LOUISIANA CLAYS.

By George Charlton Matson.

INTRODUCTION.

The facts that Louisiana possesses a large amount of good timber and is primarily an agricultural State have made it unnecessary to develop her clay resources for the purpose of obtaining structural materials, except in the vicinity of some of the larger cities. Nevertheless Louisiana has held high rank in the output of clay products among the States bordering on the Gulf of Mexico, though in 1915 she ranked thirty-third among all the States in the Union, producing a little less than 0.25 per cent of the total value of the clay products of the country. The increase in the value of timber, together with the rapid growth of cities, will naturally lead to the production and consumption of larger quantities of building brick, terra cotta, tile, and other building materials, and it is therefore important to consider the possibilities of obtaining suitable clays for the manufacture of these materials. For this purpose samples of Louisiana clays were collected by the writer in 1912 and submitted to the Bureau of Standards for examination.

No attempt was made to collect samples from all the localities where clays occur, as this would require a large amount of time and be very expensive. Samples were obtained from the principal geologic formations of the State, and the distribution of these formations, together with the localities from which samples were taken, is shown on the accompanying map (Pl. V). However, most of these formations contain beds of sand or sandstone and will not furnish clays except in relatively small areas, distributed throughout the regions where the formations crop out. No attempt will be made to describe all the localities where clays suitable for the manufacture of clay products have been observed in Louisiana. Such localities are numerous throughout the areas of outcrop, but the descriptions will be confined to those localities where the samples were obtained. The sequence of the geologic formations is shown in the accompanying table, the youngest formation at the top and the successively older formations below. The oldest beds included in this table, belonging to the Cretaceous system, occur at the surface at very few places within the State. They are therefore of no importance as sources of clay.

Geologic formations that crop out in Louisiana.

System.	Series.	Group and formation.	Sample Nos.
Quaternary.	Recent.		2, 7, 10, 11, 12, 14, 15, 26.
	Pleistocene.		1, 8, 9, 13, 16, 17, 18, 19, 24, 25.
Tertiary.	Pliocene.	Citronelle formation.	3.
	Miocene.	Pascagoula clay.	22.[a]
	Oligocene.	Hattiesburg clay.	
		Catahoula sandstone.	
		Vicksburg limestone.	
	Eocene.	Fayette sandstone.	
		Jackson formation.	
		Claiborne group. Yegua formation. St. Maurice formation.	5, 6, 20.
		Wilcox formation.	4, 21, 23.
		Midway formation.	
Cretaceous.			

[a] See also description of clay obtained 1 mile west of Lena, pp. 151-152. Ries, Heinrich, A report on Louisiana clay samples: Louisiana Exper. Sta., pt. 5, pp. 272-273, 1899.

GEOLOGIC DISTRIBUTION OF THE SAMPLES.

EOCENE SERIES.

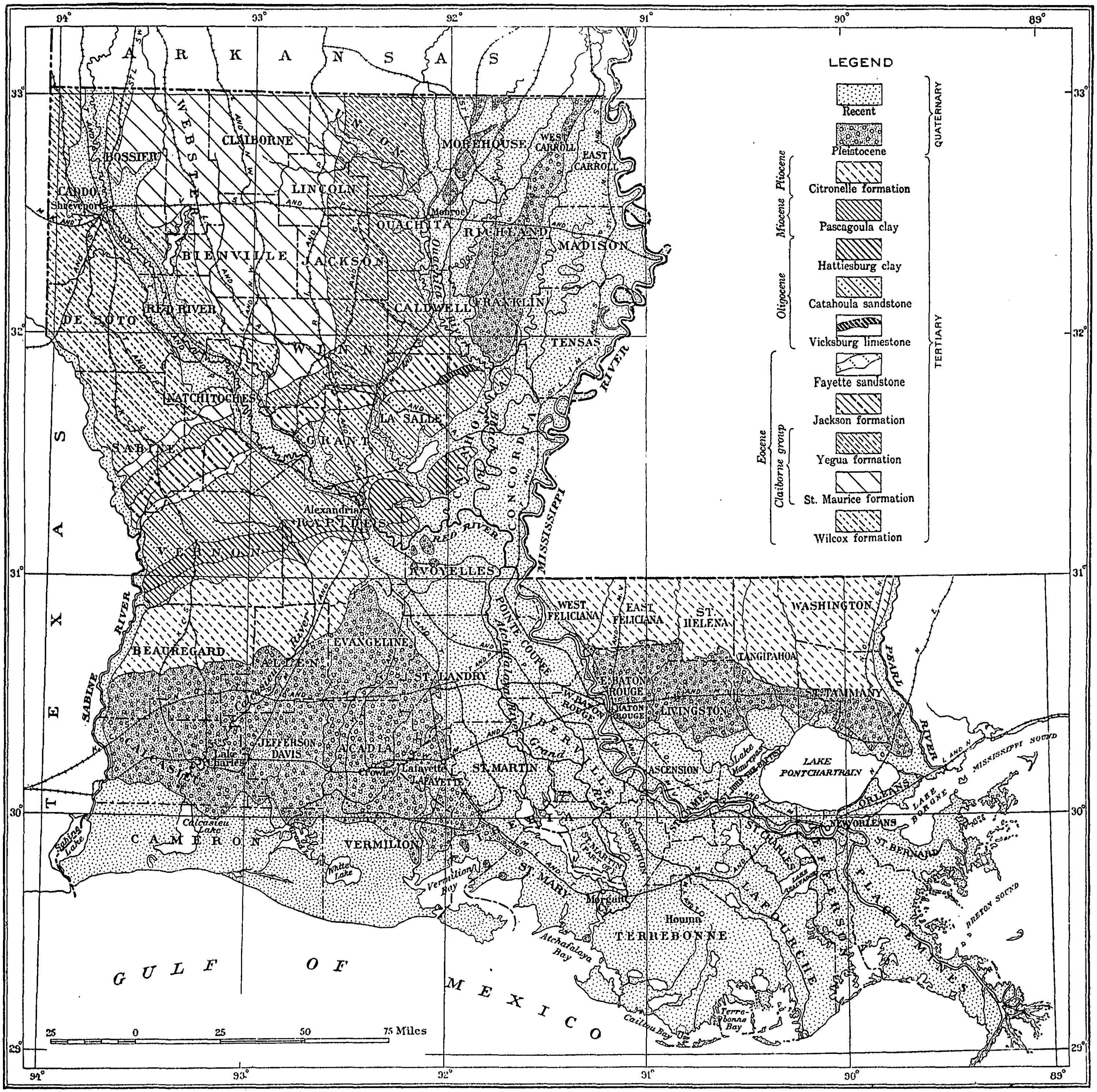
MIDWAY FORMATION.

