Stratigraphic and Mineralogic Relations and Ceramic Properties of Clay Deposits of Eocene Age in the Jackson Purchase Region, Kentucky and in Adjacent Parts of Tennessee

GEOLOGICAL SURVEY BULLETIN 1282

Prepared in cooperation with the Kentucky Geological Survey

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By WILDS W. OLIVE *and* WARREN I. FINCH

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STRATIGRAPHIC AND MINERALOGIC RELATIONS AND CERAMIC PROPERTIES OF CLAY DEPOSITS OF EOCENE AGE IN THE JACKSON PURCHASE REGION, KENTUCKY, AND IN ADJACENT PARTS OF TENNESSEE

By Wilds W. Olive and Warren I. Finch

ABSTRACT

Clay deposits in the Jackson Purchase region, Kentucky, and in adjacent parts of Tennessee, in the northeastern part of the Mississippi embayment, are the major domestic source of ball clay. The deposits are widely spaced lenses in the Wilcox, Claiborne, and Jackson Formations of Eocene age. All deposits mined, except one in the Wilcox, are in the Claiborne.

X-ray analyses of clay from deposits in each of the three formations show that clay-mineral composition varies according to stratigraphic position. The clay deposits in all formations are chiefly kaolinite, but montmorillonite, illite, and mixed-layer clay are present. Kaolinite is considerably more abundant in the Wilcox and Claiborne Formations; it averages 70 percent of the total clay in 16 samples analyzed. Montmorillonite, which rarely exceeds 5 percent in Wilcox and Claiborne clay deposits, generally makes up a large part, 14 to 50 percent, in most samples from clay deposits in the Jackson Formation. Clay that contains more than 10 percent montmorillonite is unsuited for most ceramic purposes. Thus, X-ray data indicate that the Claiborne and Wilcox Formations have greater potential as sources of ceramic-grade clay than has the Jackson Formation.

Most commercial clay deposits in Kentucky are in lenses in strata indicated by pollen to be of middle and late Claiborne age. The pollen types and lithologic relations suggest that these clay lenses were deposited in two ancient valleys.

Mineralogic and ceramic analyses of several undeveloped clay deposits in the Claiborne and Wilcox Formations indicate that they have potential value for use in ceramics.

INTRODUCTION

The clay deposits of Eocene age in the Jackson Purchase region[1] of Kentucky and in adjacent parts of Tennessee, in the northeastern part of the Mississippi embayment, are the major source of ball clay in the United States. Much information was gathered on the occurrence,

[1] Parts of Kentucky and Tennessee west of the Tennessee River were acquired from the Chickasaw Indians by treaty signed in 1818. General Andrew Jackson, who represented the United States, was placed in a position of having to conclude the treaty in his own name. Subsequently, the Kentucky part of the area covered by the treaty came to be known as the Jackson Purchase region; and the Tennessee part, as West Tennessee.

mineralogy, and ceramic qualities of the clays during investigations that were part of the cooperative geologic mapping program of Kentucky by the Kentucky Geological Survey and the U.S. Geological Survey.

The area in this report is a gently to moderately rolling plain traversed by broad, flat, north- to west-trending valleys. At places the valleys are bordered by areas of rugged relief and steep slopes. Local relief is generally less than 75 feet; however, along bluffs bordering the Mississippi River valley south of Wickliffe, local relief is more than 125 feet at many places and is as much as 200 feet at Chalk Bluffs, about 3 miles south of Columbus.

The youngest sediments, other than alluvium, in the region consist of continental gravel deposits of Pliocene(?) and Pleistocene age and loess of Pleistocene age. The gravel deposits form an extensive blanket that overlies Eocene rocks in upland areas, attains a maximum thickness of as much as 100 feet in the southeastern part of the region, and thins to less than 30 feet in the northern part. The gravel deposits are thin to locally absent in the western part. Loess, consisting predominantly of silt of late Pleistocene age, forms a blanket that conceals all older sediments throughout much of the region. In upland areas bordering the Mississippi River valley, the loess reaches a maximum thickness of more than 80 feet; here, it overlies the continental gravel deposits or rests directly on Eocene sediments. The loess thins eastward and is 8 to 12 feet thick near the eastern edge of the area, where it generally rests on the gravel deposits and, rarely, on older sediments. In valley bottoms the Eocene sediments are generally concealed by alluvium of Pleistocene and Holocene age. The alluvium ranges in thickness from a few feet in the smaller valleys to as much as 200 feet in the Ohio and Mississippi River valleys.

Exposures of Eocene sediments are patchy and discontinuous. The best outcrops are in highway and railroad cuts and in deep, narrow channels of small high-gradient streams where erosion has incised through thin alluvium. Exposures also occur on the lower parts of steep slopes but are not common because they are concealed by accumulations of colluvium that may be 5 or more feet thick. Rarely are more than 15 feet of Eocene sediments exposed in one locality. Outcrops in the eastern part of the area are fairly numerous and closely spaced; whereas, in the western and southwestern parts they are sparse and widely spaced, except along the Mississippi River bluffs where they are continuous for long distances. In areas of poor exposure, information on the lithology of the Eocene sequence is based largely on a study of samples from drill holes, which are generally spaced a mile or more apart.

PURPOSE OF REPORT AND METHODS OF SAMPLING

This report presents evidence which indicates that the mineralogic composition of clay deposits of Eocene age in the Jackson Purchase region of Kentucky and in adjacent parts of Tennessee varies according to stratigraphic position. Mineralogic composition of samples from undeveloped clay deposits is compared with that of samples from developed deposits. Based in part on the comparison of mineralogy and in part on data from ceramic tests, the potential use or type of clay is indicated.

The evidence presented is based primarily on results of investigations of 34 samples, most of which were taken from outcrops, but a few were obtained by augering. Those from outcrops are grab samples taken from freshly cleaned exposures. Three clay bodies were sampled by augering with a truck-mounted, 4½-inch-diameter auger, and one sample was collected with a 1½-inch hand auger. All augered samples are from depths of 105 feet or less. Only one sample was taken from most clay bodies; hence, results of X-ray diffraction and ceramic analyses reported for individual samples do not necessarily represent the entire composition or ceramic characteristics of a large clay body.

ACKNOWLEDGMENTS

The analytical work for this report was done by others. R. P. Christian and H. A. Tourtelot, both of the U.S. Geological Survey, supplied X-ray diffraction and size analyses of clay samples, and R. H. Tschudy (1965a, 1965b, 1966, 1967) provided palynologic data that facilitated stratigraphic correlations. The writers are grateful to the managements of The Kentucky-Tennessee Clay Co. and The Old Hickory Clay Co. for their permission to publish data on samples of commercial-grade clay obtained from their mines in Kentucky and Tennessee. Data on ceramic tests of samples from undeveloped clay deposits were provided by M. V. Denny and M. E. Tyrell of the U.S. Bureau of Mines.

PREVIOUS WORK

Loughridge (1888, p. 84–118) was one of the first to discuss the economic potentialities of clay deposits in the area. He described numerous clay deposits and presented several chemical analyses and results of ceramic tests. Chemical and ceramic data for many deposits were included in a report by Easton (1913). The history and methods of clay mining in the Jackson Purchase region of Kentucky were discussed by Gildersleeve (1945), who also described stratigraphic sections from several pits and presented chemical and ceramic data on different types of clay mined in the area. Whitlatch (1940) reported on the clay industry in West Tennessee and described numerous undeveloped clay deposits. Data on ceramic tests of samples from clay exposed at many localities in the Jackson Purchase region of Kentucky are in several publications by the Kentucky State Geological Survey (Floyd and Kendall, 1955; McGrain and Kendall, 1957; McGrain and others, 1960; Walker, 1953).

Pryor and Glass (1961), in a report on the mineralogy of Cretaceous and Tertiary clay deposits from the upper Mississippi embayment, listed data from X-ray analyses of samples from Eocene clay deposits. As indicated by their index map (Pryor and Glass, 1961, p. 40) and by location descriptions (Pryor, written commun., 1966), all Eocene samples used in their study are from the lower and middle parts of the Eocene sequence. Merschat and Larson (1967) reported that X-ray and thermal analyses of more than 60 samples from Eocene clay deposits in West Tennessee, including that part of Tennessee in figure 2, show that the deposits are composed dominantly of kaolinite and quartz.

STRUCTURE

Eocene formations exposed in the region strike parallel to the periphery of the Mississippi embayment and dip west to south toward the embayment axis, which roughly coincides with the east valley wall of the Mississippi River valley. Owing to a lack of key horizons and to general concealment, the angle of dip of the strata can only be approximated. Correlation of surface and subsurface data indicates that the regional dip of the unconformity at the base of the Eocene series is westward and southward at slightly more than 30 feet per mile. Locally, exposed Eocene strata have high-angle dips in directions acutely variant from the regional dip; however, outcrops rarely afford sufficient information on the cause of these erratic attitudes. Many may be caused by slumping shortly after deposition; others may be due to faulting, which can be demonstrated with certainty at very few localities.

GENERAL STRATIGRAPHY

Eocene strata of the Jackson Purchase region of Kentucky and adjoining areas of Tennessee are part of a thick sequence of sediments that range in age from Upper Cretaceous to Holocene. A generalized description of the sequence is presented in table 1. The Eocene section is composed largely of sand, clayey sand, silt, and clay; it attains a maximum thickness of about 1,350 feet at the southern edge of the area along the Mississippi embayment axis. Fossil palynomorphs, including pollen, dinoflagellates, and hystrichospheres, from beds at irregular intervals throughout the Eocene section indicate that the sediments were deposited in fresh-water and near-shore marine environments (R. H. Tschudy, oral commun., 1967). Eocene sediments unconformably overlie the Porters Creek Clay of Paleocene age which is composed of montmorillonitic clay and glauconitic sand.

