negative 1, Frame 25]. Half of Upper Third (Tip) of Item 22, Showing Layering and Iron Oxide Precipitation. See also Table 2b.

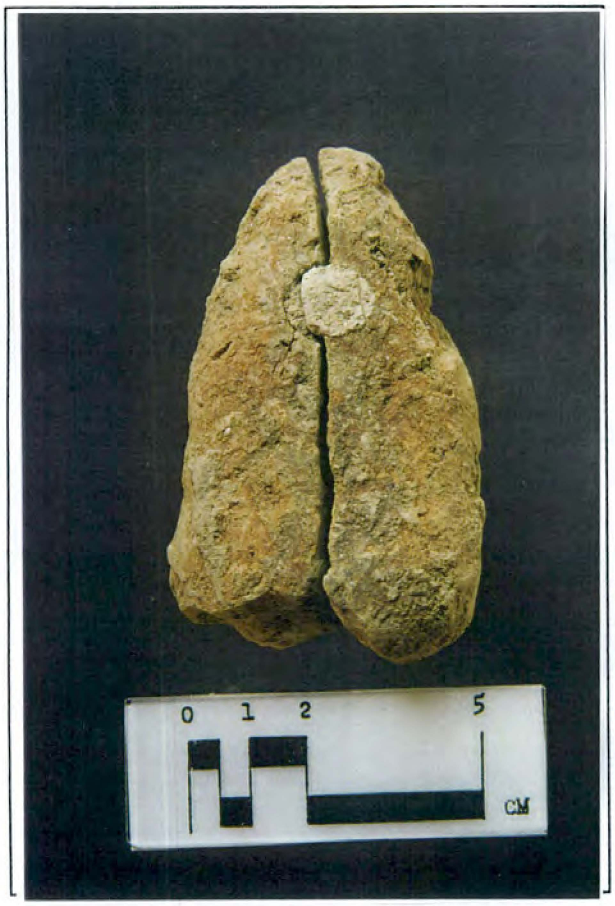


Figure 7 [Negative 1, Frame 32]. Item 20, Mended. Note three things: The through-object longitudinal crack, the gley inclusion, and the irregular base. If a clay object was cracked, the majority tended to have a primary longitudinal crack. Secondary cracks seemed to split the longitudinal halves into three pieces. The damaged base probably resulted from the object having been set on then adhering to something while still moist, and loosing the bit of base when lifted.

Figure 8 [Negative 1, Frame 35]. Item 20, Opened. This shows the detail of the gley plug rolled into the object. Also shown is how the object had been formed by the melding together of two smaller pieces, indicated by the comparative smoothness of the "break" faces.

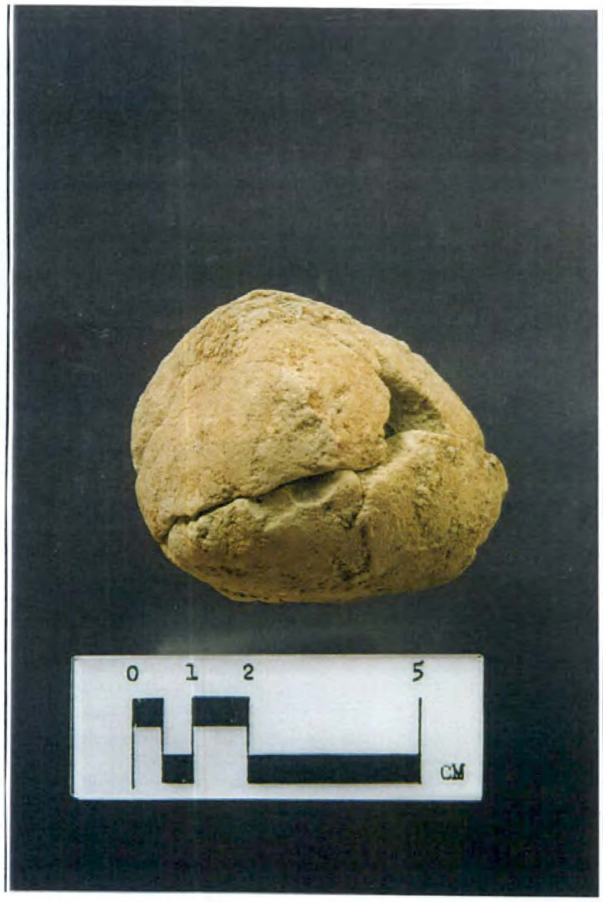


Figure 9 [Negative 1, Frame 26]. Three-Quarter View of Item 25, Mended. Only about two-thirds of Item 25 was present. The flattened base is on the left.

