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Investigation of brick, tile, and "mortar" and their possible raw materials from archeological excavations, Fort Raleigh, North Carolina

by

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This report is preliminary and has not been edited or reviewed for conformity with Geological Survey standards or nomenclature.

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Introduction

This report is a summary of a brief investigation of brick, tile, possible mortar fragments, and two samples of clayey sands that may have been used in making these objects, all from the Fort Raleigh National Historic Site, North Carolina. Fort Raleigh was constructed in 1585-1586 and was the first attempt by the English to establish a settlement in America. The brick and tile are, therefore, the first structural clay products used by English-speaking people in the United States. All samples and specimens were collected in archeological excavations by J. C. Harrington, National Park Service, and were submitted to the Geological Survey, July 1, 1965, by him and J. M. Corbett, also of the National Park Service, with an oral request that it be determined whether the ceramic objects could have been made from local materials, and for possible identification of the mortar. The brick and tile and the excavation in which they were found are described in detail by Harrington (1962, p. 22-23). The archeological specimens and "clay" samples and their descriptions submitted are as follows:

No. 1. Local clay from sound bank at end of old panel road, about 4 feet deep.

No. 2. Local clay from excavated area F-65-1; 3 feet deep.

No. 3. 4 brick fragments.

No. 4. 1 tile fragment.

No. 5. 6 "mortar" fragments (larger, thick type).

No. 6. Small pieces of thin "mortar" of type resembling construction mortar on bridge [locality not listed].

No. 7. Unidentified material, cat. #273.

No. 8. Unidentified material, cat. #298.

Investigations and observations

The archeological specimens and clayey sands were investigated by several methods. All samples and specimens were examined under the binocular microscope. Specimens 7 and 8 appeared similar in mineral composition to the brick and mortar materials of samples 3 and 5, and no further study was made of them. Test pieces of the "local clay" were made and fired along with chips of brick fragments. The mineralogy of a "local clay" and several archeological specimens was determined by optical and X-ray methods.

"Local clay" sample 2 was selected for investigation, because it contains approximately the same proportions of clay and silt as the brick specimens. "Local clay" sample 1 was not studied other than by microscopical observation, because it is much lower in silt and clay content than sample 2, and when wet probably would not develop sufficient plasticity to be workable. A note on the bag containing sample 1 indicates that it came from a natural exposure, whereas sample 2 was obtained from an excavation. Probably much of the clay deposited at the sample 1 locality has been removed by weathering and erosion. "Local clay" sample 2 is approximately 68 percent sand and 32 percent silt and clay (less than 230-mesh U.S. Series sieve) and is, therefore, a clayey sand and not a clay. Most of the sand grains are medium or fine, but minor quantities of coarse and very fine grains are also present.

As observed with the binocular microscope, the mineral character of "local clay" sample 2 and all archeological specimens from Fort Raleigh, except the tile (specimen 4), appears remarkably similar in mineralogy of sand-size particles, range in grain size, degree of roundness, frosting of quartz grains, and abundance of heavy minerals and fine-grained material. That these materials are all much alike in mineral content was confirmed by X-ray examination of the "local clay," chips from two fragments of brick, and one chip of mortar (fig. 1). All these materials are virtually identical in mineral composition, consisting chiefly of quartz, and containing minor quantities of feldspar and clay minerals and traces of several heavy minerals. Illite and chlorite clay minerals occur in about equal proportions in all material examined by X-ray methods, and together they make up 15 to 20 percent of the "local clay" and brick.

Test pieces made from "local clay" (sample 2) are similar to the brick (specimen 3), and both have very similar physical properties after firing at several different temperatures. The "local clay" is plastic when wet and forms and air dries without excessive shrinkage and warping. Air-dried pieces are sufficiently cohesive to withstand much handling without falling apart. Test pieces of "local clay" and chips from brick specimens all are weak and friable, and all are reddish-yellow 5YR7/8 (Munsell Soil Color Charts, 1954) after firing at 1,000°, 1,200°, 1,800°, and 2,000°F. Test pieces from "local clay" and the brick specimens are, therefore, of very poor quality after firing at temperatures as high as 2,000°F.

Only one of the fragments of brick (specimen 3) shows evidence of appreciable discoloration from firing. This fragment probably was never fired as high as 1,575°F, because it still contains illite, a clay mineral identified by its prominent basal (001) reflection at about 10 angstroms (fig. 1). Illite was partially destroyed in a test piece fired at 1,200°F and completely destroyed in one fired at 1,800°F. Most illites are destroyed at about 1,575°F (Grim, 1962, p. 103), and presumably the discolored brick never reached this temperature. The other brick specimens which are not discolored may have never been more than baked; and possibly clayey sand was used as adobe, and baking occurred in fireplaces constructed of sun-dried brick.