TABLE 1.—*Generalized section of stratigraphic units of Late Cretaceous to Holocene age in the Jackson Purchase region*

System	Series	Formation	Thickness (feet)	Character
Quaternary	Holocene and Pleistocene	Alluvium and lacustrine deposits	0–185	Brown to gray silt, sand, and gravel; rarely calcareous. Thickest beneath flood plains of Mississippi, Ohio, and Tennessee Rivers.
	Pleistocene	Loess	0–80	Brown to gray silt, intermixed with minor amounts of clay and fine sand; nonstratified blanketlike deposit; locally calcareous and fossiliferous. Thickest near Mississippi River; thins eastward.
Tertiary(?) and Quaternary	Pliocene(?) and Pleistocene	Continental deposits	0–100	Brown to reddish-brown gravel; pebbles dominantly chert and subordinately quartz; scattered lenses of clay and sand; contains fairly continuous middle member composed of sand and clay in south-central part of region. Thins northward and westward.
Tertiary	Eocene	Jackson Formation	400±	Brown to gray silt and clay with thin beds and lenses of light-colored quartz sand; crossbedded in part; very sparse clay-ball sand; locally abundant carbonized plant remains; probably intergrades with Claiborne. May include beds of Oligocene age in upper 100 ft of sequence. Thickens toward axis of Mississippi embayment.
		Claiborne Formation	500±	Light-colored quartz sand with thin lenses of dominantly gray silt and clay; commonly crossbedded; numerous clay-ball sand beds; carbonized plant remains common in clay; locally contains thin lignite beds. Overlies Wilcox Formation unconformably in most of area; overlaps Wilcox in east-central part of area and lies unconformably on Porters Creek Clay.
		Wilcox Formation	350±	Light-colored clayey quartz sand and sandy clay commonly referred to as "sawdust sand" which is characterized by white kaolinite clay grains and minute striate rods; thin beds and lenses of clay and crossbedded sand; basal coarse sand common. Unconformably overlies Porters Creek Clay.

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TABLE 1.—*Generalized section of stratigraphic units of Late Cretaceous to Holocene age in the Jackson Purchase region*—Continued

System	Series	Formation	Thickness (feet)	Character
Tertiary—Continued	Paleocene	Porters Creek Clay	200	Light- to dark-gray montmorillonitic clay, locally glauconitic; beds of gray to brown micaceous and generally glauconitic sand common in lower and upper parts; intersected at many places by vertical to near vertical clastic dikes. Overlies Clayton and McNairy Formations, conformably in most places.
Cretaceous and Tertiary	Upper Cretaceous and Paleocene	Clayton and McNairy Formations	125–275	Gray to brown interlensing sand and clay, characterized by thin laminae, blebs, and minute lenses of white clean very fine micaceous quartz sand. Lower part dominantly light-gray to brown crossbedded quartz sand; carbonized plant remains and iron-sulfide nodules common; sparse scattered lenses of chert-pebble and quartz-sand-matrix gravel in lower 50 ft. Overlies unconformable Tuscaloosa Formation and Paleozoic rocks.
Cretaceous	Upper Cretaceous	Tuscaloosa Formation	0–165	Pale-gray to pale-orange-chert-pebble gravel in a chert-sand, silt, and clay matrix; contains irregularly spaced thin lenses of chert sand, silt, and clay. Formation occurs as scattered lenses in area bordering Kentucky Lake. Unconformably overlies Paleozoic limestone, chert, and shale.

The Eocene sequence lacks marker beds, is devoid of fossil fauna, and is generally concealed by surficial deposits. Stratigraphic correlations are based mainly on regional palynological studies. Stratigraphic and palynological investigations indicate that the Eocene sequence contains strata that are equivalent, at least in part, to the subsurface Wilcox, Claiborne, and Jackson Groups of lower, middle, and upper Eocene ages, respectively. In outcrops of the Jackson Purchase region, none of these units can be subdivided, and they are therefore designated as formations. Figure 1 shows the distribution of the three formations in the Jackson Purchase region. Clay deposits in the upper 100 feet of the sequence contain a pollen assemblage that indicates they may be Oligocene in age and partly equivalent to the Bucatunna Clay Member of the Byram Formation in Mississippi. For convenience of discussion these beds are included within the Jackson Formation.

WILCOX FORMATION

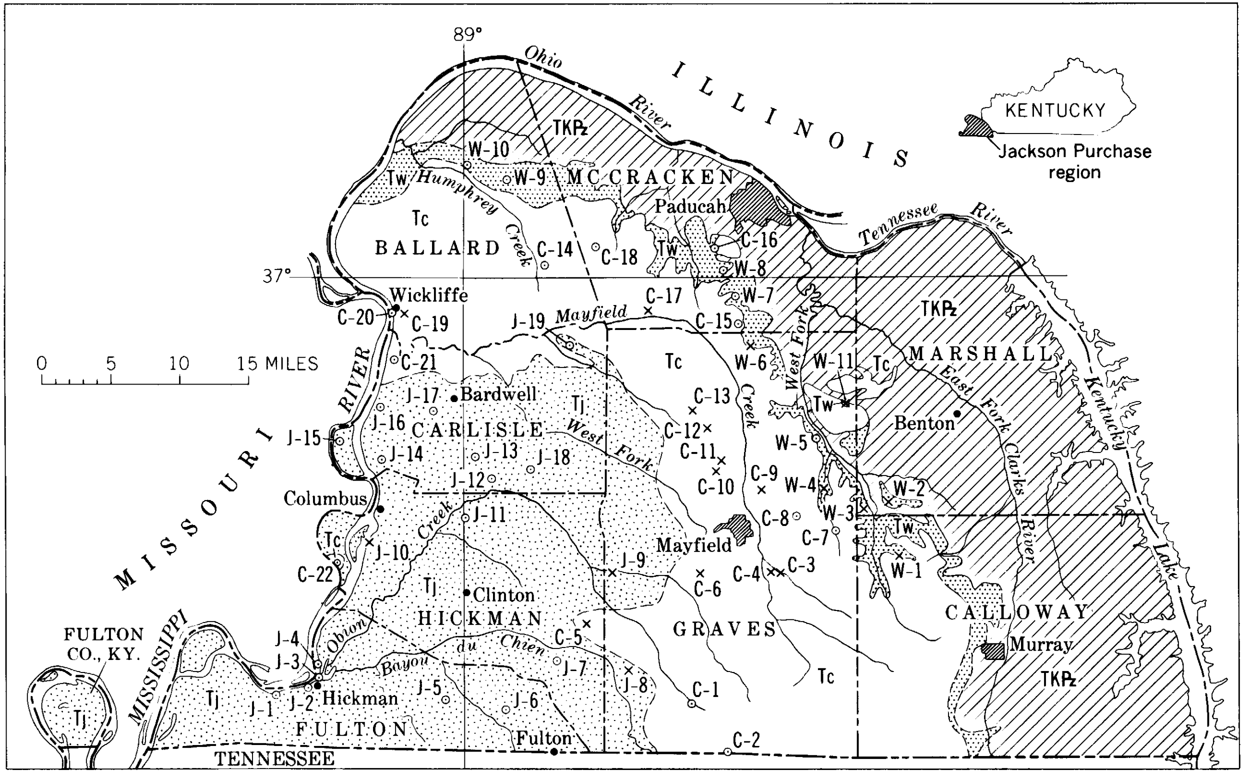
The Wilcox Formation consists mainly of thinly laminated, poorly sorted, intermixed sand, clay, and silt. Because of poor sorting, the Wilcox in general has low permeability; however, in some areas clean, well-sorted, medium to coarse sand, as much as 40 feet thick, forms the basal part of the formation and occurs as widely spaced lenses within the less permeable sediments. Much sand of the Wilcox Formation is fine, very clayey, micaceous, and white specked; because of its appearance, it is comonly referred to as "sawdust sand" (Whitlatch, 1940, p. 233). The "sawdust sand" and, at places, other sediments of the Wilcox commonly contain white, curved, striate rods with well-formed transverse cleavage. These rods are 2 to 3 mm (millimeters) long and have a length-width ratio of about 4:1. X-ray analysis (Finch, 1964; Charles Milton, written commun., 1963) shows that they are composed of kaolinite, as is most clay in "sawdust sand." The rods are similar in shape and composition to authigenic kaolinite crystals with vermicular habit described by Ross and Kerr (1931, p. 161–163, 173, pls. 39, 41, 43). Neither "sawdust sand" nor kaolinite rods, except broken pieces, have been observed in younger Eocene sediments. Lenses of clay-ball conglomerate and clay breccia, some with imbricate structure, are common in the lower part of the Wilcox and are widely spaced higher in the formation. The Wilcox attains a maximum thickness of about 250 feet in the outcrop area and is as much as 335 feet thick near the embayment axis.

Wilcox clay deposits contain varying amounts of silt and sand. The clay is light gray to black and various shades of brown, weathering dark yellowish brown to white and mottled pastel shades of red and orange. Muscovite is sparse to absent. Leaf imprints and comminuted lignitic material are abundant at some horizons. The clay is thin bedded to massive and occurs as lenses a few to a thousand feet or more across and as much as 30 feet thick. Lenses of sandy pisolitic clay 3 to 4 inches thick occur near the base of the formation at several places in the eastern part of the area.

The Wilcox Formation is overlain unconformably and, at places, is overlapped by the Claiborne Formation. In much of the outcrop area, Wilcox sediments filled stream valleys within the Porters Creek Clay.

CLAIBORNE FORMATION

The Claiborne Formation is composed of sand, clay, and lignite beds. Sand probably makes up more than 90 percent of the formation. The sand is composed of angular to well-rounded fine to medium and, at places, coarse to granular quartz, dark minerals, and, locally, muscovite. Crossbedding and cut-and-fill structures are common. Lenses of


89°
37°
Ohio
River
ILLINOIS
KENTUCKY
Jackson Purchase
region
TKPz
W-10
W-9
MCCRACKEN
Tw
Humphrey
Creek
Tc
BALLARD
C-14
C-18
Paducah
C-16
W-8
Tennessee
River
Wickliffe
C-20
C-19
J-19
Mayfield
C-17
W-7
C-15
C-21
Tc
W-6
West Fork
W-11
MARSHALL
0
5
10
15 MILES
J-17
Bardwell
Tj
C-13
East
Fork
J-16
CARLISLE
West
Fork
C-12
Creek
Benton
Kentucky
J-15
J-14
J-13
J-18
C-11
W-5
Clarks
RIVER
C-10
C-9
W-4
W-2
J-12
Columbus
J-11
C-8
W-3
Creek
C-7
MISSOURI
J-10
Mayfield
River
C-22
J-9
C-6
C-4
C-3
W-1
Clinton
HICKMAN
CALLOWAY
Lake
GRAVES
FULTON
CO., KY.
MISSISSIPPI
J-4
Obion
C-5
Murray
J-3
Bayou
du
Chien
J-7
J-8
J-5
J-6
C-1
Tc
Hickman
J-2
J-1
FULTON
Fulton
C-2
TENNESSEE

EXPLANATION

Surficial deposits of Pliocene(?), Pleistocene, and Holocene age not shown

Tj — Jackson Formation
May include some sediments of Oligocene age

Tc — Claiborne Formation

Tw — Wilcox Formation

(Eocene; TERTIARY)

TKPz — Older rocks
Includes Tertiary, Cretaceous, and Paleozoic formations, undifferentiated

(DEVONIAN, MISSISSIPPIAN, CRETACEOUS, AND TERTIARY)

Contact
Dashed where approximately located; short dashed where inferred. Concealed for most part by younger continental deposits, loess and alluvium

