

THE CLAYS OF FLORIDA.

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The clays of Florida that are being utilized include those from which building brick and tile are made, the white-burning ball clays or plastic kaolins, and fuller's earth. The production of building brick during 1916 amounted to 31,129 million, the value of which, including a small amount of tile and fire-proofing brick, was \$226,362. The production of plastic kaolin is limited at the present time to the output of three plants under the management of two companies. During 1916 five plants were engaged in mining fullers' earth, the production from these five plants being about 90 per cent. of the total production of this material in the United States.

In their geologic relation the clays of Florida all lie above the Oligocene limestones since beneath these formations are Eocene limestones which, at least in the peninsular section of the State, extend uninterruptedly to a great depth.

The fuller's earth clays lie within the Alum Bluff formation which, according to the vertebrate fauna obtained within recent years, is Miocene. The clays used in brick making vary in age probably from the Miocene to the Pleistocene or Recent. The geographic distribution of the clays likewise is irregular, although all that are being utilized are found in the northern part of the State—within 200 miles or less of the north line.

The Florida Common Clays.

No clays suitable for making vitrified brick have been located within the State. In 1915 a series of tests of 25 samples of Florida clays was made by the Bureau of Standards laboratory at Pittsburgh. The clay samples for these tests were collected by the Florida Geological Survey. The 25 samples tested represented clays from 21 counties in Florida. Each sample approximated 250 pounds in weight and was representative, as nearly as could

be judged, of the clay of the locality from which it was taken. These tests were not successful in locating any clays that would serve in the manufacture of vitrified brick. Although previously published in the reports of the Florida Geological Survey, the results from a few of these 25 tests on the common clays of Florida may be here included for convenience of reference.

Sample No. 1, Jackson County.—The clay works with some difficulty in the stiff-mud condition; water of plasticity in per cent. of dry weight, 40.80 per cent.; warped and cracked during the drying treatment; linear drying shrinkage, in terms of wet length, 9.95 per cent.; linear burning shrinkage in terms of dry length, at 850° C., 0.77 per cent.; at 1010° C., 4.59 per cent.; at 1130° C., 6.60 per cent.; at 1250° C., 7.55 per cent.; color after burning, light red at lower temperatures, changing to dark red at higher; per cent. porosity, at 850° C., 36.75 per cent.; at 950° C., 40.55 per cent.; at 980° C., 34.30 per cent.; at 1010° C., 30.30 per cent.; at 1040° C., 24.20 per cent.; at 1070° C., 24.00 per cent.; at 1100° C., 26.10 per cent.; at 1130° C., 25.15 per cent.; at 1160° C., 23.65 per cent.; at 1190° C., 23.60 per cent.; at 1220° C., 23.85 per cent.; at 1250° C., 20.70 per cent. A somewhat plastic and sticky clay of high drying and burning shrinkage. The clay retains a porous structure at 1250° C., and cannot be used in the manufacture of vitrified ware burned in commercial kilns. The clay may be used in the manufacture of common and building brick.

Sample No. 2, Washington County.—The clay possesses good working plasticity and molding behavior; water of plasticity, 36.0 per cent.; a few cracks developed by drying; linear drying shrinkage, 9.42 per cent.; linear burning shrinkage, at 850° C., 0.55 per cent.; at 1010° C., 1.57 per cent.; at 1130° C., 7.75 per cent.; at 1250° C., 8.10 per cent. A good light buff color is developed by burning; per cent. porosity, at 850° C., 36.80 per cent.; at 950° C., 35.30 per cent.; at 980° C., 34.75 per cent.; at 1010° C., 34.50 per cent.; at 1040° C., 30.75 per cent.; at 1070° C., 25.70 per cent.; at 1100° C., 22.45 per cent.; at 1130° C., 19.70 per cent.; at 1160° C., 17.95 per cent.; at 1190° C., 15.70 per cent.; at 1220° C., 14.60 per cent.; at 1250° C., 12.55 per cent. A buff burning clay of good plasticity and a relatively high drying shrinkage.