The Midway formation is exposed at only a few places in Louisiana, and the areas of outcrop are so small that the formation can not be an important source of clays for commercial use.

WILCOX FORMATION.

GENERAL FEATURES.

The Wilcox formation is at the surface over a large area in northwestern Louisiana, extending from the northern boundary of the State southward nearly to Many. This formation contains numerous clay beds that are distributed throughout the greater portion of the



MAP SHOWING THE DISTRIBUTION OF CLAY-BEARING FORMATIONS IN LOUISIANA AND THE LOCALITIES WHERE SAMPLES WERE COLLECTED.

area in which it crops out. Associated with these clay beds are beds of sand and sandstone, and many of the clays are so sandy that it would be necessary to test those found at any particular locality in order to determine their value. A sample (No. 21) was collected near Mooringsport, in Caddo Parish, and two samples (Nos. 4 and 23) were collected near Mansfield, in De Soto Parish. The results of tests of these samples are given in the accompanying table. The sample from Mooringsport was one of the best clays collected in the State. This formation supplies some pottery clay in Mississippi,[1] but none of the samples obtained from Louisiana would be valuable for that purpose. It is possible, however, that clay suitable for the manufacture of pottery might be found at some localities where the Wilcox formation is exposed.

CLAY LOCALITIES.

Mansfield.—At Mansfield two samples were collected, one from the brickyard of B. Y. Wemple (No. 4 in table facing p. 156), and the other from exposures at the old nursery about 2 miles north of the town (No. 23).

Section in the clay pit at Wemple's brickyard, Mansfield.

	Ft.	in.
Yellow granular surface clay	4	0
Red clay mottled gray	4	0
Fine-grained ferruginous sandstone		4

Similar clays with thin partings of sand and sandstone have a thickness of about 25 feet near this locality. The sample was a composite of the yellow and mottled clays.

Section at the old nursery 2 miles north of Mansfield, on the east side of the Kansas City Southern Railway.

	Ft.	in.
Red sand		4–6
Micaceous clay containing some fine sand	15	0

The sample obtained here was taken in such a manner as to furnish a composite of the material underlying the surface sand.

Mooringsport.—On the old Richardson farm, 2 miles south of Mooringsport, on the west side of the Kansas City Southern Railway, two samples were collected—one, weighing about 50 pounds, from the upper bed of blue clay and one, weighing about 25 pounds, from the lower clay bed. These two samples were mixed, and the resulting composite sample (No. 21) was tested in the laboratory.

Section in clay pit on the old Richardson farm, Mooringsport.

	Feet.
Red granular clay containing some fine sand	2
Light-gray to blue micaceous clay with thin laminae of sand	6
Unexposed	4
Blue micaceous clay with thin laminae of sand	3

[1] Logan, W. N., The pottery clays of Mississippi: Mississippi Geol. Survey Bull. 6, pp. 131-210, 1914.

CLAIBORNE GROUP.

GENERAL FEATURES.

The Yegua and St. Maurice formations of the Claiborne group occupy a wide area in north-central Louisiana, as shown on the accompanying map. Samples were collected from the St. Maurice formation at Natchitoches, Natchitoches Parish, and at Winnfield, Winn Parish. The sample procured at Ruston, in Lincoln Parish, probably came from the Yegua formation. The sample from Ruston (No. 5) was one of the few samples obtained in Louisiana that could be vitrified below a temperature of 1,230° C. The sample from Winnfield (No. 20) is of particular interest because, unlike most of the Louisiana clays, it burned to a buff color instead of red. Clays similar to those represented by these samples may be obtained at many localities where the Claiborne formations are exposed.

CLAY LOCALITIES.

Natchitoches.—At the brickyard of Hughes & Aaron, Natchitoches, the silt and clay shown in the subjoined section are mixed together in brickmaking, and a composite sample (No. 6) of the two was taken.

Section at the brickyard of Hughes & Aaron, Natchitoches.

	Ft.	in.
Gray silt	1	2
Gray massive clay	5	0

Ruston.—A sample (No. 5) was obtained near Ruston from the brown shale of the following section:

Section at Randolph's brickyard, half a mile west of Ruston.

	Feet.
Yellow clay containing a few nodules of limonite	3
Brown shale	6–15
Coarse sand	2+

Winnfield.—The sample collected near Winnfield (No. 20) was a composite of the light and dark shale.

Section at Gunn's brickyard, half a mile west of Winnfield.

	Ft.	in.
Gray sand	4	0
Red clay, slightly sandy	3	6
Light-gray shale, containing some yellow laminae	5	0
Dark-gray shale with some thin sand partings	4+	

JACKSON FORMATION AND FAYETTE SANDSTONE.

The Jackson formation and Fayette sandstone occupy a narrow belt extending from a point near Hornbeck eastward to Catahoula Parish. No samples were taken from this belt by the writer because the areas covered by these formations are small. Both of the formations will furnish some clays suitable for the manufacture of ordinary clay products, such as building brick, but the outcrop is narrow and at some distance from the larger cities, and it is probable that clays equally good or better could be obtained from other formations nearer the places where the products would be utilized.

A sample of shale from the Fayette sandstone in sec. 17, T. 3 N., R. 11 W., was examined by Ries,[1] in his laboratory at Cornell University. His tests included a mechanical analysis with the following results:

	Per cent.
Clay and fine silt	42.10
Very fine sand	57.25
	99.35

The amount of water required to temper the sample was 31 per cent, and the shrinkage on air drying was 11 per cent. The tensile strength of the air-dried briquet was good, amounting to 75 pounds per square inch. At cone 3 (about equivalent to a temperature of 1,208° C.) the clay had burned to a light red, with a total shrinkage of 12 per cent; and at cone 6 (about equivalent to a temperature of 1,269° C.) the color was brownish red and the total shrinkage was 14 per cent. Ries regards this clay as suitable for the manufacture of face brick when burned to a temperature of cone 6.

OLIGOCENE AND MIOCENE SERIES.

The Oligocene series includes the Vicksburg limestone, a marly formation occupying only a small area in Louisiana; the Catahoula sandstone, a formation that is predominantly sandy with some clay beds; and the Hattiesburg clay. The Miocene series contains a single formation, the Pascagoula clay. Clay beds are much more numerous in the Hattiesburg and Pascagoula clays than in the Catahoula sandstone and they are all of the same general type as that represented by sample 22, collected at Leesville, with the exception of local beds of calcareous clay. The Leesville sample was too plastic and shrank too much (see table facing p. 156) while being dried to be useful, but it could probably be utilized for the manufacture of ordinary clay products provided it was mixed with some sand.