×C-2 Outcrop ⊙J-1 Drill hole

Fossil locality

Symbol refers to USGS paleobotanical locality number given below. J, *sample of Jackson age;* J-6 *and* J-7, *may be of Oligocene age;* C, *Claiborne age;* W, *Wilcox age. Depth of drill-hole sample, in feet, enclosed in parentheses. Palynomorphs identified by Tschudy (1965a,b, 1966, 1967)*

J-1, *D3946(103)*
J-2, *D4083(71)*
J-3, *D3879(85)*
D3880(42)
J-4, *D3881(69)*
J-5, *D1891(120)*
J-6, *D3005(65)*
J-7, *D3006(60)*
J-8, *D1898*
J-9, *D3765*
J-10, *D3763*
J-11, *D3940(89)*
J-12, *D3819(120)*
J-13, *D3837(103)*
J-14, *D3836(40)*
J-15, *D3955(127)*
J-16, *D3960(70)*
J-17, *D3882(130)*
J-18, *D3956(100)*
J-19, *D3838(56)*

C-1, *D3008(75)*
C-2, *D3009(75)*
C-3, *D3377*
C-4, *D3193*
C-5, *D3375*
C-6, *D3040*
C-7, *D3428C(43)*
C-8, *D3457(45)*
C-9, *D3558*
C-10, *D3339*
C-11, *D3348*
C-12, *D3332*
C-13, *D3338*
C-14, *D3680(88)*
C-15, *D3958(66)*
C-16, *D3528(26)*
C-17, *D3521*
C-18, *D3527(97)*
C-19, *D1667*
C-20, *D3884(56)*
C-21, *D3888(100)*
C-22, *D3821(165)*

W-1, *D3762*
W-2, *D3743*
W-3, *D3767*
W-4, *D3515*
W-5, *D3460(35)*
W-6, *D3018*
W-7, *D3954(55)*
W-8, *D3479C(32)*
W-9, *D3967(90)*
W-10, *D3747(52)*
W-11, *D3601*

FIGURE 1.—Geologic map of the Jackson Purchase region, Kentucky, showing fossil localities.

clay breccia and clay-ball conglomerate occur at various horizons throughout the unit. The Claiborne Formation, the thickest unit in the Eocene sequence, attains a maximum thickness of about 600 feet near the Mississippi embayment axis.

The clay of the Claiborne Formation ordinarily occurs in widely spaced lenses and in many lenses is interstratified with argillaceous sand and silt, clean sand, and lignite. These lenses are as much as 50 feet thick and a mile across. The clay of the Claiborne Formation generally appears similar to that of the Wilcox Formation, although there are small differences in their mineralogic compositions.

The contact with the Jackson Formation is poorly exposed and probably is gradational.

JACKSON FORMATION

The Jackson Formation is composed, as are other Eocene units, of sand, silt, and clay. As in the Wilcox and Claiborne, the sand consists dominantly of angular to rounded, fine to coarse, granular quartz and minor amounts of dark minerals and muscovite. Some sand in the Jackson, unlike that in the Claiborne, contains several percent chert, which provides a means of distinguishing it from the Claiborne. It is not readily distinguished, however, from cherty sand in local lenses and beds in the continental deposits of Pliocene(?) and Pleistocene age.

Though poorly exposed, silt of Jackson age was penetrated in several test drill holes in the southwestern part of the region; a thickness of more than 250 feet was reported from one hole. The silt is commonly yellowish brown and sandy, and it contains coaly plant remains at some horizons.

Clay of Jackson age is dark to light gray, bluish gray, yellowish brown, and olive green. It is commonly sandy and micaceous and locally contains coaly plant material. In many outcrops along the bluffs of the Mississippi River, the clay is hard and brittle, and south of Hickman it commonly contains numerous irregularly shaped opallike masses as much as 5 mm across.

Clay deposits in the Jackson Formation are thin to thick bedded and lenticular. Sequences consisting predominantly of clay and subordinately of silt are as much as 100 feet thick in areas bordering the Mississippi River in Fulton and southern Hickman Counties. These sequences thin and intergrade with sand northward and eastward. In updip areas, widely spaced lenses in the lower part of the formation resemble, in appearance and size, those of the underlying Claiborne Formation.

ECONOMIC GEOLOGY

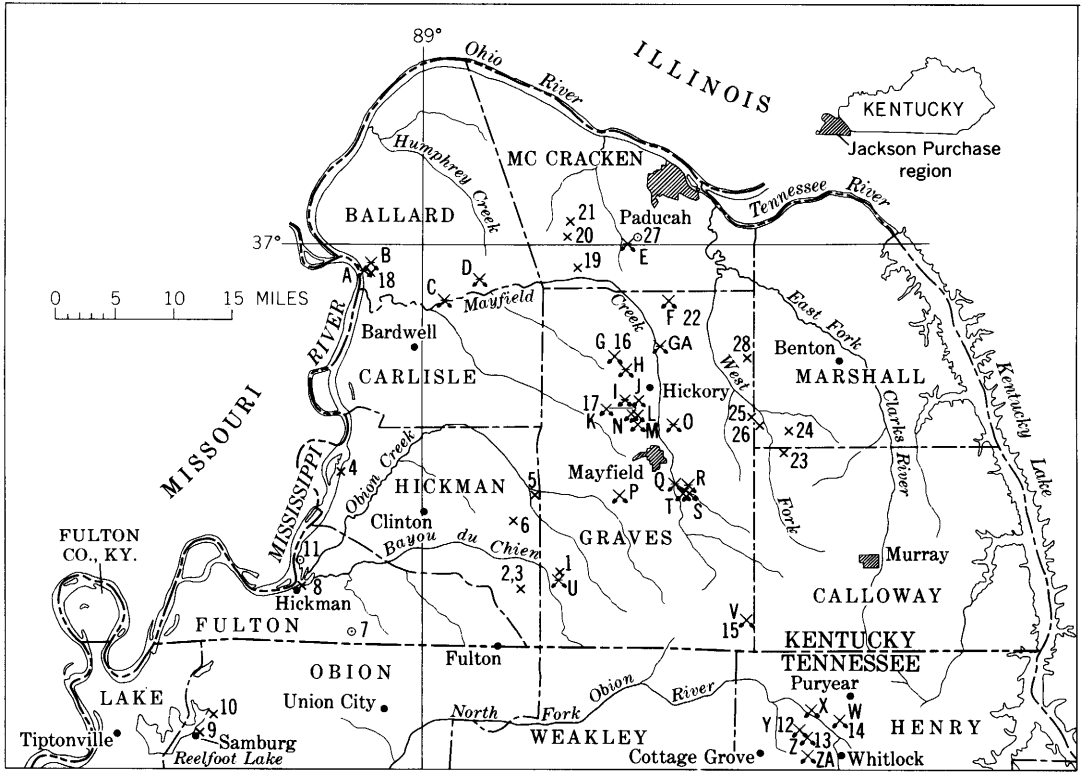
HISTORY OF CLAY PRODUCTION

Although some clay was probably extracted commercially in the 1820's during early settlement of the area, it was not until the late 1800's that clay mining contributed significantly to the economy of the area. The industry received great impetus during World War I when importation of clay from European sources practically ceased (Whitlatch, 1940, p. 3), and by 1940, mines producing from Eocene strata of West Tennessee and the Jackson Purchase region of Kentucky were supplying more than 80 percent of the ball clay used in the United States. As shown in table 2, total clay production from the Jackson Purchase region, Kentucky, during the period 1900–60 amounted to more than 2,880,500 short tons valued at more than $25 million. Production figures for years after 1960 are not available. The bulk of ball clay produced in Kentucky came from pits in central and northern Graves County (see fig. 2). A small amount was from the La Clede-Christy and American pits in Ballard County. All pits except one are in the Claiborne Formation; the Dunning clay pit in Graves County is in the Wilcox Formation. An unreported amount of pottery clay was produced from pits in McCracken, southeastern Ballard, and southern Graves Counties.

TABLE 2.—*Ball-clay production from the Jackson Purchase region, Kentucky, 1900–60*

[1900–41, from Gildersleeve (1945, p. 111–112); 1942–60, compiled from U.S. Bur. Mines (1943–61)]

Date	Short tons	Dollar value	Remarks
1900–41	1, 028, 188	7, 789, 476	Not included are indeterminant tons, 1902–14 and 1919–20.
1942	80, 259	696, 788	
1943	69, 982	622, 309	
1944	72, 729	669, 419	
1945	80, 077	744, 599	
1946	98, 918	990, 301	
1947	99, 951	1, 072, 203	
1948	103, 426	1, 155, 530	
1949	89, 281	1, 076, 531	
1950	105, 690	1, 325, 161	
1951	111, 215	1, 411, 175	
1952	107, 211	1, 372, 695	
1953	100, 482	974, 637	Also, produced fire clay.
1954	96, 483	1, 263, 526	Also, produced a substantial part of Kentucky's fire clay.
1955	111, 600	1, 498, 950	Do.
1956	115, 243	1, 501, 550	
1957	102, 000	Not reported	
1958	94, 200	1, 333, 000	
1959	111, 600	Not reported	
1960	102, 000	do	
Total	2, 880, 535	25, 497, 850	


ILLINOIS
MISSOURI
KENTUCKY
Jackson Purchase region
KENTUCKY
TENNESSEE
0 5 10 15 MILES
89°
37°
Ohio River
Tennessee River
Kentucky Lake
MISSISSIPPI RIVER
Humphrey Creek
Mayfield Creek
Obion Creek
Bayou du Chien
West Fork
East Fork
Clarks River
North Fork Obion River
Reelfoot Lake
BALLARD
MC CRACKEN
CARLISLE
HICKMAN
GRAVES
MARSHALL
CALLOWAY
FULTON
FULTON CO., KY.
LAKE
OBION
WEAKLEY
HENRY
Paducah
Bardwell
Hickory
Benton
Mayfield
Clinton
Murray
Hickman
Fulton
Union City
Tiptonville
Samburg
Puryear
Cottage Grove
Whitlock

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EXPLANATION

×21 Outcrop ⊙7 Drill hole ×16 Clay pit

Sample locality

Number identifies sample described in table 3

×P Active ×U Inactive

Clay pit

Letter symbol identifies name of pit in following list:

A, *LaCleade-Christy*
B, *American*
C, *Hall*
D, *Unnamed*
E, *Niehoff*
F, *Dunning(Boaz)*
G, *Lamkin*
GA, *Unnamed*
H, *Warren*
I, *Excelsior*
J, *Cooley*
K, *Powell*
L, *Chapman No. 3; Blalock No. 1*
M, *Blalock No. 2*
N, *Campbell*
O, *Ray*
P, *Mayfield*
Q, *Unnamed*
R, *Thomson and Bennett-Phillips*
S, *South 40*
T, *Bennett*
U, *Unnamed*
V, *Bell City*
W, *Scott, Monroe, Cole, and others*
X, *Martin*
Y, *Paschall No. 5*
Z, *Etheridge, Wade, and others*
ZA, *Milligan and Howard*

Figure 2.—Map of the Jackson Purchase region, Kentucky, and adjacent parts of Tennessee, showing location of samples and clay pits.