May be used in the manufacture of buff colored face brick, although care must be exercised in drying. The clay must be burned above 1250°C . in order to attain low porosity.

Sample No. 3, Santa Rosa County.—The clay has good working plasticity and molding properties; water of plasticity, 28.90 per cent.; no drying difficulties; linear drying shrinkage, 6 per cent.; linear burning shrinkage, at 850°C ., 0.64 per cent.; at 1010°C ., 0.21 per cent.; at 1130°C ., 1.44 per cent.; at 1250°C ., 1.17 per cent.; burns to salmon color, changing to buff at higher temperature; per cent. porosity, at 850°C ., 35.30 per cent.; at 950°C ., 35.80 per cent.; at 980°C ., 36.20 per cent.; at 1010°C ., 34.86 per cent.; at 1040°C ., 33.60 per cent.; at 1070°C ., 32.15 per cent.; at 1100°C ., 31.10 per cent.; at 1130°C ., 29.55 per cent.; at 1160°C ., 29.05 per cent.; at 1190°C ., 28.80 per cent.; at 1220°C ., 28.05 per cent.; at 1250°C ., 27.30 per cent. A clay possessing good working and drying qualities but which cannot be vitrified at the burning temperatures of commercial kilns. Test pieces burned to 1250°C . are easily cut by a knife. This clay is of value only in the manufacture of porous common building brick, etc.

Sample No. 4, Escambia County.—Appears to have good working behavior and plasticity; water of plasticity, 21.95 per cent.; drying behavior satisfactory; linear drying shrinkage, 5.75 per cent.; linear burning shrinkage, at 850°C ., 1.28 per cent.; at 1010°C ., 0.05 per cent.; at 1130°C ., 0.26 per cent.; at 1250°C ., 1.16 per cent.; color after burning, light to dark red; per cent. porosity, at 850°C ., 28.65 per cent.; at 950°C ., 29.30 per cent.; at 980°C ., 28.20 per cent.; at 1010°C ., 27.90 per cent.; at 1040°C ., 27.75 per cent.; at 1070°C ., 25.85 per cent.; at 1100°C ., 26.95 per cent.; at 1130°C ., 25.70 per cent.; at 1160°C ., 27.95 per cent.; at 1190°C ., 26.80 per cent.; at 1220°C ., 19.90 per cent.; at 1250°C ., 20.20 per cent. A clay possessing good working and drying behavior, but one which retains a porous structure at temperatures as high as 1250°C . The clay is suitable for common and face brick, etc., but not for paving brick or other vitrified ware.

Sample No. 5, Walton County.—Plasticity and working properties good; water of plasticity, 28.30 per cent.; drying behavior

satisfactory; linear drying shrinkage, 6.75 per cent.; linear burning shrinkage, at 850° C., 0.34 per cent.; at 1010° C., 0.35 per cent.; at 1130° C., 2.17 per cent.; at 1250° C., 2.25 per cent.; color after burning, salmon to light red; per cent. porosity, at 850° C., 33.60 per cent.; at 950° C., 33.20 per cent.; at 980° C., 35.40 per cent.; at 1010° C., 34.35 per cent.; at 1040° C., 32.80 per cent.; at 1070° C., 30.50 per cent.; at 1100° C., 29.85 per cent.; at 1130° C., 28.60 per cent.; at 1160° C., 27.55 per cent.; at 1190° C., 27.80 per cent.; at 1220° C., 27.10 per cent.; at 1250° C., 26.00 per cent. A red burning clay having good working and drying behavior, but retaining a porous structure. Test pieces burned to 1250° C. are easily scratched by a knife. This clay is suitable for the manufacture of porous common and building brick. Not practical to vitrify in commercial kilns.