Figure 10 [Negative 1, Frame 29]. The Three Pieces of Item 25. Note particularly how the object was made up of separate pieces that had been rolled together.

Figure 11 [Negative 1, Frame 23]. Cross-Section of Base of Item 22. This shows the rolling and layering associated with the making up of the conical clay objects. Note how the piece came apart: This basal section was a separate hunk of paste that had been welded to the object. A similar kind of break, partially formed, is shown by the crack around the 9 - 12 o'clock arc of the object.

Figure 12 [Negative 1, Frame 37]. Cross-Section of Base of Item 18. This shows as concentric layers the compact rolling out of the object. Again note that the break face really is more a separation face, similar to what is shown in Figure 11.

Figure 13 [Negative 2, Frame 19]. Surface of Item 20, Showing Patchiness of Iron Oxide Precipitation at Surface, along with Sand and Mica in Paste. Magnification 20x; scale = 0.1 mm.

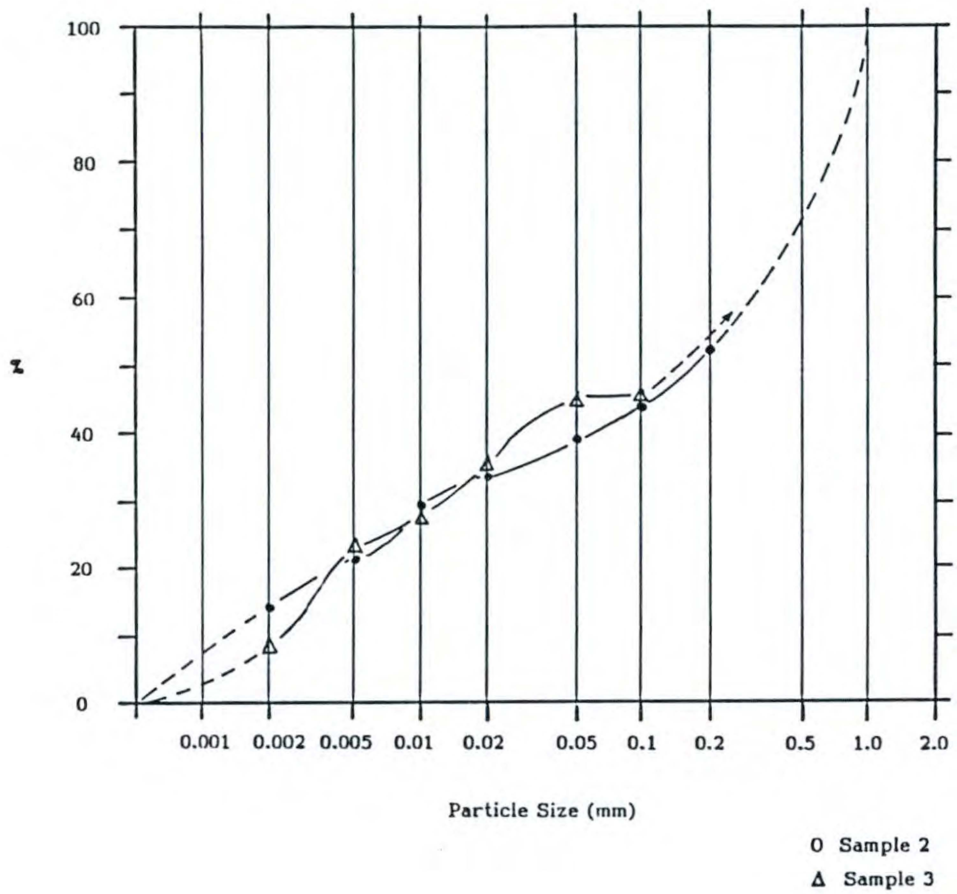
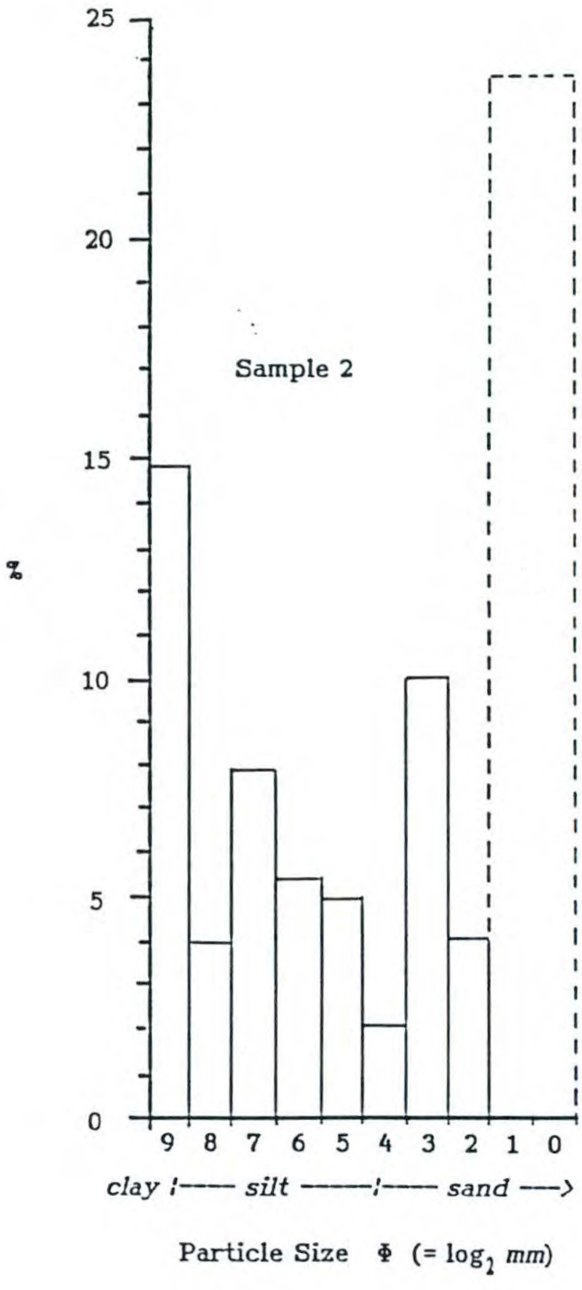