Much ball clay has been produced from pits in the Claiborne Formation in northern Henry County, Tenn. The tonnage of clay produced during 1938—from these pits, combined with that produced from other parts of Henry County and from Carroll and Weakley Counties, Tenn.—is reported by Whitlatch (1940, p. 1).

GENERAL DESCRIPTION OF DEVELOPED CLAY DEPOSITS IN THE CLAIBORNE FORMATION

The developed clay deposits in the Claiborne Formation are lenses in which the clay is interstratified with sand, silt, and lignite. The clay is thin to thickbedded and massive. Thickness of beds ranges from 1 or 2 feet to more than 15 feet. In some deposits, clay with different qualities is produced from different beds, and aggregate thickness of all beds exceeds 30 feet. The quality of clay produced from a single bed may vary laterally and vertically. The manner in which the quality varies is shown by stratigraphic sections reported by Gildersleeve (1945, p. 99, 104, 108–109) and by illustrations and sections reported by Whitlatch (1940, p. 68, 82, 99). Thickness of overburden, which consists mostly of sand, gravel, and silt, is generally less than 60 feet, and the deposits are worked by open-pit methods.

The areal extent and shape of developed deposits are indicated, in a general way, by the size and shape of clay pits. In Kentucky, clay pits range from about ¼ acre, barely 100 feet in longest dimension, to 60 acres, about 1,000 feet wide and 2,500 feet long. Most pits have irregular outlines but in plan view are circular to elongate. The long dimension of the elongate pits trends north to east-northeast. Most pits in the Claiborne Formation of Kentucky occur in a 2-mile-wide arcuate belt that follows the general strike of the strata as shown on published geologic maps (Olive, 1963; Blade, 1965; Finch, 1965; Finch and Minard, 1966; Swanson and Wilshire, 1967). Fossil pollen indicates that sediments within the belt range from middle to late Claiborne age. About 20 miles southeast, another belt with a northerly trend is suggested by the shapes and arrangement of clay pits in northwestern Henry County, Tenn. Pollen assemblages (R. H. Tschudy, written commun., 1966) from clay deposits within this belt indicate that the belt contains sediments that range from lower to middle Claiborne age.

ORIGIN OF CLAY DEPOSITS

Seeking evidence concerning environments of deposition, R. H. Tschudy (written commun., 1968) examined pollen assemblages obtained from the Claiborne Formation at localities shown in figure 1. Many assemblages contain taxa, such as fresh-water algae and water fern, that indicate deposition in lakes and fresh-water ponds. Others contain large spores that are not likely to have survived long-distance transport. A clay sample from locality C–15 (fig. 1) yielded abundant hystrichospheres, a few dinoflagellates, and abundant plant tissue, which point to a marine or near-shore marine depositional environment. A sample from locality C–7 (fig. 1) contained much trash and a few hystrichospheres, which suggest a marine or brackish-water enviroment. The shapes and distribution of the clay bodies and the ecologic information provided from a study of pollen assemblages suggest that the climate during Claiborne time was warm and humid with heavy seasonal rainfall; the terrain was a rather flat plain traversed by south- to east-flowing, meandering, low-gradient, aggrading streams that occupied broad flat shallow valleys. Flooding following seasonal rains caused shifts in the major channels and abandonment of channel segments, which became locales for accumulation of clay deposits and associated sediments.

Stratigraphic and paleontologic evidence suggests that developed clay deposits in northwestern Graves County accumulated in a southerly trending valley. Less positive evidence indicates that deposits in the central part of the county were laid down at a later time in a south- to west-trending valley.

Six large and several small clay deposits west and south of Hickory, Ky., occur within a band ½ to 1 mile wide and 8 miles long (Blade, 1965). The band follows the general strike of the rocks; the northern two-thirds trends N. 50° W., and the southern part trends due north. Several clay deposits within the band have a northerly trend. All deposits are at about the same altitude; the bottom of each occurs within a 10-foot interval, between 430 and 440 feet in altitude. Four clay samples, C–10 through C–13 (fig. 1), from within the band are reported by Tschudy (1965a) to contain pollen assemblages of upper Claiborne age. The assemblages, though similar, are not identical, and according to Tschudy (1965a, p. 29) contain a "* * * particular type of peltate leaf hair * * *" that has not been recognized in other deposits from the area. The evidence suggests that the deposits were laid down at about the same altitude and at about the same time; the linear shape and trend of the band and individual clay deposits suggest that the deposits accumulated in a broad north-trending valley.

Clay deposits of the Ray, South 40, Bennett, and Mayfield pits (fig. 2) in central Graves County are also at a nearly concordant level. The bottom of each deposit is between 410 and 445 feet altitude. The outlines of the Bennett and Mayfield pits are elongate and trend about N. 75° E. and N. 80° E., respectively; the Ray and South 40 pits have circular shapes. The pits are within a band that trends at an oblique angle across the general trend of the Claiborne Formation. Although one might expect the deposits to decrease in age westward in the direction of the regional dip, palynologic evidence suggests that they are about the same age. Pollen samples C–3, C–4, C–6, and C–9 (fig. 1) from the South 40, Bennett, Mayfield, and Ray pits, respectively, and samples C–5 and C–8 from undeveloped clay deposits within the band contain assemblages that according to Tschudy (1965a, 1965b) are common to the Cockfield (uppermost Claiborne) and Moodys Branch (lowermost Jackson) Formations in Mississippi. If the deposits are the same age, their distribution suggests that they were deposited during late Claiborne time in valleys that trended south to west across older sediments.

MINERALOGY

As shown by X-ray analyses (table 3), all samples of clay deposits consist predominantly of quartz and clay minerals; size analyses (table 4) show that these minerals occur as clay-, silt-, and sand-size particles. A few samples contain as much as several percent cristobalite and plagioclase; some contain dolomite, calcite, and potassium feldspar, ranging in amounts from a trace to as much as 1, 2, and 3 percent, respectively. Samples 16, 21, 27c, and 28b (table 3) contain as much as 1 percent feldspar, which was not identified according to type.

Clay minerals, listed in order of most common occurrence, are kaolinite, mixed-layer clay, illite, montmorillonite, and chlorite. Kaolinite is the only clay mineral that occurs in all 36 samples; it is dominant in 29 and shares primary rank with montmorillonite in one (table 3). Mixed-layer clay and illite, which are present in all but a few samples, generally occur in small to moderate amounts, but in some samples they are abundant; in two samples mixed-layer clay is dominant. Montmorillonite occurs in a little more than half the samples and is dominant in four. Beidellite is a component of the mixed-layer clay in sample 2. Chlorite is a minor clay-mineral constituent in five samples (table 3).

Tests conducted on 15 of 33 samples containing mixed-layer clay show that mixed-layer clay in 10 samples contains more illite than montmorillonite; in four samples it contains more montmorillonite than illite; and in one sample montmorillonite and illite are equal (table 3).

The mineralogic composition of clay deposits (table 3) varies according to the stratigraphic position of the deposits. Analyses of seven samples suggest that clay deposits of the Wilcox Formation are composed mostly of kaolinite and illite. Montmorillonite, mixed-layer clay, and chlorite occur in small amounts in some Wilcox samples and are not present in others. The major constituent of clay deposits of the Claiborne Formation is kaolinite. In all 11 Claiborne samples, kaolinite

TABLE 3.—*Description and X-ray mineralogic analyses of clay samples from the Jackson, Claiborne, and Wilcox Formations*

[Includes two sand samples for which the clay fraction was investigated. X-ray analyses by R. P. Christian (indicated by asterisk) and H. A. Tourtelot, using methods described by Schultz (1964), except that total clay is reported as the difference between the sum of the nonclay minerals and 100 percent. Precision of determinations generally within 10 percent. Italicized numbers are estimates outside the normal interpretation of X-ray data. † indicates sample tested to determine ceramic properties, p. 42–63. Whole-rock analyses, in percent, calculated from X-ray diffraction data. Illite includes clay-size mica, chiefly muscovite]

Sample and locality on map (see fig. 2)	Description of location (7½-minute quadrangle, county, and State)	Kentucky coordinates (coordinate system shown on U.S. Geol. Survey topographic maps of Kentucky)	Lithologic description	Whole-rock analyses, in percent							Clay-mineral fraction, in percent					
				Quartz	Cristobalite	Plagioclase	Potassium feldspar	Calcite	Dolomite	Total clay	Kaolinite	Illite	Montmorillonite	Mixed-layer clay	Proportions of montmorillonite (M) and illite (I) in mixed-layer clay	Chlorite
Jackson Formation																
1*	Outcrop (shown in Finch, 1963), west side of U.S. Route 45, 2.5 miles north of center of Water Valley, Water Valley quad., Graves County, Ky.	1,107,750 110,800	Light-gray, slightly carbonaceous, silty clay.	42	----	?	?	?	?	58	33	11	20	36	M>I	----
2*	Outcrop (shown in Finch, 1963) at altitude 420 feet, 0.43 mile south-southwest of Mount Zion Chapel, Water Valley quad., Hickman County, Ky.	1,088,900 101,550	do	27	1	----	1	----	----	71	34	8	47	11	M>I	----
3*	Outcrop (shown in Finch, 1963) at altitude 440 feet, 0.24 mile southwest of Mount Zion Chapel, Water Valley quad., Hickman County, Ky.	1,088,900 103,900	do	72	----	?	----	----	----	28	75	8	15	2	M>I	----
4*	Outcrop in Chalk Bluff bordering Mississippi River, Wolf Island quad., Hickman County, Ky.	1,010,800 161,100	Light-gray, slightly carbonaceous and micaceous, silty clay.	27	----	----	?	----	----	73	51	7	14	28	M=I	----
5*†	Railroad cut, 0.24 mile north-northwest of Baltimore Church, Dublin quad., Hickman County, Ky.	1,100,400 140,550	Dusky-brown, slightly carbonaceous and micaceous, silty clay.	53	----	?	?	?	?	47	65	8	----	27	I>M	----
6*†	Railroad cut, 0.83 mile north-northeast of Jackson Chapel, Dublin quad., Hickman County, Ky.	1,093,950 126,200	do	46	----	----	----	?	?	54	72	14	----	14	I>M	----
7†	Drill hole 44 of Olive (1967), depth 22–47 feet, 1 mile east of Mount Harmon Church, Cayce quad., Fulton County, Ky.	1,015,100 85,250	Light-grayish-brown clay.	23	----	----	----	----	----	77	*50*	----	*50*	----	--------	----