Sample No. 11, Duval County.—Fairly plastic, fairly good working qualities; water of plasticity, 27.4 per cent.; dries satisfactorily; linear drying shrinkage, 9.6 per cent.; linear burning shrinkage, at 990° C., 0.05 per cent.; at 1110° C., 0.82 per cent.; at 1230° C., 2.34 per cent.; at 1320° C., 3.97 per cent.; red burning; per cent. porosity, at 850° C., 28.1 per cent.; at 950° C., 26.8 per cent.; at 980° C., 25.7 per cent.; at 1010° C., 25.8 per cent.; at 1040° C., 24.8 per cent.; at 1070° C., 24.6 per cent.; at 1100° C., 22.5 per cent.; at 1130° C., 22.5 per cent.; at 1160° C., 20.4 per cent.; at 1190° C., 16.6 per cent.; at 1220° C., 11.5 per cent.; at 1250° C., 7.5 per cent. A sandy surface clay of fair working and drying behavior. A decrease in porosity is noted with increase in temperature, although it is doubtful whether a vitrified product may be manufactured from this material, owing to the relatively high temperatures necessary.

Sample No. 12, Clay County.—Very plastic, and possesses fair working qualities; water of plasticity, 34.4 per cent.; excessive drying shrinkage; linear drying shrinkage, 12.22 per cent.; linear burning shrinkage, at 990° C., 1.45 per cent.; at 1110° C., 3.48 per cent.; at 1230° C., 4.87 per cent.; red burning; per cent. porosity, at 850° C., 24.4 per cent.; at 950° C., 22.7 per cent.; at 980° C., 19.6 per cent.; at 1010° C., 18.7 per cent.; at 1040° C., 18.7 per cent.; at 1070° C., 17.4 per cent.; at 1100° C., 17.3 per cent.; at 1130° C., 16.8 per cent.; at 1160° C., 16.9 per cent.; at 1190° C.,

16.0 per cent.; at 1220° C., 14.4 per cent.; at 1250° C., 13.8 per cent. A plastic red burning clay having a high drying shrinkage. Care must be exercised in drying heavy pieces. This clay has a relatively low porosity at commercial kiln temperatures and attains a fairly dense structure.

Sample No. 21, Jefferson County.—Medium plastic with fair working properties; water of plasticity, 32.6 per cent.; no drying difficulties; linear drying shrinkage, 9.77 per cent.; linear burning shrinkage, at 990° C., 0.22 per cent.; at 1110° C., 1.09 per cent.; at 1230° C., 0.55 per cent.; at 1320° C., 0.49 per cent.; buff burning; per cent. porosity, at 990° C., 35.6 per cent.; at 1020° C., 34.0 per cent.; at 1050° C., 33.2 per cent.; at 1080° C., 33.4 per cent.; at 1110° C., 33.8 per cent.; at 1140° C., 33.6 per cent.; at 1170° C., 33.6 per cent.; at 1200° C., 33.7 per cent.; at 1230° C., 32.8 per cent.; at 1260° C., 34.4 per cent.; at 1290° C., 33.7 per cent.; at 1320° C., 33.5 per cent. A sandy buff burning clay which retains an open porous structure at temperatures up to 1320° C. May have some use in the manufacture of soft porous common building brick.

Sample No. 22, Polk County.—Medium plastic with fair working properties; water of plasticity, 24.9 per cent.; no drying difficulties; linear drying shrinkage, 6.28 per cent.; linear burning shrinkage, at 950° C., 0.37 per cent.; at 1100° C., 0.47 per cent.; at 1220° C., 0.08 per cent.; at 1310° C., 0.24 per cent.; burns red; per cent. porosity, at 950° C., 35.6 per cent.; at 1010° C., 35.8 per cent.; at 1040° C., 35.6 per cent.; at 1070° C., 36.0 per cent.; at 1100° C., 34.8 per cent.; at 1130° C., 33.8 per cent.; at 1160° C., 33.8 per cent.; at 1190° C., 33.7 per cent.; at 1220° C., 33.6 per cent.; at 1250° C., 33.7 per cent.; at 1280° C., 33.4 per cent.; at 1310° C., 33.6 per cent. A sandy red burning material which retains an open porous structure at temperatures up to 1320° C. May have some use in the manufacture of soft porous common building brick.