Ries[2] tested a sample of clay obtained 1 mile west of Lena, probably from the Catahoula or the Fayette sandstone. It is described as a coarse-grained sandy clay that slaked very rapidly, required 21 per cent of water to temper, and had an air shrinkage of 10 per cent when dried. Its mechanical composition was as follows:

	Per cent.
Clay and fine silt	73.5
Very fine sand	26.3
	99.8

[1] Ries, Heinrich, A report on Louisiana clay samples: Louisiana Exper. Sta., pt. 5, pp. 274-275, 1899.
[2] Idem, pp. 272-273.

The dry briquets had a tensile strength of 45 pounds to the square inch, which Ries thought would be sufficient for a brick clay, though a higher tensile strength was regarded as desirable. At cone 3 (about equivalent to a temperature of 1,208° C.) the clay showed signs of incipient fusion and was bright red. At cone 5 (about equivalent to 1,248° C.) the color had changed to a deep red and the product had begun to sinter, though even at this temperature the brick was not vitrified. It is probable that this sample more nearly represents the character of material that may be obtained from the Oligocene and Miocene formations than the sample collected near Leesville.

PLIOCENE SERIES.

CITRONELLE FORMATION.

The Citronelle formation occupies a broad area south of the outcrop of Pascagoula clay, and although it is predominantly sandy it contains a large number of thin beds and lenses of clay. The character of the clay beds found in this formation is shown by sample 3, which is suitable for the manufacture of common building brick.

PLEISTOCENE AND RECENT SERIES.

GENERAL FEATURES.

The Pleistocene and Recent deposits cover wide areas in southern Louisiana and occupy the lowlands adjacent to the streams. The Recent deposits are especially abundant in the broad valley of the Mississippi and its principal tributaries. The largest plants in Louisiana for the production of clay products are in the areas of the Pleistocene and Recent deposits, and for that reason a large number of samples was collected from these deposits. Samples 2, 7, 10, 11, 12, 14, 15, and 26 are from Recent deposits, and samples 1, 8, 9, 13, 16, 17, 18, 19, 24, and 25 from Pleistocene deposits. The principal localities where Pleistocene samples were collected are Baton Rouge, Lafayette, Lafayette Parish; Slidell, St. Tammany Parish; Opelousas, St. Landry Parish; and Lake Charles, Calcasieu Parish. The samples from the Recent deposits were collected from terraces in the river valleys at Alexandria, Shreveport, and Delhi. The samples from Baton Rouge and Delhi represent clays that may be vitrified below 1,230° C., and the sample from Lafayette was one of the best clays collected in the State. The samples from Slidell and Baton Rouge were tested with particular care, because it was thought that if the clays were found to be suitable for the manufacture of fireproofing and similar materials they might be utilized in the manufacture of these materials for the New Orleans market. A number of samples were taken from the Salmen Brick & Lumber Co.'s pits at Slidell, representing beds of different character, and it was found that although some of them were too sandy for the manufacture of hollow blocks and tile, others would be suitable for those purposes. In order to utilize the better grade materials it would be necessary to separate the sandy materials from the more plastic clays. The samples from Baton Rouge were not suitable for the manufacture of fireproofing materials, but if the surface material represented by sample 7 were mixed with the more plastic clays represented by the other samples in proper proportions the mixture could be used for such products.

CLAY LOCALITIES.

Lafayette.—The sample obtained at Lafayette (No. 1) was from the basal clay bed of the accompanying section, which differs from the upper bed in being slightly lighter colored and containing dark-colored granules.

Section at the pit of the Roy Brick Co., Lafayette.

	Feet.
Dark silt loam	2- 3
Yellow clay	8-10
Yellow "buckshot" clay	10+

Lake Charles.—The sample collected at the Delatte & LaGrange brickyard, Lake Charles (No. 16), is a composite of all the clay beds in the pit.

Section at the brickyard of Delatte & LaGrange, Lake Charles.

	Feet.
Dark sandy loam	1-2
Light-gray silty clay containing small nodules of iron oxide	5
Dark-red clay with thin layers and lenses of sand and locally some shells	6
"Quicksand"	3

Another brickyard at the south edge of Lake Charles afforded an opportunity to examine a somewhat better section of materials. Thin laminae of sand occur in the clay at this pit.

Section of the clay pit at the south edge of Lake Charles.

	Feet.
Dark sandy loam	1-2
Dark-gray clay containing small nodules of limonite	3
Dark-gray clay, mottled yellow, containing shells at some localities.	8

Slidell.—The sections at Slidell differ so much that no satisfactory description can be given. The samples were all collected in a long pit belonging to the Salmen Brick & Lumber Co. The thickness of the clay exposed in this pit ranges from 6 to 8 feet and the samples were taken at intervals along the east wall of the pit beginning at the north end.

Sample 18 was obtained from a dark clay bed 3 feet thick; sample 17 from a bed of mottled blue clay 3 feet thick; sample 25 from a bed of blue clay, mottled gray, 5 feet thick; sample 24 from a clay similar to that of sample 25 but slightly more sandy; sample 8 from a massive gray clay about 6 feet thick; sample 9 from a bed of blue clay, mottled buff, 6 feet thick; sample 5 from blue clay dredged from a canal at a depth of 7 feet. Sample 9 is one of the two samples obtained in Louisiana that burn buff instead of red. This clay pit contains a very large variety of materials which can probably be utilized in many different ways by arranging suitable mixtures of materials from different beds.

Delhi.—The sample obtained at Delhi (No. 14) was a composite of the two beds shown in the section.

Section of alluvium at Delhi.

	Feet.
Red clay	2
Gray clay	5

Baton Rouge.—Several samples were obtained in the Connell brickyard, Baton Rouge, as indicated in the subjoined section.

Section at the W. P. Connell brickyard, Baton Rouge.

	Feet.
Fine sandy silt	⅓–½
Chocolate-colored clay	4
Fine silty sand	1–1½
Chocolate-colored clay	6
Sample 7 included the materials to this depth, with the exception of the fine sandy silt at the surface.	
Buff clay	4½–5
This bed was represented by sample 10.	
Buff clay containing concretions of calcium carbonate	1½–2
Sample 11 was obtained from this bed.	
Blue clay mottled yellow	45
Fine brown silty sand	1
Blue clay	15
Sample 12 included all the beds of clay below sample 11.	
Fine yellow sand	2+

Monroe.—The sample obtained near Monroe (No. 15) was a composite of the clay beds below the sandy loam.

Section in the clay pit of the Monroe Brick Co., 1 mile east of Monroe.