TABLE 3.—*Description and X-ray mineralogic analyses of clay samples from the Jackson, Claiborne, and Wilcox Formations*—Continued

Sample and locality on map (see fig. 2)	Description of location (7½-minute quadrangle, county, and State)	Kentucky coordinates (coordinate system shown on U.S. Geol. Survey topographic maps of Kentucky)	Lithologic description	Whole-rock analyses, in percent							Clay-mineral fraction, in percent					
				Quartz	Cristobalite	Plagioclase	Potassium feldspar	Calcite	Dolomite	Total clay	Kaolinite	Illite	Montmorillonite	Mixed-layer clay	Proportions of montmorillonite (M) and illite (I) in mixed-layer clay	Chlorite
			Jackson Formation—Continued													
8a	Outcrop, 0.1 mile east of end of Hickman seawall, Hickman quad., Fulton County, Ky.	990,050 105,750	Upper clay, contains biotite and volcanic glass.	16	6	8	----	----	----	70	18	----	52	30	--------	----
8b	do	990,050 105,750	Pale-grayish-yellow, blocky, silty clay.	18	----	8	----	----	----	74	3	4	78	10	--------	5
8c	do	990,050 105,750	Lower clay, micaceous.	21	7	----	----	----	----	72	*30*	----	*50*	*20*	--------	----
9a	Outcrop in low cuts along dirt road at junction with Tennessee Route 22, 0.5 mile northeast of Samburg, Samburg quad., Obion County, Tenn.	------------	Opalized clay	35	11	----	----	----	----	54	*70*	----	*15*	*15*	--------	----
9b	do	------------	Fragmental clay	30	7	----	----	----	----	63	54	----	17	29	--------	----
9c	do	------------	Soft clay between buttresses of hard clay.	35	7	----	----	----	----	58	58	4	23	15	--------	----
10	Outcrop in roadcut of Tennessee Route 22, 3 miles northeast of Samburg, Samburg quad., Obion County, Tenn.	------------	Claystone	63	10	----	----	----	----	27	45	12	32	11	--------	----
11*	Sample from depth of 105 feet in drill hole on east shore of Mississippi River, about 2.5 miles north of Hickman, Hickman quad., Fulton County, Ky.	972,300 101,350	Greenish-gray, slightly micaceous, silty clay.	25	----	2	2	----	----	71	15	7	33	45	--------	----
			Claiborne Formation													
12*	Paschall No. 5 clay pit, 4.1 miles northeast of Cottage Grove, Cottage Grove quad., Henry County, Tenn.	------------	Brownish-gray ball clay.	4	----	----	?	----	----	96	70	5	----	25	I>M	----
13*	Etheridge mine, 4.3 miles east-northeast of Cottage Grove, Cottage Grove quad., Henry County, Tenn.	------------	Pale-gray sagger clay.	23	----	?	----	----	----	77	83	6	----	11	I>M	----
14*	Scott mine, 2.35 miles southwest of junction of U.S. Route 641 and Tennessee Route 140 in Puryear, Puryear quad., Henry County, Tenn.	------------	Dark-gray wad clay.	34	----	?	----	1	----	65	79	14	----	7	I>M	----
15*	Clay pit (shown in Olive, 1963), 0.4 mile southeast of Bell City, Lynn Grove quad., Calloway County, Ky.	1,192,950 84,550	White clay	34	----	1	----	1	1	63	67	9	----	24	I>M	----

16	Lamkin clay pit (shown in Blade, 1965), 2 miles west-northwest of West Viola, Ky., Hickory quad., Graves County, Ky.	1,137,600 206,800	Pale-gray clay	20	----	----	----	----	----	80	70	22	----	8	----	----
17a	Middle of Powell pit (shown in Blade, 1965), 1 mile southeast of Hickory, Hickory quad., Graves County, Ky.	1,147,400 187,900	do	20	----	----	----	----	----	80	90	5	----	5	----	----
17b	Bottom of Powell pit	1,147,400 187,900	do	18	----	----	----	----	----	82	77	13	----	8	----	2
18*†	Outcrop, 0.4 mile east of Wickliffe City limit, north side Kentucky Route 440, Wickliffe quad., Ballard County, Ky.	1,028,800 245,800	Gray clay	43	----	?	?	?	?	57	61	8	16	15	M>I	----
19*†	Outcrop, 3.8 miles east of Lovelaceville in Illinois Central Railroad cut, 450 feet north of overpass at south end, Lovelaceville quad., McCracken County, Ky.	1,121,000 247,450	Dark-gray carbonaceous, slightly silty clay.	31	----	?	----	?	?	69	68	9	3	20	I>M	----
20*†	Outcrop (shown in Olive, 1966), 0.75 mile south of Camelia, Heath quad., McCracken County, Ky.	1,117,250 261,300	White clay	26	----	2	----	2	?	70	76	9	----	15	I>M	----
21†	Outcrop (shown in Olive, 1966), 0.9 mile north-northeast of Camelia, Heath quad., McCracken County, Ky.	1,118,600 269,600	Tan clay	23	----	----	----	----	----	77	72	18	----	10	----	----
	Wilcox Formation															
22	Dunning clay pit (shown in Finch, 1964), 0.3 mile northwest of Mount Pleasant Church, Symsonia quad., Graves County, Ky.	1,161,500 229,300	Pale-gray clay	37	----	----	----	----	----	63	65	23	5	7	----	----
23*†	Outcrop (shown in Wilshire, 1963), 0.25 mile northwest of Collie Cemetery, Kirksey quad., Calloway County, Ky.	1,212,100 159,150	Dark-grayish-brown clay.	32	----	1	----	2	1	64	54	43	----	3	I>M	----
24*	Outcrop (shown in Olive and Davis, 1968), 0.43 mile east-southeast of Brewers School, Oak Level quad., Marshall County, Ky.	1,214,600 170,450	White clayey "sawdust sand."	62	----	1	----	?	?	37	87	10	----	3	I>M	----
25	Outcrop (shown in Olive and Davis, 1968), 0.6 mile southeast of Smith Cemetery, Oak Level quad., Graves County, Ky.	1,198,700 176,100	White sandy pisolitic clay.	23	----	----	----	----	----	77	00	----	----	----	----	----
26	Outcrop (shown in Olive and Davis, 1968), 0.1 mile west of minnow pools on Moss Branch, Oak Level quad., Marshall County, Ky.	1,202,700 174,000	White clayey sand, "sawdust sand."	70	----	----	----	----	----	30	84	14	----	----	----	2
27a	Drill hole G of Finch (1966), 2 miles south-southeast of Lone Oak, altitude 429–439 feet, Paducah West quad., McCracken County, Ky.	1,150,700 259,300	Dark-olive-gray, nearly silt-free clay.	25	----	----	3	----	----	72	48	16	26	10	----	----
27b†	Drill hole G, altitude 424–429 feet	1,150,700 259,300	do	27	----	----	----	----	----	73	28	20	26	18	----	8
27c	Drill hole G, altitude 419–424 feet	1,150,700 259,300	do	18	----	----	----	----	----	82	35	10	20	22	----	13
	Average, sample 27	1,150,700 259,300	do	(23)	----	----	----	----	----	(77)	(37)	(15)	(24)	(17)	----	(7)
28a†	Outcrop (shown in Olive and Davis, 1968), 1.5 miles west-southwest of Oak Level, Oak Level quad., Graves County, Ky.	1,198,100 204,000	Unweathered clay.	27	----	----	----	----	----	73	55	31	----	14	----	----
28b	do	1,198,100 204,000	Weathered clay	33	----	----	----	----	----	67	62	38	----	----	----	----
	Average, sample 28	1,198,100 204,000	(Clay)	(30)	----	----	----	----	----	(70)	(59)	(34)	----	(7)	----	----

TABLE 4.—*Size analyses of whole-rock samples from the Jackson, Claiborne, and Wilcox Formations*

[Analyses by R. P. Christian. Particle sizes 0.062–1.0 mm determined by dry-sieve method; sizes below 0.062 mm by Bouyoucos (1936) hydrometer method. See figure 2 for sample localities and table 3 for mineralogic analyses of each sample]

Formation	Sample	Cumulative percent smaller than particle size, in millimeters												
		Sand								Silt		Clay		
		1.0	0.7	0.5	0.35	0.25	0.175	0.125	0.088	0.062	0.031	0.004	0.002	0.001
Jackson Formation	1				<100	<100	<100	99.8	97.6	93.2	77.9	41.8	38.0	24.6
	2					<100	99.9	99.5	98.6	97.6	86.7	48.8	46.9	37.1
	3	99.9	99.9	99.9	99.8	99.7	99.2	86.6	57.7	42.7	31.0	20.1	15.2	14.4
	4						<100	99.9	98.4	92.8	71.6	35.2	31.9	17.4
	5						<100	<100	99.9	99.6	79.3	31.9	29.1	14.8
	6		<100	<100	<100	<100	<100	<100	99.8	98.0	72.1	35.3	34.9	24.7
Claiborne Formation	12					<100	99.6	98.8	97.7	96.8	80.3	66.8	63.9	50.8
	13		<100	<100	<100	<100	99.9	99.5	97.9	95.3	84.8	74.8	74.8	61.5
	14					<100	99.9	99.7	99.1	97.5	84.2	46.8	41.7	28.1
	15							<100	99.9	99.6	90.4	53.4	52.6	31.9
	18							99.9	99.7	97.8	75.5	44.2	41.5	27.4
	19					<100	<100	<100	99.8	99.2	87.7	58.7	52.7	43.6
	20							<100	<100	99.9	95.9	75.9	73.9	58.9
Wilcox Formation	23	<100	<100	<100	<100	<100	<100	<100	<100	99.9	92.4	81.4	76.4	54.5
	24	<100	<100	99.9	98.5	96.1	77.7	57.4	42.7	37.3	32.1	22.3	19.5	15.0

makes up nearly two-thirds or more of the clay-mineral fraction. Illite and mixed-layer-clay contents are variable, but neither exceeds 25 percent of the clay fraction. Only two Claiborne samples contain montmorillonite. The composition of clay deposits in the Jackson Formation varies over a wide range. Kaolinite is the dominant clay mineral in 8 of 15 samples; amounts of kaolinite and montmorillonite are equal in one; montmorillonite is dominant in four; and mixed-layer clay is dominant in two. Montmorillonite, ranging in amounts from 14 to 78 percent, is present in all but three samples.