Figure 14. Preliminary Particle Size Distribution. USDA and ISSS (International Society of Soil Science) systems consider clay-sized particles to be less than 0.002 mm (ϕ = +9.0); the Wentworth and ASTM/AASHO (American Society for Testing and Materials/American Association of State Highway Officials) systems consider clay-sized particles to be less than 0.005 mm (ϕ = +7.5). The ISSS system considers sand-sized particles to be greater than 0.025 mm; the other three consider sand-sized particles to be greater than 0.05 mm (ϕ = +4.25) (Wentworth, USDA) or 0.0625 mm (ϕ = +4.0). Sample 2 was drawn from various crumbs, and may well have included partially kneaded material, dust/dirt placed on the working surface, as well as fragments from complete conical clay objects. Sample 3 probably came entirely from complete conical clay objects.



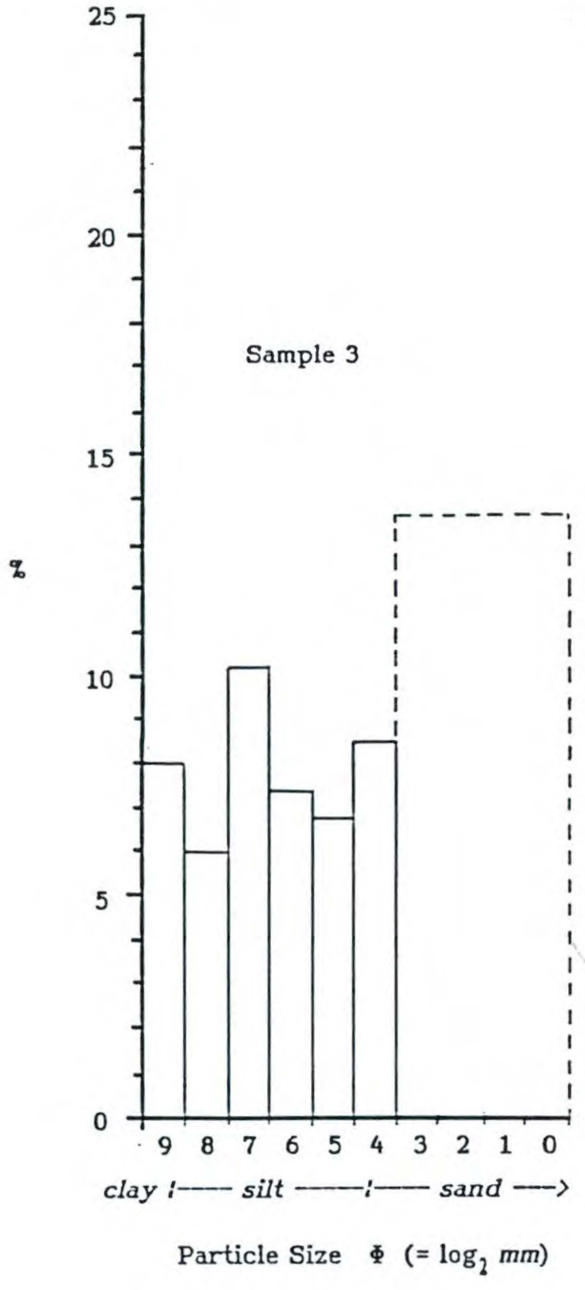


Figure 15. Preliminary Particle Size Distribution. Sample 2 was drawn from various crumbs, and may well have included partially kneaded material, dust/dirt placed on the working surface, as well as fragments from complete conical clay objects. Sample 3 probably came entirely from complete conical clay objects.

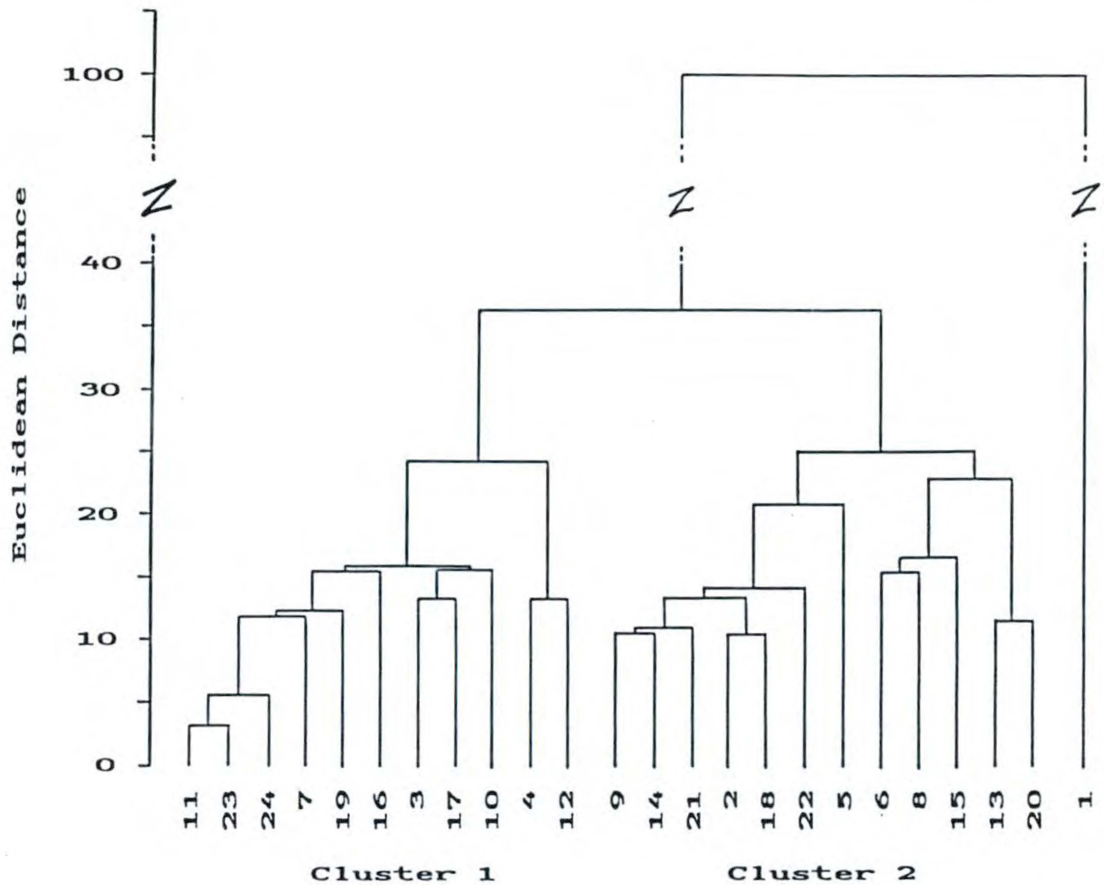


Figure 16. Cluster Analysis of the 24 Complete or Nearly Complete Conical Clay Objects. See also Tables 2 - 5.