	Feet.
Yellow sandy loam	3–4
Light-brown clay	8
Dark-blue clay with some shells	4

Shreveport.—The clay at Shreveport contains fragments of partly decayed wood and leaves. The sample (No. 2) was typical of the deposit below the sandy loam. A similar clay was collected near Alexandria, but there was so much water in the pit that the materials could not be examined.

Section in the clay pit near Red River, Shreveport.

	Feet.
Red sandy loam	1½
Massive red clay, with a few thin partings of fine sand	15

TESTING OF THE CLAY SAMPLES.

The clay samples were tested in the laboratory of the Bureau of Standards at Pittsburgh, and the accompanying table, together with the following description of the methods of examination, show the character and results of the tests.

PREPARATION OF THE CLAY.

Each sample of clay was ground dry in a 5-foot Stevenson pan. If the clay contained hard lumps or pebbles that were not reduced by grinding, it was screened dry through an 8-mesh sieve. After the clay was ground to the desired fineness water was added and the sample tempered in the pan until a consistency suitable for manufacture by the stiff clay process was obtained.

The plastic clay was passed through a small Mueller auger machine, having a circular die 2¼ inches in diameter. By means of a miter box 30 disks 1 inch in thickness were cut from the column of clay molded by the circular die. The samples of clay received were numbered from 1 to 26 consecutively. Five of the wet disks were weighed, carefully dried, and again weighed, and the percentage of water required for tempering the clay was determined from the average losses in weight of the five test pieces.

The volumes of three cylindrical pieces of each clay were measured in a voluminometer, the pieces were dried, and the volumes were again determined. The average volume shrinkage in terms of the dry volume was determined from the decrease in volume due to drying as measured.

DRYING TREATMENT.

The test pieces of each clay were first dried in air at room temperature and then in a gas drier at 80° C. before placing in the test kiln. Clays whose machine-made test pieces cracked during the drying treatment were remolded. The clay was reground and tempered with water, and briquets were prepared by pressing it by hand into a brass mold 4 inches in length, 2 inches in width, and 1 inch in depth. The hand-made test pieces were dried in the same manner as the pieces molded on the auger machine.

BURNING.

The burning was done in a down-draft test kiln, fired with natural gas. A number of the test pieces of each clay were placed in the kiln in such a manner that two trials of each clay could be drawn at different temperatures. The first trial pieces were drawn at 950° C., and other pieces at 20° intervals until the clay reached its maturing point or temperature.

The temperatures in the kilns were measured by platinum-rhodium thermocouples, the kiln temperature being increased at the rate of 40° C. an hour after 950° C. was reached. As the hot trial pieces were drawn from the kiln they were placed in an auxiliary furnace, heated to redness for the purpose, and the whole allowed to cool down slowly.

POROSITY OF THE BURNED TEST PIECES.

The porosities of the burned test pieces were determined in the usual manner by substituting in the formula $\frac{W-D}{W-S}\times 100$ = per cent of porosity, in which D=dry weight of the test pieces, W=wet weight of the test piece (absorption in vacuo), S=suspended weight of the saturated piece.

By plotting a porosity temperature curve, a very clear idea of the vitrification behavior of the clay may be gained, and also an indication as to the class of ware that may be manufactured from the clay.

Information as to the color, hardness, tendency to effloresce, etc., was gathered from the burned test pieces drawn from the kiln.

SUMMARY OF RESULTS.

Perhaps the two greatest difficulties encountered in the working of the clays were the lack of plasticity and bonding power of some of the clays and the excessive plasticity and tendency to crack in drying of others.

All of the samples except Nos. 17 and 20 developed a red color in the burning. Nine clays, samples 3, 4, 6, 9, 17, 18, 19, 24, and 25 preserved an open structure with little decrease in porosity when fired to temperatures as high as 1,250° C. These clays were sandy, some being very low in plasticity and others developing good working plasticity. It is not commercially practicable to manufacture vitrified ware from clays of this type, owing to the high temperatures which they require.

Samples 7, 13, and 14 are sandy in character, yet may be vitrified at temperatures below 1,230° C., differing in this respect from the remainder of the sandy clays.

Samples 1 and 21 show perhaps the best working, drying, and burning behavior of all the clays tested.

The buff-burning clays, Nos. 17 and 20, have good working and drying qualities but maintain an open structure at relatively high temperatures.

Samples 2, 15, and 16 are of inferior quality. In addition to their excessive plasticity and tendency to crack during drying, these clays are easily overburned.

None of the clays are suitable for the manufacture of vitrified clay products, and as paving brick and sewer pipe. Those showing excessive plasticity require the addition of sand to make them workable. On the other hand the excessively sandy materials must be mixed with plastic clay to render them fit for manufacturing purposes. By thus improving the working qualities, when necessary, these clays can be made suitable for common bricks, drain tile, hollow bricks, and the simpler shapes of fireproofing.

SECTIONS OF THE CLAY-BEARING FORMATIONS OF LOUISIANA.

The accompanying diagrams (figs. 14, 15) show the general character of the principal clay-bearing formations of Louisiana, although these formations vary in character from place to place and the sands of one part of a section may be replaced by clays at another locality, or vice versa. However, at any locality a considerable portion of the formations will be clay.