Size analyses of samples from 15 clay deposits, four of which are developed, are presented in table 4. The combined sand and silt content in each sample, except samples 20 and 23, exceeds by as much as 37.8 percent the amount of quartz determined by X-ray analysis (table 3). This relation implies that in all but two samples a part of the fraction reported as silt is composed of aggregates of grains. A rather small number of aggregates of grains probably occurs in the sand-size fraction, which makes up less than 10 percent, and generally less than 5 percent, of all samples except samples 3 and 24; sample 24 is from a sand deposit. In samples 20 and 23, the sand and silt content is exceeded by the amount of quartz, a fact indicating that some quartz is contained in the clay fraction. Thus, if discrete grains cannot be distinguished from aggregates of grains, accurate size analyses cannot be made, and comparison of data between samples will be misleading. The data, however, do have value as an index to the degree of disaggregation of clay particles and can indicate the maxima and minima within the various size ranges. For example, the data reported for sample 1 show that the clay-size-particle content cannot be less than 41.8 percent and the sand content cannot be more than 6.8 percent. The maximum amount possible for silt would be 58.2 percent, even if all material reported as sand were composed of aggregates of silt grains.

Sand-content maxima in four commercially developed deposits, represented by samples 12–15, range from 0.4 to 4.7 percent, and silt maxima range from 25.2 to 53.2 percent. The minima for clay range from 46.8 to 74.8 percent. Size analyses of samples 2, 19, 20, and 23, all from undeveloped deposits, are comparable to those from the commercially developed deposits.

TYPES OF CLAY

In the ceramics and clay-mining industries, clays are variously typed or classified according to their ceramic properties and use, source of origin, and mineralogic composition. Most clays produced from Eocene rocks of Kentucky and Tennessee are broadly classified as fire clay, which includes several types of clay resistant to heat. Based largely on their uses, they are designated by the trade names ball, wad, and sagger clay. The following descriptions are summarized from Whitlatch (1940, p. 11–12):

Ball clay.—Very fine grained to colloidal, essentially grit-free, highly plastic; characterized by high-bonding power. The best ball clays have high green strength, are white to near white and ivory when fired and have high density at certain temperatures.

Wad clay.—" * * * possesses a high degree of plasticity and toughness, making it suitable for rolling into the long strips or 'wads' used for grouting joints of saggers when they are set up in bungs in the kiln. [It is] characterized by a fairly high content of fine-to-medium-grained silica and is, consequently, sufficiently open-firing at moderately high kiln temperatures to prevent sticking of the wad to the sagger."

Sagger clay.—Strongly plastic clay that is fairly refractory but resistant to repeated heating and cooling; any clay—including ball, wad, and sandy clay—that is suitable for "making saggers, the containers in which delicate pottery wares are placed for protection from dirt and kiln gases during firing."

RELATIONS BETWEEN TYPE AND MINERALOGY

The clay type is determined by many interdependent factors such as mineralogic composition, grain size, and the presence of accessory components such as organic material, soluble salts, and ferric, titanium, magnesium, and calcium oxides. Of these factors, only those determined by X-ray-diffraction and size analyses are dealt with in this report.

Grim (1962, p. 147) observed that plastic fire clays are composed largely of kaolinite, small amounts of illite, and, at times, montmorillonite. Published literature contains little information on permissible percentages of these minerals in fire clay.

Montmorillonite, though used in small quantities as a plasticizer in otherwise low-plastic clay, is undesirable in large amounts in the manufacture of fine ceramics. It has excessively high shrinkage, and because it fires to a buff or reddish color, it is undesirable in the manufacture of products such as whiteware. Information on percentages of montmorillonite allowable for the various groups of clay is sketchy. Parker, Warren, and Morcom (1951) give evidence to indicate the presence of small amounts of montmorillonite in china clays; and Smoot (1963, p. 311) reports: "Although a certain amount of montmorillonite is generally found in ball clays, the proportion rarely exceeds 10 percent." It is assumed from the foregoing that more than 2 or 3 percent of montmorillonite is undesirable in china clays and that more than 10 percent is deleterious in most ball clays.

In a study of British clays used in the fine ceramic industries, Holdridge (1963) calculated mineralogic composition on the basis of

100 percent kaolinite, mica, and quartz. The composition of each clay type studied by Holdridge varies, with some exceptions, within the limits given in table 5.

TABLE 5.—*Range in percent of kaolinite, mica, and quartz in clays used in British fine ceramics industries*

[Compiled from Holdridge (1963, p. 353–354)]

Types of clay	Range in percent		
	Kaolinite	Mica	Quartz
China	70–95	4–26	0–7
Ball:			
Best potting clay [1]	60–90	5–30	0–20
Second-quality ball clay and stoneware clay	30–60	15–40	10–45
Siliceous ball clay	15–40	5–25	45–75
Fire	30–80	5–25	10–60

[1] An undefined term used by Holdridge, possibly to indicate pottery clay.

In identifying the minerals and deriving the percentages reported in table 5, Holdridge apparently combined data from X-ray and chemical analyses. According to Holdridge (1963, p. 352), "* * * alkali associated with clays has been attributed to mica which has been calculated as a mixture of muscovite and paragonite." Mica, as reported by Holdridge, is equivalent to the illite, montmorillonite, mixed-layer clay, and chlorite of the X-ray analyses in table 3. These minerals, designated IMC are grouped together in table 6 to show the amount of material supplying sodium and potassium to the clay mixture for comparison with Holdridge's mica. Cristobolite is grouped with quartz.

Mineralogic compositions of samples 12–16, 17a, 17b, and 22, all from developed clay deposits, approximate compositions reported for British ball clays (compare tables 5, 6). Compositions of samples 19–21 and 23, all from undeveloped clay deposits, approximate those of British and locally produced ball clays. The composition of sample 18 is comparable to that of fire clay in table 5, and the composition of sample 6 compares favorably with that of either fire clay or siliceous ball clay. The composition of other samples does not compare favorably with that of British or locally produced commercial-grade clays, either because the samples contain lower percentages of kaolinite and sources of alkali or because the montmorillonite content exceeds 10 percent.

The four samples in table 3 that have 1 to 3 percent calcite or calcite and dolomite contain about 1 to 2 percent CaO and MgO. These amounts are larger than those found by Holdridge (1963, p. 359–363).

TABLE 6.—*Calculated kaolinite, other clay minerals (IMC), and quartz content of clay samples from the Jackson, Claiborne, and Wilcox Formations*

[Calculated from data for corresponding samples in table 3]

Sample	Percent		
	Kaolinite	IMC	Quartz
Jackson Formation			
1	19	39	42
2	24	48	28
3	21	7	72
4	37	36	27
5	31	16	53
6	39	15	46
7	39	38	23
8a	14	62	24
8b	2	78	20
8c	22	50	28
9a	38	16	46
9b	34	29	37
9c	34	24	42
10	12	15	73
11	11	63	26
Claiborne Formation			
12	67	29	4
13	64	13	23
Clairbore Formation—Continued			
14	52	14	34
15	43	22	35
16	56	24	20
17a	72	8	20
17b	63	19	18
18	35	22	43
19	47	22	31
20	55	18	27
21	56	21	23
Wilcox Formation			
22	41	22	37
23	36	31	33
25	77	0	23
27a, 27b, 27c	28	49	23
28a, 28b	41	29	30

DESCRIPTION, CERAMIC PROPERTIES, AND POTENTIAL USE OF UNDEVELOPED CLAY DEPOSITS

In order to determine their ceramic properties, samples of several clay deposits, for which mineralogic analyses are reported in tables 3 and 6, were tested by laboratories of the U.S. Bureau of Mines (USBM). A brief description of the geography and geology of each deposit and the results of ceramic tests are presented below. The data on ceramic properties are based on preliminary laboratory tests and will not suffice for plant or process design.

SAMPLE 5
(USBM Lab. No. K–3–2)

Location and altitude: Cut bank along east side of Illinois Central Railroad, 0.24 mile NNW. of Baltimore Church, Dublin 7½-min quad., Kentucky; 330 ft alt.

Nearest railroad: Immediate vicinity.

Stratigraphic position: Jackson Formation.

Description of clay body: Total thickness, not determined; 10 ft thick in outcrop; consists of silty, carbonaceous, dusky-brown clay exposed over a distance of 300 ft in cuts adjacent to railroad; intergrades with sand at south end of exposure and is truncated by erosion at north end.

Overburden: 7–8 ft of sand; 15–20 ft of gravel; and 12 ft of silt.

Raw properties: Low plasticity; water of plasticity, 35.7 percent; drying shrinkage, 2.5 percent; dry strength, low; drying defects, none; pH, 4.4; color, gray; not effervescent in HCl.

Slow-firing test:

Temperature (°F)	Color	Hardness	Percent total shrinkage	Percent absorption	Bulk density
1,800	Cream	Poor bond	5. 0		
1,900	do	do	5. 0		
2,000	do	do	5. 0		
2,100	Ivory	3	7. 5	32. 2	1. 40
2,200	do	3	7. 5	30. 7	1. 42
2,300	Gray	3	10. 0	22. 7	1. 57

Remarks: Low green strength; poor ceramic bond; high absorption at all temperatures; pyrometric cone equivalent, 23.

Bloating test: Negative.

Potential use: Body component in artware and for stoneware or glazed structural tile mixtures.

SAMPLE 6

(USBM Lab. No. K-3-3)

Location and altitude: Cut bank along west side of Illinois Central Railroad, 0.83 mile NNE. of Jackson Chapel, Dublin 7½-min quad., Kentucky; 440 ft alt.

Nearest railroad: Immediate vicinity.

Stratigraphic position: Jackson Formation.

Description of clay body: 15 ft of silty, carbonaceous, dusky-brown clay; poorly exposed in east-facing cut; weathers dusky brown in upper part of exposure; size and thickness, not determined.

Overburden: As much as 30 ft of gravel and 15 ft of silt; 10–15 ft of sand may occupy the zone between the clay and the gravel.

Raw properties: Low plasticity; water of plasticity, 33.6 percent; drying shrinkage, 2.5 percent; dry strength, low; drying defects, none; pH, 5.9; not effervescent in HCl.

Slow-firing test:

Temperature (°F)	Color	Hardness	Percent total shrinkage	Percent absorption	Bulk density
1,800	Cream	2	2. 5	30. 2	1. 40
1,900	do	2	2. 5	30. 1	1. 39
2,000	do	2	2. 5	24. 4	1. 47
2,100	Ivory	3	5. 0	23. 4	1. 52
2,200	do	3	5. 0	28. 1	1. 45
2,300	Gray	3	5. 0	25. 3	1. 49

Remarks: Low green strength; poor ceramic bond; high absorption at all temperatures; pyrometric cone equivalent, 23.

Bloating test: Negative.

Potential use: Body component in artware and for stoneware or glazed structural tile mixtures.

