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THE CLAYS OF ARKANSAS

BY

JOHN C. BRANNER

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PREFACE.

By E. C. Eckel.

The following report on the clays of Arkansas was prepared by Prof. John C. Branner, while State geologist of Arkansas, for publication by the State Survey. The work of the organization was unexpectedly discontinued, leaving no provision for the publication of this report. Under the circumstances Professor Branner offered the manuscript for publication as a bulletin of the United States Geological Survey. As some years have elapsed since the original preparation of the manuscript, it has been necessary to bring up to date, so far as possible, the commercial and statistical data included in the report. Advantage has also been taken of recent Survey work in Arkansas to introduce later observations on the geology of certain districts. Mr. A. F. Crider has accordingly revised the sections on the geology and clay industries of the southeastern counties, while Mr. E. F. Burchard has revised the discussion of the Paleozoic clays and of certain areas in northwestern Arkansas, with a view chiefly to bringing the nomenclature into accordance with present Survey usage.

THE CLAYS OF ARKANSAS

By JOHN C. BRANNER.

CHAPTER I.

TOPOGRAPHY AND GEOLOGY.

GENERAL FEATURES.

The broader topographic and geologic features of Arkansas are not local and characteristic but are rather portions of several physiographic divisions which find completed expression in areas beyond the borders of the State. Nearly all that part of the State lying northwest of a line drawn diagonally across it from northeast to southwest (from Randolph County to Little River County) is comparatively elevated, and is divided by the Arkansas River valley into the Ozark Plateau (including the Boston Mountains) on the north and the Ouachita Mountain region on the south. This northwestern portion is underlain by limestones, sandstones, and shales, which are approximately horizontal in the Ozark region, broadly folded in the Arkansas Valley, and highly folded and distorted in the Ouachita Mountains.

The Ozark Plateau region north of the Boston Mountains is deeply dissected by stream erosion. Its topography is therefore rugged, but the local elevations rise to the same general level. In the Boston Mountain region, which overlooks the plateau from an irregular northward-facing escarpment 500 to 700 feet above it, the topography is largely of the terrace and escarpment type, being developed on sandstones and shales. Stream dissection has made this area also very rough and broken.

The Arkansas Valley represents a worn-down plain. Low residual hills and ridges rise above it, and its streams flow in valleys cut below the general level.

Studies of the Ouachita Mountains by J. A. Taff[a] show that the uplift of this range involves a thickness of nearly 5 miles of rock.

[a] Taff, J. A., Structural features of the Ouachita Mountain Range in Indian Territory: Science, new ser., vol. 11, No. 266, Feb. 2, 1900, pp. 187–188.

The structure is Appalachian, and the massive sandstone and novaculite ridges, primarily arched by folding and compression, have become accentuated by the more rapid weathering of the upturned edges of interstratified shales until great contrasts of relief have resulted. The anticlinal ridges of the Ouachitas trend nearly east and west, are roughly parallel, and rise 500 to 1,000 feet above the intervening valleys, or to altitudes of 1,600 to 2,100 feet.

Bordering the plateau region on the southeast and extending eastward beyond the borders of the State across the Mississippi Valley and southward to the Gulf of Mexico is a lower belt, underlain by younger, softer strata of marls, chalks, clays, sands, and gravels. Low altitude and slight topographic relief characterize this portion of the Gulf Plains. Crowleys Ridge, in the northeastern part of the State, is a remnant of a once extensive plain that stood at a level slightly higher than the present ridge. The slope of the whole is gulfward, and the plain is trenched by many broad, shallow valleys bordered by terraces with steep escarpments.

The older rocks are of Paleozoic age, ranging from early Ordovician sediments, through the Silurian and Devonian, to those of the later Pennsylvanian epoch of the Carboniferous period. The newer deposits represent interrupted sedimentation, beginning with the early Cretaceous and including Tertiary and Quaternary deposits.

Besides the sedimentary deposits certain small areas of intrusive rocks occur at Fourche Mountain, south of Little Rock, and at Magnet Cove, near Hot Springs. These rocks have been studied and described by the late J. Francis Williams,[a] and the areas near Little Rock which contain bauxite have been described by the writer,[b] but were afterward remapped by C. W. Hayes.[c] These rocks consist mainly of elæolite syenite, popularly termed granite, and were intruded into the sedimentary rocks probably late in Cretaceous time.

ORDOVICIAN SYSTEM.

The Ordovician beds are the oldest sedimentary rocks certainly recognized in Arkansas. They consist of a thick series of magnesian limestones, sandstones, siliceous limestones, and cherts, and cover all or portions of the following counties in northern Arkansas: Randolph, Lawrence (western half), Independence (northern part), Sharp, Fulton, Izard, Stone (northeastern part), Baxter, Marion, Boone, Searcy (northeastern part), Newton (northern part), Carroll (northwestern part), and small portions of Benton and Washington.

[a] Williams, J. Francis, The igneous rocks of Arkansas: Ann. Rept. Geol. Survey Arkansas for 1890, vol. 2, 1891.

[b] Branner, J. C., The bauxite deposits of Arkansas: Jour. Geology, vol. 5, 1897, pp. 263-289.

[c] Hayes, C. W., The Arkansas bauxite deposits: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1901, pp. 440, 446, and 454.

These rocks are, for the most part, nearly horizontal, but show gentle folds at some places, while at others they are somewhat faulted.

Ordovician rocks appear also in an area south of the Arkansas River Valley, in the Ouachita Mountain country. In this region they include the novaculites and the rocks immediately underlying them. They are exposed in portions of Pulaski, Saline, Garland, Hot Spring, Montgomery, Polk, and Pike counties.[a]

The Ouachita Ordovician rocks are composed chiefly of novaculites and shales. They have been pressed together from the north and south, so that the beds have been thrown into a series of sharp east-west folds. After they were folded erosion cut away the tops of the arches, leaving the hard novaculites as prominent ridges over the whole area.

SILURIAN SYSTEM.

Silurian rocks are known only in the northern part of the State. They rest conformably on beds of Ordovician age, but have been recognized at only a few places—in the region just west of Batesville and at points as far west as St. Joe, in Searcy County. These Silurian beds are limestones, at some places overlying a bed of shale of probable Ordovician age. The areas of these beds are too small to be represented on the accompanying map (Pl. I), so they have been included with the Ordovician.

DEVONIAN SYSTEM.

The Devonian period is represented by beds of variable character—in some places a black shale, in others a sandstone containing phosphate nodules. The thickness of the shale ranges from a few inches to 70 feet; that of the sandstone ranges from 5 to 75 feet. These rocks are known only in northern Arkansas, where they follow the contact between the Silurian and Carboniferous rocks from near Batesville westward to the vicinity of St. Joe, in Searcy County. They have been recognized also along White River northeast of Fayetteville, and in the northwest corner of the State, at Sulphur Springs, where both shale and sandstone are well developed. Although the phosphatic nodules occur sparingly in places in the lower few inches of the overlying basal Mississippian limestones, there was probably a break in sedimentation between the two formations, and the nodules have been reworked into the younger beds from the débris of the older. This formation also is so limited that it is mapped with the Ordovician rocks.

[a] A report on this area by L. S. Griswold appears in Ann. Rept. Geol. Survey Arkansas for 1890, vol. 3, 1891.

CARBONIFEROUS SYSTEM.

MISSISSIPPIAN SERIES.

Several divisions of the Mississippian rocks have been recognized in Arkansas. Brief mention is made of each of these owing to the important bearing which the limestones and shales have on the production of clays and, consequently, the necessity for guidance in identifying the formations and in determining their areal distribution.

Boone formation.—The Boone formation consists in the main of a series of cherty limestones and cherts that has been known as the "Boone chert," a name given to the series on account of its wide distribution in Boone County. Below these over a large area in the northern part of the State lies the St. Joe limestone member of the formation, a well-marked bed of gray or pink crystalline limestone, which is the basal Carboniferous bed. It is easily recognized by its color, texture, and its marked contrast with the beds that usually underlie it. This limestone forms an almost unbroken outcrop from the vicinity of Mountain View, in Stone County, to the State line near Seligman, Mo. Where the cherts contain much limestone they form, on decay, a very fertile soil. The fine farms of Boone County about Harrison, Valley Springs, Belfonte, and Rally Hill are on the "Boone chert." This formation covers the greater part of Benton County and the northern and western parts of Washington County. Where the chert is comparatively free from limestone beds the soil is too meager for agriculture and forms the "flint hills" of western Carroll and northern Madison counties and the watersheds north of Marshall and southwest of Rush Creek, in Marion County, and the hilltops about Elixir Springs, Boone County, and Doddsville, Marion County.

Moorefield shale.—In the vicinity of Batesville there is a bed of shale lying on the Boone formation. It is well exposed around Moorefield, from which place it is named. In that locality it has a thickness of from 50 to 75 feet. To the west, at Marshall, it is not over 35 feet thick, and evidently it does not extend much farther westward. The shale has a light grayish or bluish color and is very friable. In places it is sandy. It is not important, but is described here in order to give the full sequence of rocks in the section along the northern border of the Boston Mountains.

Batesville sandstone.—Next above the Moorefield shale is the Batesville sandstone, so named from the town of Batesville, which is built on this sandstone. It is present along the base of the slopes of the isolated hills and mountains north of the Boston escarpment, in Independence, Stone, Searcy, Newton, Boone, Carroll, Madison, Washington, and Benton counties. The rock is coarse, cream-colored to brown, often false bedded, and in some places contains beds of

shale interstratified with sandstone. A light sandy soil results from its disintegration. It serves as an excellent reservoir, for the wells that penetrate it usually find in it an abundance of good soft water.

Fayetteville formation.—Next above the Batesville sandstone lies a formation consisting principally of black or dark-gray carbonaceous shale, at many places thinly laminated. Near its base there is generally a thin bed of hard, dark gray or blue limestone, while its middle part commonly grades from a sandy shale to a true sandstone, and where the sandstone phase predominates this portion of the formation is distinguished as the Wedington sandstone member. The shale is well developed in the valley of West Fork of White River near Fayetteville, from which it is named, and the Wedington sandstone member is particularly prominent southwest of Fayetteville, in Wedington Mountain, where it attains a thickness of 150 feet—perhaps one-half the total thickness of the formation. The softness of the shale causes it to erode so easily that its outcrop is usually marked by a valley. Where exposed, the shale disintegrates readily and forms a black and fertile soil. The composition of the unweathered shale renders it suitable material for brick making. The shale beds are practically constant from the Oklahoma line to Sulphur Rock, east of Batesville.

Pitkin limestone.—Above the Fayetteville shale or the Wedington sandstone in northern Arkansas there is nearly everywhere a thin, inconspicuous bed of limestone—the Pitkin—characterized by screw-like stems of the fossil bryozoan *Archimedes*. This formation is regarded as the highest in the Mississippian series.

PENNSYLVANIAN SERIES.

Morrow formation.—Under the name Morrow formation are included several beds of limestone, sandstone, and shale which vary much in thickness, arrangement, and character, and are of but little topographic prominence. These beds lie just below the sandstone of the "Millstone grit" series of the Arkansas Survey, and, as a rule, form the middle part of the escarpment of the Boston Mountain range. South of Batesville, near Jamestown, these beds have a total thickness of about 200 feet, while in a section in the north face of the mountains, south of Fayetteville, they are about 400 feet thick. The soil derived from them is highly fertile, but the land, being for the most part very precipitous, is so badly located for agricultural purposes that it is not generally cultivated. It possesses, however, a fine timber growth and several available limestone beds.

Winslow formation.—The Winslow formation lies upon the Morrow formation and makes the summit and southern slopes of the Boston Mountains, except in the deeper ravines where older rocks have been

exposed. Rocks of this formation also occur on the tops of the outliers immediately north of the Boston Mountains.

The formation consists of beds of sandstone and shale, with a few thin local layers of limestone. The sandstone beds range in thickness from 3 feet to more than 50 feet. One of these beds, and in places two, near the base of the formation, are conglomeratic, containing waterworn quartz pebbles of small size. These gritty beds at and near the base of the Winslow formation were described by the Arkansas Geological Survey in the report on Washington County as the "Millstone grit." The shales, which constitute probably 75 per cent of the formation, are as a rule black and carbonaceous, though less so than the shales of the Morrow formation. Coal occurs within this formation but only in beds too thin to be profitably worked. The Winslow formation in the Boston Mountain region extends up to the base of the series of rocks that contain the workable coal beds in the Arkansas coal field, and its total thickness is estimated to be more than 1,500 feet.

South of the Boston Mountains the Winslow formation is represented in a part of the thick series of sandstones and shales that underlie the coal-bearing rocks in the Arkansas coal field. This series of rocks was referred to in the publications of the Arkansas Survey as the "Lower or Barren Coal Measures." The uppermost formation in this series has been described in the report of the Arkansas coal field [a] and in publications on the Indian Territory coal field as the Atoka formation. This formation in Oklahoma and Arkansas ranges in thickness from 3,000 to probably 5,000 feet. Beneath the Atoka formation there are other formations of sandstone and shale of probable Pennsylvanian age, aggregating 12,000 to 15,000 feet in thickness.[b] These rocks make the rugged country of the Ouachita Mountain region south of the Arkansas coal field, and the Arkansas River Valley east of the coal field and south of the Boston Mountains.

In the study of the fire clays and clay shales of the State the shale beds of the "Lower or Barren Coal Measures," as well as of similar beds in the productive coal-bearing rocks, are of much importance. In the region of the Boston Mountains and in the lower region of similar formation on the east the rocks of the "Lower Coal Measures" lie flat, or approximately so, and their outcrops and distribution are thus very simple and are easily traced. In the region south of this area of horizontal beds, however, the same rocks are thrown into folds that become more and more abrupt toward the south. The upper portions of these folds are worn away by erosion, and the sandstones are left as ridges while the soft beds of shale are degraded.

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[a] Bull. U. S. Geol. Survey No. 326, 1907.

[b] Branner, J. C., Thickness of the Paleozoic sediments in Arkansas: Am. Jour. Sci., 4th ser., vol. 2, 1896, pp. 229–236.

The soil derived from the rocks of the "Lower Coal Measures," being deficient in lime and in some places rather thin, is only moderately fertile.

Hartshorne sandstone.—The Hartshorne sandstone lies at the base of the productive coal-bearing rocks of the Arkansas coal field. It is known to have a great areal extent, and is found cropping out around the edges of the coal-bearing rocks from the east end of the Arkansas coal field westward into Oklahoma. It is 100 to 300 feet thick, and contains minor beds of shale in its central and upper parts.

McAlester group.—Above the Hartshorne sandstone there is in the productive coal-bearing rocks a series of shales and sandstones with a number of beds of workable coal. The McAlester group is divisible into three formations—(1) a lower, known as the Spadra shale, consisting of three or more beds of coal and minor strata of sandstone; (2) a middle, called the Fort Smith formation, composed chiefly of sandstone and shaly sandstone beds with one or more workable beds of coal; (3) an upper, described as the Paris shale, consisting partly of beds of sandy shale with some sandstone and one or more workable beds of coal. These formations of the McAlester group are

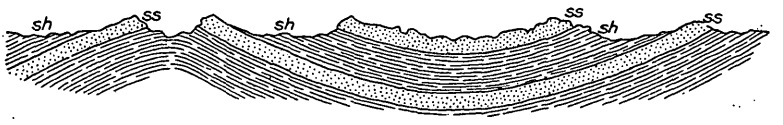

FIG. 1.—Ideal section across folds in the Carboniferous rocks of western Arkansas. *sh*, Shale; *ss*, sandstone.

described in the report on the Arkansas coal field.[a] The Spadra shale is 400 to 500 feet thick, the Fort Smith formation 375 to 425 feet, and the Paris shale 600 to 700 feet.

Savanna formation.—Overlying the McAlester group there is in the productive coal series a formation consisting of several sandstone members separated by shales. This is known as the Savanna formation. It occurs in Arkansas only in the tops and upper slopes of Poteau, Sugarloaf, Short, and Magazine mountains. That part of the Savanna exposed in Arkansas is estimated not to exceed 1,000 feet, and constitutes approximately the lower two-thirds of the formation.

The rocks of this formation, as well as the other rocks of the productive coal series, are all more or less folded, so that the shale outcrops depend on the character and direction of these folds and can therefore be determined only after a study of the structure of the region. It can be said, however, that the shale outcrops generally lie in the valleys parallel to the ridges, so that a cross section of the region would show the rocks to have the relations shown in fig. 1.

[a] Bull. U. S. Geol. Survey No. 326, 1907.

OCCURRENCES PRECEDING THE CRETACEOUS.

Deposition of the rocks from the Ordovician beds to those of the Pennsylvanian took place over the same general area. The exposures of the Mississippian and the rocks below that horizon have resulted from the erosion or removal of rocks that once overlay them. Had the entire area of the State continued submerged during Mesozoic time, Triassic, Jurassic, and Cretaceous rocks would most probably be found to overlie the Carboniferous formations. The distribution of the Cretaceous rocks, however, shows that at the close of Carboniferous time a large area became dry land, and that the shore of the Cretaceous ocean crossed the southwestern part of the State somewhere below the northern border of the Cretaceous area shown on the geologic map (Pl. I).

CRETACEOUS SYSTEM.

Rocks of Cretaceous age occur in but a small portion of the State. They are present, concealed in some places by later deposits, in a roughly triangular area south of the Ouachita Mountains and west of Arkadelphia. The Tertiary-Cretaceous border lies slightly southeast of the St. Louis, Iron Mountain and Southern Railway between Arkadelphia and Texarkana. The rocks are not folded or bent, but dip to the southeast at a low angle. They are usually unconsolidated, contain considerable calcium carbonate, and form, on decay, a very fertile black soil. The Cretaceous deposits have been described in detail,[a] so that they need not be further mentioned here, except to call attention to the fact that later observations have shown that the Arkadelphia shale at Arkadelphia is Cretaceous and not Tertiary, as was originally supposed. Cretaceous rocks have also been recognized at a few places north of Little Rock.

TERTIARY SYSTEM.[b]

Clays, sands, and gravels of Tertiary age cover the greater part of eastern and southern Arkansas. In the rocks of this age and near their base, at Benton and near Malvern, there are valuable beds of potter's clays. These beds dip gently to the southeast. They are all more or less sandy, and but few of them are hard and consolidated. At the lignite mines of Ouachita County, however, some of the sands are indurated to very compact sandstones, and at some places in Crowleys Ridge they form the hardest of quartzites. Though the

[a] Hill, R. T., Ann. Rept. Geol. Survey Arkansas for 1888, vol. 2, pp. 66–174; also Taff, J. A., The chalk of southwestern Arkansas: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1901, pp. 687–742; Branner, J. C., The cement materials of southwest Arkansas: Trans. Am. Inst. Min. Eng., vol. 27, 1898, pp. 42–63.

[b] For details of the Tertiary geology of the State see The Tertiary geology of southern Arkansas, by G. D. Harris: Ann. Rept. Geol. Survey Arkansas for 1892, vol. 2, 1894.

Tertiary is widespread in the eastern and southern parts of the State, it is at many places overlain by a thin coating of Quaternary deposits, so that the true character of the Tertiary beds is more or less obscured.

The lignites exposed along Saline and Ouachita rivers, the marls exposed at White Bluff and Red Bluff on Arkansas River, and the shell marl on Little Crow Creek, St. Francis County, are all Tertiary. The hard sandstones in Crowleys Ridge about Gainesville are of the same age.[a]

QUATERNARY SYSTEM.

A thin sheet of sedimentary materials, consisting of sands, clays, and gravels, cover the Tertiary area of the State and some of the adjacent Paleozoic rocks. The country lying north of Arkansas River and east of the Paleozoic hills belongs to the Quaternary. The lowest strata exposed in Crowleys Ridge belong to the Eocene. All the river bottoms are of recent origin, while the loess capping Crowleys Ridge and likewise the river terraces and second bottoms of all the important streams belong to the Pleistocene. The waterworn materials that cover the foothills of Lawrence, Independence, Pulaski, Saline, Hot Springs, Clark, Pike, Howard, and Sevier counties are of late Tertiary or Pleistocene age.

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[a] Call, R. E., The geology of Crowleys Ridge: Ann. Rept. Geol. Survey Arkansas for 1889, vol. 2, 1891.

CHAPTER II.

CHARACTER, ORIGIN, OCCURRENCE, AND USES OF ARKANSAS CLAYS.[a]

CLASSIFICATION OF THE CLAYS.

No sharply defined classification of the common clays is altogether satisfactory, for clay is not a definite compound nor a well-defined mineral species, and the qualities and values of clays depend upon physical and chemical properties which vary within wide limits, so that the various kinds of clay grade imperceptibly into one another. The clays of this State may be classified, however, with reference to their mode of formation, as: (1) Residual clays, (2) clays of mechanical origin, (3) clays and kaolins of chemical origin, and (4) bauxite. They will be briefly discussed in this order.

RESIDUAL CLAYS.

Clays and kaolins are chiefly secondary products derived either directly or indirectly from feldspathic rocks—that is, from rocks composed either entirely or largely of the mineral feldspar, such as granite, syenite, and gneiss. The feldspathic rocks may be either eruptives—that is, rocks injected in a molten condition from below into or through crevices in the earth's crust—or they may be the crystalline rocks that underlie our oldest sedimentary rocks. Whenever and wherever these rocks occur near the surface they decay—many of them very slowly—and form kaolins or clays containing more or less impurities. When the rocks contain little else than feldspar, or when the minerals that would stain or otherwise injure kaolin are removed in solution, they form, on decomposition, kaolin of more or less value; but when they contain considerable quantities of iron, manganese, or other discoloring impurities they form clays of various colors. Such clays and kaolins are said to be derived directly from feldspathic rocks.

The precise process of the alteration of the solid syenites of the Fourche Mountain region to kaolins and clays is illustrated by the following analysis. The column marked "blue syenite" shows the composition of the original unaltered rock, the column marked "decom-

[a] Persons wishing to consult other works on clays will find a bibliography of the subject in Bull. U. S. Geol. Survey No. 143, 1896; a second edition of that bibliography was published by the American Ceramic Society at Columbus, Ohio, in 1906.

posed blue syenite" shows the chemical alteration of this same rock in process of decomposition, while the column headed "kaolin" shows the last stage of alteration to kaolin.

Analyses of pulaskite (blue syenite) and its decomposition products.

[Brackett & Smith, analysts.]

Constituents.	Blue syenite.	Decomposed blue syenite.	Kaolin.
Silica (SiO_2)	60.03	50.65	46.27
Titanium (TiO_2)	.....	.06	.....
Alumina (Al_2O_3)	20.76	26.71	38.57
Ferric iron (Fe_2O_3)	4.01	4.87	1.36
Ferrous iron (FeO)	.75	.....	.....
Lime (CaO)	2.62	.62	.34
Magnesia (MgO)	.80	.21	.25
Manganese (MnO)	Trace.	.....	.....
Potash (K_2O)	5.48	1.91	.23
Soda (Na_2O)	5.96	.62	.37
Phosphorus (P_2O_5)	.07	.....	.....
Water (H_2O)	.59	8.68	13.61
	101.07	94.33	101.00

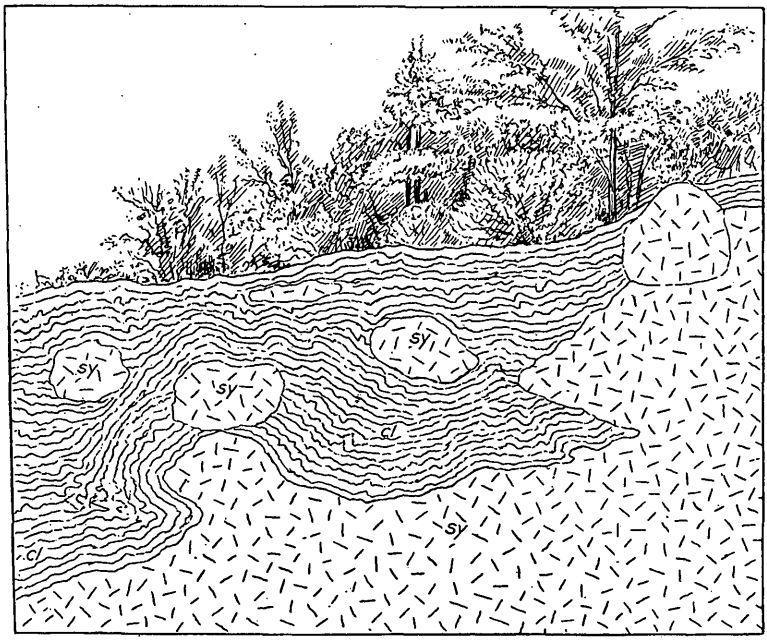

FIG. 2.—Residuary clay formed by decomposition of syenite in place, in railway cut 3 miles south of Little Rock. *sy*, Syenite; *cl*, clay.

It should be noted that the changes in passing from syenite to kaolin consist chiefly in the absorption of water, the removal of the more soluble materials, such as lime, potash, and soda, and the consequent increase of the percentage of alumina.

This blue syenite is at many places traversed by cracks or joints that break it into great angular fragments. Water charged with

organic acids which are derived from decaying vegetable or other organic matter, on penetrating these cracks causes the rock to decay, the decomposition processes attacking the masses at first along these openings and then extending inward until only a rounded bowlder is left; later still the whole mass is converted into clay, the soluble parts of the rock having been washed out by the percolating water. Vast quantities of clays are formed in this way by the decay of the crystalline rocks, and no doubt such decay has been going on since the crust of the earth began to harden.

Fig. 2, sketched in the railway cut 3 miles south of Little Rock, illustrates this method of forming clay, the clays at that place having been derived directly from the syenites by decomposition.

Bruno Kerl[a] holds that feldspar may even be decomposed by water alone at high temperatures and under strong pressure, yielding

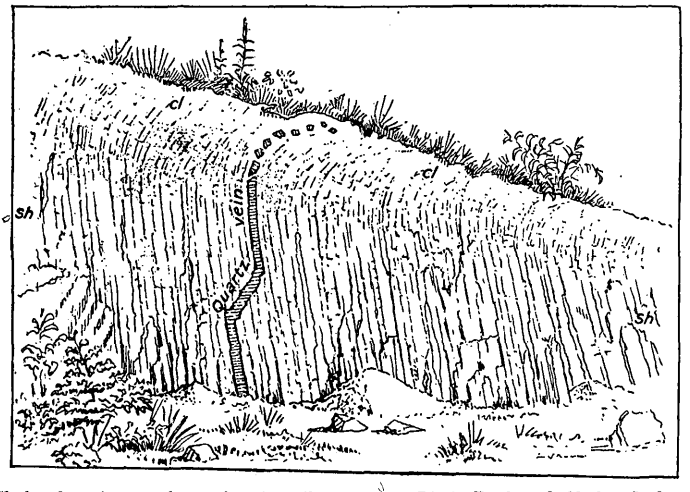

FIG. 3.—Shales decaying at the surface in railway cut at Little Rock. *sh*, Shale; *cl*, clay formed by decomposition of shale in place.

clay, silicate of potash, and silicic acid. Carbonic acid may produce similar decomposition at ordinary temperatures and without pressure.

Fig. 3 is a sketch made in the railway cut about a mile west of the union depot at Little Rock. The clays at the top of the ground here are simply the decayed upturned edges of the shales exposed in the railway cut. Deeper down the shales are compact and undecomposed.

The thin vein of quartz in the shale evidently once passed upward into the extension of the shales, but as the shales decayed and formed a soft clay the quartz, not being so readily attacked by weathering agents, simply broke into irregular fragments and remained in the clay or shale after it was decomposed. Any other insoluble materials in the shale, such as sand, would thus be left as an impurity or grit in the clay.

[a] Handbuch der gesammten Thonwaarenindustrie, Braunschweig, 1879, p. 29.

The clay in this place is derived directly from the shale. But the shale itself is an argillaceous rock which was originally made from clays and sediments that washed down from land where some of the old feldspathic rocks were decaying or had decayed. This residuary clay is thus derived directly from shale, but indirectly from feldspathic rocks.

Fig. 4 shows the derivation of clay from limestone by decomposition, the lime of the rock being dissolved out and carried away, the clay, iron, sand, and whatever insoluble impurities the rock contained being left behind. This clay is of a deep red color. It contains some fragments of the limestone from which it is derived—small pieces not yet completely decomposed. This limestone contains nodular pieces of chert or flint, and as these do not decay, or at least do not decay so rapidly as the limestone, they are left as loose pieces in the clay. The clay in this case comes from the impurities

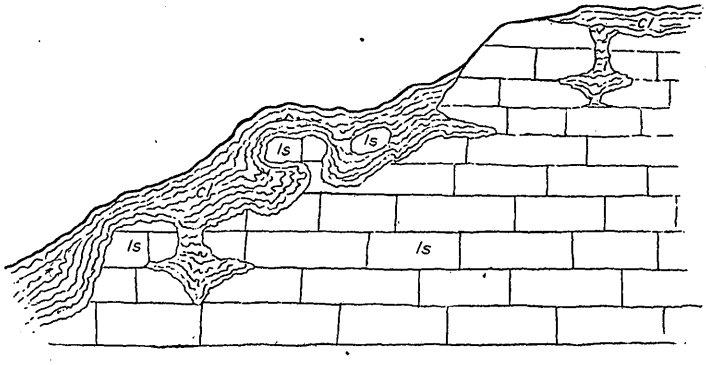

FIG. 4.—Section on Dry Creek, Carroll County, showing formation of clay by decomposition of limestone. *ls*, Limestone; *cl*, clay.

in the limestone, and these impurities, in so far as they form clay, were deposited as an argillaceous silt with the calcareous material that forms the limestone. This will serve to explain at once the origin of the clays of some limestone regions and the great blanket of clay found over most limestone regions, as well as that found in caves and in crevices and fissures in limestones.

Clays thus formed and lying where they originated are the residue from the decay of some hard rock, and are therefore called residuary clays. Other illustrations might be given to show how clays are derived from other kinds of rocks than those mentioned, but these are enough to show what is meant by residuary clays. The decomposition of rocks and the formation of residuary clays may be seen in almost every part of the elevated portion of the State.

It is evident that the clays derived from any of the rocks mentioned must vary more or less among themselves, according to the amount and character of the insoluble contents of the rocks from

which they are derived. Wherever these residuary clays are exposed at the surface they are usually still further modified by weathering and by organic agencies. When they are washed into streams, sorted by the currents, and deposited again they form what are known as redeposited clays.

CLAYS OF MECHANICAL ORIGIN.