No.	Source and character of sample.	Working behavior.	Drying behavior.	Color after burning.
1	Roy Brick Co.'s pit on northeast edge of Lafayette, La.; yellow surface clay.	Plasticity and working behavior in stiff-mud condition through the auger machine good. Water of plasticity, 30 per cent.	Test pieces required careful drying treatment. All pieces were dried in air without cracking. Drying shrinkage, 41.4 per cent in terms of dry volume.	From light red or salmon at the lower temperatures to dark red and black at the higher. The color is not of the best. The best burning temperature would be about 1,190° C. Some cracking of the test pieces occurred during the burning.
2	Shreveport, La.; dark red, probably a swamp clay; contains pieces of leaves, bark, and other organic matter, also some lime in a finely disseminated form and quartz sand.	The clay was ground dry in the pan and screened through an 8-mesh sieve. When tempered with water the clay develops excessive plasticity and laminates in passing through auger machine. Owing to the stickiness of the clay it adheres to the die of the machine and does not mold into a smooth column.	All the test pieces made on the machine cracked during the drying. Additional test pieces were molded by hand in brass mold and dried more satisfactorily, although some of the pieces cracked and warped. Volume drying shrinkage, 58.4 per cent.	From light red to dark red. The color is not pleasing. A white efflorescence or scum appears on the surfaces of all the burned test pieces. The test pieces burned to 1,110° and 1,130° C. are vesicular or swollen. Best burning temperatures, 1,050° to 1,090° C.
3	Cut of Gulf, Colorado & Santa Fe Ry., De Ridder, La., ½ mile south of station; a mottled red and yellow surface clay containing a few pebbles.	This is a sandy clay and is lacking in plasticity and bonding power. It does not work well in the auger machine and would probably work better if molded by hand. The water required for tempering was 27.6 per cent of the dry weight of the clay.	Drying behavior satisfactory. The test pieces dried easily both in air and in a steam dryer. Drying shrinkage, 31.4 per cent of the dry volume.	From light red at the lower temperatures to dark red at the higher. The color is not poor. The clay does not vitrify below 1,250° C.
4	B. Y. Wemple's brickyard, Mansfield, La.; a mottled red and yellow sandy surface clay very similar to sample 3 in appearance.	Owing to its sandy nature the clay is somewhat low in plasticity and bonding power, although it may be molded by an auger machine. The water required for tempering was 28.4 per cent of the dry weight of the clay.	Drying behavior satisfactory. Drying shrinkage, 25.8 per cent of the dry volume.	From light red or salmon at the lower temperatures to dark red at the higher. The color is not of the best. The clay does not vitrify below 1,250° C.
5	Brickyard at Ruston, La.; mixture of a lump of sandy clay and fine-grained gray clay.	Grinding in a wet pan developed good plasticity. The clay behaved satisfactorily when worked through the auger machine. Laminations were to be seen.	Difficulties were experienced in drying the test pieces made from this clay. All the pieces made on the auger machine and a few of the test pieces molded by hand cracked during the drying. The drying shrinkage was excessive, being 67.7 per cent of the dry volume of the test pieces.	Red; becoming darker at the higher temperatures. The color is not of a pleasing tone. Best burning temperature, 1,190° to 1,230° C.
6	Hughes & Aaron brickyard, Natchitoches, La.; mottled red and yellow sandy surface clay. (Clay used for dry-press building brick; try flashing and vitrifying.)	Developed good working plasticity on tempering with water. The working behavior through the auger machine was good; very few laminations developed. 27.2 per cent water was required for tempering the dry clay.	Dried without cracking or warping. Drying shrinkage, 36.4 per cent of the dry volume.	Red. Owing to the sandy nature of the clay some of the test pieces cracked in burning. The pieces burned to the higher temperatures were flashed to a black color but were not vitrified.
7	W. P. Connell's factory, Baton Rouge, La.; sandy yellow surface clay.	Plasticity and working behavior through the auger machine very poor, owing to the sandy nature of the clay. Tempering water added, 23.8 per cent of the dry weight of the clay.	Drying behavior excellent. Drying shrinkage, 14.5 per cent of the dry volume of the test pieces.	Red, darkening with increase of burning temperature. Best burning temperature about 1,190° C.
8	Salmen Brick & Lumber Co.'s factory, Slidell, La.; mottled gray and yellow surface clay.	Developed excessive plasticity; test pieces made on the auger machine were laminated. The water required for tempering was 28.7 per cent of the dry weight of the clay.	All the test pieces made on the auger machine cracked during drying. Test pieces were remade by hand in a brass mold, but these also cracked. Shrinkage in terms of the dry volume, 40.5 per cent.	Red, darkening with increase of temperature. Best burning temperature about 1,210° C.
9	....do....	Developed good working plasticity and worked nicely through the auger machine. The water required for tempering was 21.9 per cent of the dry weight of the clay.	Drying behavior satisfactory. The clay being sandy, the test pieces were easily dried. Drying shrinkage, 23.4 per cent of the dry volume.	Red. Little decrease in porosity with increase in temperature. The clay has its best structure when burned about 1,250° C.
10	W. P. Connell's factory, Baton Rouge, La.; soft yellow surface clay.	The clay is highly plastic and laminates in passing through the auger machine. Water required for tempering, 34.9 per cent of the dry weight of the clay.	The test pieces molded by the auger machine were badly cracked. Test pieces molded by hand were also cracked during drying. Drying shrinkage, 53 per cent of the dry volume.	Red, darkening at the higher temperatures. Best structure developed when burned above 1,150° C.
11	W. P. Connell's factory, Baton Rouge, La.; surface clay.	The clay is excessively plastic and laminates badly in passing through the auger machine. Water required for tempering, 38.5 per cent of the dry weight of the clay.	The test pieces made on the auger machine cracked into pieces during drying. Test pieces molded by hand also cracked. Volume drying shrinkage, 64.6 per cent.	....
12	....do....	The clay is highly plastic and laminates excessively in passing through the auger machine. Water required for tempering 52 per cent of the dry weight of the clay.	All of the machine-made test pieces cracked during drying. Test pieces made by hand were also cracked.	....
13	Opelousas, La., one-fourth mile south of Southern Pacific station, 100 yards east of track from brickyard; brown surface clay.	The clay developed very little plasticity and bonding power. Worked with difficulty on the auger machine. Water required for tempering, 27.9 per cent of the dry weight of the clay.	Drying behavior excellent; no warping or cracking. Drying shrinkage, 19 per cent of the dry volume.	Red, the shade being darker at the higher temperatures. Test pieces burned to 1,210° and 1,230° C. were highly vitrified. Best structure when burned from 1,190° to 1,230° C.