SAMPLE 7

(USBM Lab. No. 1665–D)

Location and altitude: Auger hole drilled at 328 ft alt, 1.17 miles N. 48° E. of the village of State Line, Cayce 7½-min quad., Kentucky (Olive, 1967). Sample is from between altitudes 281 and 306 ft.

Nearest railroad: 3.5 miles E. (Railroad through State Line, Ky., on topographic map of Cayce quad. has been removed.)

Stratigraphic position: Jackson Formation.

Description of clay body: Not exposed. Total thickness, not determined—auger penetrated 25 ft of clay between depths of 22 and 47 ft without reaching base; 3–12 ft of clay similar in appearance to that of sample 7 was penetrated in four auger holes drilled within a radius of 1.4 miles, south and west of the sample 7 locality.

Overburden: 22 ft of silt; sandy and slightly pebbly in lower 1 ft.

Raw properties: Long-working, smooth, plastic; water of plasticity, 44.8 percent; drying shrinkage, 7.5 percent; dry strength, fine; drying characteristics, good, very slight scum.

Slow-firing test:

Temperature (°F)	Color	Hardness	Percent linear shrinkage	Percent absorption	Approximate specific gravity
1,800	Pinkish-gray	Hard	7.5	5.0	2.57
1,900	Cream	do	7.5	6.8	2.54
2,000	do	Very hard	9.0	8.9	2.50
2,100	Buff	do	11.0	12.0	2.48
2,200	Buff gray	Steel hard	11.0	20.6	2.32
2,300	Light gray	do	11.0	58.0	2.25

Remarks: Light color; shrinkage, a little high; absorption, high; scum, barely noticeable.

Bloating test: Negative.

Other tests: Solu-Bridge K factor, 5.00.

Potential use: Stoneware and pottery, if washed and quartz added.

SAMPLE 18

(USBM Lab. No. K–3–1)

Location and altitude: Natural exposure in south-flowing stream, 0.4 mile E. of east city limit of Wickliffe, 100 ft N. of Kentucky Route 440, Wickliffe 7½-min quad., Kentucky and Missouri; 300 ft alt.

Nearest railroad: 0.4 mile S.

Stratigraphic position: Claiborne Formation.

Description of clay body: Natural exposure; consists of 4 ft of light-gray clay that contains fragments of carbonized wood, overlain by 2 ft 7 in. of lignite that, in turn, is overlain by 8 ft of light-gray clay; sample from lower clay bed; base, not exposed. Drill hole 200 ft S. penetrated 52 ft of clay between altitudes 307 and 359 ft.

Overburden: As much as 15–20 ft of interlayered sand and clay, and approximately 40 ft of gravel and 10 ft of silt in upland areas to east and west.

Raw properties: Moderate plasticity; water of plasticity, 26.4 percent; drying shrinkage, 5.0 percent; dry strength, good; drying defects, none; pH, 7.5; color, gray; not effervescent in HCl.

Slow-firing test:

Temperature (°F)	Color	Hardness	Percent total shrinkage	Percent absorption	Bulk density
1,800	Light tan	3	5.0	19.2	1.70
1,900	do	3	5.0	18.4	1.73
2,000	do	3	7.5	16.4	1.78
2,100	Buff	3	7.5	13.8	1.83
2,200	do	4	7.5	13.3	1.85
2,300	Gray	5	7.5	12.3	1.84

Remarks: Good buff color at 2,200° F; pyrometric cone equivalent, 20.

Bloating test: Negative.

Potential use: Flue lining; might also be suitable for medium-weathering-grade face brick.

SAMPLE 19

(USBM Lab. No. K-3-5)

Location and altitude: Illinois Central Railroad cut, known locally as Coleman cut, 3.8 miles E. of Lovelaceville, Lovelaceville 7½-min quad., Kentucky (Finch, 1968); 406–409 ft alt.

Stratigraphic position: Claiborne Formation.

Description of clay body: Exposed for nearly 3,000 ft along strike and for 700 ft in dip direction; more than 40 ft thick. At sample locality, top is at 423 ft alt, and base is at 380 ft. Clay quarried from the abandoned pit in the lower part of the clay body was made into pottery in the mid-1920's (L. R. Laxson, resident Coleman Cut Rd., oral commun., 1966).

Overburden: 0–6 ft of loessal silt; 0–20 ft of gravel and pebbly sand, lower few feet locally iron-cemented; 0–30 ft of loose sand. Total overburden ranges from 0 to 50 ft.

Raw properties: Working properties, low plasticity; water of plasticity, 31.2 percent; drying shrinkage, 2.5 percent; dry strength, low; drying defects, none; pH, 5.9; not effervescent in HCl.

Slow-firing tests:

Temperature (°F)	Color	Hardness	Percent total shrinkage	Percent absorption	Bulk density
1,800	Cream	3	5.0	38.9	1.25
1,900	do	3	5.0	37.4	1.29
2,000	do	3	5.0	34.9	1.32
2,100	Ivory	3	10.0	25.4	1.50
2,200	do	5	10.0	23.2	1.55
2,300	Gray	5	12.5	17.3	1.88

Remarks: Low green strength; poor ceramic bond; high absorption at all temperatures; pyrometric cone equivalent 23.

Bloating test: Negative.

Potential use: Body component in artware and for stoneware or glazed structural tile mixtures.

SAMPLE 20

(USBM Lab. No. 1652)

Location and altitude: Natural exposure, 0.8 mile S. of Camelia, Heath 7½-min quad., Kentucky (Olive, 1966); 445 ft alt.

Nearest railroad: 4.85 miles N.

Stratigraphic position: Claiborne Formation.

Description of clay body: Exposed over a distance of 300 ft near bottom of narrow stream channel; 5 ft thick (determined by hand augering) near upstream end of exposure.

Overburden: 1–3 ft of unconsolidated medium- to coarse-grained clayey sand, overlain by 4–10 ft of sandy gravel and gravelly silt. Overburden in upland areas adjacent to exposure may be as much as 30 ft thick.

Raw properties: Long-working, smooth, plastic; water of plasticity, 25.8 percent; drying shrinkage, 0.6 percent; dry strength, fine; drying characteristics, good, scum; pH, 7.32; color, white.

Slow-firing test:

Temperature (° F)	Color	Hardness	Percent linear shrinkage	Percent absorption	Approximate specific gravity
1,800	Pink white	Fairly hard	4.5	4.5	2.58
1,900	do	do	4.5	4.6	2.56
2,000	Yellow white	Hard	4.5	4.9	2.58
2,100	do	Very hard	9.5	9.2	2.56
2,200	Cream	do	9.5	12.1	2.54
2,300	do	Steel hard	10.5	19.3	2.49

Remarks: Yellow scum on surface; wavey surface; off-white color; high shrinkage; high absorption. Addition of $BaCO_3$ would remove scum. Either washing the clay or addition of a barium salt would remove the soluble salts in the clay and probably lower the absorption percentage in the firing. Addition of grog would reduce shrinkage. Pyrometric cone equivalent, 23–24.

Bloating test: Negative.

Other tests: Solu-Bridge K factor, 2.00 (causes yellow scum).

Potential use: Low-duty refractory and sagger mix. A borderline clay between a kaolin (china) clay and a ball clay.

SAMPLE 21

(USBM Lab. No. 1665–E)

Location and altitude: Natural exposure in the channel of Black Branch, 0.9 mile N. 17° E. of Camelia, Heath 7½-min quad., Kentucky (Olive, 1967); 415 ft alt.

Nearest railroad: 3.25 miles N.

Stratigraphic position: Claiborne Formation.

Description of clay body: Exposed at intervals over a distance of 150 ft. Total thickness, not determined, but hand-auger hole near middle of outcrop area penetrated 11 ft of clay without reaching base.

Overburden: Alluvium that consists of 3–6 ft of sandy gravel and gravelly sand, overlain by 6 ft of sandy silt.

Raw properties: Long-working, smooth, plastic; water of plasticity, 31 percent; drying shrinkage, none; dry strength, fine; drying characteristics, fine; pH, 4.71; color, tan.

Slow-firing test:

Temperature (°F)	Color	Hardness	Percent linear shrinkage	Percent absorption	Approximate specific gravity
1,800	Pale pink	Soft	0.5	4.0	2.55
1,900	do	Fairly hard	.5	4.1	2.61
2,000	do	Hard	5.0	4.6	2.59
2,100	Cream	Very hard	10.0	7.7	2.60
2,200	Buff	Steel hard	14.0	15.1	2.54
2,300	Light gray	do	14.0	53.7	2.43

Remarks: Shrinkage, a little high; high absorption, slightly higher than sample 20; quartz, too fine to remove effectively. Addition of grog would reduce shrinkage. Pyrometric cone equivalent, 25–26.

Bloating test: Negative.

Other tests: Solu-Bridge K factor, 0.45.

Potential use: Doubtful low-duty refractory clay (shrinkage too high); fair ball clay; art pottery clay.

SAMPLE 23
(USBM Lab. No. K-3-4)

Location and altitude: Natural exposure in west-flowing tributary of Caney Branch, 1.9 miles E. of Mount Olive Church, Kirksey 7½-min quad., Kentucky (Wilshire, 1963); 470 ft alt.

Nearest railroad: 8.3 miles E.

Stratigraphic position: Wilcox Formation.

Description of clay body: Thickness, not determined; 2–5 ft of dark-gray to black clay exposed over a distance of 300 ft, between altitudes 460 and 475 ft, in tributary of Caney Branch, and over a distance of 250 ft in a smaller channel that enters the tributary from the north. Clay intergrades with thinly laminated sand and clay at lower end of exposure and is concealed by alluvium at upper ends.

Overburden: 4–8 ft of alluvial silt in valley bottom and possibly as much as 35 ft of gravel and 15 ft of silt in adjacent upland areas.

Raw properties: Low plasticity; water of plasticity, 34.2 percent; drying defects, none; drying shrinkage, 2.5 percent; dry strength, low; pH, 4.4; color, gray; not effervescent in HCl.

Slow-firing test:

Temperature (° F)	Color	Hardness	Percent total shrinkage	Percent absorption	Bulk density
1,800	Cream	2	2.5	32.0	1.43
1,900	do	2	2.5	30.0	1.48
2,000	do	3	5.0	26.8	1.56
2,100	Ivory	6	10.0	17.2	1.72
2,200	do	6	10.0	15.9	1.85
2,300	Gray	6	15.0	6.1	2.11

Remarks: Low green strength; poor ceramic bond at firing temperatures below 2,100° F.; pyrometric cone equivalent, 20.

Bloating test: Negative.

Potential use: Body component in artware and for stoneware or glazed structural tile mixtures.

SAMPLE 27b

(USBM Lab. No. 1665–B)

Location and altitude: Auger hole about 3 miles SSW. of Paducah, Paducah West 7½-min quad., Kentucky (Finch, 1966); 424–429 ft alt.