Clays may be produced by grinding to a fine powder any rock that will produce clay upon decomposition. When thus pulverized some of these rocks, possibly all of them, become more highly hydrated or take up more water of crystallization,[a] a change which is probably explicable, in part at least, upon the theory that much more rapid decomposition is produced by finely dividing the material so as to expose a very large surface to decomposing agencies. The trituration of rock fragments dashed against one another either by the current of a stream or by the action of waves wears the fragments round, forming cobblestones, pebbles, sand, and mud. More mud than sand is formed in this operation—in other words, the greater part of the material passes almost directly from the condition of a solid rock to that of a clay. This clay is carried along by the water until the current is checked, when it gradually sinks to the bottom and forms a bed or layer. But whether the argillaceous sediments carried into the sea by streams are of mechanical or chemical origin, they all go to form new beds of clays over the bottom of the sea. All parts of the earth's surface above the ocean's level are being gradually cut down by the slow but never-ceasing processes of weathering and erosion and are carried away either in chemical solution or in mechanical suspension. In this process of degradation the heavier materials are left behind for further disintegration, while the lighter—that is, the clays and fine sands—are carried away by streams. This mechanical separation by water goes on constantly, and during the eons of geologic time the results of such agencies have accumulated until they have ultimately produced an impressive and almost incredible total.

KAOLIN.

The distinction between clay and kaolin, except in a mineralogical sense, is an arbitrary one, for the two grade imperceptibly into each other. Both kaolin and clay are derived chiefly, either directly or indirectly, from feldspathic rocks by decomposition. Kaolin is composed of silica, alumina, and water, usually with a little impurity, while clay has the same constituents, but its impurities form a larger percentage of its composition. These impurities are often in the

[a] Daubrée, A., Géologie expérimentale, p. 252.

form of free silica or fragmentary quartz, and this being anhydrous an analysis of the material shows a smaller percentage of water than is found in the purer clay or kaolin. Thus, while kaolin usually contains about 12 per cent of water, the clays have less than 8 per cent.[a]

Kaolin deposits may originate in three ways—(1) by the alteration of feldspar in place; (2) by chemical action other than the ordinary alteration of feldspar, as illustrated by rectorite; (3) by the washing down and redepositing of kaolin formed in place. The great bulk of our kaolins, however, are derived directly from feldspar. The process by which feldspar or feldspathic rocks are changed to kaolin is kaolinization. Syenite, which is generally known in Arkansas as "granite," is made up largely of feldspar, and when the feldspar decomposes, as it always does sooner or later, it forms kaolin. The other ingredients of the syenite, however, such as hornblende, mica, iron, pyrites, and quartz, remain in the residuary material, so that it does not form pure, clean kaolin, but is generally an impure clay. Below are analyses of feldspar, of a variety of Arkansas syenite, and of a syenite partly changed into clay.

Analyses of feldspar, syenite, and kaolin.

	Feldspar.[a]	Blue syenite.[a]	Decomposed syenite.[b]	Kaolin.[c]
Silica (SiO_2)	66.39	60.03	58.50	46.27
Alumina (Al_2O_3)	18.13	20.76	25.71	38.57
Ferric oxide (Fe_2O_3)	1.44	4.01	3.74	1.36
Ferrous oxide (FeO)		.75		
Lime (CaO)	.16	2.62	.44	.34
Magnesia (MgO)	.06	.80	Trace.	.25
Potassium (K_2O)	8.51	4.48	1.96	.23
Soda (Na_2O)	5.36	5.96	1.37	.37
Phosphoric acid (P_2O_5)		.07		
Water	.42	.59	5.85	13.61
	100.47	101.07	97.57	101.00

[a] From Fourche Mountain, Little Rock, Ark.
[b] From Pulaski County, railway cut 2 miles north of Sweet Home.
[c] From sec. 9, T. 1 S., R. 12 W.

These analyses show that in passing through the process of decomposition from a hard blue syenite to a kaolin the rock loses part of all its ingredients except alumina and water, which are proportionately increased; or perhaps it would be better to say that the removal in solution of some of the constituents leaves others predominant. The change from feldspar to kaolin goes still further, but the feldspar contains less iron and is therefore more liable to end in a clean white kaolin than is the ordinary rock.

[a] Of course no reference is here intended to prophyllite or rectorite, which are hydrous silicates of alumina and contain less than 8 per cent of water. Those substances, however, are not likely to be mistaken for common clays.

POTTERY CLAYS.

By pottery clays is here meant such as are commonly used in the manufacture of crocks, jars, jugs, and churns at the potteries now in operation, and not the poorer kaolins that might be used for similar purposes. All the clays of the State that are or have been used for the manufacture of pottery are grouped here under the head of pottery clays, whether or not they are available for other and more important uses. The common pottery clays of Pulaski, Hot Spring, Saline, Clark, Hempstead, and Miller counties, and those in other of the southeastern and eastern counties of the State, are all of sedimentary origin and of Eocene or lower Tertiary age. They were laid down in nearly horizontal beds, which generally dip toward the southeast at a low angle, so that beds that outcrop at or near the Paleozoic highlands lie at depths that become greater toward the southeast. In nature these Tertiary deposits vary from coarse sands through earthy marls to fine plastic clays. Many of the clay beds contain impressions of fossil leaves and small sticks of wood—materials that evidently sank, with the clays that inclose them, to the bottoms of the swamps or lagoons that once covered this region.

While the pottery clays dip to the southeast and gradually descend to greater depths beneath the surface, the beds do not preserve throughout the characters they may display at a single exposure. It is a well-known fact in geology that sedimentary beds may vary in character and thickness from one point to another; indeed, they are even more liable to vary than to be constant in thickness and character. So while the pottery clays may be of uniform thickness and quality toward the southeast, or may even improve in quality and increase in quantity, it must not be inferred that this is proved. It is possible that they form lenticular masses; but in any case, those who would prospect for pottery clays within the Tertiary area of the State would do well to bear in mind their structural features and their possible variations.

Although sediments are deposited in approximately horizontal beds, the pottery clays about Benton and elsewhere in the Tertiary region of the State occur as fragmentary beds in isolated hills. After the Tertiary beds had been laid down they were elevated, so that from being soft muds and sands at the bottom of the sea or of lagoons they came to form "dry land." But all "dry land," or all of the crust of the earth that stands uncovered by water, is subjected to eroding agencies which cut it down and wash it away, leaving its surface scored and furrowed by gullies, ravines, and valleys. By this process the beds of former sediments are carried away, whether they be sands, gravels, or clays, while over the surface is spread out a thin covering of the less soluble or less portable material.

CLAYS FOR DRAIN TILES.

There is no lack of clay in this State available for the manufacture of good drain tiles. The light-blue clays through the country lying between Beebe and Kensett and thence to Judsonia, and between Kensett and West Point, in White County, are available for the manufacture of tiles. The clays about Brinkley, Monroe County, are well adapted to tile making. Along the western base of Crowleys Ridge in Phillips, Lee, and St. Francis counties, and on both sides of the ridge in Cross, Poinsett, Craighead, Greene, and Clay counties, these clays are abundant and of excellent quality. They abound also along Bradshaw and Terre Noir creeks in Clark County.

In the counties south and southeast of Little Rock clays available for tile making occur both as surface soils in the valleys (not alluvial) and in the widespread stratified Tertiary beds of the region.

In the hilly regions north of the Cretaceous and Tertiary area of the State drain tiles are not likely to come into demand except, perhaps, in the bottom lands, but wherever they may be wanted they can be made from the brick clays that have accumulated in the valleys.

Along the Petit Jean and Fourche le Fevre the surface soils of the lowlands are generally available for tiles. In the neighborhood of Arkansas River tile-making material may be found in abundance in the terraces of brown and reddish clays that lie just outside of the "second bottoms." Any of these clays will be improved for tile making if they are allowed to weather through a winter.

The demand for drain tiles has hitherto been so limited that but little work has been done in manufacturing them. Whatever benefits may come from the drainage of the soil are either unknown to the average landowner or are disregarded, while the expense of procuring tiling and draining has acted as an additional drawback to the custom of underdraining in places where it would be of great service. There can be no doubt, however, that many of the most fertile lands of the State of Arkansas that now lie unused could be brought under cultivation if they were only properly drained. The custom of underdraining must necessarily be adopted by our farmers in the near future, and when fairly tried it will soon prove its own importance on certain kinds of lands. It is especially true of the lowlands within the Quaternary area of the State. R. E. Call, who has paid especial attention to the Crowleys Ridge region, is of the opinion that thousands of square miles that now lie idle along White, Cache, L'Anguille, and Arkansas rivers can be brought under profitable cultivation by some system of underdraining.

BUCKSHOT CLAYS.

Character.—In many places in this State and at some places over a great many square miles, both in the Paleozoic highlands of the western part of the State and in the Tertiary and Quaternary lowlands of the east, there is a kind of clay, usually of an ashen color, but often mottled red, gray, and yellow, that contains great quantities of nodules of iron (limonite) varying in size from that of a pin head to that of a walnut. This is one of the soils known as "buckshot" land, a name doubtless given to it on account of the size and form of these nodules.[a] The nodules at some places lie along a broad but well-defined line at a uniform depth from the surface; in others their depth varies greatly; they may be on the surface or may lie as deep as 5 or 6 feet below.

Origin of the "buckshot."—The process by which these nodules are formed seems to be as follows: The iron was originally distributed through the uppermost bed of the surface clay. Vegetation growing and decaying on the surface furnished vegetable acids to waters that penetrated the soil and dissolved out the iron from the upper portions of the beds. As the iron-charged waters penetrated the clays the iron was precipitated at points a short distance below the surface to form the buckshot nodules. These nodules are never very abundant on hillsides or steep slopes,[b] but occur for the most part on gentle slopes and in the soils of the "slashes" or flat lands on which the water stands or has stood during wet seasons. The leaching of the iron from the upper beds of clay leaves them usually of a pale ashen or cream color, while the admixture of organic matter sometimes gives them a leaden color.

Carbonic acid is probably one of the most active agents in dissolving the iron from the surface soil and redepositing it at lower depths. But on descending with water through the upper layers, so long as water stands upon the ground, carbonic acid will not give up its iron. If it should pass downward the iron would remain in solution, and if it flowed away laterally the iron would be precipitated only when the water came near the surface. It therefore seems probable that this iron remains in solution until the wet grounds become dry, when it is precipitated by the evaporation of the water. As might be expected from the conditions under which these lumps of iron are formed, they vary in size and in their distance from the surface, and the bands in which they are arranged vary in thickness.

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[a] In Arkansas another kind of soil is also known as buckshot land. The latter is calcareous alluvial soil containing considerable clay. After being plowed the clods, on weathering, break into small cuboidal lumps, which appear to have suggested the name buckshot by their size rather than by their shape. This soil is usually very fertile, while that containing the limonite nodules is rather poor.

[b] At Forrest City a band of limonite nodules is exposed in a railway cut 43 feet below the surface. This probably represents the ancient soil cited by Chamberlin and Salisbury as underlying the loess. (See Call's report on The geology of Crowleys Ridge: Ann. Rept. Geol. Survey Arkansas for 1889, vol. 2, p. 159, and Pl. I, fig. 2, p. 206.)

Uses.—In many parts of the State these buckshot clays are used for making common bricks, but they are not very well adapted to such use. The iron lumps cause hard black spots in the bricks, and the clay is more or less troublesome to work by hand, for the nodules tear the hands of the brick molders and catch on the sides of the molds These difficulties could be averted by crushing or screening the clay, but it is doubtful whether the expense of such a process would be warranted in making ordinary bricks.

It is of much importance to find that some of these lowland clays have been used successfully in the manufacture of Portland cement at Whitecliffs, in Little River County. In reply to inquiries about the clays employed, the secretary of the company, Mr. W. J. Kelly, kindly furnished the following information.:

The first clay we used for making cement was taken from the SE. ¼ SE. ¼ sec. 35, T. 11 S., R. 29 W., on the west side of Little River, the analysis of which is as follows:

Analysis of cement-making clay mined on Little River near Whitecliffs.

SiO_2	72.64
Al_2O_3	13.91
Fe_2O_3	3.72
CaO	.20
MgO	.45
Total volatile	7.53

As this deposit is across the river from the works, we experimented with the clays on the east side of the river and found a bed of clay one-fourth of a mile south of the plant.

The bed of clay on this side of the river is several acres in extent and 16 feet thick in the SW. ¼ SW. ¼ sec. 36, T. 11 S., R. 29 W. The analysis of this clay is as follows:

Analysis of brick clay mined on Little River near Whitecliffs.

SiO_2	74.54
Al_2O_3	14.47
Fe_2O_3	1.79
CaO	.73
MgO	.41
Total volatile	6.26

Alkalies not yet determined.

From this clay we also made 2,000,000 red brick in 1897 and 1898. There is no stripping whatever, as the deposit starts at the surface. We have a narrow-gage railroad from the plant to the pit.

THE LOESS.

The loess constitutes the upper 30 to 90 feet of the higher portions of Crowleys Ridge from Dee post-office, in Craighead County, southward to Helena, in Phillips County. At Helena it attains its maximum thickness. Throughout the areas of its distribution, both in Arkansas and in other States, it usually contains large numbers of limy concretions, or puppets, which are highly characteristic of its soils.

Throughout the region it covers in Arkansas the loess may be readily recognized by its fineness and by its light-yellow or buff color. In certain localities it becomes slightly darker in color, possibly by reason of the presence of organic matter, or it may even be blotched with dark-brown and reddish colors. Close examination of these blotches reveals the fact that the color is due to a superficial coating of iron oxide on the individual grains.

This loess is especially suited to the manufacture of superior grades of brick. Care is necessary in its preparation for molding, however, and discrimination is required in respect to the mixture of soils from the neighboring hills. Where the soils of the hillsides are largely made up of sands and gravels derived from local outcrops of the Tertiary strata, as they are in some places about Jonesboro, Harrisburg, Gainesville, and Wynne, they are unsuited to the manufacture of good brick. At other localities, notably near Marianna, at Forrest City, and at La Grange, the slopes of the hills, along their lower margin, contain many small nodules of limonite, which render the soils less valuable for brick manufacture. If these nodules be removed by screening, the soils can be used successfully in brick manufacture. But at all these localities there are abundant deposits of clean loess that furnish unlimited opportunities for brickmaking.

The bricks made from the Crowleys Ridge loess usually burn to a good color—cherry-red for hard, and a lighter shade of red for the soft burned ones.

Near Marianna, in the SW. ¼ SW. ¼ sec. 19, T. 2 N., R. 4 E., many acres are covered by a peculiarly colored modification of the loess, which contains a higher percentage of iron oxide than the typical loess. It is a very fine homogeneous deposit and fills the lower portion of all the creeks, ravines, and gullies of the neighborhood. It will prove a superior brick clay and will burn to a rich, uniform red. It is well adapted to the manufacture of ornamental front and pressed brick.

The hilly country north of Poinsett County differs from other parts of the State in the distribution of the loess and its relations to the Tertiary strata. The loess there is found only on the slopes of the hillsides or on the low spurs of the ridge wherever they extend far from its main mass, and it is there a less prominent geologic feature than it is in the country south of Craighead County. In this hilly country its relations to the Tertiary sands and gravels are such that in most localities the loess deposits are more sandy and apparently less homogeneous; the quality of brick that may be made from this soil, while excellent, will not be so fine as that made from unmodified loess.

In Memphis, St. Louis, Des Moines, Council Bluffs, and Ottumwa, Iowa; Omaha, Nebraska City, and David City, Nebr.; St. Joseph,

and Kansas City, Mo., and other cities where loess soils are used in brick manufacture, grinding mills are employed to reduce them to the finest powder. In this condition they are fed at once to great dry-pressing machines, from which they are immediately set in kilns. When it is treated thus, or in a similar manner, no material is better suited to brick manufacture. The processes employed in brick manufacture must be varied with the variation in the nature of the brick earth used.

SLOPE SOILS.

At all points along the ridge country, except Helena, the reworked loess is commonly employed in brick manufacture. It occurs on the sides and at the foot of the ridge. The soil is stripped a few inches, to remove the mass of vegetable matter, and the subsoil, to a depth varying from 1 to 5 feet, is used for brickmaking. The clay is thrown into pits, with water, and allowed to stand for two or three days or a week, when it is pugged. It is then molded and dried in the usual manner.

The soils and clays of the slopes present the greatest range of variation in character. They differ greatly within short distances, at places becoming very clayey, at others sandy, or even gravelly. The variation in microscopic appearance is due to the relative erosion, both of amount and rate, to which the various strata have been subjected. In many places, as at Harrisburg, in Poinsett County, and at Wynne, in Cross County, the loess soils have been largely removed by erosion, so that the underlying Tertiary sands have been exposed and the soils of the slope have become more sandy than soils of the same class about Forrest City, Marianna, La Grange, and Helena. The characters exhibited appear to differ locally, also. Where the slope is rather steep the clays and intermingled sands alike are eroded away, having been carried down to the lower lands and redeposited over the flat country as a thin surface soil or sandy loam, but in situations where the slope is less marked the clays alone are carried off, while the sands and gravels are left behind. This appears to be the explanation of the character of the soils along all that portion of the ridge country or slope north of Jonesboro, on the eastern side of the ridge. There the slope of the ridge is gentle and the conditions are favorable for the removal of the clay. But on the west slope of the ridge from Craighead County northward to the Missouri line the slope of the ridge is abrupt, and the erosive agents carry off all that is movable, whether it be sand, gravel, or clay. These are again mixed with much organic matter on the plains below and immediately adjoining the ridge, which modify the soil.

From these slope soils are manufactured most or all of the bricks produced at Paragould, Gainesville, and Jonesboro. Commonly only

a few inches of the surface soils are stripped off and used, care being taken not to go too deep into the subsoil, which is too stiff to mold well with the processes employed, and which is, besides, but little different from the ordinary limonitic or hardpan clays of the bottoms. This soil extends out from the ridge toward the east, surmounting the low divides between the numerous drainage areas. The soils higher up in the hills contain more loess clay and less limonite, but commonly more sand.

With such marked differences in the characters of the slope soils or clay at localities very near one another, it is not surprising that the bricks produced exhibit every degree of color, finish, hardness, and durability.

CLAYS AND KAOLINS OF CHEMICAL ORIGIN.

It has been stated that kaolin was derived directly by decomposition of feldspathic rocks. While this is true in a general way, all kaolin is not made in this way. It occurs in small quantities in regions of Paleozoic rocks, where it forms thin bands or fills small pockets. In these places it seems to have been formed by chemical action. It is true that kaolin is practically insoluble, but certain forms of silica are equally insoluble, yet these very forms are soluble under certain conditions if time enough is allowed for solution. The same is doubtless true of kaolin, otherwise we should not have deposits which are far removed from the original feldspathic rocks and which can be explained by no other theory. Either kaolin is soluble in some substance or under certain conditions of which we are as yet ignorant, or it is soluble in the waters that usually traverse the rocks when plenty of time is allowed for reaction to take place.

In any case the kaolin (newtonite) found in small pockets in the rocks of the northern part of the State was not deposited as a sediment as were the shales and sandstones and limestones of that region, nor was it derived by decomposition directly from feldspathic rocks, but it is a secondary deposit, derived by chemical action from the sedimentary beds above and about it.[a] The same is true of rectorite, which occurs in Garland County.

BAUXITE.

The pisolitic clays and kaolins associated with the bauxites of Arkansas, in so far as their origin is understood, do not appear to fall under any of the foregoing classes. Their composition varies from that of an iron ore carrying 55 per cent of metallic iron to that of a true kaolin with but little or no iron. In some places they pass by gradual transition into true bauxite—that is, a hydrated oxide of

[a] See Chapter III of this report, p. 34.

alumina; in others they are a true kaolin, a hydrous silicate of alumina. In Arkansas, as in southern France and in Ireland, where similar deposits occur, they are associated more or less intimately with eruptive rocks. They occur in pockety deposits of uncertain distribution, with a tendency to form horizontal lenticular beds varying greatly in thickness as well as in character. Their origin is involved in some obscurity.[a]

[a] The most comprehensive report on Arkansas bauxite is that of Dr. C. W. Hayes, published in Twenty-first Ann. Rept. U. S. Geol. Survey, 1899-1900, pt. 3, pp. 441-472. An earlier paper by J. C. Branner (Jour. Geology, vol. 5, 1897, pp. 263-289) contains a brief bibliography of bauxite.

CHAPTER III.

GEOLOGIC AGE AND GEOGRAPHIC DISTRIBUTION OF THE CLAYS.

CONDITIONS GOVERNING DISTRIBUTION.

The distribution of clays depends on the distribution of the geologic formations from which they are derived, and hence on geologic structure. From what has been said of the origin of clays it will be seen that their distribution throughout the State must necessarily depend on the State's geologic history, or the manner and order in which the rocks have been made and unmade. Where we have the crystalline rocks, which yield kaolin on decay, there we may look for kaolins, and in order to look intelligently we must know the distribution of those particular rocks. The clay shales we can expect to find only in association with the Paleozoic rocks, and as they are abundant in the rocks of the Carboniferous system we must ascertain the distribution of the rocks of that age. The Tertiary and Cretaceous clays can be found only with the Tertiary and Cretaceous rocks, and in searching for them it is essential to know the areas of these rocks in the State, the position in which they lie, the character of the various beds, and the places the clays occupy in the series.

These instances are cited for the purpose of showing how indispensable to an intelligent search for clays is a knowledge of geologic structure and the areal distribution of the various geologic formations. A geologic map of the State (Pl. I) is inserted in this report for the purpose of furnishing this information.

PALEOZOIC CLAYS AND SHALES.

The clays of the Paleozoic areas of the State consist of shales of Paleozoic age found in place, and of alluvial or other clays of recent age spread over the lowlands. The clays of the latter class are derived indirectly from the Paleozoic rocks of the surrounding regions and may form brick earths or pottery clays.

When clays are subjected to a great pressure for a long time they become hard and stonelike, forming what are known as shales and slates. Nearly all of the clays of Paleozoic age have been crushed under pressure so great and for so long a time that they have become thus hardened into shales.

The clay shales which were derived from the wear and decay of other rocks were originally deposited in horizontal beds in the water of the

ocean or of bays and swamps, and if they are now thrown into folds, raised into mountains thousands of feet above the ocean, and hardened into stone, it is only because they have been crushed till they are hard, pressed laterally into folds, and elevated until they stand high above their original positions. Subaerial erosion has subsequently removed much accompanying and surrounding material, and in places these shales have weathered into residuary clays, such as have been described on page 20.

The clays of the Paleozoic regions have values peculiarly their own, for while the clays of the Tertiary area of the State are especially well adapted to the manufacture of pottery, those of the Paleozoic regions are largely adapted to the production of fire bricks, sewer pipes, and paving bricks.

The Paleozoic rocks have furnished the greater part of the refractory material of the world. These clay and clay shales do not as a rule possess as high refractory properties as bauxite, steatite, graphite, or magnesite, but the latter are much less abundant and are for this reason much more expensive, while articles made from clays and shales are sufficiently refractory for most of the common uses for which refractory materials are employed, and the abundance and cheapness of such clays insure for them a constant and ever-increasing demand. In the United States the clays and clay shales of the Carboniferous rocks are extensively used for certain manufacturing purposes, while raw clays are shipped to points all over the country to be used for the manufacture of retorts and furnace linings of special forms.

The various zinc-smelting works in the United States make their own retorts, and the clays used for this purpose are brought to the reduction works from well-known Paleozoic beds. And it should not be forgotten in this discussion of the character and distribution and uses of the clays of this class that their value, other things being equal, is determined by their proximity to manufacturing centers and to competing lines of railway transportation. These important factors have built up the fire-clay industries of St. Louis and Cheltenham.

The St. Louis, Iron Mountain and Southern Railway extends along the eastern edge of the Paleozoic area of Arkansas north of Arkadelphia. The southern border of the Paleozoic runs nearly due west from a point on Ouachita River a few miles north of Arkadelphia.

Within this Paleozoic area the clays and clay shales are unevenly distributed. In the Ordovician region, lying north of the Boston Mountains, shales and clays of value are much less abundant than they are in the Boston Mountains and in the Carboniferous rocks farther south. Again, in the Silurian region of the great Ouachita anticline, running from near Little Rock to the Indian Territory line, in Polk County, there are many mountains of novaculite in

which there are but few valuable beds of shale. In the great river bottoms of the Arkansas there are large tracts covered by river silts that are not available for the manufacture even of the most ordinary building bricks. However, there is not a single county in the entire Paleozoic area in which fairly good brick clays may not be found.

CRETACEOUS AND TERTIARY CLAYS.

It is only for the sake of convenience in presentation that the Cretaceous and Tertiary clays of the State are here treated in the same chapter. A glance at the geologic map of Arkansas accompanying this report (Pl. I) shows that rocks of Cretaceous age outcrop over a relatively small part of the State.[a] They are found in only about seven counties.

During Tertiary time, a period not far removed from the present, geologically, a large part of the State of Arkansas was covered by the ocean. The western shore of the Tertiary sea entered the State on the southwest somewhere in the vicinity of Ultima Thule, and passed into Missouri near the line between Clay and Fulton counties. The western margin of the Tertiary, as shown on the geologic map (Pl. I), marks approximately the old shore line. With the northern limits of this sea we are not now concerned, but on the east it extended nearly to Tennessee River, covering all of eastern Arkansas, while almost all the State of Mississippi lay beneath its waters.

All waters that flowed into this Tertiary sea carried down great quantities of sands and clays, just as to-day sands and clays are being carried out into the Gulf of Mexico by the Mississippi and by all the surface waters that flow into it. This material was spread out over the floor of the sea in beds as nearly horizontal as the nature of the bottom and the currents would permit, and with them were mingled the shells and bones of animals that lived and died in the water and the leaves and stems of plants that were floated out by the streams. Later the land was elevated until the silt of that ancient sea bottom now stands 375 feet (at Little Rock) above the present ocean's level.

During this depression of the land the Tertiary clay beds of the State were deposited, and the conditions under which these beds were formed satisfactorily account for their characters, their distribution, and their included fossils.

Should we go back a little further in geologic time we should be able to account also for the clay beds of the Cretaceous region in the southwestern corner of the State. The conditions under which they were deposited differed but little from those under which the Tertiary clays were formed. Neither the Cretaceous nor the Tertiary

[a] The Cretaceous geology of the State has been described by Prof. R. T. Hill in Ann. Rept. Geol. Survey Arkansas for 1888, vol: 2.

clays are hard, but neither are they geologically very old, nor have they been subjected to that great pressure that has so often affected the older clay beds of the earth's crust, many of which now form shales and slates.

The Tertiary geology of Arkansas south of Arkansas River has been described in detail by Prof. Gilbert D. Harris,[a] and the Tertiary and later beds of the Crowleys Ridge region of northeastern Arkansas by Dr. R. E. Call.[b] The present report does not undertake to deal with questions of stratigraphy within the Cretaceous, Tertiary, and Quaternary areas, except in so far as they relate to the details of the clay deposits.

The general geology of the Cretaceous and Tertiary portions of the State should be fairly well understood by those who have to deal with the clays that occur in those formations. The Cretaceous beds are older than those of Tertiary age, which they underlie. They are exposed in the counties west of Arkadelphia, namely, in Clark, Nevada, Pike, Hempstead, Howard, Sevier, and Little River. Everywhere in this region they slope gently toward the southeast.

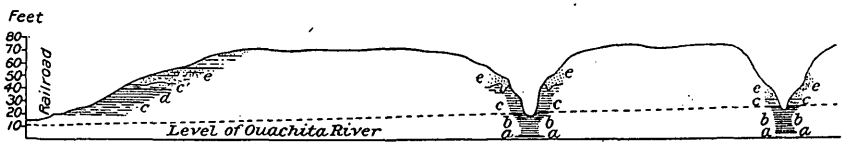

FIG. 5.—Section at Arkadelphia, Ark., extending from a point near the Baptist school southward to the Iron Mountain Railway. *a*, *b*, Sands; *c*, *c'*, Arkadelphia shale; *d*, clay; *e*, gravel.

They are made up of beds of chalk, marl, gypsum, sandstone, and clay. The clays of this group, however, are of comparatively small importance. The only extensive beds noted are the blue clays exposed near the railway in the south side of the town of Arkadelphia. These clays were originally called the Arkadelphia shale by Prof. R. T. Hill and were believed by him to belong to the Tertiary.[c] Later, however, Prof. G. D. Harris found that they belong to the Cretaceous.[d]

It is not known that the Arkadelphia shale has any economic value. It is usually so interbedded with thin laminæ of sand that it can not be used for the manufacture of pottery, but probably this same bed may elsewhere be suitable for the manufacture of pottery or available as fuller's earth. This shale bed is exposed at several places about the town of Arkadelphia and also on the upper part of Big Deciper Bluff 5 miles southwest of the town. The yellow sandy clay overlying the chalky marl on the Wright place, on Little

[a] Ann. Rept. Geol. Survey Arkansas for 1892, vol. 2.
[b] Ann. Rept. Geol. Survey Arkansas for 1889, vol. 2.
[c] Ann. Rept. Geol. Survey Arkansas for 1888, vol. 2.
[d] Ann. Rept. Geol. Survey Arkansas for 1892, vol. 2, pp. 15–19.

Deciper Creek, seems to be the same shale bed. Professor Harris has identified the Arkadelphia blue shale again on Mine Creek, near the old town of Nashville, where it is 4 feet thick.[a]

Within the Cretaceous area there are large areas covered with buckshot clays. These clays are not of Cretaceous age, but are much newer—Pleistocene and Recent—and are made of the residue of any clay-bearing strata that may be at hand after the decomposition of the underlying rocks. In the low, flat lands, commonly known as "slashes," thin beds of plastic clays are found at places where acidulated waters have leached the iron from the soil. Some small potteries get their clays from such places. The supply of available clays of this kind is uncertain, and most of the areas covered by them are small. Such clays occur in the flat lands of the Cretaceous, Tertiary, and Quaternary areas of the State, which, however, are not alluvial lands, properly speaking.

Reference has been made to the waterworn materials that occur in the Tertiary region of southern Arkansas. This material is at some places extremely coarse, made up of cobbles the size of a man's head or even larger, and at others consists of pebbles no larger than a hickory nut. This gravel spreads over and obscures the outcrops of the Tertiary beds throughout the region, and is especially thick along the foothills on the northwestern margin of the Tertiary exposures. In thickness the deposit varies greatly, being in one place only a few inches and in another from 25 to 40 feet thick. In some places it has a tendency to accumulate in depressions; in others it is found in considerable quantity only on the hilltops. Inasmuch as the presence of this waterworn material often interferes not a little with prospecting for pottery clays these peculiarities of its distribution should be kept in mind by prospectors and clay miners.