14	Collins brickyard, Delhi, La.; sandy surface clay.	Plasticity and bonding power very low. Molded into test pieces on the auger machine with difficulty. Water required for tempering, 29.8 per cent of the dry weight of the clay.	Drying behavior excellent; no warping or cracking. Drying shrinkage, 22 per cent of the dry volume.	Red. Appearance similar to that of sample 13. Test pieces burned to 1,230° C. were vitrified. Best burning temperature, 1,230° C.
15	Monroe, La.; surface clay....	The clay is excessively plastic and produces a laminated structure in passing through the auger machine. Water of plasticity, 33.6 per cent.	Test pieces made on the auger machine cracked during drying. Test pieces made by hand were also slightly cracked. Drying shrinkage, 48 per cent of the dry volume.	Red. The test pieces burned to 1,110° and 1,130° C. were well vitrified. Test pieces burned above 1,130° C. were overburned, as shown by a vesicular structure. Best burning temperature, 1,110° to 1,130° C.
16	Lake Charles, La.; reddish surface clay.	The clay is excessively plastic and produces a laminated structure in the auger machine. Water of plasticity, 31.2 per cent.	Test pieces made on the auger machine cracked during drying. Test pieces molded by hand also developed small cracks. Drying shrinkage, 50.5 per cent of the dry volume.	Red. Test pieces burned to 1,090° and 1,110° C. were vitrified. Test pieces burned above 1,110° C. were overfired, being swollen. Best burning temperature, 1,070° to 1,110° C.
17	Salmen Brick & Lumber Co.'s factory, Slidell, La.; soft, sandy, gray clay.	The plasticity of the clay is somewhat low, owing to its sandy nature, but it may be worked very satisfactorily on the auger machine. Few laminations were produced in the column. Water required for tempering, 21 per cent of the dry weight of the clay.	No drying difficulties were encountered. Drying shrinkage, 15.2 per cent of the dry volume.	Buff or cream. At the higher temperatures the cream color faded to gray. The color is very pleasing. Best burning temperature, above 1,250° C.
18	Salmen Brick & Lumber Co.'s factory, Slidell, La.; soft, sandy clay.	Although sandy, the clay when molded on the auger machine produced a smooth column with few laminations. Water required for tempering, 22.7 per cent of the dry weight of the clay.	Drying behavior excellent, owing to the open structure of the molded test pieces. Drying shrinkage, 28.7 per cent of the dry volume.	Pinkish buff, the pink being more conspicuous at the higher temperature. Does not vitrify at 1,233° C. or below.
19	Salmen Brick & Lumber Co.'s factory, Slidell, La.; sandy surface clay; appearance very similar to that of sample 18.	Although a sandy clay, the plasticity was sufficient for molding on the auger machine. A smooth column having few laminations was produced. The water required for tempering was 20.9 per cent of the dry weight of the clay.	Owing to the porous structure of the unburned test pieces, the drying behavior was good. Drying shrinkage, 16.9 per cent of the dry volume.	Salmon, becoming darker at the higher temperatures. The red color was more noticeable than in the test pieces burned from sample 18. Best structure when burned above 1,250° C.
20	Gunn's brickyard, Winnfield, La.; soft clay having a shaly structure.	It was necessary to grind and screen the clay through an 8-mesh sieve before tempering in order to reduce the harder lumps. The tempered clay is plastic and works nicely through the auger machine, although difficulties were encountered from laminations. The water required for tempering was 28.3 per cent of the dry weight of the clay.	Drying behavior fairly satisfactory, although there was a tendency to crack along the lines of laminations. Drying shrinkage high, being 35.9 per cent of the dry volume.	A pleasing buff color at lower temperatures, fading to gray at higher temperatures. The clay has its best structure when burned to above 1,250° C.
21	Mooringsport, La.; 25 pounds of one clay and 50 pounds of another mixed in proportions received and made into test pieces; samples have a shaly structure.	The mixture developed good working plasticity and worked nicely on the auger machine, producing a smooth column with few laminations. The water required for tempering was 27.1 per cent of the dry weight of the clay.	Dried nicely without cracking. Drying shrinkage, 33.2 per cent of the dry volume.	Salmon or light red at lower temperatures, the shade becoming darker at the higher temperatures. Best burning temperature, 1,190° to 1,230° C.
22	North edge of Leesville, La.; surface clay.	The clay is excessively plastic and sticky and could not be worked on the auger machine on account of extreme laminations and inability to produce a smooth column of clay.	All test pieces cracked during the drying treatment. Drying shrinkage, 50 per cent of the dry volume.	....
23	Two miles north of Mansfield, La., near old nursery; soft, red clay.	Screening was necessary in order to remove pebbles occurring in the sample. The clay is highly plastic, and its behavior through the auger machine is not of the best. Water required for tempering, 36.1 per cent of the dry weight.	All test pieces made on the auger machine cracked during drying. Test pieces were then pressed by hand into a brass mold. The drying behavior of the handmade pieces was better, although there was some cracking. Drying shrinkage, 45.7 per cent of the dry volume.	A good red, darkening with increase of temperature. Best burning temperature, 1,150° C.+.
24	Salmen Brick & Lumber Co.'s factory, Slidell, La.; sandy clay.	This clay is low in plasticity and bonding strength and was worked with difficulty in the auger machine. The water required for tempering was 21.1 per cent of the dry weight of the clay.	Drying behavior excellent. Drying shrinkage, 15.7 per cent of the dry volume.	Salmon at the lower temperatures, the shade becoming darker at the higher temperatures. Best burning temperature, 950° to 1,250° C.+.
25	....do....	Plasticity somewhat low. Works poorly on the auger machine. Water required for tempering, 18 per cent of the dry weight of the clay.	Drying behavior fair. Owing to the low bonding strength of the clay, some of the test pieces cracked in drying. Drying shrinkage, 15.2 per cent of the dry volume.	Light red or salmon at lower temperatures, darker red at the higher temperatures. Burning temperature, 950° to 1,230° C.+.
26	Alexandria, La.; clay as received had been molded into unburned bricks.	A very plastic clay which gives a laminated structure in the auger machine. Water required for tempering, 25.4 per cent of the dry weight of the clay.	Care must be exercised in the drying of this clay when molded on an auger machine. Owing to the laminated structure, the clay cracks. Drying shrinkage, 32.9 per cent of the dry volume of the clay.	Fairly good red. Best burning temperature, 1,130° C.