Nearest railroad: About 3 miles E. of drill hole.

Stratigraphic position: Wilcox Formation.

Description of clay body: Penetrated in auger hole from 416 to 449 ft alt; underlain by dark-gray sandy clay to 391 ft alt; clay crops out in floor of creek 1,400 ft to south, at 415 ft alt.

Overburden: At auger hole, 12 ft of loess and gravel.

Raw properties: Long-working, smooth, plastic; water of plasticity, 41.0 percent; drying shrinkage, 5.0 percent; dry strength, fine; drying characteristics, good, slight scum; pH, 7.30; color, gray.

Slow-firing test:

Temperature (° F)	Color	Hardness	Percent linear shrinkage	Percent absorption	Approximate specific gravity
1,800	Pale tan	Soft	6.0	3.3	2.49
1,900	do	Fairly hard	6.0	3.8	2.45
2,000	Tan	Hard	11.0	5.9	2.42
2,100	Brown	do	15.0	9.5	2.39
2,200	Gray brown	Very hard	18.5	27.5	2.30
2,300	Gray	Steel hard	18.5	74.6	2.25

Remarks: Fair color; high shrinkage; very high absorption; slight scum on surface.

Preliminary bloating test: Crushing characteristic, good; particle size, −¾ inch +½ inch; retention time, 15 min.

Temperature (° F)	Bulk density	Lb per cu ft	Percent absorption	Remarks
1,900	2.28	142	9.7	Very slight expansion.
2,000	1.92	120	7.8	Slight expansion.
2,100	1.50	93	5.9	Fair expansion, fair skin.
2,200	.96	60	7.4	Good expansion, good skin.

Observation: Good lightweight aggregate possibilities.

Other tests: Solu-Bridge K factor, 5.20.

Potential use: Art pottery, after being washed.

SAMPLE 27c

(USBM Lab. No. 1665–C)

Location and altitude: From same auger hole as Sample 27b, at the interval of 419–424 ft alt.

Stratigraphic position: Wilcox Formation.

Raw properties: Long-working, smooth, plastic; water of plasticity, 45.2 percent; drying shrinkage, 5.0 percent; dry strength, good; drying characteristics, fair, slight warping, scumming, slightly rough; pH, 6.88; color, gray.

Slow-firing test:

Temperature (°F)	Color	Hardness	Percent linear shrinkage	Percent absorption	Approximate specific gravity
1,800	Pale tan	Fairly hard	6.0	2.6	2.45
1,900	do	do	7.5	2.8	2.41
2,000	Tan	Hard	14.0	4.3	2.34
2,100	Brown	do	14.0	4.5	2.36
2,200	Gray brown	Very hard	16.0	10.1	2.26
2,300	Gray	Steel hard	19.0	20.8	2.21

Remarks: Fair color; high shrinkage; slightly high absorption; surface scum.

Preliminary bloating test: Crushing characteristic, fair; particle size, −¾ inch +½ inch; retention time, 15 min.

Temperature (°F)	Bulk density	Lb per cu. ft	Percent absorption	Remarks
1,900	2.37	148	8.1	Slight expansion.
2,000	2.34	146	6.5	Do.
2,100	1.70	106	7.4	Fair expansion.
2,200	1.60	100	6.7	Fair expansion, fair skin.

Observation: A little heavy for lightweight aggregate material.

Other tests: Solu-Bridge K factor, 5.60.

Potential use: Art pottery, after being washed.

SAMPLE 28a
(USBM Lab. No. K-1-3)

Location and altitude: Natural exposure, 1.45 miles WNW. of Oak Level, Oak Level 7½-min quad., Kentucky (Olive and Davis, 1968); 430 ft alt.

Nearest railroad: 4.3 miles NE.

Stratigraphic position: Wilcox Formation, overlain unconformably by Claiborne Formation.

Description of clay body: Uppermost 1–3 ft exposed over a distance of 300 ft along the channel of Riley Branch; total thickness, not determined.

Overburden: 3–6 ft of alluvial silt and gravel beneath flood plain of Riley Branch, and possibly as much as 10 ft of sand, 20 ft of gravel, and 5 ft of silt in upland areas.

Raw properties: Moderately plastic; water of plasticity, 25.8 percent; drying shrinkage, 2.5 percent; dry strength, good; drying defects, none; color, tan.

Slow-firing test:

Temperature (°F)	Color	Hardness	Percent total shrinkage	Percent absorption	Bulk density
1,800	Tan	2	5.0	15.1	1.80
1,900	do	3	7.5	10.2	1.97
2,000	Light brown	4	12.5	.8	2.30
2,100	Dark brown	6	Expanded		
2,200	Melted				
2,300	do				

Remarks: Color, marginal for face brick; short firing range.

Bloating test: Particle size, −¾ inch +½ inch; retention time, 15 min.

Temperature (° F)	Bulk density	Lb per cu ft	Percent absorption	Remarks
1, 900	1. 70	106	20. 6	
2, 000	1. 83	114	12. 9	
2, 100	1. 67	104	4. 5	
2, 200	. 98	61	5. 3	Melted.

Observation: Not a good bloating clay.

Potential use: Structural tile.

SUMMARY AND CONCLUSIONS

A comparison of the mineralogy of the clay-mineral fraction of all samples analyzed by X-ray diffraction reveals significant differences in the percentages of kaolinite, illite, montmorillonite, and mixed-layer-clay minerals as related to stratigraphic position. Kaolinite content is greater than 60 percent of the clay-mineral fraction in all 11 Claiborne samples, in four of seven Wilcox samples, and in four of 16 Jackson samples (table 3). Illite, though present in most samples from all formations, is least prevalent in samples from the Jackson Formation and is most abundant, as much as 43 percent, in samples from the Wilcox Formation. Montmorillonite accounts for 14 to 78 percent of the clay-mineral fraction in 13 samples from the Jackson Formation and is an uncommon constituent in samples from the Wilcox and Claiborne Formations. Mixed-layer clay is present in most samples studied, but largest percentages occur in those from the Jackson Formation. Six samples from the Jackson contain more than 25 percent mixed-layer clay.

Clay bodies of the Claiborne and Wilcox Formations generally contain large amounts of kaolinite and little or no montmorillonite and have greater potential as sources of commercial-grade clay than do those of the Jackson Formation, which generally contain montmorillonite in excess of 10 percent (fig. 3).

Mineralogic and size analyses and ceramic tests indicate that undeveloped clay bodies from various parts of the Jackson Purchase region and from different parts of the stratigraphic section have potential value for use in ceramics. Of clay bodies studied, those with the desirable characteristics of fine texture, high kaolinite and low quartz contents, and with little or no montmorillonite are represented by samples 19, 20, and 21 (table 3), all from the Claiborne Formation, and possibly sample 23 (table 3) from the Wilcox Formation. Other undeveloped clay bodies probably are not suited for use in fine ceramics because of their mineralogic composition or because they are too coarse

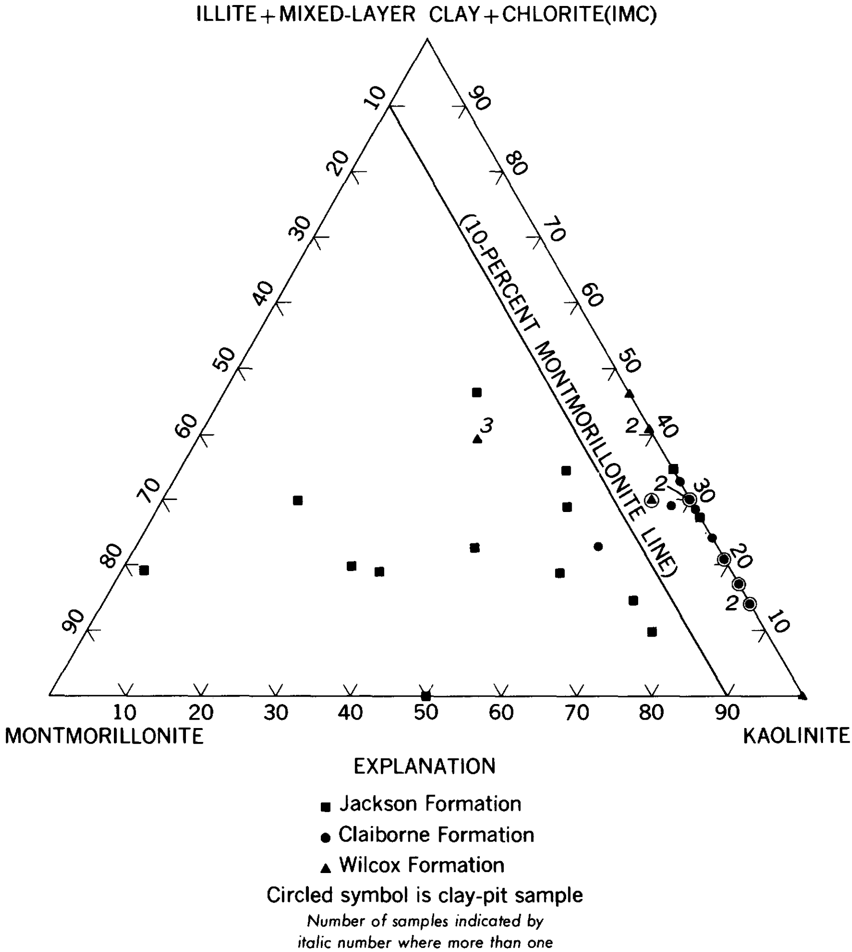

FIGURE 3.—Clay mineralogy of samples from Eocene clay deposits (based on analyses given in table 3).

grained; however, they have potential for use in the manufacture of stoneware, pottery, artware, brick, and structural tile.

Sample 23 has the finest particles of all samples analyzed for size distribution (table 4). More than 76 percent of the sample is made up of particles less than 0.002 mm; 81.4 percent is less than 0.004 mm. The clay-mineral fraction contains 43 percent illite (table 3), which far exceeds that in samples from commercially exploited clay bodies in the area. The percentages of kaolinite, IMC, and quartz are within ranges found by Holdridge (1963) in second-quality ball clays and stoneware clays (tables 5, 6); however, the lime content is probably higher than in ball clays studied by Holdridge.

About one-third the "sawdust sand" of samples 24 and 26 (table 3) is composed of clay, of which more than 80 percent is kaolinite. Deposits of "sawdust sand" in the Wilcox Formation are large and extensive and, if beneficiated, may prove valuable as sources of high-grade ceramic clay. Much additional investigative work involving detailed drilling, sampling, and ceramic testing will be needed to prove adequate reserves of clay that have uniform mineralogic composition and ceramic properties.

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