The presence in the pottery clays of leaf impressions has been mentioned. A small collection of these was made and sent to Lester F. Ward, of the United States Geological Survey, for the purpose of ascertaining whether they threw any light upon the geologic age of these clays. Professor Ward's conclusions on this subject are that the beds are probably lower Tertiary, but he says that the specimens from the Henderson clay pit, north of Benton, Saline County, "have a very curious and suggestive resemblance to some of the Amboy clay leaves, and I strongly suspect that you have gotten into the Cretaceous."

It is interesting to know that the fossil leaf impressions from these clays are probably all of new species, but the fact that they are new, as Professor Ward remarks, decreases their diagnostic value in determining the age of the deposits. The age of the pottery clays could not therefore, without more collecting at least, be decided

[a] Ann. Rept. Geol. Survey Arkansas for 1892, vol. 2, pp. 20-21.

by the fossil plants peculiar to the beds themselves. Marine fossils of Eocene age have been found east of the outcrops of the clays, however, at Warren, in Bradley County; at Monticello, in Drew County; at Rison, Kingsland, and about New Edinburgh, in Cleveland County; and at White and Red Bluffs, on Arkansas River, in Jefferson County. The pottery clay beds of Saline and Hot Spring counties seem to dip beneath the fossil-bearing beds mentioned above, and must therefore be not later than Eocene. For these reasons these beds are spoken of in this respect as being of Tertiary age.

With this understanding of the general characters, age, and origin of the common Tertiary pottery clays of the State we may take up the details of their occurrence.

The Tertiary clays are the most important in the State of Arkansas. As already stated, they, with their accompanying sands, marls, and organic deposits, underlie a large part of the State east and south of the St. Louis, Iron Mountain and Southern Railway south of Arkansas River. North of this and east of the Paleozoic hills the sediments are chiefly Quaternary deposits, except Crowleys Ridge, the lowest part of which is Tertiary. Most of the beds of this series were laid down in the sea when it extended over all of southern and eastern Arkansas and as far north as the mouth of Ohio River. The sediments that were washed into this Tertiary sea sloped gently toward the middle of the gulf, and the hardened beds they formed, now lifted above sea level, still retain that slope. During Tertiary time the land must have risen from beneath the water more than once, for we have at many places beds of lignite that could be formed only as swamp deposits. After the lignites had been formed the land was again depressed and covered by the sea and the accumulation of sediments continued. Everywhere over the area those sediments were laid down in beds that were approximately horizontal but dipped gently seaward. After the final elevation of these beds above the sea, the streams carved out our present topography in the uppermost of the Tertiary beds.

From this brief sketch it will be seen that the sediments laid down during Tertiary time vary from place to place in thickness and in character, just as any marine sediments of the present time vary. Some of the beds are clays and some of them are sands and gravels. The fresh-water or land deposits also vary, just as such deposits vary at the present time.

The fire clays of the Crowleys Ridge region are everywhere associated with beds of Tertiary lignites, which outcrop in the basins of several of the larger streams. Lignites and fire clays occur in the NE. ¼ NE. ¼ sec. 26, T. 4 N., R. 4 E.; NW. ¼ SW. ¼ sec. 8, T.

11 N., R. 4 E.; NE. ¼ NE. ¼ sec. 20, T. 10 N., R. 4 E.; sec. 30, T. 16 N., R. 5 E.; and in sec. 36, T. 19 N., R. 6 E.

At each of these localities the fire clays underlie the lignite beds, and from this relation it is fair to infer that similar clays occur under all the lignite beds in this area. No attempts have been made to use these clays for making fire bricks or tiles.

In the first-named section, which is in St. Francis County near the Lee County line, on the east side of Crowleys Ridge, the exposure is well up in the hillside, facing a small ravine tributary to St. Francis River. The clay is from 3 to 4 feet thick, but is difficult of access and extensive stripping will be required to mine it, or if a drift be made into the hillside it will require timbering. This clay is light drab in color when wet, but it dries to white or nearly white.

The association of lignite and fire clays serves to explain the light color of the clays. Around all the lignite deposits in the Crowleys Ridge region there are extensive beds of blue or black clays, containing selenite crystals, which pass into these light-colored clays by hardly perceptible gradations. Some masses of lignite detached from great beds near at hand are imbedded in the horizontally stratified blue clays that overlie the lignite beds. The clays in contact with these masses are lighter colored, some of them almost white, having apparently been bleached by the action of the organic matter of the lignite. The lighter color of the underlying fire clays is due to the same processes. Organic matter that finds access to clays and soils acts as a powerful discoloring agent; from black or blue or even red they may be changed to drab or white. This phenomenon is well illustrated along Copperas Creek in Cross County, near La Vesque, at the base of the great section there exposed, and also along the base of the Cherry Valley section, where the organic matter is in the form of leaves and other vegetable detritus. In Greene County, in sec. 35, T. 19 N., R. 5 E., and along the clay bottoms of Bolivar Creek, at the point where the lignite forms the base of the cliff in sec. 8, T. 11 N., R. 4 E., similar phenomena are to be seen.

At the Cherry Valley locality the lignite outcrops on the surface of the ground, and not far away from it is an outcrop of the underlying fire clay. This clay forms the bed of Bolivar Creek for a distance of half a mile or more, passing under it and into the high bluffs that face it. A local dip of this bed carries it under the bed of lignite that outcrops in the bottom of Bolivar Creek a half mile or more to the west. At the locality of best exposure it passes northward under a cultivated field and doubtless extends entirely beneath it. A quarter of a mile farther east it again appears in a thin bed higher up in the hillsides, and finally disappears under a heavy talus derived from the adjacent hills.

At the point of the section where the lignite is exposed in its greatest thickness 3 or more feet of this clay appear in the hillside facing the stream. It is chocolate brown when wet, its color being due to the presence of minute particles of finely divided lignite, for there is no other coloring matter present.

The third locality is on a small stream known as Otter Creek, 1½ miles northwest of Bay Village. The drab fire clay is about 2 feet thick on the immediate bank of the stream. The clay extends over much of the surrounding region and is of comparatively easy access. It has been put to no use thus far.

The fourth locality is in Greene County, on the banks of Beech Creek, where the fire clays are indurated into a soft light-drab shale with conchoidal fracture. It passes under a cultivated field near the stream to the west and disappears in the high hills that border the creek on the east.

Above the clays in this Beech Creek section lie indurated and quartzitic Tertiary sandstones. If these deposits are ever deemed of sufficient importance to work, they can be ground so that they may be used. The outcrop extends for a long distance up the stream, and there is no doubt that these clays underlie all the country immediately adjoining.

Another locality in Greene County where fire clays occur is southwest of the place last mentioned, in sec. 10, T. 17 N., R. 4 E. An analysis of this clay was made at the St. Louis Sampling and Testing Works and is reported as follows:

Analysis of clay from Greene County.

Moisture	17.64
Combined water and organic matter	6.63
Silica (SiO_2)	70.43
Alumina (Al_2O_3)	19.15
Lime (CaO)	.52
Magnesia (MgO)	Trace.
Iron	1.70
Alkalies	1.84
	100.27

The clay at this place outcrops on the side of a hill, in a ravine near its base, and may be connected directly with that found at the Lovelady place, in sec. 30, T. 18 N., R. 5 E. It could be employed in the manufacture of fire bricks of ordinary grades, as well as for sewer pipes, tile work, and similar uses.

In sec. 30, T. 19 N., R. 6 E., there is a deposit of fire clay in the bank of a small stream. Probably the same bed is reached in a well in the Cache bottoms, 1½ miles farther southwest. These beds appear to be related to those on Beech Creek near Lovelady. They

are of drab color and are exposed in the stream to a thickness of 5 feet or more.

No pottery clays are known in the Crowleys Ridge region. It is probable, however, that local deposits may be found in some of the low grounds of the slashes of the region.

Throughout the Crowleys Ridge country, wherever erosion has gone deep enough to reach the cross-bedded Tertiary sands, it has exposed numerous thin undulating strata of bright-red, pink, purple, gray, white, or yellow ochers. In certain localities, as in the Prussian Jewish Cemetery at Helena; at Double Head Bluff, in St. Francis County; at Wittsburg, on Wolf Creek, in Poinsett County; at Gainesville, in Greene County, and at Chalk Bluffs, in Clay County, these clays are found in abundance. Commonly, however, they are much intermixed with sands and are very patchy in their occurrence.

The only uses to which they are known to have been put are for painting outbuildings and fences and in dyeing cloth. Since they are so local in occurrence and are commonly found in small quantities they are not believed to possess any economic value.

Analysis of pink clay from Gainesville, Greene County.

[Specimen dried at 110°–115° C. Brackett & Smith, analysts.]

Silica (SiO_2)	71.17
Alumina (Al_2O_3)	18.44
Ferric oxide (Fe_2O_3)	2.77
Lime (CaO)	.25
Magnesia (MgO)	.44
Alkalies, by difference	.90
Loss on ignition	6.03
	100.00
Air-dried sand in air-dried clay	14.52

In the roadway on the west edge of the village of Gainesville several feet of this clay outcrops in pockets. There is no continuous deposit of it in the immediate vicinity of the village, though one occurs in deep washes near the roadway in sec. 32, T. 18 N., R. 5 E. In this locality the pink pipe clay occurs in beds that range in thickness from 4 to 15 inches and are separated by cross-bedded white sands.

At Wittsburg there is another deposit of pipe clay which is characteristically patchy and wanting in continuity. In the west edge of the village, in a gulley crossed by the roadway leading to Wynne, there are beds of pipe clay that are in places as much as 3 feet thick. In color they range from white to deep red, through drab, yellow, and pink. A sample of the red and pink clay of this locality was analyzed with the following results:

Analysis of pink clay from Wittsburg.

[Specimen dried at 110°–115° C. R. N. Brackett, analyst.]

Silica (SiO_2)	69.55
Alumina (Al_2O_3)	15.20
Iron oxide (Fe_2O_3)	8.10
Lime (CaO)	.58
Magnesia (MgO)	.97
Potash (K_2O)	.52
Soda (Na_2O)	.50
Phosphoric acid (P_2O_5)	.20
Loss on ignition	5.72
	101.34
Water at 110°–115° C	2.24
Air-dried fine white sand	25.48

QUATERNARY CLAYS.

The Quaternary deposits of Arkansas occupy a large area east and south of the Paleozoic group. South of Arkansas River these deposits, except along the larger streams, are comparatively thin, and between them lie many outcrops of the underlying Tertiary and Cretaceous sediments. North of Arkansas River the Quaternary deposits are much thicker. In all the flat country of northeastern Arkansas Quaternary deposits completely cover all the older formations. Tertiary rocks outcrop along the base and sides of Crowleys Ridge.

Crowleys Ridge enters the State in Clay County and runs due south to Helena, in Phillips County. The country traversed by this ridge is low and, from a geologic point of view, somewhat monotonous. Its geology as related to the clays and clay industries can be presented most conveniently by a brief statement of the geologic features of Crowleys Ridge itself.

The Quaternary clays of the Crowleys Ridge region are either (1) loess or ridge clays, or (2) ridge-land clays, found west of Crowleys Ridge.

The first of these soil and clay groups is found mainly on the higher portions of Crowleys Ridge. The second occurs only on the more elevated portions of the low country, but its chemistry and distribution present certain peculiar and interesting facts that call for its separation from the soils of the lowlands proper.

From Helena nearly to Jonesboro the loess is the characteristic soil of the higher portions of Crowleys Ridge. At some places where ravines are eroded along the eastern margin of the ridge, at right angles to its trend, this material forms precipitous walls, the bottoms of which rest on gravels and sands. In other localities loess soils overspread the slopes of the hills to varying depths. These redeposited loess soils are not so homogeneous as the undisturbed

portions of the loess, for they contain more or less gravel and sand, derived from the neighboring hills.

The limonitic buckshot lands, as has already been stated, are widely distributed, for, owing to the method of their formation, they are liable to be made wherever the conditions indicated exist. Therefore the buckshot are not confined to clays of any particular age. The conditions most favorable for their formation, however, as might be expected, have existed and still exist in the widespread flat Tertiary and post-Tertiary portions of the State, and in the hardpan of the prairie region.

The region between Crowleys Ridge and White River is diversified with prairie and wooded lowlands and traversed by low ridges which have a general north-south trend parallel to the drainage lines. Though they stand only from 5 to 15 feet above the general level, they nevertheless constitute a remarkable topographic feature. On these ridges several towns and villages are located—Surrounded Hill, Brinkley, Wheatley, and Palestine, for example.

The geology of these low divides is not positively made out. The soils which usually cap them are entirely different from those which form the surface of the distinctively prairie region. It is commonly a yellowish-brown loam resembling the loess soils of Crowleys Ridge, but it is not an alluvium. Beneath it are the buckshot clays, as is shown in well sections. Extensive deposits of this loam occur in portions of secs. 10, 11, 14, 15, and 22, T. 3 N., R. 2 W. The ridge extends away toward Clarendon, but disappears in the pine flats a few miles south.

The buckshot clays cover nearly all the country contiguous to and west of Crowleys Ridge. They also form a narrow belt along the eastern edge of the ridge south of Poinsett County; but this eastern belt entirely disappears at places in the southern portion of the ridge. These clays have been noted at but few places in the country east of St. Francis River, where the lands are composed mainly of alluvium, and are in great part subject to periodic overflows. In the region west of the ridge these clays constitute all the second bottoms along L'Anguille, Cache, and White rivers, and at many places along those streams they appear from beneath the alluvium. This statement holds also for the White River region south of the Bald Knob and Memphis branch of the Iron Mountain and Southern Railway. The entire prairie region of St. Francis, Cross, and Poinsett counties is underlain by this soil. Farther west, in Woodruff, Monroe, Prairie, and Lonoke counties, it is commonly observed either in the washes on the prairies or in the "post-oak slashes" of that region, and is penetrated in all well sections. All the post-oak regions of the Crowleys Ridge area are characterized by soil of this sort. In some localities, as at Forrest City, Marianna, Jonesboro, and Paragould, it

ascends the slopes of the hills a number of feet (at some places as much as 40 feet) above the general level of the surrounding region. It occurs also in occasional small basins at the very top of the ridge, but is there mixed with loess and is not so sandy as it is in the lowlands. In many localities in the Cache and L'Anguille bottoms it rises to the surface and forms the soil over extensive areas.

The buckshot clay is commonly a light-gray sandy clay, nearly impervious to water, containing an abundance of small nodules of limonite. There are usually several thousand of these little nodules to the cubic foot of earth. At many localities the clay is removed from the soil, or it never was present, so that the soil now consists of only the coarser sands and the limonite. These nodules lie in countless thousands on the surface, giving a characteristic lumpy surface to the soil, which, where they so occur, is too poor to support even a scanty vegetation. Along the borders of some streams and ravines the nodules have weathered out to form layers a foot or more in thickness, notably at the mouth of England Creek (in the NE. ¼ SW. ¼ sec. 19, T. 10 N., R. 4 E.) and in the valley of Big Creek about Jonesboro.

In general, then, it may be said this limonitic hardpan, or buckshot, is found over all the low country for 50 miles or more west of Crowleys Ridge. On the east of the ridge it is but a narrow fringe along its base below Poinsett County, but north of this county it spreads over the whole region as a subsoil, in places rising to the surface and varying in depth from 3 to 7 feet. It extends eastward to the alluvial bottoms of the St. Francis. Along Cache River in Greene and Clay counties much of the land is made up of these slashes or buckshot soil.

This buckshot soil is used at Jonesboro, Gainesville, Paragould, and Rector for the manufacture of bricks, but it is ill suited for this purpose. The limonite is reduced to metallic iron in the parts of the kiln next to or near the fire, and this gives the bricks a black, spotted appearance, which contrasts unpleasantly with the color of the body of the brick. In the yards employing this brick earth the processes of molding are crude and none of the higher grades of machinery are in use; all the bricks are hand molded and none are re-pressed.

REMARKS ON THE ANALYSES.

Comparison of the analyses given in the table on pages 236–237 will help to an understanding of the colors of the bricks made in the region. Clay for making bricks of good red color should contain iron; clay for brown bricks should contain manganese. The brick earths from Paragould and Jonesboro and one sample from Harrisburg contain most manganese; the others contain but a trace or none

of it. The rich colors of the Jonesboro-Paragould bricks therefore seem to be due to these two substances. Clays that are deficient in both these substances, or that contain one of them in lumps—as the soil from the buckshot land at Harrisburg—will make bricks of poor color, which, however, may be modified or improved by the addition of soils containing iron or manganese.

The colors of bricks depend also on the degree of heat to which the kilns are raised and the chemical combination of the iron or manganese. Careful manufacturers of bricks keep close watch on these important factors and produce bricks of uniform color and hardness. In the Crowleys Ridge region the refinements of brick manufacture have not been attempted, although the loess soils found there are preeminently suited to the production of fine brick.

CHAPTER IV.

REPORT BY COUNTIES.

ARKANSAS COUNTY.

The southern portion of Arkansas County lies in the flat bottom lands of White and Arkansas rivers. The central and northern parts are higher. All the large streams of the county flow south. Between the streams are gently rolling prairies, which vary in width from 2 to 15 miles. The Stuttgart and Arkansas River Railroad follows the main ridge or prairie land from Stuttgart to Gillett. The ridge ends about 5 miles south of Gillett.

The prairie or ridge land in the northern part of the county extends eastward to White River. From near Searcy to Crocketts Bluff, in Arkansas County, a series of bluffs or steep banks extend along the west side of White River. The character of the country along the river is made apparent by such names as Devall Bluff, Mount Adams, and Crocketts Bluff. South of Crocketts Bluff the high bank on the west side of White River gradually falls away into low bottom lands.

The soils of the county fall naturally into two groups—(1) the alluvial sandy soils along the rivers and large streams and (2) the prairie soils. The soils of the prairie lands are reddish to gray clay, which has a maximum thickness of 30 feet. Below the surface clay comes a bed of quicksand, or common fine sand, which furnishes the water supply for the shallow wells of the district.

The following well record at Stuttgart gives the characteristic strata of the prairie lands:

Section of strata at Stuttgart.

	Feet.
Drab-colored clay	1– 1½
Red to brownish clay	8–10
Reddish sand	3–15
Red or blue clay, locally called soapstone	8–15
Gray quicksand	3–30
Gravel, water bearing	3–12
Quicksand	(?)
Clay	(?)

A bed of lignite is found at many places just above the bed of gravel.

The only clay product manufactured in the county is common building brick, made from the surface red clay at Stuttgart.

ASHLEY COUNTY.

The rocks all through the higher parts of the county belong to the Eocene (Tertiary). The lowlands along Saline River, on the west and east of Overflow Creek, and along Bayou Bartholomew are mostly alluvial lands, where only brick clays may be looked for; or they are "slashes," where occasional pockets or thin beds of common pottery clays may be found.

The beds of the higher portions of the county are nearly horizontal and consist, for the most part, of sands and clays in various combinations and occasional beds of lignite.

The well sunk at the court-house at Hamburg is said to have passed through the following section:

Section in well at Hamburg.

	Feet.
Sandy soil	3–4
Not recorded	23
White pipe clay	10
Red clay	3–6
White quartz sand	20
Pebble bed.	

The pipe clay of this well section suggests that valuable clays may be found at some places in Ashley County, probably on slopes where the streams have cut deep into the soil. They will probably be found also in the deep wells.

G. D. Harris, while working on the geology of Ashley County, was informed that in the wells "a blue or light-gray clay occurs to a depth of 40 feet. This clay contains some leaf impressions." The character of plant-bearing clays found in other counties in Arkansas suggests that the clays may be available for making pottery and for other purposes.

The only clay-working industry in Ashley County is a common brick plant run by Nolly Brothers at Hamburg.

BRADLEY COUNTY.

The northern and western part of Bradley County is a rolling country which slopes gradually toward the bottom lands of Ouachita River. On the east the lands drop away rather abruptly toward Saline River. Along the larger streams—the Ouachita, the Moro, and the Saline—the soils are mostly alluvial, and the original Tertiary sedimentary beds are exposed at only a few places. G. D. Harris states that "the undisturbed Tertiary deposits of Bradley County consist of light-colored lignitic clays, usually intermixed with more or less light-colored siliceous sand. Bluish or black clay is occasionally met with in digging or boring wells, and there is some pure lignite."[a]

[a] Tertiary geology of southern Arkansas: Ann. Rept. Geol. Survey Arkansas for 1892 vol. 2, p. 119.

He found gray clays exposed on the road running north from Johnsville toward Warren and 4 or 5 miles from the former town. He gives the following record of the well of Lee Hammaker, in sec. 8, T. 12 S., R. 6 W.:

Record of well of Lee Hammaker.

	Feet.
Light, even-bedded clay	28
Clay ironstone	2
Reddish-white and yellow clay	5
Blue fossiliferous clay	6
Clay ironstone	1
Black sand with water	5

At Alga Bluff, on Saline River, in sec. 21, T. 13 S., R. 9 W., a section about 75 feet thick is exposed. The lower half of this section contains two thin beds of lignite and two beds of clay—one 3 feet thick, between the beds of lignite, the other 16 feet thick, overlying the upper bed of lignite. These clays have not been examined chemically, but they are worthy of examination and practical tests.

At Crawfords Bluff, on Saline River, beds of lignitic clay are exposed again. In the region between Johnsville and Long View, wherever the drainage has cut deep channels, these lignitic potter's clays are to be looked for beneath the heavy gravels.

About one-half mile west of the point where the railway from Monticello to Warren crosses Saline River the railway cuts a terrace-like ridge. The upper 4 feet exposed in this cut is a bright-red soil, and the underlying bed is purple clay.

About Warren the surface loam is in many places adapted to brick-making, but so far as could be learned no clays of importance beyond the brick earths have been found in the immediate neighborhood. The Tertiary (Eocene) fossiliferous beds are exposed in the railway cut in the town. Over all of Bradley County the Tertiary (Eocene) beds are either exposed at the surface or are concealed by their own weathered remains or by a thin sheet of Pleistocene gravel and sand. Most of the weathered Tertiary clays of this county form excellent brick clays.

In sec. 20, T. 14 S., R. 9 W., a well dug beside the road leading from Warren to Johnsville has the following section:

Section in well in sec. 20, T. 14 S., R. 9 W.

	Feet.
Sandy loam	2
Red sandstone with pebbles	8
White pipe clay	4
Sand.	

It may reasonably be expected that valuable clays will be found in connection with the lignites known to exist at various places in

Bradley County. One of these exposures of lignite was visited at Goulets Island, on Saline River, in sec. 24, T. 17 S., R. 10 W. The following section is exposed on the left bank of the stream at that place:

Section at Goulets Island, Saline River.

	Feet.
Sand and clay	6
Clean sand	10
Pebbles and sand	10
Lignite	2
Blue-gray sand and clay	2

The only clay in this section underlies the lignite, and is too far below the surface and contains too much sand to be of any practical value. The lignite is too thin to be worked and has no value

Several years ago the statement was published that "Thirty-six varieties of commercial clays and shales * * * have been found * * * within a radius of 3 miles from the town [of Warren], of which twenty consist of material used in the manufacture of vitrified pipe and paving brick, and the remainder * * * material used in the manufacture of terra cotta, drain tile, earthenware, and pressed brick."[a] Such a statement must be accepted with allowances. As pointed out elsewhere in this report, whether a clay is available for a given purpose can generally be determined only by practical tests. It should not be forgotten also that a clay, in order to be commercially useful, must be abundant, accessible, and cheap. In spite of the fact that the clays of Bradley County have not been tested as they deserve to be, the geology of the county leads to the reasonable belief that it contains large bodies of valuable clays. Only one establishment in Bradley County is engaged in the manufacture of clay products. This is a plant for making common soft-mud brick, located at Warren, and operated by Moore & Gannway.

CALHOUN COUNTY.

GENERAL GEOLOGY.

The geology of Calhoun County can best be understood by a study of the bluffs exposed along the right bank of Ouachita River in Union and Ouachita counties. These bluffs are made up of a series of clays, sands, and lignites which rise to a height of 200 or more feet above the ordinary stage of the water in the river. These soft beds now end abruptly at the river or at the margin of its immediate valley, but originally they extended across what is now the flood plain of the Ouachita and covered Calhoun County, as they still do, though in a modified way.

[a] De Malher, M. L., Arkansas Gazette, January 20, 1884, p. 5.

The section observed on the right bank of the Ouachita at Wilmington Landing gives a better idea of the geology of Calhoun County than any single exposure known in the county itself. That section is therefore repeated at this place.

Section at Wilmington Landing.

	Feet.
Sand on the hilltop	2
Sandy clay	5
Light-gray clay	2
Pinkish clay	3
Fat buff clay with sandy patches and lignite	16
Tough, sandy light-colored clay	7
White sand	3
Brown coal or lignite	3
Fat dove-colored clay	3
Sand with clay laminæ	5
Pink sandy clays and sands	10
Concealed	10
Level of Ouachita River	90

In dealing with the geology of Calhoun County we should remember that the beds exposed in the section at Wilmington Landing formerly covered the region to the east and north, and that water has gradually cut away the beds and lowered the whole land surface to its present level.

Beyond the river at Wilmington and farther north, toward Summerville, for several miles, the country is very nearly flat and but little elevated above the flood plains of the river. There is, however, an almost imperceptible rise as one approaches Hampton, and a short distance north of Hampton the country is at or about the same elevation as the elevated country at Wilmington Landing.

Over the lower country in the southern part of the county, and indeed almost everywhere east of the Ouachita, the lands are made up of river silts and alluvial and buckshot clays, so common in the slashes and boggy "crawfish lands." This surface covering is of later date than the underlying stratified beds, which are everywhere obscured. The Recent materials cover the older sediments throughout the county by spreading out over the flood plains of all streams.

On the higher lands of Calhoun County there is a widespread overwash of waterworn pebbles. Most of these pebbles are of novaculite, but many quartz pebbles are mingled with them. The novaculite that makes up the great bulk of the gravels is so restricted in its distribution that there can be no question about the origin of these pebbles. The novaculite rocks extend from a point near Little Rock on the east to Hot Springs and Dallas, in Polk County. Almost everywhere they form mountains, generally very steep and rugged. It is from these mountains of novaculite that the novaculite pebbles have been spread out like a great blanket over all the counties

of the State lying south of the Ouachitas or novaculite ridges of Pulaski, Saline, Hot Springs, Montgomery, Pike, and Polk counties. The quartz of the pebble beds is doubtless derived from the same region, for the novaculite shales are noted for the great number of thin quartz veins they contain. The fact that the pebbles generally underlie the silts and alluvial beds of the flood plains of the streams shows, too, that they are older than these silts. They seem to have been brought to their present position at the time when the Tertiary land was emerging from the bed of the sea, having been spread out by the undertow of the retiring waters.

These gravels are most abundant on the tops of the highest hills of the region, where they make excellent roads, or beneath the soils along streams. This is because they were originally spread over an approximately flat region; subsequent erosion has removed some of this material, thus making valleys in which the gravels are concentrated beneath the silts and soils that have later accumulated above them.

CLAY DEPOSITS.

Beneath the gravels and immediate surface soils lie the soft Tertiary beds referred to as cropping out in the bluffs of the Ouachita. These deposits contain many beds of pottery clay. Only a few of the outcrops of these beds can be noted here, but anyone who will bear in mind the general geologic structure of the region, as stated above and as shown in the section on page 17, can readily trace the beds and will know where to look for these clays when they have been found at a single locality.

About 3½ miles north of Hampton, at a point where the Hampton-Chambersville road crosses Rocky Branch, on the slope of a hill about 150 feet south of the stream, is a bed of greenish-gray potter's clay. It is not well exposed and neither its upper nor its lower limit could be seen when the place was examined, but it appears to have a thickness of about 4 feet. It can not be stated positively that the clay exposed is in place, but if it is the bed will be found to continue both up and down Rocky Branch at the same elevation, and it is quite probable that it may be found also on the north side of this stream at about the same elevation.

About 3 miles south of Chambersville, just south of Whitewater Creek, at a place where the Hampton-Chambersville road ascends about 40 feet from the bottoms to the higher land, probably in the SW. ¼ sec. 3, T. 12 S., R. 13 W., potter's clay is exposed in the face of the hill in the road. The thickness of these beds can not be determined without digging, but they seem to be from 10 to 20 feet thick at the place mentioned, and are well above all possible overflow of the neighboring streams. The outcrop extends around the face of the hill to the northeast and southwest from the road, while the

beds penetrate the hill to the south. In all probability the outcrop will also be found following the face of the hills that skirt the valley of Whitewater Creek along its right bank.

In the Chambersville-Hampton road, a little more than a mile south of the outcrop last mentioned, similar potter's clay is exposed in a gully on the north side of the road.

About 2 miles south of the point where the same road crosses Whitewater Creek potter's clays are exposed again by the roadside in the brow of a low hill facing northwest. This place is probably in the SW. ¼ sec. 15, T. 12 S., R. 13 W., about a quarter of a mile southeast of Dawson's schoolhouse. The following is the section exposed:

Section in SW. ¼ sec. 15, T. 12 S., R. 13 W.

Soil with pebbles and silicified wood.	Feet.
Greenish lead-colored clay	5
Brown coal	2
Clayey sands (base concealed)	4

Some of the cobbles in the soil overlying this section are 6 inches in diameter. With the exception of the fossil wood and a little quartz they are all of novaculite.

The outcrops of clay and brown coal extend both to the north and south of the road.

A little more than a mile south of Chambersville, probably in the SW. ¼ sec. 27, T. 11 S., R. 13 W., on Henry Clay's place, a bed of potter's clay 4 or 5 feet thick is exposed beside the road. It contains a few leaf impressions, and in general appearance closely resembles the clays used at Perla. This clay bed will be found to continue to the east of the Chambersville-Hampton road into the woods, while to the west it skirts the low hill north and west of Henry Clay's farmhouse.

Mr. Siebenthal reports a bed of gray plastic clay, from 6 to 10 feet thick, on the railway at a place where it crosses from Cleveland County into Calhoun County, in sec. 4, T. 11 S., R. 13 W., and the same bed again about 500 paces west of the first-mentioned exposure. Good pottery clay is reported on the Jordan place, in sec. 6 of this same township, and also on the Lightfoot place, 1 mile south of Little Bay.

So far as the geology of Calhoun County has been studied it leads to the conclusion that the pottery clays will be found in a long series of outcrops skirting the Champanolle on both sides and along the west side of Moro Creek, following up the larger streams like Whitewater. They will be found also in the hillsides along the upper part of Locust Bayou and along the east side of Two Bayou toward its head. These clay beds vary in thickness and in character, but for all practical purposes they may be regarded as inexhaustible.