The Florida Plastic Kaolins.

Occurrence.—The plastic kaolins of Florida present problems of exceptional interest. The formation which holds the clays is

probably co-extensive or nearly so with the physiographic type known as the Lake Region of Florida. This belt of country extends in the peninsula of Florida from Clay County on the north to near the middle of DeSoto County on the south, a distance of about 150 miles. In width the belt varies from 10 to 30 or 40 miles. Small lakes are numerous. Their basins, as a rule, are circular in outline and relatively deep with steep sides. The uplands are sandy and well drained. A similar type of topography, underlaid probably by the same formation, is found in several counties in west Florida between the Suwanee and Choctaw-hatchee rivers.

The clay in this formation is intimately associated with coarse sand from which it is removed by washing. Mica is also present and is removed by screening. The sand in this formation is usually coarse and in places affords the sharpest and best building sand found in Florida.

The place of the clay-bearing formation in the geologic time scale is difficult to determine owing to the complete absence of fossils. It overlies the Oligocene limestones. There is also some reason for believing that it lies at a stratigraphic level higher than the fuller's earth beds and hence is not older than the Miocene. However, inasmuch as no one of the later fossiliferous formations is found overlying this formation, it has not been possible to fix its age more definitely.

The two localities at which this clay is being worked are Edgar in Putnam County and Okahumpka in Lake County. At Edgar, 4 to 10 feet of loose sand lies above the kaolin-bearing sand. This top sand is coarse—containing silicious pebbles up to one-third of an inch across. The large pebbles are flattened and all are rounded. The kaolin-bearing sands beneath are gray in color, although the weathered surface is sometimes slightly iron-stained. They are said to have a total thickness of 30 feet or more and are underlaid by a sticky, blue clay. It is reported that beneath the blue clay a fuller's earth occurs, and that this in turn passes at a depth of about 70 feet into a scarcely indurated shell stratum. A well put down by the Edgar Plastic Kaolin Company is reported to have passed through coarse superficial sand, 10 feet; kaolin-bearing sands, 30 or more feet; sticky, blue clay with fuller's

earth beneath, about 40 feet; scarcely indurated shell stratum, 20 feet. The well terminated on a hard limestone at the depth of 90 feet, probably the Chattahoochee limestone, which is Upper Oligocene in age, or possibly the Eocene limestones which lie next beneath—the Chattahoochee formation being usually wanting along the eastern slope of the peninsula.

The kaolin in Lake County occurs under conditions similar to those found in Putnam County. The superficial sands here, as at the Edgar mines, are coarse and contain white, silicious pebbles. The kaolin-bearing sands are gray in color except where stained red with iron. A small amount of mica, found in the kaolin sands, is screened out in the process of washing.

The sand-clay mixture of this formation is often well adapted to road construction, and is frequently so used, especially when somewhat colored by iron-staining as it often is near the surface.

The Florida kaolin-bearing formation is plainly sedimentary in origin and represents, as indicated by the rather coarse sand, a relatively near-shore accumulation of material. The association of the finely divided clay with the coarse quartz sand and the mica is one of the problems of this formation.

Mining.—In mining the Florida kaolin the overburden, which consists of a few feet of sand or iron-stained sand and clay, is removed—usually by the hydraulic process. The clay itself is lifted chiefly by suction pumps which are carried on a floating dredge. The pits are first of all opened to the water table level, which lies at a moderate although varying depth, depending upon the topography. The dredges are then floated on the water that accumulates in the pit. The dredge itself carries a relay station. On some of the dredges this relay pumping station, corresponding to the sump-hole of ordinary hydraulicing, is itself submerged. The pump removing the clay from the sump-hole has a capacity slightly greater than the pump which brings the clay to the sump-hole. Thus, notwithstanding the fact that the process goes on just below the surface of the water, no part of the clay is lost at the relay station because all that goes into the bin is removed at once—the suction of the pump preventing the escape of the floating particles of clay.