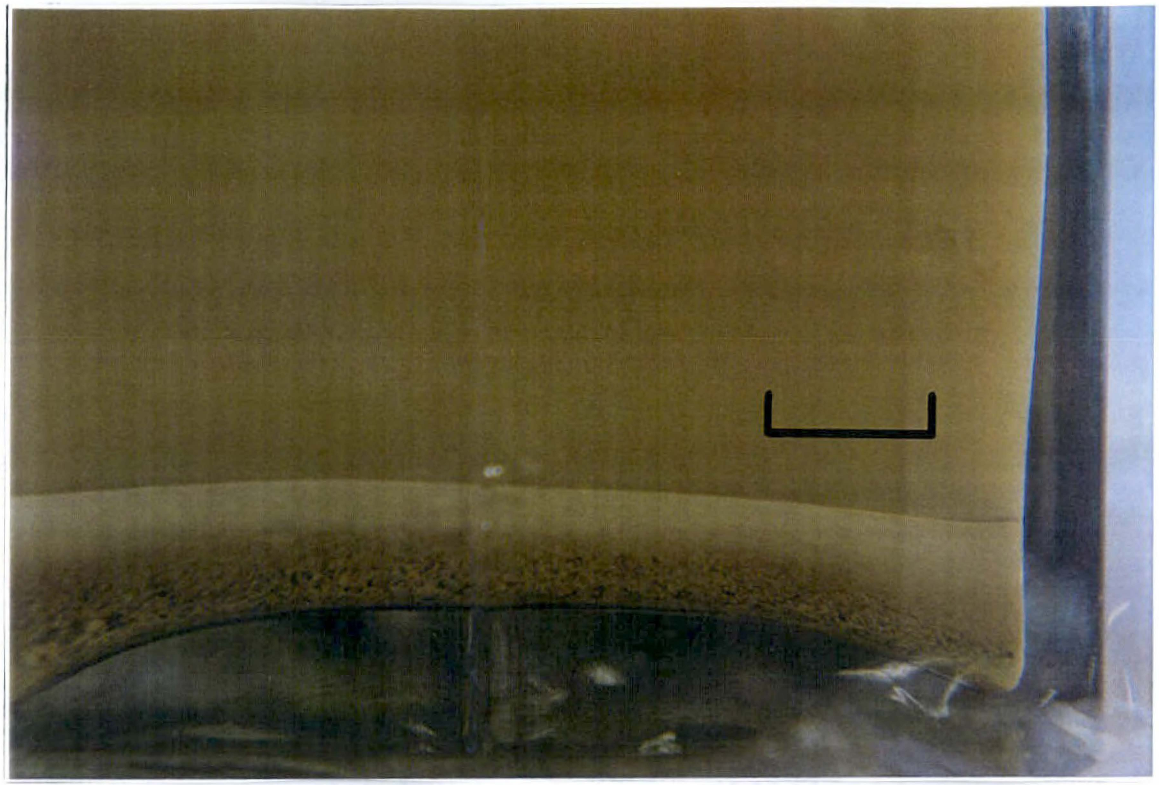


Figure 17 [Negative 2, Frame 24]. Sediment Accumulation at Bottom of Sedimentation Vessel after 29 Hours: Sample 3. Scale: 10.0 mm. After 29 hours, all particles larger than 0.0009 mm in diameter would have reached the bottom of the vessel. Note the separation of silt-clays from the fine sand. Also note the pale, off-white color of the silt-clays, presumably because the original iron oxide had been transported to then precipitated on the surface of the clay object.

Figure 18 [Negative 1, Frame 20]. Base Fragment (Item 34), Showing Impression of Matting or Cloth.