Clays available for ordinary pottery occur here and there in the wet slashes along the larger streams and along Ouachita River, but these deposits are limited in quantity and, as compared with the stratified Tertiary clays, are of inferior quality. It does not appear that the pottery clays of Calhoun County have ever been utilized, even for local purposes, and transportation facilities will need to be improved before the excellent clays of this county can be turned to much account.

CLAY COUNTY.

The only clays of economic importance found in Clay County are common brick clays. The most abundant brick clay is the loess, which occurs on the top and sides of Crowleys Ridge throughout the county. Along a narrow belt of country at the foot of Crowleys Ridge, on both sides, the loess has been reworked by the streams and forms a second bottom. The reworked product is very similar in appearance and composition to some phases of the loess. It usually has a more yellowish color, due to the presence of iron oxide obtained from the highly ferruginous sand underlying the loess on the ridge. Where the yellow second-bottom clay is constantly covered with water the iron oxide is largely leached out and the clay becomes a white glady soil.

The second-bottom land is much narrower on the west of the ridge than on the east. Patches of country between Cache and Black rivers are covered with white to gray buckshot clay. It is doubtless of the same age as the white glady land on the east side of the ridge. At various places in the county between the west edge of Crowleys Ridge and Current River the surface is covered with alluvial sand, which overlies the hardpan or buckshot clay where the latter has not been removed by the present streams.

The reworked loess at Pratt is being made into common building bricks by the Pratt Brick Company. This is the only plant in the county engaged in the manufacture of clay products.

CLEVELAND COUNTY.

GENERAL GEOLOGY.

The geology of the extreme northwestern part of Cleveland County is similar to that of Saline and Hot Spring counties; that of the central part is like that of Union and Calhoun counties, where there are so many good clays; while that of the southeastern portion is like that of Drew and Ashley counties. It is probable that there are many clay deposits in Cleveland County available for pottery, fire bricks, sewer pipe, etc.

The work in Cleveland County was done by Prof. G. D. Harris, who gives the following résumé of the geology of the lowest beds in the northwestern section:[a]

A small portion of the northwestern quarter of this county is doubtless underlain by lignitic deposits. Records of well borings at Pinchback's mills, according to Mr. J. C. Simmes, of New Edinburg, show no traces of molluscan remains. The materials commonly passed through are sands and dark lignitic clay. In the vicinity of Cross Roads Church, about 4½ miles northwest of Kingsland, fossils belonging to the Jackson horizon were found in the form of casts and impressions in concretionary ferruginous sandstone. Wells near Kingsland and farther west are said to pass through 25 or 30 feet of sandy clay of a light-yellowish color, and then to encounter bluish clay or lignite. The bluish clay at some places continues for 30 feet or more, when it gives way to soft and sandy material that furnishes water in abundance.

The higher beds that cover all the central part of the county belong to the middle or Claiborne division of the Eocene (Tertiary), and are similar in the main to the beds of Calhoun and Union counties.

Below is given the record of a well on the land of J. B. Williams in the SW. ¼ SW. ¼ sec. 1, T. 9 S., R. 11 W.

Record of well on land of J. B. Williams.

	Feet.
Soil and sands	20
Joint clay	20
Clay with gypsum	10
Shells	10
Leaves	5
Dark-blue earth	12
Coarse white sand	4

On Mount Elba, just south of Bridges Bluff on Saline River, 3½ miles south of Toledo, the following section is exposed:

Section at Mount Elba.

	Feet.
Pebbly dark soil	2
Yellowish clayey sand	7
White chert pebbles	7
Light lignitic clay	3
Concealed to the water	15

Several other sections reported by Professor Harris in Cleveland County contain clays, but it is not clear whether they are valuable. Bed No. 4 in the following section reported by him appears to be one of promise. The locality is 5 miles southwest of New Edinburg, on the Moro Bay-Pine Bluff road.

Section near New Edinburg.

	Ft.	in.
Soil, sand, and a few pebbles	2	
Light, evenly laminated blue-gray clay	4	
Light-gray micaceous clay		6
Leaf-bearing bluish-gray clay	8	

[a] Ann. Rept. Geol. Survey Arkansas for 1892, vol. 2, p. 57.

CLAY INDUSTRY.

There is an abundance of good brick clays over a large part of the county. The Leali Pressed and Fire Brick Company's brick plant at Kingsland, with a capacity of 20,000 bricks a day, has been in operation since about 1901. The plant manufactures dry-pressed, stiff-mud, and fire brick. Shale and common clay are used. The bricks are dried in a Standard steam drier, and burned in both up-draft and down-draft kilns, which hold from 75,000 to 400,000 bricks. The Raymond stiff-mud machines and the Berg dry-press machines are used. The former has a capacity of 40,000 and the latter of 20,000 bricks a day.

The company is preparing to move its plant to Little Rock, and will operate there under the name of The Southern Brick Company.

COLUMBIA COUNTY.

CLAY DEPOSITS.

All of Columbia County lies within the Tertiary-Quaternary region. The general geology of the county is favorable to the discovery of pottery, tile, sewer pipe, and refractory clays, and wherever such beds may be found the horizontality and uniformity of the geologic structure will make prospecting for them very simple.

The details of the geology of Columbia County have not been sufficiently studied to determine the precise geologic position or the geographic distribution of the more valuable clays, but clays of excellent quality will doubtless be found in abundance in the county. It seems most probable that they will be found not in the higher parts of the great watershed that runs through the middle of the county, but well down its sides and along the sides of the valleys of the larger streams.

The usual "deer-lick" clays are found in the wet slashes, but it is not thought that clays of this class are of sufficiently good quality or sufficiently abundant to warrant exploitation, except, perhaps, in a very limited way, to meet small local demands. The stratified clays are abundant and good, and when a good bed is found there is never much difficulty in determining its relations to the accompanying beds or in tracing it over the adjoining country.

On the road leading from Magnolia to Mount Holly, in the NE. ¼ sec. 3, T. 17 S., R. 20 W., there are some greenish-gray pottery clays, at least 3 feet of which is exposed. The upper part of this bed is discolored by iron, but the discoloration seems to be only superficial. Sandy fire clays are exposed in a gully on the side of the same road 9 miles east of Magnolia.

At a few places between this locality and Mount Holly there are small outcrops of pinkish sandy clays containing leaf impressions,

but as a rule these beds are too sandy to make good pottery clays. The probabilities are, however, that the same beds at localities other than those examined may yield excellent clays, since they are of the same general character and appearance and contain the same fossil leaves as the pink fossiliferous clays used successfully at Perla switch, in Hot Spring County.

A quarter of a mile west of Mount Holly some promising-looking dove-colored clays are exposed at the side of the road. This clay, however, contains a few pebbles, and it may not prove to be of value. Beneath this gray clay are pinkish beds with leaf impressions.

The following is the record of a well dug by Mr. G. O. Bailey on his land near Magnolia, in the N. ½ sec. 34, T. 16 S., R. 20 W.:

Section of Bailey's well near Magnolia.

	Feet.
Surface soil	6
Cream-colored clay	15
Sand and pink clay mixed	3
Brown potter's clay	5

The second bed in this section contains a good many impressions of plants. The clay has not been analyzed, but its texture and color suggest its availability for the manufacture of good pottery. It contains 39.44 per cent of cream-colored sand. This sand is very fine, only 1 per cent of it being caught on a wire gauze having 100 meshes to the inch and 3 per cent on one having 150 meshes to the inch, the remainder passing through.

The third member of this section is of a light-pink color. It is very fine and clear of grit, but this pure part of the clay is so mixed with small pockets of rather coarse sand that in its present condition it is not available for fine pottery. The occurrence of this bed, however, is interesting, and suggests that a clean bed of excellent clay may yet be found. There is 29.08 per cent of clean white sand in clay No. 3, which includes that of the sand pockets as well. A large part of the sand, 36 per cent, is caught on a sieve having 100 meshes to the inch. In order to determine whether the body of it might not be kaolin the sand was washed from a sample of No. 3 and the water expelled by ignition. The loss was 9 per cent. The percentage of water in true kaolin is 13 per cent, while ordinary clays have 5 and 6 per cent. This can not, therefore, be regarded as a sandy kaolin, although it contains a higher percentage of water than ordinary pottery clays.

The brown clay in which the well ends is identical in color and texture and general appearance with the brown clays successfully used at Perla switch in the manufacture of pottery and fire bricks. It contains 28.92 per cent of fine light-brown sand, the lower brown clay at Perla switch containing 21.9 per cent. All the sand in this brown

clay is very fine, only a little more than 1 per cent of it being caught in a sieve having 150 meshes to the inch, the remainder passing through. This lower bed, like that at Perla, contains many impressions of leaves and stems of plants; indeed, the whole section seems to be very similar to the clay pits at that place.

It is reported that clays similar to those found in Bailey's well have been passed through in digging several wells in the neighborhood, and that in some of them the lower brown clay has been penetrated to a depth of 10 or 12 feet without having been passed through.

CLAY INDUSTRY.

The McIntyre Company has a small brick plant at Magnolia. The plant was established in 1884. Surface clay is used, from which is made a red common building brick. The bricks are molded by hand, dried in the open air and sunshine, and burned in an up-draft kiln. About three days are necessary to dry the bricks sufficiently to place them in the kiln; nine days are required for burning. Wood is used as fuel. The output is 5,000 a day. The molds are $8\frac{1}{3}$ by $4\frac{1}{4}$ by $2\frac{1}{2}$ inches.

CONWAY COUNTY.

GENERAL GEOLOGY.

The general geology of Conway County is the same as that of Faulkner County, and the clays of the two counties are therefore of the same character and have the same geologic distribution.

The surface rocks in Conway County, except the later deposits along Arkansas River, are entirely in the "Lower Coal Measures." The hard rocks are alternate sandstones and shales that lie nearly flat in the northern part of the county and are thrown into gentle folds in the southern part. The ridges here, as in other portions of the State, are capped by sandstone or are made up entirely of sandstone, while the valleys are generally underlain by shales.

Starting about $2\frac{1}{2}$ miles west and a little north of Morrillton, the Morrillton anticlinal fold of the rocks runs due east to Cadron Creek, crossing that stream in sec. 8, T. 6 N., R. 14 W. The group of parallel ridges and valleys involved in this fold have a width of 3 miles in Conway County. The relations of these ridges to one another are not apparent to anyone passing across the county on the railway, because the railway does not cut across them, but follows the valleys, and is therefore parallel to the lines of structure.

CLAY DEPOSITS.

Varieties.—The principal clays of Conway County are of the following four varieties:

1. The clay shales and the clays derived directly from them by disintegration.

2. The limonitic buckshot clays.
3. The leached clays of the slashes.
4. The alluvial chocolate clays of the second bottoms along Arkansas River.

Clay shales.—The clay shales are interbedded with the sandstones and are in the main, similar in character and distribution to those of Faulkner, White, and Pulaski counties. Where they have the proper composition they are available for the manufacture of paving bricks, sewer pipe, and fire-clay products. No chemical analyses have been made of specimens of shales of White County, but the analyses of the Round Mountain shales of White County and of the Little Rock shales of Pulaski County may be accepted as indicating in a general way the character of the clay shales to be found in Conway County.

Buckshot clays.—The buckshot clays cover a large part of the higher valleys of the county. These are used for making common bricks, but owing to the presence in them of the buckshot or small nodules of iron the bricks are often covered with dark-brown spots. These spots are likely to be produced in any well-burned bricks made of the buckshot clays.

Leached clays.—The leached clays are probably only modifications of the buckshot clays. Both the leached clays and the buckshot clays are derived indirectly from clay shales, and chemically altered by weathering and leaching. Where waters charged with organic acids stand for a long time in shallow pools in the slash lands, the underlying clays are often leached of their iron and made available for the manufacture of coarse pottery. Such clays are found in Conway County in the wet places on the second bottoms of the Arkansas River, Point Remove Creek, and Cadron Creek.

The alluvial chocolate clays of Conway County are in every respect similar in character and topographic position to those of Faulkner County.

Old Lewisburg terrace clay.—At Old Lewisburg, 1 mile south of Morrillton, a red clay caps all the elevations. This clay has a maximum thickness of about 20 feet and shows four distinctly colored beds. As seen at a point 250 yards southeast of the ferry, the exposures in a deep gully are as follows, beginning at the top:

Section at Old Lewisburg.

	Feet.
1. Flesh-colored clay containing much sand	7
2. Dark-red plastic clay containing a few small siliceous concretions	4–5
3. Pinkish clay, with numerous small siliceous concretions	3–4
4. Yellowish and mottled sandy clay overlying the black shale that outcrops along the river south of the ferry	4–5

The dividing line between these beds of clay is fairly distinct, though they grade slightly into one another. Bed No. 2 contains

less sand, apparently, than any of the others. Bed No. 4 is evidently a decomposition product of the black shale that underlies the region about Old Lewisburg and that crops out along the river bank above and below the ferry. This shale contains much sand, and at some places, as just above the ferry, it contains beds of shaly sandstone. It has a dip of 25° S. Beds 1, 2, and 3 are foreign to this locality and are not derived from this shale bed.

The whole site of the town of Old Lewisburg is underlain by the clay mentioned in the section, except where these beds have been cut through by gullies. Bricks have been made from the clay at the south edge of the town of Old Lewisburg. This clay has about the elevation of No. 1, but the clay exposed in the old pit did not show so much sand as bed No. 1 in the gully where the section was taken. The clay of the pit is red. These bricks are reported by Mr. Morloch, who helped to tear down some of the buildings made from them, to be soft and crumbling. No bricks have been made here since Old Lewisburg was in its prime, many years ago.

Clays south of Morrillton.—The ridges south of Morrillton are each formed by a heavy bed of sandstone, dipping south at an angle of 25°. Between these two sandstone ridges is a black, gritty shale, forming a red brick clay. The shale bed is about 275 feet thick.

This clay resembles that of the valley in which Morrillton stands. The clay in this valley is found mostly on the north slope of the south ridge and on the south slope of the north ridge. Where the same clay occurs in the bottom of the valley it contains more sand than it does on the slopes of the ridges.

Brick clays at Morrillton.—About 150 paces west of the public school building in Morrillton, on the north slope of the ridge, is a bed of reddish plastic clay, from which bricks have been made. This clay is sticky, but contains small iron "buckshot" nodules and is sandy, though the amount of sand is not excessive. This same clay bed extends all along the northern slope of this ridge, which is the first one south of the town. It is uniform in color and plasticity and in the amount of buckshot it contains. It is the product of the decomposition of the black, sandy, southward-dipping shale that underlies the whole valley in which Morrillton is built. This surface clay at no place appears to have a thickness of more than 2 or 3 feet. The clay formerly used at W. M. Morloch's brickyard, a little more than half a mile east of the railway station at Morrillton, is red, contains sand and iron, and is only 1 to 2 feet thick, the partially decomposed underlying shale coming close to the surface of the ground. The shale fragments seen on the surface hereabout are weathered to a light-greenish color. The shale that forms this clay belongs to the same bed as that forming the clay

at the base of the ridge immediately south of the town, but geologically it is about 200 feet lower. The character, color, and plasticity of the clay are the same as those of the clay west of the public schoolhouse. This plant has now gone out of business.

One mile northeast of Morrillton, at a place where the road runs northward past Thomas D. Hawkins's house, a 2-foot bed of red clay, with little sand, is cut through by the road. Where the road crosses the point of the ridge that rises toward the east from the northeast edge of the town there is a similar red clay.

Red clay like that at the localities described above is to be found on nearly all of the slight elevations in the valley and near Morrillton. The bed does not exceed a very few feet in thickness at any place. It is derived from the bed of black gritty shale that underlies this valley and is all of about the same color, has the same amount of sand, and contains much iron in the form of buckshot nodules. It makes a very good quality of brick so far as hardness and durability are concerned, though its color is somewhat injured for special uses by the black iron blotches.

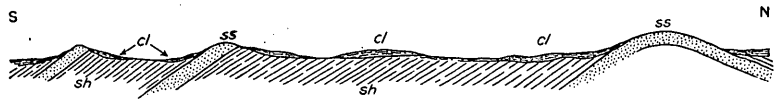

FIG. 6.—Section east of Morrillton. *cl*, Clay; *sh*, shale; *ss*, sandstone.

This clay is good for common bricks or common tiles, but would not be available for sewer tiles, nor can it be used for any other than common bricks.

The shale that makes up the valley is apparently about the same throughout in thickness, color, hardness, and percentage of sand, and yields a pretty uniform residuary clay. The bed of shale is from 550 to 600 feet thick, and under the town of Morrillton and east of it dips south, but turns over the nose of the anticline at the northeast corner of the town and dips north. A north-south section 1 mile east of Morrillton, from the sandstone in the south side of the anticlinal nose to the second ridge south of Morrillton, is shown in fig. 6.

This section represents the thickness of the rocks about 1 mile east of Morrillton, and shows how the clay occurs on the shale in Morrillton. Where the section is taken the clay is mostly eroded away at the north side. At present no clay industries are reported from Conway County.

CRAIGHEAD COUNTY.

GENERAL GEOLOGY.

The eastern half of Craighead County is occupied by St. Francis River, the Hatchie Coon sunk lands, and a broad belt of low, undrained swamp lands, which extend westward to the narrow fringe of post-oak lands adjacent to Crowleys Ridge.

The country east of Lake City is made up of sunken lands that are subject to frequent overflow, except along some of the slightly elevated areas which are covered with "sandblows." The sandblows consist of fine white sand which has accumulated in small, more or less separate areas and is surrounded by darker colored loam or sand. The country from Lake City to Nettleton is a flat buckshot soil, with a growth of scrubby willow oak, post oak, black oak, and an occasional hickory, white oak, and persimmon. The long-trunked sweet gum and cottonwood are entirely absent.

In the southern part of Craighead County Crowleys Ridge is but one-half mile across, narrower than at any other point between the Missouri line and Helena except where it is cut in two by L'Anguille River in Lee County. North of Jonesboro it widens out, and near the northern border of the county it is broader than at any other point in the State.

The white buckshot land extends westward from the foot of Crowleys Ridge to within about one-half mile of Cache River. Cache River bottom is from 6 to 10 feet lower than the buckshot land to the east, and along the railroad in the northwest corner of the county it is 1 mile wide.

The top of the ridge throughout the county is generally covered with buff-gray to yellowish loess. This is underlain by coarse gravel, which in places has become cemented into a compact conglomerate.

In the northern part of Craighead County the eastern slope of the ridge is more gentle than on the western side. The western slope is very precipitous and affords a better opportunity for the study of the stratigraphy of the ridge.

The following section, obtained 4 miles west of south of Lorado, in Craighead County, affords the best exposure of the Tertiary in the county:

Section 4 miles west of south of Lorado, on the old William Lane place.

	Feet.
Yellowish to Indian red clay on tob of ridge	40
Coarse gravel (Lafayette)	2– 8
Very hard, coarse-grained white sandstone, which in places has become a quartzite	15
Variegated cross-bedded sands interbedded with stratified clays	15

A continuation of the Tertiary strata in Crowleys Ridge is given below, in a general record of the deep wells at Jonesboro:

Record of deep wells at the city water plant, Jonesboro.

	Ft.	in.
Red clay (loess)	20	
Gravel, mixed with red clay	4	
Joint clay	10	
Coarse yellow sand		10
Pipe clay	25	
Gumbo	10	
Sand, very fine on top, grading downward into coarse sand and gravel, water bearing	60	
Very tough gumbo	50	
Blue mud with iron concretions, extending downward to 1,200 feet.		

CLAY INDUSTRY.

Jonesboro and vicinity.—The brick industry of Craighead County is confined to the vicinity of Jonesboro, on Crowleys Ridge, where five plants have been established for the manufacture of wet-mud and dry-pressed bricks.

The following is an analysis made from one of the brick clays at Jonesboro.

Analysis of brick earth from the surface at Jonesboro.

[Dried at 110°–115° C. Brackett & Smith, analysts.]

Silica (SiO_2)	79.49
Alumina (Al_2O_3)	8.71
Iron (Fe_2O_3)	3.43
Lime (CaO), Magnesia (MgO), Alkalies (by difference)	2.10
Manganese (MnO)	2.44
Loss on ignition	3.83
	100.00
Air-dried sand in air-dried clay	33.40

Jonesboro Brick Company.—One of the largest plants in the State is that of the Jonesboro Brick Company, where soft-mud and dry-pressed bricks are made. The machines for molding the two kinds of bricks are placed under the same shed and run by a central power plant.

The clay used for the dry press is loaded into carts at the pits by hand and drawn to the dry shed, where it is permitted to remain for months before it is made into bricks. When sufficiently tempered it is molded into bricks and set in the kiln. The capacity of the machine is 20,000 bricks a day. The bricks are burned in stationary up-draft kilns, and it requires twelve to fourteen days to burn them.

When thoroughly burned the bricks are of a cherry-red color and are considered substantial.

The wet-mud machine has a capacity of 30,000 a day, but it requires just twice the number of men to operate it.

The clay used for making the wet-mud bricks is the same as that used in the dry-press machine, except it is not stored in sheds and tempered before it is used. It is hauled from the pit in carts and dumped into small cars, which are drawn up an incline by means of a wire rope attached to a large drum. The cars are unloaded into a bin and fed into the machine by means of a belt with cups upon it. The bricks are removed from the machine and dried on pallets in covered racks. It requires from four to six days for drying, and seven to nine days for burning. Stationary up-draft kilns are used. Wood is used exclusively for burning.

Barton Lumber and Brick Company.—On the lot adjoining the Jonesboro Brick Company's plant, near the depot of the Jonesboro and Lake City Railroad, is the plant of the Barton Lumber and Brick Company, where both wet-mud and dry-pressed bricks are made. The bricks are molded by steam and the wet mud is dried by air in covered racks. They are burned in up-draft clamp kilns, and require about eight days for burning. A kiln that is built 34 bricks high is burned until it settles about 8 inches.

Saxe Brick and Tile Company.—At the time it was visited in June, 1905, the plant of the Saxe Brick and Tile Company was under construction. When completed the plant will have a capacity of 10,000 4-inch tile a day, or its equivalent. Tile will be the principal product if it can be made from the clay. Both soft- and stiff-mud machinery have been installed. The American Clay Worker end-cut automatic machine has been erected for making stiff-mud bricks and tile. Both open-air and steam-heating sheds will be used for drying the product. Down-draft clamp kilns are to be used, wood and coal serving as fuel.

Patrick Brothers Brick Company.—The plant of the Patrick Brothers Brick Company was established in 1905 for the manufacture of soft-mud building bricks. The bricks are made from the common, surface reworked loess clay. They are dried in the open air by means of the pallet and rack system. It requires from six to nine days for drying and from six to seven days for burning. Wood is used for burning. The capacity of the machine is 12,000 to 15,000 bricks a day. The size of the green bricks is 9 by $4\frac{3}{8}$ by $2\frac{1}{2}$ inches. The total shrinkage in drying and burning is $\frac{3}{4}$ by $\frac{1}{2}$ by $\frac{1}{4}$ inch.

Logan & Collans plant.—No particulars of the Logan & Collans brick plant were obtained.

CRAWFORD COUNTY.

GENERAL GEOLOGY.

The general geology of Crawford County is similar in the main to that of Franklin County on the east and to that of Sebastian County on the south. The southern part of the county—a little more than half of it—is covered by the upper division of coal-bearing rocks of the Carboniferous system. The northern part is made up of rocks that underlie the coal-bearing beds. Most of the rocks of the northern part of the county dip gently toward the south. The coal-bearing rocks are chiefly sandstones and shales, and the valuable clays of the county are to be looked for in these clay shales or in the clays formed by their disintegration. Other kinds of clays of later age that are spread over the lowlands will be spoken of under the head of brick clays.

In sec. 24, T. 9 N., R. 32 W., the following geologic section is exposed along Arkansas River in the hills north of the town of Van Buren.

Section in hills north of Van Buren.

	Feet.
Gray sandstone on hilltop	20
Slaty shales	120
Hard gray sandstone	20
Dark slaty shales	170
Sandstone	4
Dark shale at base.	

Especial attention is directed to this section as showing the enormous thickness of the shales of Crawford County in the vicinity of Van Buren, on the very banks of Arkansas River. The importance of the section and the thickness of the shales will be seen when it is realized that many of these shales are available for the manufacture of paving bricks, sewer pipes, and certain fire-clay products It should be remembered also that these same beds spread over a considerable part of Crawford County.

One other section may be given as a type of Crawford County rocks and their sequence. This section is on the east part of the hill in the SW. ¼ sec. 12, T. 10 N., R. 29 W.

Section in SW. ¼ sec. 12, T. 10 N., R. 29 W.

	Feet.
Brown sandy shale	15
Flaggy sandstone	10
Sandy shales	10
Thin-bedded sandstone	10
Sandy shale	5
Massive sandstone	10
Concealed	40

	Feet.
Dark-gray shale	20
Compact sandstone	20
Shale	20
Concealed to the creek bed	80

Some of the shales in the above section are sandy, but sandy shales are liable to become argillaceous as the beds are traced from one locality to another.

CLAY DEPOSITS.

Character of material.—Especial emphasis should be laid upon the fact that the value of the clay shales of Crawford County is untested. Not long ago it was supposed that only plastic clays were available for the manufacture of paving bricks. The experience of the brickmakers of Fort Smith, Ark., as well as that of manufacturers at Cheltenham, Mo., and other places, shows that many shales are available for brickmaking when properly treated. The localities mentioned here must not therefore be regarded as the only ones in the county, or even the most important ones. They are merely a few beds that were noted in the course of work done along other lines of investigation. The notes on clays in section 10 are by C. E. Siebenthal; the remaining notes on the clays of Crawford County are by William Kennedy.

Plastic clays.—A plastic cream-colored clay, somewhat iron stained, was found in digging a well in the SW. ¼ SW. ¼ sec. 10, T. 10 N., R. 30 W., on George Meador's place. The bed is said to be about 8 feet thick. The same clay is said to occur in many of the wells in this section. It was formerly used for the manufacture of smoking pipes.

A bluish-mottled plastic clay is exposed in the NE. ¼ SW. ¼ sec. 8, T. 10 N., R. 30 W.

Fire clays.—The disintegrated shales exposed in the various localities in the neighborhood of Alma afford a material suitable for the manufacture of articles requiring a clay of rather high fusing point.

Near Fine Spring, in the NE. ¼ SW. ¼ sec. 18, T. 10 N., R. 30 W., the clay is divided into an upper bed of yellow clay, 4 inches thick, overlying a bed of dark-blue clay. The thickness of this blue clay is not known, but it is said to have been dug into by Mr. W. M. James, the owner of the land, to a depth of 7 feet.

This same kind of clay is also found in the E. ½ NW. ¼ SE. ¼ sec. 18 and the NW. ¼ SW. ¼ sec. 17 of the same township and range. The deposit at Fine Spring is in the side of a hill, and is so covered with detritus as not to be visible without digging. This detritus consists for the most part of blocks of sandstone and shaly fragments derived

from beds overlying the clay. These overlying beds have a thickness of more than 50 feet.

To obtain this clay it will be necessary to resort to mining. The thickness of the material will favor this, and there is an abundance of timber in the neighborhood for mining purposes. It is not possible at present, however, to foresee the depth to which the soft clays may reach before assuming their normal condition as shales. The deposit lies within 2½ miles of Rudy station, on the St. Louis and San Francisco Railroad, and 5 miles from Alma, on the St. Louis, Iron Mountain and Southern Railway. This clay is said to have been tested at St. Louis and at Fort Smith, but no satisfactory information could be gained regarding the parties interested in or making the tests. The dark clay has been tested in the laboratory of the Arkansas Geological Survey for loss in burning. The clay burned to a whitish-yellow color and the loss due to the burning amounted to 9.71 per cent.

Van Buren clays.—The most valuable soft clays at and around Van Buren are those formed by the disintegration of the Carboniferous shales. The localities mentioned below are the ones at which the deposits appear to be most suitable and most advantageously situated for working.

About 3 miles northeast of Van Buren, in the SW. ¼ NW. ¼ sec. 16, T. 9 N., R. 31 W., close to Hendrick's coal opening, is a light-blue clay which burns to a bright yellow. Small test pieces of ware said to have been made from this clay show good, sound texture and a bright yellow color. No definite information, however, could be obtained regarding the parties who made these tests

The bed varies in thickness from 18 inches to 6 feet. The clay was tested for brickmaking purposes at Fort Smith by Pendell & Morrison for Mr. L. D. Middleton. Eleven carloads of this clay were manufactured into 4,500 bricks, which were used by Mr. Middleton to line his limekiln at Fayetteville. The limekiln was kept burning for twenty-seven consecutive days. At the end of that time the bricks were examined and found in perfect order, though highly vitrified. In the manufacture of these bricks Messrs. Pendell & Morrison were troubled by the stickiness of the clay, and in order to work it in their machine were obliged to mix with it the sandy, brownish-yellow clay used in making their ordinary building brick. No definite proportion was observed in the mixture, however, only enough of the sandy clay being added to render the material workable.

Analyses of the clays used in making these bricks are given below.

Analysis of clay from SW. ¼ NW. ¼ sec. 16, T. 9 N., R. 31 W.

[Brackett & Smith, analysts.]

Silica (SiO_2)	64.63
Alumina (Al_2O_3)	24.71
Iron (ferric) oxide (Fe_2O_3)	3.71

Lime (CaO)	0.31
Magnesia (MgO)	.41
Potash (K_2O)	2.03
Soda (Na_2O)	.94
Loss on ignition	6.52
	102.26
Sand in specimen, very fine	3.43
Water at 110°–115° C	3.02

The following analysis gives the combination of the sandy clay mixed with the above, obtained from Messrs. Pendell & Morrison's brickyard:

Analysis of clay from Pendell & Morrison's yard, Fort Smith.

[Brackett & Smith, analysts.]

Silica (SiO_2)	76.26
Alumina (Al_2O_3)	11.74
Iron (ferric) oxide (Fe_2O_3)	4.54
Lime (CaO)	.39
Magnesia (MgO)	.79
Potash (K_2O)	1.28
Soda (Na_2O)	.98
Loss on ignition	3.82
	99.80
Sand	47.79
Water at 110°–115° C	3.71

The clay from Van Buren is said to have been tested by the Laclede Company at Cheltenham, Mo., and by the Clinton Pottery Company at Clinton, Mo., but the results of these tests have not been ascertained.

On Bridge's place, in the SE. ¼ NW. ¼ sec. 36, T. 10 N., R. 32 W., about 3½ miles from Lily station on the St. Louis and San Francisco Railroad, is a light-blue clay which burns to a yellow.

Mr. Meyers sent some of this clay to St. Louis, where it was made into biscuit ware for decorative purposes. The ware has a bright yellow color. The name of the manufacturer of the ware could not be learned.