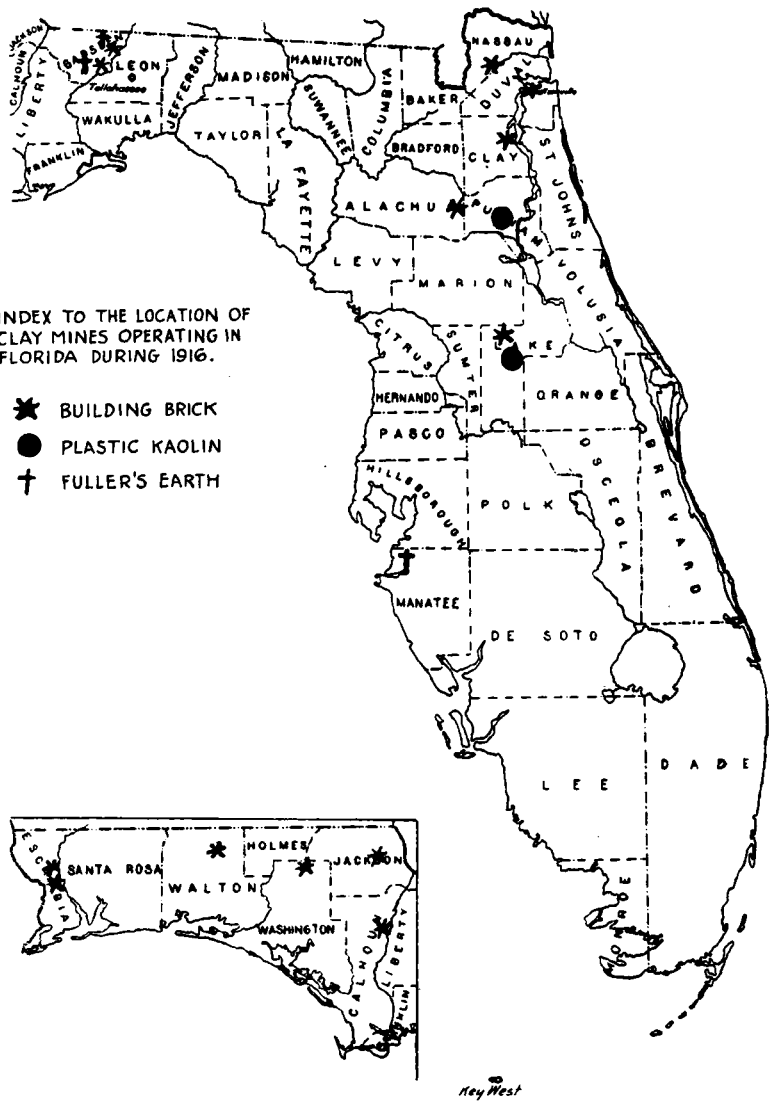


FIG. I.

From the relay pumping station on the dredge the material passes through the washing station where the coarse sand and clay balls are removed to settling tanks. From the settling tanks the clay is again pumped into compressors. After the excess of moisture is removed by compression, the clay is further artificially dried for shipment.

All of the plastic kaolin produced in Florida is shipped out of the State and is used chiefly or entirely in mixing with other clays where it is of value because of being plastic as well as white burning and refractory. Chemical analyses of this clay have been previously published and are accessible. On the map, which accompanies this paper, is indicated the location of the plants in Florida which are producing this clay, and also the location of the brick clay and fuller's earth plants of the state. The bibliography which follows includes references to some of the relatively few papers that have been published on the Florida clays.

Ries, Heinrich, "Clays of the United States East of the Mississippi River," *U. S. Geol. Survey*, Prof. Paper No. 11, pp. 83-85 (1903).

Matson, George C., "Notes on the Clays of Florida," *U. S. Geol. Survey, Bull.* 380, 346-357 (1909).

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Memminger, C. G., "Florida Kaolin Deposits," *Eng. Mining J.*, 57, 436 (1894).