Burning behavior (per cent porosity).

No.	950°	970°	990°	1,010°	1,030°	1,050°	1,070°	1,090°	1,110°	1,130°	1,150°	1,170°	1,190°	1,210°	1,230°	1,250°
1	24.7	....	24.4	22.9	23.8	21.8	21.7	17.2	15.4	13.4	....	11.7	10.4	1.1	0.1	....
2	15.5	16.7	8.4	8.9	5.8	5.5	3.5	1.2	30.5	32.0	....	....	....	....	....	....
3	37.1	37.1	37.1	37.0	37.0	36.5	36.7	35.8	35.7	34.7	....	34.3	34.3	34.4	33.9	....
4	36.3	....	35.7	35.3	35.4	35.2	35.0	34.4	34.1	33.8	....	33.0	31.9	31.8	28.5	....
5	21.8	23.9	23.1	23.7	19.7	19.8	18.1	16.0	15.0	14.8	14.3	13.3	11.0	9.9	7.2	3.1
6	27.0	....	27.4	27.4	27.6	27.9	27.9	26.9	27.2	26.8	....	26.4	25.7	25.3	24.8	....
7	39.2	39.3	38.6	38.4	37.8	36.3	34.0	33.1	28.0	26.6	20.9	15.1	....	....	....	....
8	24.7	....	24.6	....	24.4	....	22.5	....	21.2	....	20.3	....	18.8	....	....	....
9	26.6	26.0	26.6	25.9	25.9	25.9	25.5	25.4	25.0	24.1	24.1	24.0	24.0	....	22.6	22.4
10	22.2	23.0	22.6	19.3	20.0	20.0	18.3	18.6	19.4	16.7	16.2	....	....	....	....	....
11	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
12	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
13	38.8	38.0	37.9	37.7	36.8	34.7	31.0	30.8	28.0	24.2	19.6	13.7	8.7	0.5	0.5	....
14	39.4	38.9	38.8	38.4	38.0	36.6	34.9	33.6	32.8	31.0	27.0	24.1	19.9	14.3	0.7	....
15	25.0	23.9	23.3	22.4	20.3	20.0	17.9	14.5	3.2	2.4	Overburned.					
16	19.6	18.7	18.0	16.5	13.1	13.1	6.7	4.2	2.3	24.7	34.2	34.3	....	....	....	....
17	36.1	35.5	36.1	35.9	36.1	34.7	35.6	35.7	34.9	34.1	33.3	32.9	33.4	34.5	33.5	32.4
18	25.8	26.3	26.3	25.6	25.4	25.3	24.1	24.5	22.3	22.5	22.5	22.1	....	....	22.4	....
19	28.1	28.0	27.3	28.3	29.0	28.6	28.9	29.2	27.9	....	26.9	26.7	26.7	26.8	26.6	26.6
20	27.1	25.8	26.0	26.4	26.2	24.8	23.1	23.0	22.2	20.7	20.3	19.8	19.3	18.7	....	18.2
21	27.0	26.9	27.1	26.9	26.3	24.8	21.2	18.4	16.7	15.1	12.4	....	7.7	1.9	2.2	12.1
22	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
23	30.7	29.9	29.9	29.0	27.8	22.8	20.2	19.3	17.2	16.2	....	16.8	....	....	....	....
24	35.2	....	35.6	35.5	25.3	33.5	35.1	35.1	34.7	34.2	....	34.5	33.7	33.5	33.4	32.8
25	25.9	26.1	26.4	26.4	26.7	26.7	26.3	26.6	25.6	25.7	25.6	24.8	24.2	24.4	24.3	....
26	23.3	21.6	22.0	21.4	20.9	20.5	19.8	14.7	8.4	2.1	Overburned.					

No.	Remarks.
1	This clay may be used in the manufacture of common building brick, and possibly of drain tile. The ware must be carefully dried in order to avoid cracking. The test pieces made from the clay were well vitrified at 1,210° and 1,230° C. The clay overburns at 1,250° C.
2	This clay is very poorly suited to the manufacture of clay products. Owing to the poor working, drying, and burning behavior difficulties would be encountered throughout the process of manufacture. The "scumming" or "whitewashing" which appears on the surfaces of the burned test pieces would in itself be a serious detriment. The vitrification behavior of the clay is not good, owing to the suddenness with which overburning or "bloating" develops.
3	A clay of this type may be used in the manufacture of common red building brick of high porosity. The plasticity is too low to permit its use in the manufacture of drain tile. There is comparatively small decrease in porosity with increase of burning temperature It would not be practicable to manufacture a vitrified product from this clay owing to the high burning temperature required.
4	A clay very similar in behavior to sample 3. It is sandy and low in plasticity and could not be molded into drain tile on an auger machine. A porous structure is maintained at a relatively high burning temperature, and manufacture into vitrified ware would not be commercially practicable. The commercial use of this clay would be limited to the manufacture of common red building brick
5	A plastic surface clay having a high drying shrinkage and a tendency to warp and crack during the drying treatment. The behavior in burning is satisfactory, the decrease in porosity being fairly uniform with increase in temperature. A clay of this kind may give rise to difficulties from cracking during the drying treatment if used for the manufacture of clay products.
6	A surface clay that is somewhat sandy but possesses sufficient plasticity for working by the stiff-mud process. A tendency to crack during the burning was noted. The decrease in porosity with increase in temperature up to 1,230° C. was small. Burning to a higher temperature to vitrify this clay is not commercially practicable. A black color may be produced by a reduction of the air supply to the kiln near the finish of the burn. It is not possible to obtain a flash or golden color from this clay.
7	A red-burning sandy surface clay very similar in behavior to samples 3 and 4. The clay may be used in the manufacture of porous common building brick by the soft-molding process. The plasticity is low for manufacture by the stiff-mud process.
8	A highly plastic surface clay which laminates on passing through the auger-machine and cracks in drying. The addition of nonplastic material would be necessary in the manufacture of this clay by the stiff-mud process.
9	A sandy but plastic clay which works nicely by the stiff-mud process and dries safely. The clay attains a low porosity at a relatively high temperature, and it would not be commercially practicable to manufacture vitrified ware from a clay of this type. The clay may be used in the manufacture of porous red building brick and possibly drain tile.
10	A highly plastic red-burning surface clay having a high drying shrinkage. Difficulties in the manufacture of this clay would be encountered owing to the tendency to crack during drying.
11	Owing to the high plasticity and high volume shrinkage all trial pieces made were cracked during the drying treatment, and burning tests were not made on this sample.
12	Burning tests were not made, owing to the cracking and breaking of the trial pieces prepared for burning.
13	A red-burning sandy surface clay of rather low plasticity. At the higher temperatures the clay vitrifies to a low porosity and sound structure. The clay may be manufactured into building brick, preferably by the soft-mud process, although it may possibly be worked by the stiff-mud process. The bonding power is too low to allow manufacture into draintile.
14	A red-burning sandy surface clay of low plasticity. Suitable for manufacture into common building brick by the soft-mud process. Working on an auger machine is accompanied by difficulties, owing to the low plasticity. The clay is very similar in its behavior to sample 13.
15	A highly plastic and sticky red-burning surface clay. Owing to the high drying shrinkage, manufacture of the clay would be accompanied by difficulties during the drying treatment.
16	A highly plastic red-burning surface clay very similar to sample 15 in working, drying, and burning behavior. Owing to its high percentage of drying shrinkage, the clay cracks during drying, and its manufacture into clay products would therefore be accompanied by difficulties.
17	A buff-burning sandy clay which retains a porous structure to 1,250° C. The material is valuable in the manufacture of porous common and face brick and other porous wares. The clay vitrifies at a relatively high temperature, and its manufacture into vitrified ware of low porosity is not commercially possible.
18	A buff to pink burning sandy clay similar to sample 17 in behavior. It would not be commercially possible to vitrify this clay, as test pieces burned to 1,230° C. still retained an open structure. The clay may be used in the manufacture of porous building brick. The plasticity is low for draintile manufacture.
19	A sandy surface clay, burning to a salmon color and maintaining a porous structure to 1,250° C. The clay may be used in the manufacture of porous building brick, etc. It is not commercially possible to vitrify this clay.
20	A buff-burning clay of good plasticity and working qualities. The test pieces burned to 1,250° C. were not vitrified. A clay of this type may be used in the manufacture of common and face brick, draintile, etc.
21	A mixture of the two clays may be used in the manufacture of common or face brick, draintile, fireproofing, etc. The clay has a very good vitrification range and may be used in the manufacture of vitrified ware. The test pieces burned to 1,250° C. were overburned.
22	Owing to the poor drying behavior of this clay, satisfactory test pieces for burning could not be prepared.
23	A red-burning plastic surface clay which cracks in drying. Manufacture into clay products may be accompanied by difficulties on this account.
24	A sandy red-burning surface clay of low plasticity and bonding strength. Maintains a porous structure at a relatively high temperature. The clay can not be vitrified commercially. May be used in the manufacture of porous building brick, preferably by the soft-mud process.
25	A sandy red-burning surface clay of low plasticity and bonding strength. Maintains a porous structure at a relatively high temperature. The clay can not be vitrified commercially. May be used in the manufacture of porous building brick, preferably by the soft-mud process.
26	A red-burning plastic clay which laminates when molded by an auger machine. The clay has a well-vitrified structure when burned to 1,130° C. The clay overburns above 1,130° C., as shown by the vesicular structure developed.