Clay from this locality is said to have been tested at St. Louis, by the Clinton Pottery Company at Clinton, Mo., and by Messrs. Sailor & Bevens at Weir City, Kans., the last-named firm having used it for the manufacture of retorts. The analysis is given below.

Analysis of clay from Bridge's place, sec. 36, T. 10 N., R. 32 W.

[Brackett & Smith, analysts.]

Silica (SiO_2)	67.64
Alumina (Al_2O_3)	21.57
Ferric oxide (Fe_2O_3)	2.48
Lime (CaO)	.27

Magnesia (MgO)	0.62
Potash (K_2O)	1.63
Soda (Na_2O)	.57
Loss	5.53
	100.31

Sand.

Water at 110°–115° C	2.85

The same class of clay is said to have been found in wells in the E. ½ N. ½ SW. ¼ sec. 36, and also in a well 10 feet deep in the E. ½ NW. ¼ sec. 31, T. 10 N., R. 31 W., where it is reported to be 4 feet thick.

An excavation made in the SE. ¼ NE. ¼ sec. 17, T. 9 N., R. 31 W., by J. L. Rea, in prospecting for clay similar to that found on the western side of sec. 16, passed through about 10 feet of Carboniferous shales, but encountered no soft clay.

In digging foundations for a house on Mrs. Moore's farm, near Lees Creek, in sec. 15, T. 9 N., R. 32 W., a fine white clay was discovered under the creek bottom land. On the road from Van Buren to Dora station there are several exposures of yellow clay, in places overlain by red clay. At Mrs. Moore's house and along the northern half of the southeast quarter of the section the red clay overlying the yellow has an average depth of about 2 feet.

In the NE. ¼ SW. ¼ sec. 17, T. 9 N., R. 32 W., a well 10 feet deep passed through 18 inches of fine gray clay at the bottom of the well.

In the SW. ¼ NE. ¼ sec. 30, T. 9 N., R. 31 W., the underlying clay is mottled, and has a thickness of 3 feet. On the east side of the hill on which Mr. Meyers's house is situated a stiff dark-red clay overlies the mottled clay. This red clay is similar in appearance and texture to that in the N. ½ SE. ¼ sec. 15, T. 9 N., R. 32 W.

Near the Van Buren freight depot of the St. Louis and San Francisco Railroad the blue and red clays rest directly upon black shale.

In the SE. ¼ SW. ¼ sec. 18 and the SW. ¼ NE. ¼ sec. 19, T. 9 N., R. 31 W., the railroad cuts expose a brown clay resting upon a mottled red and yellowish-white clay.

Brick clays.—At the western end of the town of Alma there is an area covered by a brownish brick earth showing in places a depth of 5 to 7 feet. It lies in T. 9 N., R. 30 W., in the following sections: SW. ¼ SW. ¼ sec. 5; SE. ¼ SE. ¼ sec. 6; the greater part of E. ½ sec. 7; the west side of sec. 8; and the land extending southward to the creek in the SW. ¼ NW. ¼ sec. 17.

In the SW. ¼ NW. ¼ sec. 17 the brownish-yellow brick earth is underlain by a yellowish-blue clay, which rests upon Carboniferous shale. Both clays contain nodules of iron, which become more plentiful toward the base of the beds.

From the eastern end of the town of Alma to Dyer station, in sec. 36, T. 10 N., R. 30 W., on the St. Louis, Iron Mountain and Southern Railway, this brownish-yellow brick earth lies on both sides of the railway track. At Dyer it has a yellowish color. It is exposed in the cuts east of Dyer as far as Mulberry.

No bricks are made at Alma. In 1886 two or three kilns were made from the brick earth in sec. 9 for local use by Hon. M. F. Locke. They were hand made and burned to a gray color and are spotted with iron.

The fuel used at Alma is chiefly wood, but coal can easily be obtained from Sullivant's mine, 2 miles from town. Wood ranges in price from $1.25 to $2 a cord, and coal costs $2.50 a ton delivered.

On the west bank of Clear Creek, at the place where it is crossed by the St. Louis, Iron Mountain and Southern Railway, 1¼ miles west of Alma, the following section is exposed:

Section on Clear Creek, near Alma.

Yellow brick clays.
Mottled fawn colored and yellow clay.
Waterworn cobbles.
Black shales of the "Coal Measures."

The yellow and mottled clays of this section aggregate about 25 feet in thickness. These clays become thinner west of Clear Creek.

Bricks were formerly made at Van Buren, but work there has been discontinued. They were manufactured from a brownish clay found lying between the line of the St. Louis and San Francisco Railroad and the shale escarpment to the west. This ground lies chiefly in the SE. ¼ sec. 24, T. 9 N., R. 32 W., and the SW. ¼ sec. 19, T. 9 N., R. 31 W. The clays used for brickmaking are similar to clays in other districts in the western part of the State. The beds are divided by a colored line into an upper and a lower division. The lower division is darker and contains more iron than the upper. This upper division is a light-brown sandy clay and is about 2 feet thick in the vicinity of Van Buren.

CRITTENDEN COUNTY.

Crittenden County lies entirely in the overflowed land of the Mississippi, its surface standing but a few feet above low-water mark along the river. The lowest point along the Kansas City, Fort Scott and Memphis Railroad (Frisco System) between Memphis and Deckerville is 223 feet and the highest point 228 feet above sea level.

The surface of the county is marked by small lakes, abandoned stream channels, and sluggish streams. Near Marion, Grassy Lake, and other places there are deep depressions, doubtless representing former channels of the Mississippi. The one north of Marion is about 1 mile wide and has trees growing in it 3 to 4 feet in diameter. The

oxbow shape of the depression and its continuation across the country indicate that it is an old river channel and not simply a depression.

The old channel at Grassy Lake is about 1 mile wide and the level of the water is 20 feet or more below the level of the country at Crawfordville.

Most of the soil of the county is composed of sand and silty clay, resulting from repeated overflows of Mississippi River. At no place is the material suitable for making common bricks unless the yellowish surface loam that occurs at a few places near the center of the county may be used for this purpose. Crawfordville and Earl are situated on small ridges which are said to extend in a northeast-southwest direction. These ridges contain at the surface a thin surface loam which is somewhat similar to the yellow loam in the prairie lands west of Crowleys Ridge.

At present no bricks are manufactured in the county.

CROSS COUNTY.

GENERAL GEOLOGY.

Crowleys Ridge extends through Cross County near the center in a north-south direction. The eastern half of the county is a low bottom country traversed by St. Francis River and St. Francis Bayou. Almost the entire area east of the ridge is covered by alluvial deposits. St. Francis Bayou hugs the foot of Crowleys Ridge, which forms a steep erosion scarp across the county.

The geology of the county is best studied along the steep eastward-facing bluffs of Crowleys Ridge. The lower Tertiary strata outcrop at the base of the ridge and extend 65 to 75 feet up its sides; above this comes 18 to 20 feet of waterworn pebbles and coarse sand, which corresponds to the Lafayette of Mississippi and Tennessee, and is but roughly stratified. This in turn is overlain by loess, with a maximum thickness of 50 to 60 feet.

The following is a section along the creek east of Wynne, at a point three-fourths of a mile southeast of the 3-mile post on the railroad:

Section 3 miles east of Wynne.

	Feet.
1. Loess capping top of hill; in places stratified and containing numerous lime concretions and land shells; lower 5 feet contains sand and pebbles derived from underlying Lafayette...	18
Unconformity; top of Tertiary.	
2. Coarse oxidized sands and pebbles, which correspond to the Lafayette of Mississippi and Tennessee	18
3. Gray to lemon-colored sand, with thin layers of pale-gray sandy clay	20–22
4. Brown lignite and lignitic clay	1
5. Clay sand similar to No. 4	8
6. Landslide, which has covered the rest of the hillside to base bluff	30

The bed of the creek one-half mile north of the above locality is 65 feet below the top of the Tertiary beds in the above section. The Tertiary strata of the section at the creek for 30 feet above the water, forming a continuous section with the one given above, consist of dark-blue clay interstratified with coarse sand, which contains large iron concretions 1 foot or more in diameter. Besides the iron there are numerous smaller lime concretions. The blue clay where exposed in the bluff sloughs off in large, vertical slabs. It contains more or less mica, selenite, and alum salts. Thickness, 30 to 35 feet.

On the west side of Crowleys Ridge the slope is more gentle and the Tertiary strata are covered by talus from the ridge. The surface material in the adjacent level land is gray to yellowish sandy clay, which is used for brick manufacture. In the town of Wynne this surface clay is penetrated in the wells at a depth of 40 feet.

CLAY DEPOSITS.

The most important clay in the county is the common brick clay. The loess and yellow loam on the top and the west slope of Crowleys Ridge form an inexhaustible supply of common wet-mud and pressed-brick clays.

One mile east of Wynne the following section in the railroad cut shows the variation in the color and character of the loess:

Section in railroad cut 1 mile east of Wynne.

	Feet.
Light-gray to buff loess	10
Reddish loess containing fine sand	20-30
White loess with more or less scattered pebbles and sand	5-10

The reddish loess would doubtless be better adapted to the manufacture of brick than the upper or lower layer. It contains a large amount of iron oxide and would burn to a bright red. Where the calcareous loess is used without mixing it with sandy clays there is great danger of getting the bricks too soft by adding too much water.

There is a bed of good sewer-pipe and tile clay at the base of a section in the Tertiary of Cross County near the village of Cherry Valley. The locality is in the NE. ¼ NW. ¼ sec. 23, T. 9 N., R. 3 E. The clay is exposed in the bottom of the creek to a depth of 3 feet, and extend downward to an unknown depth. It is a fine light-drab clay, unctuous to the touch and apparently suited to the manufacture of sewer pipe. It is more like potter's clay than any other clay that has been found in the Crowleys Ridge country. There is a similar deposit at the base of the section exposed at Double Head Bluff in St. Francis County, near the water level. The locality is in the NW. ¼ NW. ¼ sec. 18, T. 5 N., R. 4 E. It is much thicker here than at Cherry Valley, on the opposite side of Crowleys Ridge, and it is possibly identical with it. Neither of these clays are fire clays and could not be successfully used for fire brick.

CLAY INDUSTRY.

The plant of the Wynne Brick Company is located at the foot of Crowleys Ridge, about one-half mile east of the station at Wynne. The reworked clay from the ridge is used in the manufacture of brick. Common soft-mud bricks are made, which are pugged and molded by machinery. They are dried under covered racks in the open air. Up-draft scove kilns are used for burning the bricks. The kilns hold from 100,000 to 250,000 bricks. It requires about eleven days to burn the brick, using one-fourth of a cord of wood and one-half ton of coal per thousand bricks. The clay is very easily overburned. Near the eyes in the kilns the bricks are often burned to a vitreous mass, while on the outer edges they are not burned hard enough. The loss in burning and hauling is estimated by the superintendent to be about one-third. The size of the molds used at this plant is 9 by $4\frac{3}{4}$ by $2\frac{1}{2}$ inches. When burned the bricks measure about 8 by 4 by $2\frac{1}{4}$ inches.

The water used for the boiler comes from a bored well 250 feet deep. It stands within 100 feet of the surface.

DALLAS COUNTY.[a]

GENERAL GEOLOGY.

Dallas County is in the south-central part of the State, entirely within the Tertiary area. The rocks here, as in other portions of the Tertiary area, are soft, horizontally bedded clays, sands, and brown coals, variously interstratified, the whole overlain by coarse sand and gravel of varying thickness. The northwest quarter of the county is the highest, and from this region the surface slopes eastward and southward. The topography is of the undulating character that is common in regions covered with soft and easily eroded strata.

CLAY DEPOSITS.

CHARACTER OF THE CLAYS.

Potter's, fire, and brick clays are found in Dallas County in practically unlimited quantities. That the potter's clay is of good quality is shown by the fact that the ware made from this clay compares favorably with that made from clays worked at other localities. It has been used locally to a small extent as fire clay in laying up furnaces, etc. It has also been used as a whitewash, and when so used it gives a smooth coat of a pleasing, slightly bluish tint. For such purposes it is dissolved in buttermilk and boiled, and it is claimed that the composition furnishes about as durable a coating as that made with lime.

[a] The matter relating to Dallas County is taken almost entirely from C. E. Siebenthal's report on this county in Ann. Rept. Geol. Survey Arkansas for 1891, pp. 278 et seq.

It has been found that potteries here can not compete, except in local markets, with potteries that are situated on railways and that work clay equally good. The future of the pottery industry in Dallas County therefore depends on facility of transportation of the product to markets.

CLAY BEDS WORKED.

Since the stratigraphy of these clays has not been worked out in sufficient detail to permit their discussion in natural sequence, it is perhaps best first to describe in detail those beds which have at one time or another been opened and worked, together with those of which the clays have been analyzed, and afterward to take up the miscellaneous outcrops and well records.

Butler clay.—The first clay bed opened in Dallas County was probably that which became known as the Butler bed. This bed is in sec. 4, T. 8 S., R. 15 W., about 400 yards east of the southwest section corner, on the west bank of a head of East Tulip Creek, at an elevation of 350 feet above sea level. Clay has not been taken from this pit for many years, and the only traces of early operations are seen in a hollow that was scooped out of the creek bank and has since filled with débris. In a gully about 100 yards north of this opening 4 feet of lignite outcrops and is overlain by a plastic white clay, similar to Tall's clay, which occurs about one-half mile north of this place. (See p. 76.) Clay was also taken from an old field about one-fourth mile south of the opening first mentioned, but the old pit has long been filled with débris.

Cheatham clay.—The next bed opened was the Cheatham bed, on Dry Tulip Creek, in the NW. ¼ NE. ¼ sec. 22, T. 8 S., R. 15 W. The clay was worked back a little way from the creek on a small drain, but no exposure can now be seen on account of the débris that conceals the bed. On the creek bank about 100 yards south of this locality the following section is exposed at an elevation of 260 feet above sea level:

Section near Cheatham's upper bed, Dry Tulip Creek.

	Feet.
Soil and gravel	2
Argillaceous shale	4
Soft sandstone	3½
Clay and shale	2
Lignite	1
Stiff clay (partly concealed)	4
Lignite	3–4
White, plastic clay	5

Clay has also been taken from a bluff on the west side of the creek one-half mile farther south, in the southwest quarter of the northeast quarter of the same section. The elevation above sea is 255

feet. From 6 to 8 feet of gray joint clay is exposed. The lignite bed of the upper bank was not observed here, but the upper part of the bluff is covered with débris. The clay is fine grained, with some grit, and clings strongly to the tongue. This clay has been used more extensively than any other in the county and has uniformly been pronounced good by potters.

Bird clay.—The Bird clay bed outcrops on a hillside near one of the small streams flowing from the south into Cox Creek, in the NW. ¼ NE. ¼ sec. 6, T. 7 S., R. 15 W. The same clay outcrops farther west, around the head of Cox Creek, and farther east along the breaks of the hills skirting the north edge of Gum Bottom. The portion of the bed that was worked stands 390 feet above sea level, but clay of apparently the same quality outcrops in places in the drain all the way up to the elevation of 440 feet. This would indicate that the bed is about 50 feet thick. At the pit about 15 feet is exposed. This clay is said to have the disadvantage of being difficult to dry without cracking. This fault could be remedied by a judicious admixture of other clays. When freshly exposed the clay is light bluish in color and very plastic. It is very fine grained and contains but little grit.

Analysis indicates that this is a good clay, the silica and alumina being in good proportion and the percentages of the fluxes very moderate.

Welch clay.—This bed is located in the SE. ¼ SW. ¼ sec. 6, T. 8 S., R. 15 W. The bed stands 355 feet above sea level, making it correspond very closely in elevation with the Butler clay, described above. The bed has been dug into for 7 or 8 feet, and the quality of the clay improved and its color became lighter as greater depth was reached. The clay occurs in angular lumps, is light bluish gray in color, and is very fine grained, with little grit. Mr. Welch reports that the joint spaces are filled with a crystalline substance somewhat resembling common salt, and that particles of this substance become embedded in the ware and make blisters when burning. Samples of ware made from this clay are hard and close bodied. It burns to a gray slate color when perfectly done, the softer pieces varying from yellow to brown.

Mr. Welch reports that he is unable to use the common slip glaze on this clay, for the reason that the heat necessary to melt the glaze melts the ware also, and that he is compelled to glaze with common salt, which, however, is very satisfactory. The ware made from this clay shows to some extent a feature mentioned in connection with the Bird clay—a tendency to crack and warp in the dry house.

Sullenbarger clay.—The Sullenbarger clay bed is in the NE. ¼ sec. 20, T. 8 S., R. 15 W. The clay was used by Lafayette Glass in 1870. Nothing can be seen of the clay used, as the pit has long

been filled up, but about 200 yards farther north, up the drain, 5 or 6 feet of rather dark gray clay outcrops, and this is reported to be similar to that used. It contains considerable sand, and although not very plastic has a soapy feel when rubbed in a damp state. The ware made from the Sullenbarger clay is thick and somewhat porous. A combination of this clay and the Welch clay was tried by Mr. Welch, who reports that the mixture worked more freely than the Welch clay alone and that there was less liability of cracking in drying or burning. This bed stands 260 feet above sea level. It is difficult to correlate this with any other bed in or near the Cheatham section. No outcrop of lignite was observed near by, nor was any reported in this vicinity. This clay probably comes above the Cheatham section, as the clay supplied came from an elevation of 280 feet. If these beds are to be correlated with any in the Cheatham section, it is evident that the character of the clay changes greatly in the distance between these localities.

Green's clay.—In the SW. ¼ NW. ¼ sec. 5, T. 8 S., R. 15 W., a clay outcrops at an elevation of 440 feet about 100 yards north of Mrs. M. C. Green's, in a small drain that runs west into Tunstle Creek. The bed is about 10 feet thick. The clay is light gray in color, is plastic, has little grit, and clings slightly to the tongue.

The refractoriness of this clay is not very high, yet it is by no means so low as that of the Cheatham clay, which has been very successfully used for pottery. The percentage of sand present is not large enough to be injurious. The analysis of the clay, as well as its physical appearance, indicates that it could be successfully worked into ware.

Tall's clay.—The clay at Mrs. Chloe Tall's place, in the N. ½ SW. ¼ sec. 4, T. 8 S., R. 15 W., at an elevation of 370 feet, is light grayish in color and very plastic and carries a small quantity of rather coarse grained grit. It includes small lighter or white particles.

This clay closely resembles the Bird clay, not only in physical appearance, but also in chemical composition, and will be found suitable for all uses for which the Bird clay is available. For practical purposes the quantity of this clay is unlimited.

Crowder's clay.—W. A. Crowder's clay is in the SE. ¼ NE. ¼ sec. 8, T. 7 S., R. 14 W. About 4 feet of the bed is exposed in the banks and bed of a small drain that flows into Miller Creek at an elevation of about 290 feet above sea level. The clay can be seen only in a weathered condition, but as such it is very tough, plastic, has little grit, and is one of the whitest clays examined.

In refractoriness this clay comes among those so much used for pottery about Benton, Ark., and just below the finest china clay from Cornwall, England, which it very much resembles in chemical composition. There can be no doubt that it is of the best quality.

The same bed crops out half a mile farther east, and search would undoubtedly reveal it in all the hollows in the neighborhood.

Clarks Creek clay.—In the SE. ¼ sec. 1, T. 8 S., R. 15 W., at an elevation of 280 feet, in the bank of a small drain running into Clarks Creek, there is an exposure of 4 or 5 feet of tough, plastic clay containing scarcely any grit. With the exception of about 1 foot in the middle of the bed, this clay is light gray in color. The middle layer is of lavender color and has a peculiar odor and a sharp, bitter taste.

This very interesting clay deserves a more extended examination than it has been possible to give it in this investigation. In several places within a mile or so of this occurrence, clay of apparently the same quality outcrops at the same elevation, so that there must be almost unlimited quantities of this clay.

Ramsey clay.—The Ramsey clay is exposed about one-half mile east of Ramsey post-office, in the NW. ¼ sec. 9, T. 10 S., R. 13 W. The clay crops out in a drain beside the Fordyce-Princeton road at an elevation of about 265 feet. The bed is exposed to a thickness of 10 feet. The clay is light bluish gray in color and very plastic, and the small amount of grit is very fine grained.

The proportion of alumina and silica in this clay is such that its refractoriness would be high were it not for the injurious amount of fluxes it contains, especially of magnesia, of which it contains more than any of the other clays analyzed. As it is, its refractoriness compares favorably with that of the Welch clay, and it may be used for all purposes for which the Welch clay is suitable. The quantity of this clay is apparently unlimited.

Wormac's clay.—W. L. Wormac's clay bed is in the NW. ¼ NW. ¼ sec. 29, T. 10 S., R. 14 W., at an elevation of 260 feet above sea level. It outcrops to a thickness of 4 feet at the foot of the west bank of Freeo Creek. A small drain empties into the creek at this place, and the clay crops out in this drain up to a spring which is 10 feet above and which probably emerges just above the clay. The clay also forms the bed of the creek for some distance south (downstream). This clay is of a dark slaty blue color, with a waxy luster when freshly exposed, but dries to a dull light drab.

The upper part of the bed, as exposed in the drain, is lighter in color. The clay in the creek bank breaks off in large, roughly rectangular blocks, from which small cubical pieces weather off, leaving a peculiar, angularly indented surface. The clay is plastic and the grit is very fine, being almost imperceptible.

In appearance this clay differs widely from the other clays of Dallas County, and on analysis shows a like difference in chemical composition. The degree of refractoriness is too low to permit its being used as a potter's clay, unless it be as an ingredient in other clays, and it is difficult to see how it could be beneficial as such.

The resemblance of this clay to some of the Tertiary clays that are used in refining oils is very marked, and its chemical composition is not far different from that of those clays.

Little Cypress Creek kaolin.—This bed crops out in the east bank of Little Cypress Creek, in the SW. ¼ NE. ¼ sec. 26, T. 7 S., R. 17 W., where the following section is exposed:

Section of Little Cypress Creek kaolin bank.

	Feet.
Drab sandy clay, overlain by soil, etc.	7
Ferruginous shaly sandstone	½
Drab sandy clay as upper stratum	5
White sandy kaolin	6

The elevation of the base of the section is 320 feet.

The depth exposed does not represent the full thickness of the clay, which forms the bed of the stream and extends to an unknown depth below. It passes into yellow sandy clay 100 yards downstream. How far it extends upstream can not be told, for a few yards above the exposure the outcrop is covered with débris.

In J. E. Amis's well, about three-fourths of a mile farther southeast, a bed of white sandy clay and white sand, 20 feet or more in thickness, was struck at the same elevation. This may represent the kaolin bed. (See section of the well, p. 81.)

In appearance and texture this kaolin clay resembles the commercial scouring bricks, and it was with the thought of utilizing it for this purpose that the sample was collected. When rubbed between the fingers it has a lingering soapy feel, and it was washed and analyzed to test whether this indicated a constituency of kaolin.

In refractoriness this kaolin comes close below the best washed kaolin from Brandywine Summit, Pa., which is used in the manufacture of fine chinaware. In chemical composition, however, this Arkansas kaolin differs widely from the Pennsylvania variety in having more silica and less alumina and water. It is impossible to say what effect this difference in composition will have on the physical behavior of the clay in firing, but, the refractoriness being so nearly the same, the difference in composition will probably have no especially marked effect.

Kilmer kaolin.—A bed of kaolin outcrops on J. R. Kilmer's land in the SE. ¼ SE. ¼ sec. 10, T. 7 S., R. 17 W. A white clay outcrops in the bank of a drain at the elevation of 390 feet. Between 5 and 6 feet of the clay is exposed. It contains a great deal of rather coarse sand and in its natural condition is only slightly plastic. In the dry state the sand easily separates from the finely divided clay mass, which gives a very soapy feel when rubbed between the fingers, indicating the presence of kaolin.

The analysis shows a kaolin of a fair degree of refractoriness, the water content coming more nearly up to the accepted formula for kaolinite than that in the Little Cypress Creek kaolin. This kaolin will probably be available for the same purposes as the Little Cypress Creek kaolin.

OTHER CLAY BEDS.

The following notes on clay beds, which cover not only outcrops observed, but localities where clay was reported to occur, is inserted here on account of their possible value to prospectors.

In many cases the clay has been described as "sandy." Where this term has been used the sand is usually present in quantity sufficient to overcome the plasticity of the clay, or rather to lower the plasticity below the point at which it is available for ceramic purposes. One remedy for this fault consists in mixing with the sandy clay another clay of higher plasticity. Another remedy consists in washing out the excess of sand, a process that entails so much additional expense that it is impracticable except where the washed product is of a superior quality.

The exposures will be taken up in the order of the townships, beginning at the northeast corner of the county. The elevations are given in feet above mean tide level of the Gulf of Mexico. The elevation given for a well is that of the mouth; the elevation given for a natural section is that of the base.

Township 7 S., range 14 W.—Two feet of white plastic clay outcrops in a gully about 600 yards west of Ivy post-office, and is overlain by 6 or 8 feet of gravel. This is at the same elevation as the Crowder clay, which is less than half a mile distant (see p. 76), and is probably continuous with it. Elevation, 290 feet.

White plastic clay is reported on Gum Creek, in the SW. ¼ sec. 29.

Township 7 S., range 15 W.—In the SW. ¼ NW. ¼ sec. 2, in a gully just west of the Tulip-Sandy Springs road, there is an exposure of 15 feet of clay resting on white sand. The lower 7 or 8 feet is white plastic clay of apparently fair quality. It is possible that the white sand is a sandy kaolin similar to the Little Cypress Creek kaolin. Elevation, 360 feet. (See also p. 78.)

Nancy Jones's well, SW. ¼ sec. 2. Elevation, 390 feet.

Section in well of Nancy Jones.

	Feet.
Soil, gravel, and sand	8–10
White sandy clay	25
Dark clay	25

Lee Smith's well, NW. ¼ sec. 4. Elevation, 450 feet.

Section in well of Lee Smith.

	Feet.
Soil, gravel, and red sandy clay	20
White sand	5
Tough, dark, sandy clay	25

Outcrop of sandy gray clay, half a mile east of the above. Elevation, 380 feet.

Philip Phillips's well, SW. ¼ NW. ¼ sec. 5. Elevation, 500 feet.

Section in well of Philip Phillips.

	Feet.
Soil, gravel, and sandy clay	15
Sand and clay interstratified	20
White sandy clay	15

Chris. Lawrence's well, northeast corner SW. ¼ NE. ¼ sec. 30. The well was bored and afterward filled up. Reported by S. D. Green. Elevation, 490 feet.

Section in well of Chris. Lawrence.

	Feet.
Soil, gravel, and sand	25–30
Bluish clay (and bottom not reached)	125

This well must pass through the Bird clay, but as it is a bored well no distinction was made between the plastic clay and the sandy white clay, such as is found commonly in the upper part of this ridge.

Township 6 S., range 16 W.—Rice's gin well, SE. ¼ SW. ¼ sec. 36. Elevation, 510 feet.

Section in Rice's well.

	Feet.
Soil, gravel, and yellow sand	20
Bluish white clay, with interstratified beds of yellow sand	28

This is the typical white sandy clay referred to above. The sand constitutes 64.29 per cent of the whole mass.

G. A. Williams's well, NE. ¼ SW. ¼ sec. 36. Elevation, 510 feet.

Section in well of G. A. Williams.

	Feet.
Soil, gravel, and sand	15
Sandy pipe clay	60
Sand below.	

Township 7 S., range 16 W.—J. M. Holt's well, NE. ¼ SE. ¼ sec. 2. Elevation, 460 feet.

Section in well of J. M. Holt.

	Feet.
Soil and gravel	4
Sandy white pipe clay	40

J. S. Young's well, NE. ¼ SW. ¼ sec. 2. Elevation, 460 feet.

Section in well of J. S. Young.

	Feet.
Soil and gravel	4
Sandy white pipe clay	40
Lignite	1½
Dark-drab plastic clay	38

The lower 38 feet probably represents the Bird clay.

Mrs. E. A. Rice's place, NW. ¼ NE. ¼ sec. 15. White plastic clay nearly free from sand outcrops in the bed of a drain. Elevation, 415 feet.

In the Tulip-Arkadelphia road, about 1¼ miles east of O'Neill's mill, there is a bed of dark, putty-colored clay from 20 to 30 feet thick. This clay is very plastic, has little grit, and does not stick to the tongue. Elevation, 520 feet.

Potter's clay of excellent quality is said to have been taken from the creek bank below the old milldam at Willow post-office. The place is now covered with water. Elevation, 340 feet.

Potter's clay is reported in section 14, near the southwest corner, on a drain running into West Tulip Creek. Elevation, 300 feet.

It is also reported that a bed from which Bird used to take clay occurs in section 29, on a drain running into Cypress Creek.

Township 7 S., range 17 W.—J. E. Amis's well, NE. ¼ NW. ¼ sec. 36. Elevation, 360 feet.

Section in well of J. E. Amis.

	Feet.
Red sandy clay and gravel	15
Dark-drab plastic clay	5
White sandy clay and white sand	20

This probably reaches the kaolin that outcrops on Little Cypress Creek. (See p. 78.)

White plastic clay is reported in section 22, in the banks of a small drain, and in section 35, in the bank of Little Cypress Creek.

Township 8 S., range 15 W.—A white plastic clay outcrops in the bed of Canada Creek, just below the ford of the Ivy-Princeton road. Elevation, 250 feet.

A similar clay outcrops in the road a quarter of a mile south of the preceding and 30 feet higher in elevation.

On the Ivy-Princeton road, about three-fourths of a mile north of Princeton, there is an outcrop of very sandy white clay. Elevation, 260 feet.

In a gully beside the road in the NE. ¼ NE. ¼ sec. 21 there is a bed of bluish-white joint clay from 2 to 3 feet thick. This clay has little grit and does not cling to the tongue. It passes into sand to the

north and into jointed and indurated sand of the same color 20 feet to the south. The joint cracks of the clay have been filled with sand carried by percolating waters. Elevation, 280 feet.

John C. Welch's well, in the NE. ¼ NW. ¼ sec. 19, passes through about 30 feet of white sand. It may be that this is a sandy kaolin similar to those described in the preceding pages. Elevation, 350 feet.

An outcrop of plastic gray clay occurs in the road about 400 yards east of Welch's pottery. The thickness of this bed was not apparent. Elevation, 440 feet.

There is said to be a fine bed of excellent potter's clay on a small stream north of Princeton, about 1 mile above a point where the stream is crossed by the Malvern road, 1 mile north of the town.