The tile fragments (specimen 4), as observed under the microscope, contain much more fine-grained material and are appreciably redder than either the other archeological specimens or the fired "local clay." The minerals in the tile now identifiable by X-ray methods are quartz and hematite (fig. 1). The quantity of quartz present in the tile is much lower than in the brick and mortar fragments. Most of the extremely fine grained material is probably noncrystalline. That the tile could not have been made from a raw material such as "local clay" sample 2 is indicated by the abundance of fine-grained material and the presence of hematite which is not abundant in the "local clay" or in the test pieces fired at high temperatures. Also, chips of the tile fired at 2,000°F are much harder, more dense, and redder than the "local clay" fired at the same temperature. The "local clay" fired at 2,000°F is still friable, but the tile, which probably was not fired so high, is harder and more dense. Though the tile could not have been made from material similar to sample 2, the possibility that it was made from other local materials cannot be ruled out. Iron-rich fine-grained clay or soil suitable for making tile of this type may occur at several places in eastern North Carolina.

None of the mortar fragments now contains limy material, as none of them reacted with hydrochloric acid, and no calcium carbonate minerals were identifiable in the samples examined by X-ray methods. Also, similarity in mineral character between the "mortar" and "local clay" suggests that no lime was ever present. Plastic clayey sand similar to sample 2 may have been used as dug for mortar, and if baked in a fireplace, became sufficiently hard to remain in its present form. Local clayey sands have been used, without lime, as mortar in making fireplaces in eastern Kentucky and at other places in the Appalachian Region. Some of these fireplaces have remained intact for several decades and possibly much longer. Probably the builders of Fort Raleigh used local clayey sand, without modification, as mortar.

Summary and conclusions

The mineral content of all the archeological specimens from Fort Raleigh, North Carolina, except the tile, is virtually the same as that of clayey sand, referred to in the sample descriptions submitted as "local clay"; and the brick fragments and "local clay" have essentially identical physical properties when fired. The conclusion that all the Fort Raleigh specimens, except the tile, were made from local materials, therefore, is reasonably certain. Furthermore, all brick fragments (specimen 3) and test pieces made from the "local clay" (sample 2) are of very poor quality, and it seems improbable that such poor brick would have been shipped from Europe, even in the 17th century.

The presence of illite in the brick specimens indicates that none were fired at high temperatures. Probably none were fired as high as 1,575°F, a temperature at which most illites are destroyed, and inasmuch as some illite remained in a test piece fired at 1,200°F some of the brick may never have been more than baked.

The tile contains appreciably more fine-grained material than the "local clay" sample. Also, the tile fires much more dense and redder than the "local clay," and hematite is abundant in the tile but not identifiable in fired pieces of "local clay." The tile could not have been made from the local materials represented by samples submitted; however, other clay or soil that is high in iron may occur near Fort Raleigh and may have been used in making the tile.

The specimens tentatively classified as mortar now contain no limy material and in mineral content are very much like the brick fragments. Probably this material was used as mortar as dug, and baking in a fireplace made it sufficiently hard to retain its present form.

Bibliography

Grim, R. E., 1962, Applied clay mineralogy: New York, McGraw-Hill, 422 p.

Harrington, J. C., 1962, Search for the Cittie of Raleigh, archeological excavations at Fort Raleigh National Historic Site, North Carolina: Natl. Park Service Research Ser. no. 6, 63 p., 38 figs.

Munsell Color Company, Inc., 1954, Munsell soil color charts: Baltimore, Md.

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The U. S. Geological Survey is releasing in open files the following reports. Copies are available for consultation in the Geological Survey Libraries, 1033 GSA Bldg., Washington, D. C.; Bldg. 25, Federal Center, Denver, Colo.; 345 Middlefield Rd., Menlo Park, Calif.; 504 Custom House, 555 Battery St., San Francisco, Calif.; and 7638 Federal Bldg., 300 North Los Angeles St., Los Angeles, Calif.:

1. Approximate location of fault traces and historic surface ruptures within the Hayward fault zone between San Pablo and Warm Springs, California, by Dorothy H. Radbruch. Map with text, scale, 1:62,500 (one sheet). Copy from which reproduction can be made at private expense is available in the San Francisco office shown above.

2. Gravity survey in southern Cascade Range, California, by T. R. LaFehr. 21 p., plus 48 p. appendix. 1 pl., 2 figs.

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The Geological Survey is also releasing in open files the following report. Copies are available for consultation in the Geological Survey Library, 1033 GSA Bldg., Washington, D. C.; and in the Office of the Superintendent, Fort Raleigh National Historic Site, Manteo, North Carolina:

3. Investigation of brick, tile, and "mortar" and their possible raw materials from archeological excavations, Fort Raleigh, North Carolina, by Sam H. Patterson. 12 p., 1 fig.

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