Figure 14, A, shows the general character of the Pleistocene deposits, the Citronelle formation, and the Pascagoula clay in Louisiana east of Mississippi River.

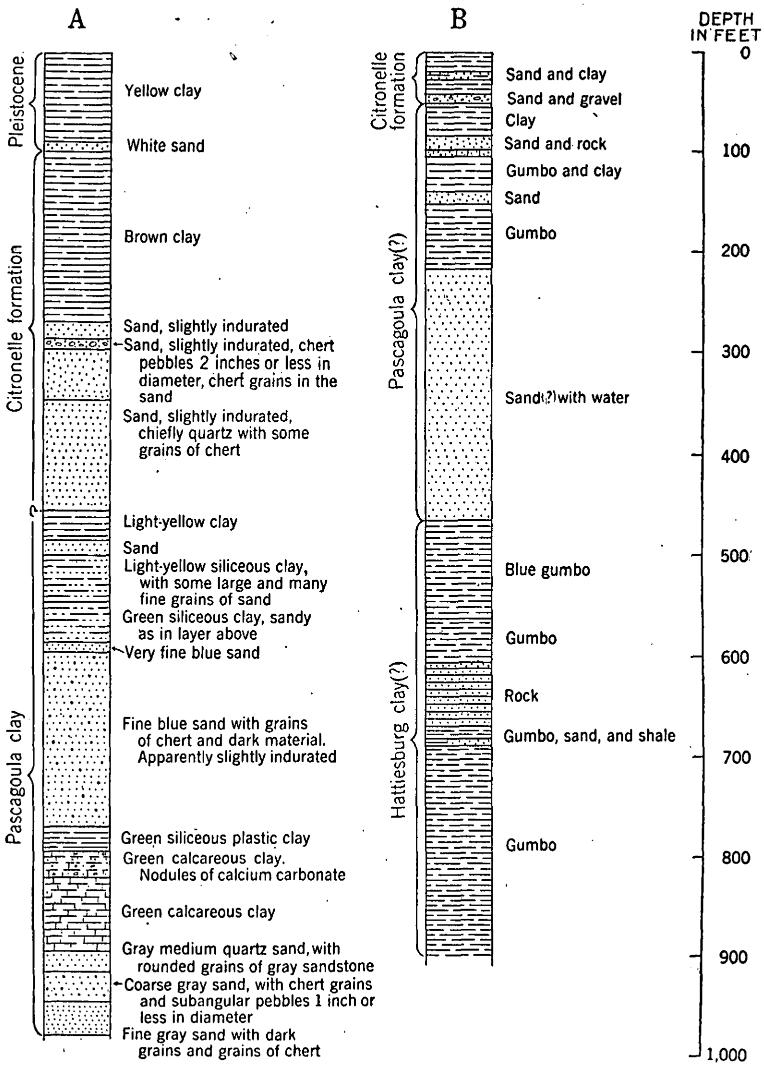


FIGURE 14.—Diagrams of wells showing the general character of clay-bearing formations of Louisiana. A, Well of B. A. Bass, East Baton Rouge Parish; B, Well of Gulf Land & Lumber Co., Fullerton, Vernon Parish.

Figure 14, B, shows the general character of the Citronelle formation, the Pascagoula clay, and the Hattiesburg clay in western Louisiana.

Figure 15 shows the general character of the Hattiesburg clay and the Catahoula and Fayette sandstones. The descriptions of materials shown in this diagram are generalized. Many of the sandstones

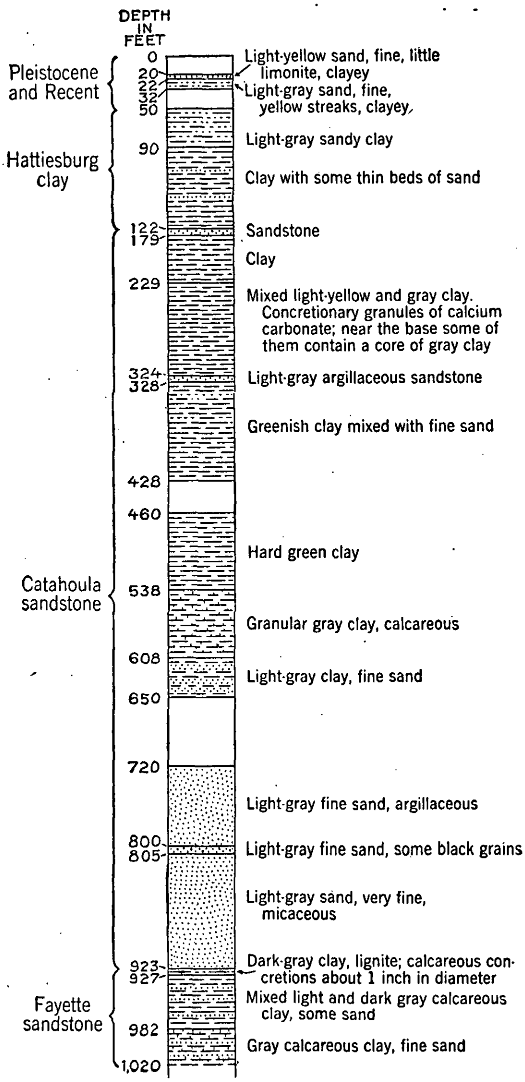


FIGURE 15.—Diagram of well at Pineville, Rapides Parish, La.

contain clay beds thick enough for the manufacture of clay products, and most of the clay beds contain some lenses and layers of sand, though not enough to interfere with the exploitation of the clays.