John C. Welch's clay bank, in sec. 17, T. 8 S., R. 15 W., is in a neighborhood that abounds in excellent clays. The beds occur also along both sides of Cypress Creek and of West Tulip and East Tulip creeks, near to the headwaters of those streams, winding in and out among the hills and cropping out in the bluffs and banks of streams. The covering of the beds varies greatly; where the overlying beds have been eroded away the covering is thin, but where they crop out in steep-sided hills it is generally thick. Where these clays have been dug they have been taken from beneath rather heavy coverings.

Mrs. Lantorn's well, sec. 17, 440 yards west of the northeast corner. Elevation, 310 feet.

Section in well of Mrs. Lantorn.

	Feet.
Soil and gravel	6
White pipe clay	10
White sand	2
White clay	27

A load of this clay was tried by Mr. Welch, who says that it works very well.

P. N. Lantorn's well, SE. ¼ NE. ¼ sec. 8. Elevation, 370 feet.

Section of well of P. N. Lantorn.

	Feet.
Soil and gravel	2
Hard bluish clay	58
Lignite	8

L. D. Lantorn's well, sec. 5, middle of the south side. Elevation, 480 feet.

Section of well of L. D. Lantorn.

	Feet.
Soil, gravel, and sand	10
White pipe clay	28

Mrs. M. C. Green's well, SE. ¼ NW. ¼ sec. 5. Elevation, 480 feet.

Section in well of M. C. Green.

	Feet.
Soil and gravel	8
White pipe clay	8
Bluish clay	27
Black "rock"	⅓
Lignite	3
Sandy bluish clay	30

A. Whitener's well, SE. ¼ NW. ¼ sec. 3. Elevation, 480 feet.

Section in well of A. Whitener.

	Feet.
Soil, gravel, and sand	15
White clay	1
Lignite	1
White plastic clay	14

This lowest clay outcrops in a gully 50 yards west of the house.

Township 8 S., range 17 W.—D. Ratliffe's well, SE. ¼ SE. ¼ sec. 2. Elevation, 290 feet.

Section in well of T. Ratliffe.

	Feet.
Soil and red clay	4
White plastic clay	30
Dark plastic clay, with ferruginous sandstone particles	10

There are scattering leaf impressions in both the light and the dark clays.

Bernard Dellamar's place, SW. ¼ NW. ¼ sec. 14. An exposure of 12 feet of dark bluish drab clay. This clay is plastic and has little grit. Elevation, 310 feet.

Outcrop of 15 feet of light-blue plastic clay beside the road in the NW. ¼ sec. 15. This clay weathers very much like the olive-green Tertiary marl. It contains somewhat more grit than the clay that is most used for ware in this country. Elevation, 320 feet.

J. R. Porterfield's well, SE. ¼ NE. ¼ sec. 17. Elevation, 350 feet.

Section of well of J. R. Porterfield.

	Feet.
Soil and gravel	17
Sand	1
Dark, soft, plastic clay, with lignite flakes and nodules of iron pyrites	16

Potter's clay is reported near the center of sec. 34; also near the northeast corner of sec. 27 and in the SE. ¼ of sec. 35.

A well in the NW. ¼ NW. ¼ sec. 36 passes through 75 feet of sand with lumps of plastic clay and ends in white sandy clay similar to that overlying the lignite bed in this region. Elevation, 280 feet. These lumps of clay are at many places embedded in the sandy strata, and have been reported in several wells.

Township 9 S., range 14 W.—Pottery clay is reported in the SW. ¼ SE. ¼ sec. 32, and in SE. ¼ SE. ¼ sec. 30.

Township 9 S., range 15 W.—From 2 to 4 feet of bluish-white plastic clay outcrops in a gully beside the road in the SE. ¼ SE. ¼ sec. 34.

In the bank of Hays Creek, SE. ¼ NW. ¼ sec. 5, there is an outcrop of about 15 feet of grayish joint clay with considerable sand. Elevation, 220 feet.

Potter's clay is reported in the NW. ¼ SW. ¼ sec. 18; also on Sand Creek, in the NW. ¼ sec. 20.

Potter's clay is reported on the Bowers place, near the center of sec. 22.

Clay which was pronounced good is said to occur in the SW. ¼ SW. ¼ sec. 6.

Grayish-green potter's clay, 10 to 12 feet thick, outcrops on the Princeton-Dalark road, in sec. 11.

Township 9 S., range 16 W.—C. C. Williams's well, NE. ¼ NE. ¼ sec. 18. Elevation, 290 feet.

Section in C. C. Williams's well.

	Feet.
Soil and gravel	8
White pipe clay	20

Township 9 S., range 17 W.—Frank Russell's well, SW. ¼ sec. 1; 15 feet of plastic clay in bottom. Elevation, 290 feet. The same clay outcrops in a spring a few yards north of the well.

Where the Fordyce-Princeton road ascends the hill at Dallas Stell's ("Stony Point"), just north of Cooks Creek, in the S. ½ sec. 18, T. 10 S., R. 13 W., halfway up the hill, is a 10-foot bed of clay which may prove valuable for pottery, though the best of the clay may be only that near the surface, which is most affected by weathering. It is possible that it is thicker than 10 feet, for the limits of the bed are not well defined.

A well dug about 1,500 feet north of Dallas Stell's house penetrates lead-colored sands with leaf impressions, and it is possible that the clay on the hillside south of the house may be the weathered edge of this sandy stratum.

Through the region traversed by the Fordyce-Princeton road many of the surface clays are well adapted for pottery, but they all contain some pebbles and would need to be screened or passed through a machine to remove these.

Many exposures of stratified beds of pottery clay have been observed along the road south of Princeton, but the region is thinly settled and it is not possible to give the land divisions on which they were found. They vary greatly in thickness, though it is probable

that many of the beds which appear to be but 2 or 3 feet thick are much thicker, and that only small portions of them are exposed.

On the road leading from Princeton to Fordyce, about 1½ miles south of the point where the Fordyce road leaves the Camden road, a 10- or 12-foot bed of pottery clay is exposed in a gully beside the road.

The road from Tulip to Dalark passes over several beds of pottery clay. They crop out, among other places, in secs. 15 and 16 of T. 8 S., R. 17 W., on the lands of George Elders, about 4 miles east of Dalark, where they are overlain by red clayey sands.

A light-colored pottery clay outcrops in the gully east of the road in the NE. ¼ NE. ¼ sec. 20.

Township 10 S., range 14 W.—White plastic clay is reported in the NW. ¼ NE. ¼ sec. 5 and the NW. ¼ NW. ¼ sec. 7.

A. B. Smith's well, SE. ¼ sec. 8. Elevation, 265 feet.

Section in well of A. B. Smith.

	Feet.
Soil, red clay and gravel	12
Bluish joint clay	40
Red sandy clay	8

This clay evidently passes into sand, for a well at the same elevation 100 feet away shows:

Section in well in SE. ¼ sec. 8, T. 10 S., R. 14 W.

	Feet.
Soil and gravel	12
White fine-grained sand	33

Potter's clay occurs in the SE. ¼ sec. 8. Ten feet is exposed in the road and in the banks of a stream that flows into Freeo Creek. Elevation, 250 feet.

Potter's clay outcrops in the Little-Bay Princeton road in the SW. ¼ sec. 16. Elevation, 265 feet.

Smith place, SE. ¼ NW. ¼ sec. 17. Two or three feet of white plastic clay is exposed in the bank and bed of Freeo Creek, immediately above the ford. Elevation, 230 feet.

R. H. Barner's well, NE. ¼ NE. ¼ sec. 20. Elevation, 275 feet.

Section in R. H. Barner's well.

	Feet.
Red clay and sand	7
Blue joint clay, sandy toward bottom	34

Between 10 and 15 feet of grayish pottery clay outcrops in the road in the NW. ¼ sec. 34. Elevation, 270 feet.

Township 10 S., range 15 W.—In a gully beside the road, north of a church in the NW. ¼ sec. 2, is an exposure of 8 to 10 feet of bluish-white plastic clay. Elevation, 235 feet.

J. T. Shankle's well, SW. ¼ NW. ¼ sec. 7. Elevation, 300 feet.

Section in well of J. T. Shankle.

	Feet.
Red sand and clay	20
White pipe clay	10
Dark lumpy clay	10

A bored well at the same elevation showed 22 feet of the dark clay and stopped in lignite. The dark clay contains a few leaves.

J. W. Richardson's place, SE. ¼ SE. ¼ sec. 9. Ten feet of gray plastic clay outcrops beside the road. Elevation, 240 feet.

Potter's clay 15 feet thick outcrops in a gully in the SE. ¼ SW. ¼ sec. 16, and is underlain by 10 to 20 feet of white sand. Elevation, 260 feet.

Potter's clay is reported in a well at the gin in the NW. ¼ SW. ¼ sec. 18.

Pottery clay outcrops in the road in the NW. ¼ sec. 21. Elevation, 260 feet.

Potter's clay is reported in the NW. ¼ sec. 22.

Township 10 S., range 16 W.—W. M. Walsh's well, NE. ¼ NW. ¼ sec. 1. Elevation, 265 feet.

Section in well of W. M. Walsh.

	Feet.
Red clay and sand	8
Black clay with leaf impressions	10
Yellow sand and clay	45
White plastic clay	4

Well stopped in the last stratum without passing through it.

On Peterson's place, NE. ¼ SW. ¼ sec. 12, a foot of light-colored clay with some grit is exposed in a drain. Elevation, 230 feet.

James Goodgame's well, NW. ¼ NE. ¼ sec. 13. Elevation, 240 feet.

Section in well of James Goodgame.

	Feet.
Soil	4
Pipe clay	17

R. E. Hogg's well, SW. ¼ SE. ¼ sec. 13. Elevation, 310 feet.

Section in well of R. E. Hogg.

	Feet.
Soil and gravel	10
Potter's clay	2–3
Sand below.	

CONCLUSIONS.

The geologic structure of the region and the known outcrops of potter's clay lead to the conclusion that such clays exist in great abundance and of excellent quality in Dallas County. Their wide-

spread distribution on both sides of East Cypress and Cooks creeks and of West and East Tulip creeks has already been mentioned. In addition to the places at which good clays are already known, there is no doubt that they will also be found on the west side of Moro Creek and on the higher lands skirting the west side of Saline River in Dallas County.

ANALYSES OF CLAYS.

Analyses of clays in Dallas County are given in the following table:

Analyses of Dallas County clays.

Clays analyzed.[a]	Silica.	Alumina.	Ferric oxide.	Titanic oxide.	Lime.	Magnesia.	Soda.	Potash.	Loss on ignition.	Sand in air-dried clay.
Cheatham clay	72.82	13.72	1.267	2.54	0.63	0.75	1.08	0.96	5.76	50.30
Bird clay	66.42	21.19	1.956	1.02	1.13	.82	1.26	.....	7.76	37.28
Welch clay	71.27	16.86	2.378	1.75	.73	.77	.46	.44	6.54	30.50
Green's clay	68.03	17.19	3.589	1.49	.81	1.00	.54	1.00	6.31	35.80
Tall's clay	62.343	20.631	4.082	1.556	.173	.668	.325	.729	9.339	16.73
Crowder clay	66.336	18.966	2.008	1.869	.256	.225	.800	.379	8.130	17.23
Clarks Creek clay	50.653	25.450	6.481	2.591	.167	.604	.242	.742	13.100	3.46
Ramsey clay	60.700	21.567	5.000	.447	.469	1.583	.297	1.526	8.608	15.25
Wormac's clay	64.734	16.569	3.796	1.234	.837	1.535	1.395	1.685	7.334	25.14
Little Cypress Creek kaolin	62.166	26.096	.341	1.302	.051	Trace.	.252	.364	9.067	67.94
Kilmer kaolin	52.269	32.207	1.781	1.505	.086	.028	.341	.271	11.170	38.57

[a] The exact locations of the clays are stated in the preceding pages.

Of the preceding eleven analyses the first four were made by W. C. Riley and the remaining seven by L. R. Lenox. It will be noticed that the clays analyzed by Doctor Riley show a much higher percentage of sand than those analyzed by Professor Lenox. The determination of the percentage of sand is at best only approximate and is a matter of individual judgment, and this accounts for the different percentages found. In two clays, which have to all appearances an equal amount of sand, the percentage of sand in the one as determined by Doctor Riley is about t ice as great as the percentage in the other as determined by Professor Lenox. In comparing the sand contents of the clays this should be borne in mind.

Each of the clays analyzed contains a considerable amount of titanic acid and smaller quantities of sulphuric and phosphoric acids. Neither of these substances is taken into consideration in the formula devised by Bischof for calculating the refractoriness of clays, so that in determining the refractoriness of the clays analyzed these constituents have been disregarded. It is highly probable, however, that they exert some influence on the fusing point of clays.

Several of the clays showing the largest percentages of titanic acid were washed and their coarser and heavier parts were examined under a microscope. Owing to the fragmentary condition of the particles it was not possible to identify any of them except the quartz.

CLAY INDUSTRY.

At present no plants are reported as engaged in the manufacture of clay products in Dallas County. The pottery industry of the county has been mainly confined to the operations of the Bird brothers and their apprentices. The first pottery was established by them, and the last active pottery in the county was owned and operated by John C. Welch, who learned the potter's trade under William Bird.

The first pottery was set up in 1843 by two of the brothers, Joseph and Nathaniel Bird. In 1844 James Bird, another brother, erected a pottery just over the county line, in Grant County, in the SE. ¼ SE. ¼ sec. 23, T. 6 S., R. 16 W. He had burned but a few kilns when he sold out, and the business was discontinued. He used clay from a bed close by the old shop.

William Bird started his first pottery in 1843, in the SW. ¼ NW. ¼ sec. 7, T. 7 S., R. 15 W. His clay came from the Butler bed. He continued steadily at work here until 1851 or 1852, when he moved his shop to the site now occupied by John C. Welch's pottery, in the NW. ¼ SW. ¼ sec. 17, T. 8 S., R. 15 W. He operated this pottery until 1861, when he sold out to Welch. While running here he used clay from the Butler bed, and later from the Cheatham beds also. Bird started another pottery at the close of the war on what is known as the Bird place, in the SW. ¼ NW. ¼ sec. 6, T. 7 S., R. 15 W. He continued here until about 1881, when he left the State. He afterward returned and followed his trade in Malvern. While at the Bird place he used clay from the Butler bed; also from the Bird bed, on the Bird place, and from Gum Bottoms. Bird has the reputation among the older inhabitants of the county of making very fine, durable ware.

John C. Welch, as before noted, learned the trade under William Bird, and in 1861 bought him out and continued the business at the same place. The capital invested, exclusive of that for location, was about $150. The kiln had a capacity of 1,500 gallons. Two wheels were run and the average annual output was 10,000 or 15,000 gallons. The product was in the form of jugs, jars, churns, and crocks, which found a market in neighboring towns—Pine Bluff, Camden, Warren, Monticello, Eldorado, Magnolia, and other places. Mr. Welch at first used clay from the Cheatham beds, but later found and worked the Welch bed. His ware was hard, close-bodied, and thin.

Nathaniel Culberson worked awhile with Welch, and between 1858 and 1865 ran a pottery near the middle of sec. 24, T. 8 S., R. 15 W. He used clay from the Cheatham beds. Fragments from the old kiln show a rather thick, porous ware.

In 1859 or 1860 a foreigner named Etl established a pottery about three-fourths of a mile north of the preceding and operated it for about three years. Besides ordinary crockery he made flower pots

with vines and flowers in relief on the sides. He used clay from the Cheatham beds.

In 1870 Lafayette Glass, after learning the trade under Welch, set up a pottery in the NE. ¼ SE. ¼ sec. 29, T. 8 S., R. 15 W. He operated here for a year and then removed to Benton and became the pioneer potter of that place. While in Dallas County he used clay from the Sullenbarger bed.

Between 1874 and 1876 E. A. Munn, a brother-in-law of Welch, ran a pottery in the NE. ¼ SE. ¼ sec. 12, T. 8 S., R. 16 W. He left there and established a pottery at Malvern. He used clay from the Welch bed. Fragments about the old kiln show a fine, hard, and close-bodied ware.

DREW COUNTY.

GENERAL GEOLOGY.

The surface soils of Drew County consist either of disintegrated Tertiary (Eocene) rocks, which underlie the whole county, or of a thin coating of gravel of later age on the Tertiary beds. The flood plains of some of the streams are of recent alluvial origin, while those of others are made of older clays. Nearly all the lands east of Hurricane Creek are alluvial. Excellent brick clays are abundant about Monticello, though some of the surface clays contain a few pebbles, and others contain iron nodules. In the western part of the town of Monticello about 30 feet of purple and mottled Tertiary clay are exposed in gullies and in the railway cut. The purple clays crack in drying and, in their present condition, are not available for brick-making. These beds are exposed in places for 2 miles west of the town of Monticello.

A well bored by Emil Boechardt at Monticello in 1889, on the southwest corner of sec. 35, T. 12 S., R. 7 W., passed through the following strata. as reported by Mr. Boechardt:

Section in well of Emil Boechardt.

	Ft.	in.
1. Loam		4
2. Red clay	5	6
3. Pipe clay and sand	15	
4. Dark clay with shells	50	
5. Sandstone		6
6. Dark clay with shells	88	6
	159	4

A sample of clay No. 6 of this section was examined by the Arkansas Geological Survey. It is a dark, fine clay with a little mica and a few fragile fossil shells of Tertiary age. It does not crack on drying, and if the beds are accessible and could be found without shells it would make a good potter's clay and would be available for the

manufacture of good fire bricks. It is probable that other Tertiary clays that underlie Drew County might, by washing, be made available for the manufacture of pottery.

At Cornish Ferry, on Saline River, a section of the Tertiary beds is exposed, having at the base a dark lignitic clay that resembles some of the pottery clays of Saline County.

CLAY INDUSTRY.

In the town of Monticello the Drew Brick Company and a plant operated by J. H. Blythe are engaged in the manufacture of common building bricks.

FAULKNER COUNTY.

GENERAL GEOLOGY.

The geology of Faulkner County is merely a repetition on a somewhat larger scale of that of the western part of White County. The rocks have been thrown into great folds and then worn away, but the folding has been, on the whole, so simple and the alternation of the sandstones and shales has been so regular, that the geologic structure of the county is easily interpreted. When this structure is understood the distribution of the clays and clay shales in the county will be readily comprehended.

The rocks of this region belong to what are commonly known as the "Barren Coal Measures." They are sandstones and shales, across which run occasional veins of quartz, and on the upturned edges of which there are patches of bog iron deposited by chalybeate springs. Locally the sandstones and shales are somewhat calcareous, but these calcareous places are only thin bands or small patches and are of little or no importance except that some of them contain fossils.

The rocks of the county are all sedimentary, having been deposited originally in horizontal layers in water. After their deposition these sediments were consolidated by the pressure of thick beds that were deposited on top of them. In the course of time they were subjected to horizontal pressure from the south and thrown into a series of parallel folds, and, rising above the water, they formed dry land. After this elevation they were acted upon by weathering and eroding agencies, the former breaking up the rocks (for these sediments, originally sand and mud, were already hardened by long pressure to sandstone and shale) and the latter washing the fine material away. But as rocks are not all equally soluble or equally acted upon by decomposing and weathering agencies, and as they are not all transported with the same facility after disintegration, some of these rocks in Faulkner County have been removed much more rapidly than others. Thus rocks which long resist decay and removal—that is,

the sandstones—stand out now as hills and ridges, while eroding agencies have scored valleys in the softer and more easily affected rocks—that is, the shales. As the rocks of this region are alternate sandstones and shales, the topographic result of this condition and action is a series of parallel valleys and ridges, running, as a rule, east and west across the county.

As a rule the axes of these rock folds are not horizontal but are a little lower at one end than at the other. From this dipping of the

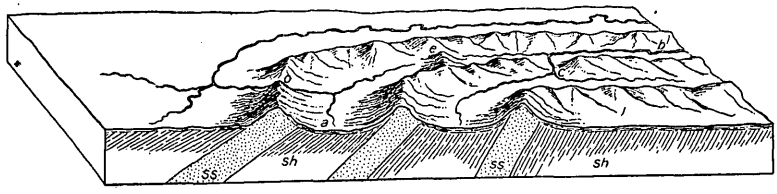

FIG. 7.—Diagram showing relations of structure to topographic relief in Faulkner County. *sh*, Shale; *ss*, sandstone; *aeb*, valley; *c*, *o*, stream piracy; *e*, watershed.

folds it results that the ridges, instead of being everywhere straight, curve around and cross the lower ends of the axes of the folds. This will be understood by reference to the accompanying diagram (fig. 7).

It will be understood from this also that the valley *aeb* is one

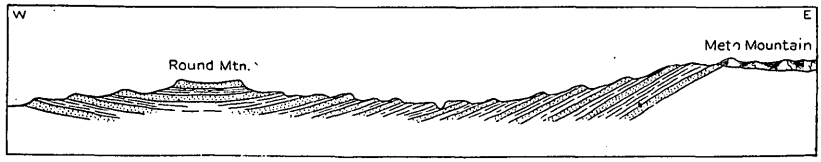

FIG. 8.—East-west section through Round Mountain and Meto Mountains, Faulkner County.

and the same geologically, although it may be divided at *e* by a watershed, or the ridge may be broken at *o* and *c*. It should also be noted that the shales that dip westward at *a* dip northward at *e*,

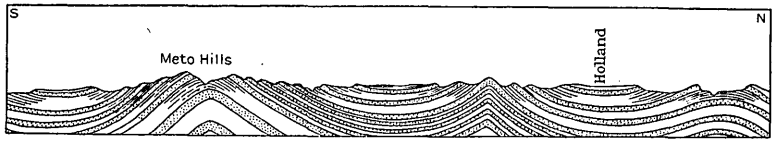

FIG. 9.—North-south section through Meto Hills.

and the same bed would dip southward on the south side of the axis of the fold.

Fig. 8 is an east-west section along the summit of Meto Mountain (a group of parallel ridges about 5 miles wide lying just north of Faulkner Gap) and across the summit of Round Mountain to Arkansas River.

A north-south section across the Meto Hills to a point about 3 miles north of the town of Holland is given in Fig. 9.

These details are sufficient to give a pretty clear idea of the geology of Faulkner County with reference to the occurrence of the clays and clay shales. The shales form the valleys of the region; the sandstones form the ridges. The shales are seldom seen at the surface, being covered usually by residuary material of one or another kind. At many places, especially in the lower valleys or "slashes," the surface soil is a "buckshot clay."[a]

About the bases of the sandstone ridges the débris from the hillsides—blocks of sandstone and sandy red clays—cover the outcrops. The shales are almost invariably found in digging wells, so that the people have an idea that the shale or "slate," as they generally call it, lies close to the surface all over the county. This appears to be the case, because the wells are usually dug in the valleys and the valleys are carved in the shales. This will be understood from the accompanying figure, which shows the geology of the region about

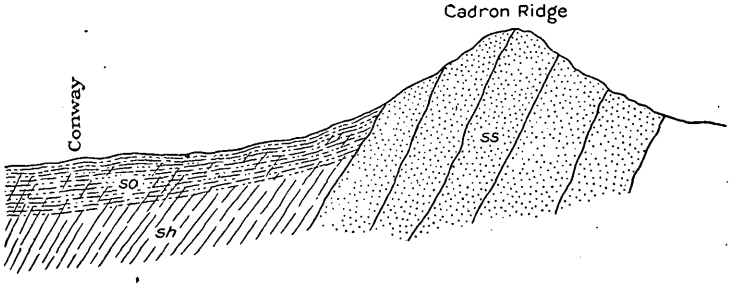

FIG. 10.—Section showing the relations of the shales of the valley to the loam and soil about Conway. *so*, Soil; *sh*, shale; *ss*, sandstone.

Conway with relation to the shales, the decayed shales, and the soil of the valley to the sandstone on Cadron Ridge, a short distance north of the town.

CLAY DEPOSITS.

The clays and clay shales of Faulkner County are of four kinds—(1) clay shales; (2) limonitic buckshot clays; (3) leached clays along the bayous and in the slashes; (4) alluvial and sandy chocolate clays skirting the bottoms of Arkansas River and in some places extending far up its affluents from this county, such as the Cadron.

CLAY SHALES.

With the preceding explanation of the geologic structure the distribution of the clay shales may be readily understood. They lie in the valleys everywhere in the county. Of course there are lowlands, like the alluvial plains of Arkansas River, made up to a considerable depth of river silt, clay No. 4 of the above list, sand, and gravel, to

[a] For the discussion of the buckshot clays see p. 28.

which this statement is not intended to apply. The alluvial materials that have filled the valleys of some of the other streams have also buried the shales to a considerable depth. These are not the places, however, in which one would expect to find the clay shales accessible for practical purposes. Indeed, while the valleys have shales of great thickness, the rocks are usually at too low an elevation to permit advantageous exploitation, on account of the expense of lifting the material from shafts or other openings and of draining these openings. Crude material to be cheap must be easily accessible and must therefore be sought on high ground, where the locality facilitates exploitation and avoids the necessity of draining the pits. There are several shale hills and ridges in the county where these conditions are favorable, and if one observes the geologic section north and south across the county it will be seen that these places are most likely to occur on the axes of the synclinal folds. One of these hills is known as Round Mountain, and is located in secs. 11 and 14, T. 5 N., R. 12 W., about on the axis of the Conway syncline. This little mountain stands about 250 feet above the general level of Cypress Valley and is in every respect similar to one having the same name in White County, which is located, like this one, on the axis of the Conway syncline. The rocks here are nearly horizontal, dipping gently to the south beneath the mountain, which is capped by a bed of sandstone that has preserved what remains of it from complete destruction. The total area covered by this mountain is about one-half a square mile.

Samples of the shale from this mountain have not been analyzed, but samples from the same beds in Round Mountain of White County have been analyzed and it is probable that they have the same or approximately the same composition. These analyses are given on page 224.

No coal has been found in the Faulkner County mountain, but the existence of a 2-foot bed of coal in the White County mountain warrants the supposition that there may be a similar bed in this one also.

Just west of Round Mountain is another though somewhat smaller hill, which has no local name. This hill has the same geologic structure as Round Mountain and is composed of the same kinds of rocks, which lie in the same position. It stands in sections 15 and 16 of the same township and covers an area of about 160 acres.

The other synclines in which the argillaceous shales abound are the Holland syncline, the Greenbriar syncline, and the Cato syncline. The shales of the Holland syncline are exposed in the Conway-Greenbriar road in sec. 13, T. 6 N., R. 14 W., where the road crosses East Cadron Creek. The body of the ridge just north of the creek at this place is of clay shale, and the whole is capped by sandstone. The ridge extends a mile to the west of the East Cadron bridge, but to the east it bends gently toward the south to sec. 15, T. 6 N., R. 12 W.,

where it curves abruptly northward, passes to the east and north of the village of Holland, and, bending upon itself, passes westward by Linden post-office.

This syncline is topographically highest at its western end, where the hills stand about 150 feet above the valley, and it sinks gradually to the east. The shales forming the body of this elevated syncline are well above water level, and as they are nearly flat there would be no difficulty in mining them. Their distance from the railway, however, will doubtless prevent their being utilized for the present.

Horseshoe Mountain, near Greenbriar, stands on the axis of the Greenbriar syncline. This mountain, like the other synclinal ridges, is composed mainly of argillaceous shale and, like them, is capped with a protecting bed of sandstone. It rises abruptly from the Greenbriar Valley, above which its summit stands about 300 feet, but sinks to a level about 100 feet above the Cadron. These shales, while available in so far as their composition, abundance, and geologic and topographic disposition are concerned, are too far from railway transportation to be of immediate use for manufacturing purposes.

Frenchman Mountain marks the axis of the Cato syncline. It is about 250 feet high at its east end, about a quarter of a mile west of the town of Cato, but becomes lower toward the west. The axis of this syncline dips toward the west, so that the mountains open westward, and the axis crosses the St. Louis, Iron Mountain and Southern Railway near Mayflower station.

The heavy beds of argillaceous shale forming the base of Frenchman Mountain are protected by the usual sandstone bed. This locality is several miles from the railroad.

The so-called Round Mountain group of ridges, lying between Preston station and Arkansas River, is made up of alternate beds of sandstones and shales that set one in the other like a nest of saucers. Many of these basic shales are adapted to the manufacture of pipes and paving bricks, but they have never been utilized. The less basic beds are available for the manufacture of refractory goods. They all occur in the greatest abundance, well located topographically, of good quality, and convenient to the St. Louis, Iron Mountain and Southern Railway.

Clays derived directly from shales by decomposition are common over much of Faulkner County, but as a rule they are so concealed and so irregular in distribution that but little can be said of them. They are to be sought on the upturned edges of the clay shales where these rocks have broken down under disintegrating influences, and as the sandstones usually form the hills and ridges and the shales the valleys, these clays are to be looked for chiefly in the valleys, between the sandstone ridges. Such clays are often spoken of by the people as "rotten slate." They are abundant at the bases of some hills of shale

where the shale talus has been broken up by long exposure to percolating waters.

Some of these clays are available for making rough pottery, such as jugs, crocks, and churns, or for making vitrified bricks or sewer pipes. The deposits are generally too small, however, to be of much importance.

LIMONITIC BUCKSHOT CLAYS.

The ordinary buckshot clay—that is, the clay containing small nodules or concretions of iron—occurs over half of Faulkner County. It is most abundant in the valleys and over the flat portions of the uplands of the county, and is least abundant on the crests of sharp ridges and in the alluvial bottoms of the Arkansas. Where it is near the sluggish bayous, and is overflowed for many days and even weeks each year, waters charged with organic matter have leached the iron from its upper portion, leaving it in places a clean, white potter's clay. This same process, operating on a minor scale, has produced the yellowish or ash-colored loam that forms the surface soil over a large portion of the county. From this loam most of the bricks of Faulkner County are made.

Beneath this more earthy surface there is generally an irregular bed or band of nodules of limonite iron that renders the clay difficult to manipulate, especially when the bricks are handmade, and produces the dark chocolate and spotted color so common in bricks from such soils.

The limonitic buckshot clay is so widely distributed in Faulkner County that it may be said to form the agricultural soil of three-fourths of the county. It is doubtless thickest in the valleys, in nearly all of which it covers large areas. It is in the "slashes," however, or wherever the ground is flat enough to prevent quick drainage, that it occurs in its most characteristic forms.

Throughout the Cypress Valley, from the Arkansas bottoms to the eastern border of the county, the buckshot limonitic clays are concealed only by the thin surface soil, which is in reality but a part of the blanket of clay soil that covers the whole region. The same is true of all the other valleys of the county, but especially of those in which there is slash land, or over which the drainage is sluggish. About Conway, Greenbriar, Holland, Enolia, and Amsteadville these clays are abundant, and are everywhere available for making such bricks as are usually made of the limonitic clays.

LEACHED CLAYS.

The leached clays are but one phase of the buckshot clays, being the upper soils from which the iron has been removed by acidulated waters. As a rule the longer the water stands on the ground the

more thoroughly is the iron leached from the soil, and it is by this process that the leached lead-colored clays are formed. Such clays are therefore most common along the sluggish streams that readily overflow their banks and spread out over wide, marshy bottoms, such as Palarm Bayou, East Cadron Creek, and Bayou Meto. And it is over the flood plains of these streams that the leached clays are most abundant; not, however, in the valleys only, but wherever the conditions for their formation are favorable.

The leached clays are available for the manufacture of the common grades of pottery, such as jugs, crocks, jars, and milk pans, but as their exploitation is not so easy as that of the Tertiary potter's clay of the southwestern counties of the State, they can scarcely compete with those clays. and can therefore be of slight and local importance.

CHOCOLATE CLAYS.

The chocolate-colored clays in some places form what are known as the "rich buckshot lands"[a] adjoining the river bottoms. They are usually too sandy to be useful for manufacturing purposes. In places they are very "fat." They are not everywhere of chocolate color, for wherever they contain much organic matter they have become black from the mixture of the organic matter with the lime with which this clay is at most places freely charged. Some of the richest agricultural lands of the State are on these chocolate clays. They are not known to have any value for manufacturing purposes.

CLAY INDUSTRY.

The Cypress Valley region about Conway[b] is covered by a yellowish clay, mottled here and there with light-gray patches. These gray patches are generally of small area and not very thick. In texture the gray clay resembles the yellow, although it has somewhat different qualities when manufactured. The upper portion of the yellow clay, from which the bricks are usually made, is of a light-yellow color, is generally about 2 feet in thickness, and is comparatively free from iron nodules. The lower division, from 24 to 30 inches thick, is of much darker color, and contains a great quantity of iron nodules ranging in size from that of a pin head to that of a walnut. This lower clay is not much used for brickmaking. The bricks made from it are stronger, harder, and more durable than those made from the upper clay, but they do not look so well.

The clays just mentioned are underlain everywhere throughout this district by a black argillaceous shale, which is more or less fractured near the surface, becoming harder and more compact as

[a] Not to be confused with the limonitic buckshot clays

[b] The notes on the brick industry at Conway were prepared principally by William Kennedy.

they are penetrated. The upper layers of this shale at some places break into kidney-shaped pieces, which shell off concentrically.

A well at John McCullough's old brickyard, in the NE. ¼ NE. ¼ sec. 1, T. 5 N., R. 14 W., gives the following section:

Section at John McCullough's old brickyard.

	Feet.
Light-yellow clay used for bricks	2
Dark-yellowish clay, brown below, and containing iron nodules	2
Broken black shale	3
Hard black shale at bottom of well.	

On the northeast corner of block 42 of the town of Conway, about 1 mile southwest of McCullough's old yard, in a well about 200 yards east of Mr. Firestone's brickyard, the shales appear at a depth of a little over 3 feet. In Firestone's pits the clay used does not exceed 2 feet in thickness. This clay is darker than that formerly used by McCullough and contains more iron nodules.

The bricks are gray in color, and where the two clay beds have been mixed the bricks are spotted. In the arch they have a tendency to melt at the ends.

Secs. 18 and 19 and 7 and 8, T. 4 N., R. 14 W.; secs. 10, 11, 12, 13, 14, 15, 22, 23, 24, 25, and 26, T. 5 N., R. 14 W.; and secs. 6, 7, 18, 19, 30, and 36, T. 5 N., R. 13 W., are covered by yellow clay similar to that around Conway.

Mr. Firestone made common bricks by hand until 1902, when he installed a machine run by steam. He now makes a stiff-mud end-cut brick. The clay is tempered and molded in a No. 7 special plunger machine, dried in the open air, and burned in clamp kilns. It requires about seven days for burning. Two kilns are in use, each of which has a capacity of 200,000 bricks. Wood is used for fuel. Daily output, 16,000 bricks. Size of bricks, 8¾ by 4¼ by 2½ inches.

FRANKLIN COUNTY.

GENERAL GEOLOGY.

In the extreme northern part of Franklin County, along Mulberry River and the tributaries entering that stream from the north, rocks are exposed that underlie the whole series of the coal-bearing rocks. These are the lowest and oldest rocks of Franklin County, and consist in part of beds of limestone. So far as is now known no clays or clay shales are associated with these old limestones. South of these exposures along Mulberry River the rocks of all the rest of the county are newer and are higher up in the geologic column and belong to the coal-bearing rocks or the series known as the "Coal Measures"—a series rich in clay shales and fire clays.

The rocks at and near the surface over most of the county are geologically somewhat higher than the coal beds found at the Ouita,

Spadra, and Coal Hill mines. The Spadra shale, with the accompanying coal, extends westward from Allister about 7 miles into Franklin County. The Spadra shale covers all the area within T. 9 N., R. 26 W., lying south of the section line between secs. 13 and 24, and extends still farther south, to Arkansas River. They likewise include secs. 25 and 36, T. 9 N., R. 27 W. Over a large part of this area clay shales are associated with the coal, and much of this deposit promises to be available for the manufacture of fire-clay products and also for sewer pipe and paving brick.

Both north and south of the area here mentioned, as well as west of it, the rocks are higher in the geologic column. They consist, however, of shales and sandstones that closely resemble those lower down, in the coal-producing rocks.

The following characteristic section, exposed on the east bluff of Arkansas River by the railroad about a mile southeast of the town of Ozark, shows the kinds and thickness of most of the rocks of Franklin County:

Section near Ozark.

	Feet.
Sandstone	50
Shale	90
Sandstone	15
Shale	70
Sandstone	10
Shale	75
Sandstone	50

In the southern part of Franklin County there is a series of rocks that stands higher in the geologic column than those included in this Ozark section. These higher rocks belong to the group which has been called in Arkansas the "Poteau." They cover all of Franklin County south of Short Mountain Creek and south of the Vesta coal bank in T. 8 N., R. 29 W. These higher rocks are likewise exposed over a comparatively small area northeast of Ozark. They form what is called the Philpott coal basin, which extends from Moomaw's coal bank eastward (and a little northward) for about 16 miles. These uppermost formations include many beds of shale and also the coal beds of the upper productive part of the coal-bearing rocks and the fire clays associated with the coal beds.

CLAY DEPOSITS.

CLAY SHALES.

Unfortunately only one analysis has been made of a sample of clay from Franklin County, but it seems safe to infer that the analyses of the shales of White, Pulaski, Johnson, and Sebastian counties give a good idea of the character of the clays and clay shales of Franklin County.

It seems probable that the fire clays and the clay shales of Franklin County that show rather high refractoriness are capable of being extensively utilized. The following three exposures along the railroad near Ozark were noted by Mr. Kennedy:

In the SE. ¼ SW. ¼ sec. 12, T. 10 N., R. 26 W., a bed of fire clay 4 feet thick underlies 2 inches of broken coal and overlies the black shales exposed in the water courses of this district. About 2 miles east of Ozark, in the NW. ¼ sec. 8, T. 9 N., R. 26 W., in a cut on the track of the St. Louis, Iron Mountain and Southern Railway, there is an outcrop of fire clay 20 inches thick lying immediately beneath 3 inches of coal. The section exposed is as follows:

Section in railroad cut 2 miles east of Ozark.

	Ft.	in.
Flaggy sandstones	4	
Coal		3
Fire clay	1	8
Arenaceous shales and thin sandstone at the base.		

Analysis of clay from railroad cut 2 miles east of Ozark.

[Brackett & Smith, analysts.]

Silica (SiO_2)	62.92
Alumina (Al_2O_3)	23.60
Ferric oxide (Fe_2O_3)	3.17
Lime (CaO)	.23
Magnesia (MgO)	.57
Potash (K_2O) / Soda (Na_2O) (by difference)	3.77
Loss on ignition (H_2O)	6.74
	100.00
Water at 110°–115° C.	2.65

On the same railroad at the end of an embankment in the NE. ¼ NE. ¼ sec. 7, T. 9 N., R. 26 W., a small stream cuts through a bed of blue and yellow shales 8 feet thick. These shales are readily disintegrated by atmospheric action and are almost free from sand. They are overlain by a bed of sandstone about 1 foot thick.

In the SE. ¼ SE. ¼ sec. 6, T. 9 N., R. 26 W., the following section is exposed on a small stream:

Section on stream in sec. 6, T. 9 N., R. 26 W.

	Ft.	in.
Thin-bedded gray sandstones	4	3
Light-grayish blue clay		2
Coal		6
Dark-blue clay		2
Soft black argillaceous shales	5	

The black shales of this section are very friable and easily ground into a paste.

About 3 miles east of Ozark, in the NE. ¼ SE. ¼ sec. 8, T. 9 N., R. 26 W., the railroad cutting has been carried through a bed of white

siliceous clay from 4 to 6 feet deep and about 140 yards long. When dry, this clay is white, but becomes bluish when wet. At both ends of the bank the clay loses its whitish color and becomes various shades of red.

RESIDUAL CLAYS.

It has already been pointed out in the chapter on the general geology of the State that the rocks of the coal regions of Arkansas which underlie the surface in Franklin County consist chiefly of alternate beds of sandstone, shale, fire clay, and coal. When argillaceous shales are exposed for a long time to weathering, they disintegrate so completely that they form plastic clays available for the manufacture of pottery, sewer pipes, paving bricks, etc. All the plastic clays found among the hills of Franklin and adjoining counties, especially those found in the upland valleys, have been formed in this way. These rocks were originally deposited as horizontal beds of sediments; but in Franklin County they have been pressed into gentle folds and worn away by erosion until they must be regarded as only the badly mutilated remains of the original deposits. But in spite of this folding and erosion and in spite of the talus of loose fragments and earth that cover the outcrops the beds may be readily traced by means of the geologic structure.

Only a few localities at which potter's clays have been found and worked will be mentioned here, but these clays can be found in abundance in Franklin County if a demand for them should arise.

On the Ozark-Kingston road, running east and west along the south side of sec. 20, T. 10 N., R. 26 W., blue and red shales of Carboniferous age appear in a ditch entering from the creek near the schoolhouse to the lane that turns north along the middle of the same section. These shales appear to be about 6 feet thick. About 30 paces farther north along this lane, in a small artificial opening, they are seen to have disintegrated into a light-blue clay, 3 feet of which is exposed at this place.

A clay or disintegrating shale, which appears to be the continuation of the shales last mentioned, occurs in the N. ½ NE. ¼ NE. ¼ sec. 29, T. 10 N., R. 26 W., as well as in the NW. ¼ NE. ¼ sec. 29 and the NW. ¼ NE. ¼ sec. 28.

TRANSPORTED CLAYS.

At Webb City, in the NE. ¼ NE. ¼ sec. 11, T. 9 N., R. 27 W., a bed of pottery clay is exposed in a ditch along the Ozark-Caulksville road. This clay is almost white, is mottled with small streaks of red, and where exposed has a thickness of 2 feet. Being of Pleistocene age and forming a horizontal bed, it probably has a considerable areal extent. The bed is covered with the usual waterworn cherty gravel

and overlies gravelly red clay, which rests unconformably on black Carboniferous shales. The section at this exposure is as follows:

Section at Webb City.

	Feet.
Watertown gravel	2
Pottery clay streaked with red	2
Gravelly red clay	2
Black shales at base.	

The upper gravel of this section is only 2 feet thick where the clay is exposed, but on the hillside south of this exposure it is probably from 15 to 20 feet thick.

BRICK CLAYS.

Enormous quantities of good brick clays lie in the second bottoms of Arkansas River south of Altus, extending eastward along the river as far as the mouth of Horsehead Creek. At some places, as on the road from Altus to Roseville, these brick clays are from 20 to 30 feet thick. The bricks made from these clays are gray in color and spotted with iron.

The area of brick earths around Ozark is limited to a small portion of the NW. ¼ sec. 36, NE. ¼ sec. 35, SW. ¼ sec. 25, and SW. ¼ sec. 26, T. 10 N., R. 27 W.

No bricks have been made at Ozark for several years. The last were made by W. A. Jennings in 1886.

About 1 mile north of the Roseville ferry, near the center of sec. 33, T. 9 N., R. 26 W., the Altus-Roseville road crosses a terrace of reddish; sandy, horizontally bedded clays similar to those of the terraces at Argenta and Fort Smith. At this locality the terrace is about 25 feet high. It may be traced for about 300 yards east of the road to a point where it is cut off by a small stream, and for about 100 yards west of the road. The clay is the same as that used for the manufacture of building bricks at Pendle & Morrison's yards in Fort Smith and at Argenta.

This terrace can no doubt be traced, at about the same elevation, from 50 to 75 feet above the river, for long distances on both sides of the river bottoms, though in many places it has been entirely removed by erosion.

At the church in the southwest corner of the SW. ¼ SE. ¼ sec. 28, T. 9 N., R. 26 W., a well about 30 feet deep shows a surface of yellow sandy clay or loam, while the materials brought up in cleaning show the bottom to be whitish gravels stained with iron.

Near the south line of the section in the SW. ¼ SE. ¼ sec. 21, T. 9 N., R. 26 W., a well 21 feet deep has the following section:

Section in well in sec. 21, T. 9 N., R. 26 W.

	Feet.
Yellow sandy clay or loam	3
Sticky yellow clay	18
Black shale at bottom.	

Some small patches of brick earth occur close to Altus. These vary in extent from 1 to 10 acres. No bricks have been made here for several years.

The following is a section at Altus station, on the St. Louis, Iron Mountain and Southern Railway:

Section at Altus station.

	Feet.
Reddish-brown clay	3
Yellow clay	2
Whitish-yellow clay, visible	1

The colors seem to be the only distinguishing features, as each of the three divisions contains pebbles and their texture is otherwise alike.

In the N. ½ SE. ¼ sec. 16, T. 9 N., R. 26 W., the road passes a band of red sandy clay. It lies upon the slope of a hill, facing north. It is about 150 yards across, but its depth is not known.

At several places around Altus there are disintegrated blue argillaceous shales. On the Roseville and Altus road these shales are among red and blue shales and thin beds of sandstone close to George Page's house, in the SW. ¼ NE. ¼ sec. 2, T. 9 N., R. 26 W., and also in a ditch at a corresponding level in the NE. ¼ SE. ¼ sec. 16.

CLAY INDUSTRY.

In the NE. ¼ NE. ¼ sec. 20, T. 10 N., R. 26 W., J. M. Van Curom at one time manufactured coarse earthenware. The material used was a partially disintegrated red and light-blue argillaceous shale, from 18 inches to 4 feet in thickness, which occurs on the tops of the hills near by. The shale is overlain by a thin layer of gravel, and owing to the difficulty of separating the two the material used in this pottery contained a considerable quantity of small pebbles, which, with the appliances employed, the owner of the shop was not able to remove entirely. The red color of this material is so marked that even when ready for burning the ware has a light-red color.

Only the commonest classes of ware used in the neighborhood, such as churns, jugs, crocks, and jars, were manufactured. A small quantity of 6-inch piping was also made, for chimney flues.

The slip used for glazing was the ordinary black or Albany glaze. The kiln was not suitable for salt glazing. Owing to the general roughness of the ware a great amount of slip was used, leaving a rough surface streaked with slip in different stages of fusion. The construction of the kiln also allowed ashes to settle on the hot ware, where it became fixed by the glazing, thus adding to the roughness of the surface.

The fuel used in this kiln was mostly oak wood, but coal was also used.

These shales make a coarse but strong ware, the loss by firing and drying being about 2 per cent. If they were properly crushed, ground, and screened, there is little doubt that good, strong sewer pipe might be manufactured from them.

GARLAND COUNTY.

About Hot Springs are many beds of argillaceous shales, which in places are decayed to soft, plastic clays. At the spring just below the old Hale bathhouse some of these shales are light colored and have decayed to a buff or dirty cream-colored clay, while the darker shales form on decay a very black, sticky mud.

Where the cut is made for the Government reservoir at the south side of the reservation, the rocks cut are black shales on the south and sandstones on the north. Both shales and sandstones are traversed by numerous quartz veins, and even where the shales have decayed and formed a soft, plastic clay broken quartz veins may be seen. These decomposed beds are injured for practical use by the presence of these small decayed quartz veins, which now remain as strings of angular quartz fragments.

These shales belong with the overlying rocks and are well above the novaculites, which end with the Garland conglomerate bed shown in the quarries on both sides of the avenue above the Hotel Arlington.

No clay industry of any kind is at present carried on in Garland County.

A peculiar form of kaolinite to which the name rectorite[a] has been given is found in Garland County in sec. 27, T. 2 N., R. 19 W. This material is tough and leathery, but it has the smooth, soapy feel so characteristic of the kaolins and of steatite. It occurs in association with the Ordovician sandstones of the region, but the deposits, so far as known, are only about a foot thick.

Analyses of rectorite from Garland County.

[R. N. Brackett, analyst.]

	1.	2.
Silica (SiO_2)	52.72	52.88
Alumina (Al_2O_3)	36.60	35.51
Iron (Fe_2O_3) (one determination)	.25	.25
Lime (CaO) (one determination)	.45	.45
Magnesia (MgO) (one determination)	.51	.51
Potash (K_2O) (one determination)	.26	.26
Soda (Na_2O) (one determination)	2.83	2.83
Loss on ignition	7.76	7.72
	101.38	100.41
Water at 110° C.	8.78	8.33

Rectorite as it comes from the ground ranges in color from pure white to reddish brown. The sheets are very flexible but entirely

[a] In honor of E. W. Rector, of Hot Springs, who originated the Geological Survey of Arkansas.

without elasticity. It is infusible before the blowpipe, but when heated in the flame of a Bunsen burner it loses water and becomes brittle. Specimens of this kaolinite were sent to ceramic works to be tested practically, and the following report was made on the results by Homer Laughlin, of East Liverpool, Ohio:

> The sample of what you call kaolinite sent me was duly received and carefully examined and tested under fire. The mineral is neither kaolin nor kaolinite, but just what it should be called I am unable to say, never in all my experience having seen any mineral of its kind. Unlike kaolin, it will not dissolve in water. It burns a white color and becomes very vitreous and strong. It can not be finished with a smooth face or skin, but roughs up like a blotting pad. It is certainly a very interesting and curious mineral, but I can think of no use for it in ceramic manufacture unless it could, after careful experiments, be made into novel ornaments.

Samples were also sent to Oliphant & Co., of the Delaware Pottery, at Trenton, N. J., but they were unable to say anything of its quality or market value.

Although rectorite is not now known to have any practical commercial value, it is mentioned here as of scientific interest and of possible future importance.[a]

GRANT COUNTY.[b]

Grant County is almost entirely within the area of the "Lignitic" (Tertiary). The surface is such as is characteristically found in the Tertiary area of this State, being a rolling surface, broken in the vicinity of the larger streams. The soils are sandy and thin on the uplands, while the higher ridges exhibit abundant novaculite gravels, at many places rudely stratified and everywhere small.

The divides are in many places wide and flat, or filled with a series of broad depressions which constitute sandy "slashes." All support a heavy growth of large and fine pine. The bottom lands are characteristically wet and clayey. They support an abundant growth of large white oak, red oak, and gum, with scattered groves of holly.

The general stratigraphy here given is the result of composite sections made up from well records and from sections in gullies and cuts made by streams. Near the mouths of the deeper ravines a sandy clay lies at the base of the hills.

The members of the Eocene (Tertiary) form a considerable portion of the surface of this county. As is well known, these members are largely arenaceous, with an admixture of thin clays of varying colors. Commonly these clays are erratically distributed in the form of small lenticular pockets. The pockets are disposed without observable vertical order, but appear to be most common near the top of the series. Their color is nearly everywhere drab to white, but at

[a] A mineralogical description of rectorite was published by R. N. Brackett and J. F. Williams in Am. Jour. Sci., 3d ser., vol. 42, 1891, pp. 16-21.

[b] The notes on Grant County were taken chiefly by R. E. Call and C. E. Siebenthal.

some places, especially where heavy beds of sand are superimposed upon them, it is some shade of red.

In the NW. ¼ SE. ¼ sec. 35, T. 4 S., R. 15 W., near the mouth of a small tributary of Saline River, there is a bed of light-drab and fine-grained fire clay, underlying a 2-foot bed of lignite. The clay is exposed for about 2½ feet, but its total thickness is not known. The locality is difficult of access and at present without transportation facilities.

The lignite found at this locality has been tried in blacksmiths' forges at Sheridan with indifferent success. Several sacks of it were taken to that village and burned in grates; it is reported to have burned well. On exposure it falls to pieces, eventually becoming a coarse powder, which circumstance would prevent its general use for fuel were it otherwise suitable.

A tough, plastic, gray clay outcrops on E. G. Davis's place, in the SW. ¼ NW. ¼ sec. 25, T. 6 S., R. 15 W. A well 300 yards west and about 25 feet higher went through 25 feet of sand. The well at the gin in Sandy Springs, which is about 400 yards south of the first well, showed from 8 to 10 feet of white sand. The road for 1½ miles southwest of Sandy Springs shows red sand but no gravel. At one place the sand much resembles chocolate clay.

About 20 feet of a dark sandy clay outcrops in a stream bank in the SW. ¼ NW. ¼ sec. 31, T. 6 S., R. 14 W.

Stephen Heard's well, near the northwest corner of the SW. ¼ sec. 31, T. 6 S., R. 15 W., shows the following section:

Section of Stephen Heard's well.

	Feet.
Red clay	15
Potter's clay	7
Red clay	8
White gravel (some bowlders as large as a man's head)	5
Clays of different colors, the lowermost containing leaf impressions.	31
White sand	3
	69

Plastic clay is reported near the southwest corner of sec. 18, T. 6 S., R. 15 W.; also on the Davis farm, near the center of sec. 10, in same township. A very white plastic clay is reported to occur in same township near the schoolhouse in sec. 9, about the middle of the west side, on a small drain flowing into Brushy Creek.

Plastic gray clay outcrops in the NW. ¼ NW. ¼ sec. 31, same township, in a drain flowing south in Gum Bottom. Similar clay which has been used for pottery outcrops in drains and is exposed on the breaks of the hills farther east all along the north side of Gum Bottom.

Section of well at Sheridan.

	Feet.
Light sandy soil with abundant novaculite pebbles; occasionally clayey	3
Small, waterworn novaculite gravels, with much purplish quartzite; rudely cross-bedded and stratified	13
White sand, with lenticular pockets of drab, red, or yellow clay; pebbles rare toward the top	43
Blue to black horizontally stratified clay, containing in its partings abundant lignite particles and mica scales. Well sections commonly end in this member, which has at no point been penetrated, at 8 to 10 feet below the top.	

In the roads from Benton to Sheridan and from Sheridan to Pine Bluff, near the top of every hill which is crossed, there are thin layers of a red or yellow ocherous clay which has nowhere been found in heavy beds. The same clays are found on the faces of the higher bluffs near all the streams and form a conspicuous feature of all the deeper washes.

Limonitic or buckshot brick clays similar to those used at Malvern occur in the bottoms of all the streams, especially in those of Lost, Hurricane, and Darysaw creeks, and in that of Saline River. The distribution of these limonitic clays is well defined. They skirt the bases of all the hills and extend over the bottoms of all the creeks and deep branches, forming the roadbed in all such localities. The cold and wet character of the bottom lands is due to their presence, for water does not readily percolate through them. Throughout the bottom lands they rise here and there to the surface in barren patches. A map of the region including the river and creek bottoms would be a map showing the distribution of the limonitic hardpan or buckshot clays.

The pine flats or pine slashes of the higher lands are of a sandy, drab-colored clay, which is used locally for building chimneys. In one place, at Sheridan, it has been employed in the manufacture of rough bricks. The clay is not well suited to this use, containing too much sand, too little iron, and burning to a poor color. The jail at Sheridan is built of bricks made from this clay—the only kiln of brick known to have been made in the county.

The region along Saline River, especially at the base of the bluffs, gives most promise of exhibiting deposits of fire and pottery clays, this region being the one that best exposes the deeper lying Tertiary clays.

At numerous localities throughout Grant County, and notably in the SW. ¼ SW. ¼ sec. 11, T. 5 S., R. 13 W., there is a highly ferruginous sandstone at places attaining a thickness of 1 foot. This rock occurs commonly well up on the sides of the hills and not infrequently caps their summits. In other localities the gravels are conglomerated,

or cemented, with iron oxides, and may be removed in large masses from the hills. Both sorts are locally used for underpinning houses and barns, and occasionally for building chimneys. In a region where other hard rock is entirely wanting, these beds appear to be very valuable for both these uses.

The water from the wells has a bitter saline taste, due possibly to epsom salts (magnesium sulphate) or to sulphate of iron. Only water coming from the numerous springs along the contact line between the gravels and the underlying clays or clayey sands appears to be free from this bitter taste.

It is believed that the beds underlying the surface members are equivalent to those at Camden.

No plant of any kind in the county is engaged in the manufacture of brick or other clay products.

GREENE COUNTY.

GENERAL GEOLOGY.

Greene County is divided into three natural topographic provinces—the St. Francis River sunken lands on the east, Crowleys Ridge in the center, and the Cache River bottoms on the west.

The St. Louis, Iron Mountain and Southern Railway from Jonesboro to Piggot runs along the second bottom land on the east side of Crowleys Ridge. The second bottom land is formed of reworked material derived from Crowleys Ridge. It is a yellow-clay soil, well adapted to the cultivation of wheat and corn. At Paragould the yellow-clay land extends about 2 miles eastward from the foot of the ridge.

East of the yellow-clay second bottom land comes a narrow band of glady clay soil which extends eastward for about 2 miles. The clay that forms this strip is a white to gray joint clay or pipe clay, which is very tough when wet but pulverizes completely when turned by the plow and exposed to the sun and rain. In texture the soil is very similar to that of the second bottom to the west.

The western edge of the white glady land marks the western limit of high water of St. Francis River. Until recent years backwater from the river would stand on the land until the iron oxide had been leached out so as to leave the soil cold and lifeless. Where the land has been drained and the water kept from standing on it, the soil within three to four years assumes a brown to yellowish color and becomes more productive.

The soil of the country east of the glade land is composed of fine silt and sand. The sandy land stands 8 to 10 feet lower than the white glady land to the west.

The Tertiary rarely appears at the surface along the eastern edge of Crowleys Ridge in Greene County, but is covered by later deposits,

consisting of Lafayette gravel and sand and loess. In one of the wells at Paragould the Tertiary was encountered below 20 feet of yellow clay and about the same thickness of iron-stained gravel (Lafayette).

On the western edge of the ridge the Tertiary sands, interstratified with variegated clays, occur at various places along the steep and in places almost vertical cliffs.

The hard quartzose sandstone ledges which are found at the foot and on the sides of the ridge near the railroad, in the northwestern part of Craighead County, outcrop in no less than five localities in Greene County. One occurs on the line between Greene and Craighead counties, one near Walcott, one near Crowley, one west and another northwest of Gainesville, and still another is reported 3 miles west of Paragould. At each place the sandstone is similar in appearance to the Tallahatta of central Mississippi, but its exact age is as yet unknown.

Buckshot clay lands and the sandy bottom land of Cache River bottom occupy the country to the west of Crowleys Ridge.

CLAY INDUSTRY.

The only clay used in the county for other than agricultural purposes is the loess and reworked loess used in the manufacture of bricks at Paragould and Gainesville. A sample was taken from the loess at the village of Gainesville, where it is employed in the manufacture of bricks. It is hardly a typical loess, but it is closely allied to it.

Analysis of loess used for brickmaking at Gainesville.

[Dried at 110°–115° C. Brackett & Smith, analysts.]

Silica (SiO_2)	81.34
Alumina (Al_2O_3)	9.71
Ferric oxide (Fe_2O_3)	3.67
Lime (CaO)	.29
Magnesia (MgO)	.33
Manganese (MnO)	Trace.
Alkalies, by difference	1.55
Loss on ignition	3.11
	100.00
Air-dried sand in air-dried specimen	35.00

The deposits from which this sample came lie on the slope of a hill, the base of which is composed entirely of Tertiary partly colored sands. Except for the small percentage of sand in the air-dried specimen and the greater oxidation of the iron this soil does not differ materially from typical loess.

The bricks from the plant of the Paragould Brick Company are made from the reworked loess. Dry-pressed and wet-mud bricks are

made. The clay for the wet-mud bricks is tempered and molded by steam, dried in covered racks, and burned in updraft clamp kilns. It requires about seven days for drying and fourteen days for burning. Wood is used for fuel.

Two kinds of clay are present in the pit. The upper, porous yellow stratum is best adapted for making brick. The lower stratum is a compact, plastic gray clay which can not be used for brick without being mixed with the overlying yellow clay. When used alone it checks badly in drying. The wet-mud machine has a capacity of 20,000 bricks a day.

The clay for the dry press is stored in a dry shed for several weeks and is then molded into bricks and set in an updraft kiln. It requires about seventeen days to burn the dry-press bricks. The machine has a capacity of 15,000 bricks a day. About 50 per cent of the bricks made at Paragould are sold at the kiln; the remainder are shipped to neighboring towns.

The following analysis was made from the reworked product of the loess at Paragould:

Analysis of brick earth from the surface at Paragould.

[Dried at 110°–115° C. Brackett & Smith, analysts.]

Silica (SiO_2)	79.07
Alumina (Al_2O_3)	8.79
Iron (Fe_2O_3)	2.54
Lime (CaO), Magnesia (MgO), Alkalies (by difference)	2.37
Manganese (MnO)	3.68
Loss on ignition	3.55
	100.00
Air-dried sand in air-dried clay	43.64

The percentage of iron found in analyses of Greene County clays is commonly sufficient to give the bricks a deep shade of red. In analyses of clay from Paragould only a trace of manganese appears. The red color of bricks made from loess clays, therefore, seems to be due to the iron alone. To get brown colors it will be necessary to add manganese-bearing clay. Lime and other alkalies form an inconsiderable portion of the whole clay. From these loess soils the best quality of pressed brick may be made. This has already been practically demonstrated at many places along the upper Mississippi River.

HEMPSTEAD COUNTY.

GENERAL GEOLOGY.

In its general features the geology of Hempstead County is very simple. The rocks of the northern part of the county are upper Cretaceous, while those of its southern part are Tertiary. The upper Cretaceous rocks are covered with great beds of waterworn material—cobblestones, pebbles, and sand. This gravel is especially abundant about Bingen and between Nashville and Hickory Creek.

The line of juncture between the Cretaceous and the "Lignitic" (Tertiary) where the latter overlaps the former enters the county at a point northeast of Hope, south of the railroad, and, following a generally southwest direction, crosses Bois d'Arc Creek about 4 miles southeast of Fulton. South of this line everything in the county is Tertiary, except, of course, the alluvial flood plains of the streams and the occasional patches of Pleistocene materials. The Cretaceous, however, dips to the southeast beneath the Tertiary, and deep wells sunk in any part of the Tertiary region must sooner or later strike the Cretaceous rocks. As elsewhere in the State, the Tertiary beds are mostly soft and are disposed in horizontal or nearly horizontal strata. The whole of this Tertiary part of the county has been more or less denuded, but in some places the streams have cut out the beds to make the valleys, leaving the remnants of these beds in the hilltops, where they are covered with a thin coating of sand, gravel, and loam.

CLAY DEPOSITS.

In southern Hempstead County, as elsewhere in the Tertiary regions, pottery clays are found in patches. This fragmentary nature of the pottery clay deposits may be due either to the original pockety nature of the sediments or to subsequent erosion, which has removed a great part of the original clay beds. In prospecting to determine the extent of known deposits these points should be determined first and prospecting carried on accordingly.

The pottery clay deposits of Hempstead County, so far as they have been practically tested, are best known in the neighborhood of Spring Hill, a town about 6 miles south of Hope, and in T. 13 S., R. 24 W., 4 miles south of Hope.

CLAY INDUSTRY.

Foley pottery.—There was formerly a small pottery 4 miles south of Hope, operated by John Foley. The clay was obtained from a bank opened in the NW. ¼ SE. ¼ sec. 18, T. 13 S., R. 24 W. The clay deposit is about 150 yards in diameter, as shown by test pits, and aggregates 14 feet in thickness. It is divided into two beds, an

upper one, 4 feet thick, of a clay that is of bluish color when wet, but nearly white when dry. This bed contains seams of indurated or slaty clay, so hard as to require grinding. The lower bed of clay is 10 feet thick, and when wet is of a pinkish hue. It contains some iron stains and weathers to a yellowish color.

The upper one of these clay beds was used for the manufacture of flower pots and the various classes of pottery demanded in the district. The lower bed was used exclusively for making fire bricks. Bricks made from this clay are light and porous, and are of a cream color. To render the clay porous enough for brick manufacturing sawdust was mixed with it before molding.

Analyses of the clays used by Mr. Foley in the manufacture of pottery and fire bricks are given below. Each specimen analyzed was dried at 110°–115° C.

Analyses of clays from beds near Hope.

[Brackett & Smith, analysts.]

	1.	2.	3.
Silica (SiO_2)	76.33	73.87	72.48
Alumina (Al_2O_3)	16.04	17.38	18.24
Ferric oxide (Fe_2O_3)	1.24	1.64	1.52
Lime (CaO)	.99	1.46	1.98
Magnesia (MgO)			
Potash (K_2O)			
Soda (Na_2O)			
Loss on ignition (H_2O)	5.40	5.65	5.78
	100.00	100.00	100.00
Sand	13.00	.....	3.62
Water at 110°–115° C.	2.23	1.92	1.69

Other clays suitable for the manufacture of fire brick may be found within a short distance of the Foley pit.

Spring Hill pottery.—Before the civil war a small pottery was operated at Spring Hill, where several beds of clay are available for pottery.

At present (1906) a pottery is operated near Spring Hill by Michael Foley. Tertiary clays, such as those used at Texarkana and Benton, are used for the manufacture of jug ware, crocks, and churns.

Hope brick works.—A large brick plant was established at Hope in 1904 by Messrs. R. E. and N. P. O'Neal. Common building bricks are made. The bricks are molded by steam in a Hercules Senior machine, dried by the pallet and rack system, and burned in updraft clamp kilns. The length of time required for drying depends on the weather. About ten days are necessary for burning. The fuel used is wood. Three kilns are used. The bricks are made from the surface clay. The plant has an output of 32,000 bricks a day.

HOT SPRING COUNTY.

GENERAL GEOLOGY.

The Tertiary border enters Hot Spring County from the northeast, in Saline Township, and crossing the Hot Spring Railroad a mile south of Butterfield and Ouachita River at Rockport, passes into Clark County a few miles above the mouth of Bayou de Roche. To the south and east of this line lie the nearly horizontal Tertiary beds, while to the north and west the county is mountainous and the Paleozoic rocks are much folded, broken, and eroded. Though it is not impossible that pottery clays may be found among the disintegrated shales of the hilly regions, the Tertiary is eminently the region of pottery clays, not only in Hot Spring County, but in the whole State of Arkansas.

The Tertiary formations have been denuded in Hot Spring County, as elsewhere, so that the uppermost beds, being deeply scored by gullies, ravines, and valleys, are more or less fragmentary. Where the pottery clay beds belong with this uppermost group they have been exposed in the sides of the hills, but their margins have been covered and concealed by the less soluble and less portable remains of the overlying beds and by waterworn materials of Pleistocene age. The structure of the region is thus obscured in spite of its great simplicity, and for this reason the pottery clays have been found only where they happen to be uncovered by some natural process, as in the channel of a stream, or artificially along roadsides or in wells.

CLAY DEPOSITS.

PERLA SWITCH CLAYS.

The only place at which the Tertiary pottery clays are known to have been worked in Hot Spring County is at Perla switch, about 2 miles east of Malvern station on the St. Louis, Iron Mountain and Southern Railway. At this place Messrs. O. C. Atchison & Co. manufacture the ordinary kinds of common pottery ware, such as churns, jars, crocks, jugs, fruit jars, sewer pipes, flue linings, and fire bricks. The clay is obtained from a bank on the west side of a small stream in the NE. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 24, T. 4 S., R. 17 W.

The section on page 113 shows the relation of the pottery clays of Atchison's pit to the hill on the west and south.

The clays are covered by 3 to 5 feet of gravelly, sandy soil, the pebbles of which are principally of quartz and novaculite.

The upper part of the clay bed has occasional pockets of pebbles, formed in cavities made by the decay of roots and stumps, the upper gravel having fallen into these openings.

The light lead-colored clays forming the upper part of the clay bed merge into mottled clays below, and these in turn are followed by snuff-colored layers, while the lowest part of the bed visible is a dark-brown mucky looking clay. Fossil leaves occur only in the two lower members. If they ever existed in the upper part of the clay they have been destroyed by the action of percolating water.

The depth of this clay bed was tested with an earth auger and was found to be 30 feet. The bed is more sandy below, however, and contains some iron pyrites, which injures it for pottery making.

The light-colored upper part (10 feet) of Atchison's clay pit is used chiefly for the manufacture of pottery. This clay burns to a hard, solid body and is easily glazed with either the Seneca Falls or Albany slip clay or with salt. The lower bed, which consists of dark clay, is utilized for the manufacture of fire bricks, sawdust

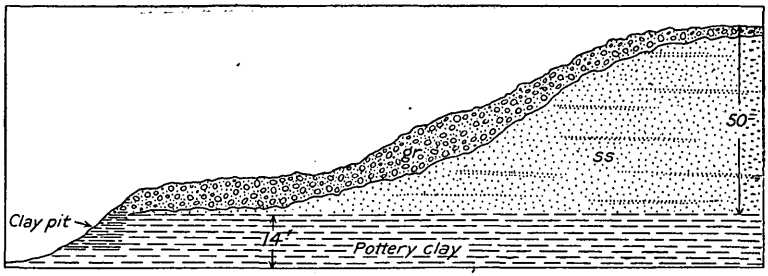

FIG. 11.—Section at Atchison's clay pit at Perla switch, Hot Spring County. *ss*, Sandstone; *gr*, gravel.

being mixed with the clay to give the bricks the necessary texture and porosity. This clay burns to a light-cream color and the ware has a remarkable bell-like, metallic ring.

Analyses of clays from Perla switch.

[Brackett & Smith, analysts.]

	Light-colored pottery clay.	Dark-colored brick clay.
Silica (SiO_2)	73.24	72.59
Alumina (Al_2O_3)	19.61	16.08
Iron (ferric) oxide (Fe_2O_3)	1.04	1.18
Lime (CaO), Magnesia (MgO), Potash (K_2O), Soda (Na_2O) (by difference)	.78	3.81
Water (H_2O)	5.33	6.34
	100.00	100.00
Water at 110°-115° C	2.01	2.08
Fine white sand	5.40	.....

On John Wilkerson's land in the N. ½ NE. ¼ sec. 35, T. 4 S., R. 17 W., there is a deposit of light-colored pottery clay from which the

Atchison Company formerly obtained its supply. This clay has been recently tested for fire bricks by the Clark Pressed Brick Company, of Malvern. It is thought that it will prove of excellent quality for this purpose.

OTHER CLAYS.

The topography of the country about Perla switch and the disposition of the Tertiary beds lead to the belief that the pottery clays found at the Perla pits may also be found on the northwest side of the railroad. Similar beds may reasonably be looked for on both sides of the railroad at Traskwood, and along the line of hills northwest of the road. These clays, however, may vary locally somewhat, both in character and in thickness, here disappearing altogether and there forming thick pockets, but are probably rather constant in geologic position.

The gravel and sand covered ridge south of Malvern is of the same geologic structure as that at Perla switch, and similar pottery clays might reasonably be expected almost anywhere in that region.

West of the ridge on which Malvern stands a dark clay containing more or less lignite is found in wells. The following is the record of a well in sec. 22, T. 4 S., R. 17 W.

Section in well west of Malvern.

	Feet.
Gravel	12
White clayey gravel	2
Black lignitic clay	13
	27

The black clay was not completely penetrated in this well, and its thickness is not known. The bed may be the equivalent of the beds worked at Perla switch. The same bed has been found in other wells in section 22.

A sample of this clay was burned with the following results:

Test of clay from sec. 22, T. 4 S., R. 17 W., showing loss on ignition.

	Feet.
Water and volatile matter	17.44
Fixed carbon	5.61
Total loss	23.05

A large bed of light-colored or white clay underlies the gravel bed in the rear of Orr's Commercial Hotel at Malvern and extends southward along the hills for several hundred feet and northward nearly across the street next east of the hotel. It varies from 6 to 8 feet in thickness, and is almost pearly white, streaked with yellow or brown—the color being produced by infiltration of iron-charged waters along cleavage joints. It is not known whether the bed has been reached in wells farther east.

The well dug for the planing mill at Rockport is said to have passed through a bed of potter's clay before reaching the fossiliferous limestone, but this clay has not been examined.

The following is the section of A. Parrish's well, near the center of the NE. ¼ sec. 7, T. 6 S., R. 17 W., as reported by Mr. Siebenthal:

Section in well of A. Parrish.

	Feet.
Red clay	1
White clay	8
Darker clay	2
Lignite	1
White clay	2

In the NE. ¼ sec. 5, T. 6 S., R. 17 W., according to Mr. Siebenthal, the Clarkson-Christopher Lumber Company's tramway cuts 20 feet of slaty-blue plastic clay which weathers very much like the olive-green clays of Little Rock. This clay contains leaf impressions. The locality is 460 feet above tide.

The following is the section record of Ford's well in the SE. ¼ sec. 33, T. 5 S., R. 17 W.:

Section of Ford's well.

	Feet.
Soil and gravel	24
Tough bluish clay	2
Sand in bottom.	

White plastic clay is reported on a small stream in the SE. ¼ sec. 3, T. 5 S., R. 17 W. Mr. Siebenthal is of the opinion that it is good potter's clay.

The following is a record of the well section at Kramer's, in sec. 19, T. 6 S., R. 17 W. This place is 430 feet above sea level (barometer):

Section of well at Kramer's.

	Feet.
Soil and gravel	10
Blue clay	15
Lignite	2
Blue clay	11
Lignite	2
Hard gray clay	2
Lignite in bottom.	

In the NE. ¼ sec. 35, T. 6 S., R. 18 W., about a quarter of a mile above Sulphur Springs, Mr. Siebenthal reports 4 feet of dark-gray clay exposed in the bank and bed of the creek. The weathered upper part of this bed is dark and is said to resemble the clay in the Perla switch beds above Malvern. It is said that some of this clay has been successfully used for manufacturing pottery. A practical test of it was made by the Rev. Mr. Clark, who burned it on the west side of the Ouachita, below Rockport.

In addition to the localities mentioned above, it is highly probable that fine pottery clays are widely distributed throughout all of that part of Hot Spring County lying south and east of the St. Louis, Iron Mountain and Southern Railway.

MAGNET COVE KAOLIN.[a]

The rocks of the Magnet Cove are largely feldspathic, and in places they are decomposed to great depths. The only kaolin found in Magnet Cove, however, occurs in a few small scattered bands and patches, while the residuary clays as a whole are full of grit, iron oxide, and incompletely decayed fragments of mica. These clays are not available for brickmaking, and even the earth used for lining chimneys is hauled from the region of sedimentary rocks outside of the cove.

A well 49 feet deep, dug at the residence of J. F. Moore, in the SW. ¼ NE. ¼ sec. 19, T. 3 S., R. 17 W., is all in eruptive rock, decayed in place, much of which is soft enough to be removed with the spade. Only very thin streaks of kaolin were found in this decayed rock.

A small deposit of kaolin is uncovered east of I. N. Johnson's house, in the southeast corner of the cove, NW. ¼ NE. ¼ sec. 29, T. 3 S., R. 17 W., and a few layers are exposed in the Hot Springs road at the west end of the cove near Thomas Holt's house, and also in his well, NE. ¼ NE. ¼ sec. 24, T. 3 S., R. 18 W.

At John Neusch's house, NW. ¼ NE. ¼ sec. 30, T. 3 S., R. 17 W., small streaks of kaolin, perhaps 2 inches wide, were found in digging a well. The earth taken from Mr. Neusch's well was examined shortly after the well was dug. The little lumps of kaolin in it are of excellent quality, but there is nothing to lead one to expect to find it in workable quantities. Afterward lumps of this kind of kaolin were sent to the office of the State survey for examination, with the report that there was an inexhaustible quantity of it, but following up this rumor it was found that the sample came from Mr. Neusch's well. None of these small deposits have any economic value. It is possible, however, that kaolin may yet be found in Magnet Cove in quantities and of a character that will render it valuable. This possibility is suggested by the nature of the rocks and by their profound decomposition.

Bringier speaks of china clay in the "Wichita" cove,[b] and Doctor Owen mentions beds of kaolin from 3 to 15 feet in thickness.[c] These reports have not been confirmed. The places referred to by Owen were "in wells dug by George Piles and Mr. Plank;" if the locations can be found it may be well worth while to verify the matter.

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[a] The geology of the Magnet Cove region is discussed in detail by Dr. J. Francis Williams in Ann. Rept. Survey Arkansas for 1890, vol. 2.

[b] Bringier, L., Am. Jour. Sci., 1st ser., vol. 3, 1821, p. 26.

[c] Owen, D. D., Second report of a geological reconnaissance of the middle and southern counties of Arkansas in 1859 and 1860, p. 162.

CLAY INDUSTRY.

Clark Pressed Brick Company, Malvern.—The plant of the Clark Pressed Brick Company is located near the main track of the St. Louis, Iron Mountain and Southern Railway, on the south side of the town of Malvern. The bricks when burned are loaded directly from the kilns into cars.

The clay used for making the brick is obtained from the second-bottom hummock of Ouachita River, about three-fourths of a mile from the kilns. A steam shovel is used in the pit for digging the clay, which is loaded into small cars. The cars are drawn to the kiln on a steel-railed tramroad by means of a small locomotive.

Through the summer and fall the common stiff-mud bricks are made, and dry-pressed brick during the winter. The clay is high in silica, burns to a deep Indian red color, and makes a durable, tough brick.

The bricks are made in an end-cut machine and dried in an artificial drier. The green bricks are then placed in large 250,000 up-draft kilns. It requires seven days for burning a kiln, using 110 tons of coal.

The plant has a capacity of 75,000 bricks a day. Forty-eight men are employed; two men in the pit, one man to run locomotive, six men in setting dried bricks in the kilns, and the remainder in feeding pug mill, carting green bricks away to drier and, when dried, to the kilns, running machinery, loading burned bricks, and firing kilns.

Malvern brick and tile works.—This plant manufactures white front, paving, and fire bricks. The white plastic clay, which is doubtless of lower Tertiary age, is used. The bricks are made in a stiff-mud machine and dried with artificial heat. The bricks are burned in round down-draft kilns.

JACKSON COUNTY.

The greater part of Jackson County lies east of White River and its principal tributary, Black River. These two rivers in this county practically mark the eastern border of the old Paleozoic rocks. The greater portion of the county is therefore in lowlands of Quaternary age. Two townships that lie directly south of Independence County are mostly in the Paleozoic area. A narrow ridge west of Depart Creek in T. 10 N., R. 4 W., contains limestone and marl bearing a fauna that belongs to the midway stage of the Tertiary. The Tertiary is recognized in but one place north of this, namely at Newark, where a bed of greensand marls has been found containing shark's teeth and some unrecognizable invertebrate fossils.

The surface of the lowland is similar to that of most of the counties in the Quaternary of this section of the State. Near the streams

there are large sand ridges of alluvial origin with a subsoil of yellow to buckshotty clay. In places these alluvial deposits extend 4 to 6 miles back from the stream. Abandoned streams can likewise be traced by old channels, with alluvial deposits extending for a greater or less distance on both sides. Some of these old channels now form lakes.

It appears that the surface of the country was originally very nearly level, with but slight depressions, sufficient to determine the location of the drainage streams. Repeated overflows carried large quantities of alluvium, which was deposited as sand ridges near the streams. The ridges farthest removed from the streams or abandoned channels are all higher than the prairie lands. The soil of the prairie lands is generally a yellowish to gray clay, in places containing more or less fine sand. The difference between the two soils is likewise marked by differences in species of virgin timber and differences in the character of crops produced. The alluvial soil is generally much more fertile than the prairie soil.

No clay products of any kind are manufactured in Jackson County. Brick clays are available at Grand Glaise, in the southwestern part of the county. The loam that forms the prairie lands back from the streams, especially in the central part of the county, could be made into common building brick. A clay subsoil that outcrops in the bank of White River at Newport is suitable for making a good building brick.

JEFFERSON COUNTY.

CLAY DEPOSITS.

The greater part of Jefferson County is covered by alluvial deposits of Arkansas River and of Bayou Bartholomew. Running along the western edge of the county, however, is a strip of the Claiborne (?) formation (Eocene), having a width of 10 or 12 miles. In the river bottoms brick clays occur here and there and in some of the slashes there are occasional patches of clay available for the manufacture of cheap grades of pottery, but the best clays of the county are in the western tier of townships. At a place called White Bluff these Tertiary beds are well exposed on Arkansas River. The accompanying section recorded at that place shows the relations of the clays to other beds.

Section at White Bluff, on Arkansas River.

	Feet.
1. Soil and sand	8
2. Light-gray sandy clay	9
3. Light-pink clay with fossil leaves	8
4. Laminated dark shaly clay	9

	Feet.
5. Dark lignitic clay with two bands of lignite	5–9
6. White sand	4–8
7. Laminated dark shaly clay	11
8. Dark-bluish sandy marl	22

Of the clays exposed [illegible] this section No. 3 is probably the most promising. They a[illegible] worth testing in any case. The nearness of these beds to wa[illegible]ansportation on Arkansas River gives them additional importan[illegible]

These beds may c[illegible]inue across the country and at other places may be found under [illegible] thinner covering than that overlying them at this place.

CLAY INDUSTRY.

Pine Bluff.—Six yards were formerly engaged in the manufacture of soft-mud bricks at Pine Bluff. The bricks were all made by hand and dried in open yards. In many instances the bricks were insufficiently dried and burned, and as a result a very common and inferior product was made. These yards have all sold out, quit business, or consolidated, and at present there are but two plants doing business in the city.

Pine Bluff Brick Company.—This plant was incorporated in 1892. Common soft-mud bricks are made. The bricks are molded by steam in a Hercules Senior machine, and dried artifically thirty-six hours in a Standard drier. Six to seven days are necessary for burning after they are thoroughly dried. They are burned in up-draft kilns, which have a capacity of 375,000 to 400,000 bricks. Wood is used for burning, about three-fourths of a cord per thousand bricks being used. The capacity of the plant is 40,000 bricks a day. The bricks are made from a sandy surface clay. Size of green bricks 2½ by 4¼ by 9 inches; shrinkage, none.

Conley brick plant.—A small brick plant is operated by J. H. Conley at Redfield, in the northwestern part of the county. The plant was established in 1898. The bricks are made from the common yellow surface clay. They are dried in the sun and burned in an up-draft kiln of 50,000 capacity. The bricks are sufficiently dried in two days to place in the kiln, and are burned in about seven days. Hard wood is used as fuel, about one-half cord being used for burning a thousand bricks. When thoroughly burned the shrinkage in a kiln 10 feet high is about 6 inches. The daily capacity of the machine is 5,000 bricks.

O'Neal & Rogers plant.—A plant has recently been established at Pine Bluff by Messrs. O'Neal & Rogers, but no particulars concerning it were obtained.

JOHNSON COUNTY.

GENERAL GEOLOGY.

The geology of Johnson County is similar in its broader features to that of Pope County to the east, of Franklin on the west, and of Logan on the south. The rocks are of the same geologic age, but there are not the same strong contrasts between the different formations that characterize either Pope or Logan County. The rocks are chiefly sandstones, shales, and coals. The lowest rocks in the county are exposed in the bottoms of the narrow valleys of the northern part of the county, on the headwaters of Mulberry River and of Little Piney Creek, and about Fort Douglas on Big Piney Creek. The rocks of the lofty mountains about Melson, Ozone, and Mount Levi, although they are much higher than those of the valleys about them, are nevertheless geologically lower than the coal-bearing beds of the Arkansas Valley about Clarksville and Coal Hill.

CLAY DEPOSITS.

CLAY SHALES.

The clays and clay shales of Johnson County that are likely to have economic value lie along the line of the Little Rock and Fort Smith Railway and along or near Arkansas River. The shales of other parts of the county are just as good intrinsically as those near transportation, but owing to the expense of getting them into market they are necessarily of less importance. For this reason but little is said here in regard to the clays and clay shales of the more remote parts of the county.

The Hartshorne sandstone bed, which forms Ouita Ridge, in Pope County, continues westward into Johnson County, forming the broad ridge east and north of Piney station. Those same sandstones continue northward through the eastern section of R. 22 W. South of Arkansas River this sandstone forms the great ridge 2 miles due south of Piney station. The Spadra shale, containing the Ouita coal bed, forms a narrow trough south of Piney station. This trough widens abruptly toward the west and north, so that the Spadra shale underlies all the country west of Piney and west and north of Knoxville for 8 miles or more. These same shales are exposed in the lower portions of the hills east and south of Clarksville, along the valley of Spadra Creek, west of the mouth of that stream to Spadra and Montana, about the base of Spadra Hill, at Hartman, and along the base of the hill just north of Hartman. Throughout this entire area of the Spadra shale clay shales available for the manufacture of paving bricks, sewer pipe, and fire-clay goods may be found, and at many places they are conveniently exposed.

These shales are at some places hard and at others are soft and plastic. Where they have not been exposed long or favorably they are liable to be hard. In places they are disintegrated to a depth varying from 1 foot to 10 feet. Where these shales are soft and plastic they may be used without grinding for the manufacture of fire bricks, stove linings, paving bricks, and sewer pipes. If the shale is not soft and plastic it can be used only after being ground.

The clays and clay shales usually accompanying the coal beds are liable to prove valuable as fire clays.

The clay underlying the coal at the Stiewell mine No. 2 at Coal Hill is hard and shaly when freshly mined but readily breaks up under the influence of the weather. When burned this clay becomes white. Its thickness is uncertain, but it is said to range from 12 to 18 inches.

At the Allister slope at Coal Hill the flooring is said to be a hard black shale, but no definite information could be obtained regarding its thickness. The waste material brought to the top contains a great quantity of black shale with plant impressions.

At Payne's mine a clay from 4 to 6 inches thick underlies the coal. The upper half inch to 4 inches is a soft, dark shale and the lower 1 to 2 inches is a soft yellow clay.

The floor of the Felker mine is a soft shale, sagger clay. It is irregular in thickness, but averages from 4 to 5 feet. In some places in the mine this clay overlies the coal to a thickness of from 2 to 4 inches.

One mile northwest of Knoxville, on the Little Rock and Fort Smith Railway, the railway grade cuts a promising-looking exposure of shales.

At Hartman station the railway has exposed the shales in a cut.

In sec. 32, T. 10 N., R. 23 W., in the bank of the stream that runs south along the east side of the road near Clarksville College, the following section is exposed:

Section in sec. 32, T. 10 N., R. 23 E.

	Ft.	in.
1. Dark-brown shale	2	
2. Disintegrated shale	1	4
3. Coal		1
4. Blue and snuff-colored shales (about)	15	
5. Black shales at the base.		

The following is an analysis of some of the clay produced by the disintegration of Nos. 1 and 2 of the above section, obtained from ditch at W. J. James's, in the southeast corner of the NW. ¼ SE. ¼ sec. 32, T. 10 N., R. 23 W.:

Analysis of distintegrated shale from sec. 32.

[Brackett & Smith, analysts.]

Silica (SiO_2)	55.36
Alumina (Al_2O_3)	26.96
Ferric oxide (Fe_2O_3)	5.12
Lime (CaO)	.30
Magnesia (MgO)	1.16
Potash (K_2O)	2.69
Soda (Na_2O)	1.03
Loss on ignition (water)	7.90
	100.52
Water at 110°–115° C	3.90

A specimen of blue clay shale overlying a 2-inch bed of coal collected by Mr. William Kennedy northwest of Clarksville in the SE. ¼ SW. ¼ sec. 31, T. 10 N., R. 23 W., has been analyzed by the Arkansas Geological Survey.

Analysis of disintegrated shale from sec. 31.

[Brackett & Smith, analysts.]

Silica (SiO_2)	51.30
Alumina (Al_2O_3)	24.69
Ferric oxide (Fe_2O_3)	10.57
Lime (CaO)	.32
Magnesia (MgO)	.63
Potash (K_2O)	2.18
Soda (Na_2O)	.72
Loss on ignition (water)	9.11
	99.52
Water at 110°–115° C	4.92

The section exposed where this specimen was taken by Mr. Kennedy is given below, and the specimen analyzed was from No. 2 of the series.

Section in SE. ¼ NW. ¼ sec. 31, T. 10 N., R. 23 W.

	Ft.	in.
1. Waterworn gravels	1	
2. Blue and yellow shales	8	
3. Coal		2
4. Blue shales with red streaks	4	
5. Black shales at base of section.		

The abundance of clays and clay shales in Johnson County and their proximity to good coal and to transportation both by railway and by water insure facilities for the extensive manufacture of paving bricks, sewer pipes, and fire-clay products.

BRICK CLAYS.[a]

So far as the Clarksville brick earths are concerned, there is but one bed that requires attention. Bricks were formerly made by W. P. Farrish in his yard north of the town, in the northeast corner of the SW. ¼ NW. ¼ sec. 32, T. 10 N., R. 23 W. These appear to be good sound bricks of a rather dark-gray color, very similar in appearance to the bricks made at Beebe and elsewhere along the Iron Mountain Railway. They hold their color well, for bricks used in buildings erected in Clarksville as long ago as 1878 still have a good color. The material from which these bricks were made is not very plentiful nor of a great extent, being confined principally to the flat tops of a few ridges. It is underlain by a lighter-colored earth containing great quantities of iron in the form of nodules ranging in size from that of a pea down to that of bird shot. This underlying material, although of excellent quality for making hard, blue bricks, can not be worked by hand in the same way as the upper clays. The iron nodules are so small that the ordinary mill or wheel will not crush them. They slip through the tempering untouched, and, although not very hard, have a tendency to tear the hands of the molder. Before this clay can be utilized it must be tempered by being passed through rollers set sufficiently close to crush the nodules completely. The clay must afterward be thoroughly mixed so as to disseminate the crushed iron throughout the mass, and thus to bring the whole to a uniform consistency and color. The bricks can then be formed either by hand molding or by machine. This clay, however, could be worked better by machine than by hand, and if such a tempering machine as the one here suggested were used an extensive area covered by this "buckshot" clay close to Clarksville station could be utilized for brickmaking.

No bricks have been made at Coal Hill and very few are used for any purpose, building stone being generally employed for chimneys or other mason work.

In the vicinity of Coal Hill an area comprising the NE. ¼ S. ½ sec. 20, the greater portion of sec. 21, the SE. ¼ and part of the SW. ¼ sec. 19, and parts of secs. 28, 29, and 30, T. 9 N., R. 25 W., are covered by a light brownish-yellow clay averaging about 2 feet in thickness. This clay contains nodules of iron, some of which are soft enough to be crushed between the fingers, and also a quantity of small sandstone pebbles. This clay rests upon soft, friable argillaceous shales having a light-gray, almost white color, streaked with black and red. The lowest shales exposed are black and friable.

Overlying the light brownish-yellow clay there are in places patches or rolls of a brown sandy loam suitable for molding sand. These

[a] Most of the notes on the brick clays of Johnson County are by William Kennedy.

patches, however, are not very thick nor of great extent. Their longer axes generally have a north-south direction.

The following section shows the relation of the clays and shales of low grounds about Coal Hill:

Section near Coal Hill.

	Feet.
Brown sandy loam	1
Brownish-yellow clay with iron nodules and small sandstone pebbles.	2
Shales with iron-stained streaks	4
Black shales at base.	

No establishments engaged in the manufacture of clay products in Johnson County are at present reported.

LAFAYETTE COUNTY.

Lafayette County lies almost wholly in the alluvial plain of Red River. The geology of these alluvial lands is as a rule less interesting than that of the higher country east and west. There is, however, a strip 6 or 8 miles wide running along the extreme eastern border of the county that has the same geology as Columbia and southern Hempstead counties, and in this region the Tertiary clays are likely to be found. In the vicinity of New Lewisville the cuts along the railroad expose no clay beds that appear to be of importance. Near Bradley station a well put down on the land of H. Smith, in the NW. $\frac{1}{4}$ sec. 13, T. 19 S., R. 25 W., has the following record:

Section near Bradley station.

	Feet.
Soil and sand	18
Red clay	9
Sand	10

About Walnut Hills are massive beds of red sand, but no clay beds were observed except bright-red ones. In the lowlands along Red River many local pockets of leached pottery clays and extensive beds of good brick clays may be found.

There are no industries of any kind in the county engaged in the manufacture of clay products.

LAWRENCE COUNTY.

GENERAL GEOLOGY.

Black River marks the boundary between the Paleozoic and Quaternary deposits of Lawrence County. The Quaternary area is a level plain having a maximum elevation of about 280 feet and a minimum of about 250 feet.

The streams all flow southwestward, roughly parallel to Black River, and narrow clay flats lie between the streams and the river. The soil adjacent to the streams is of alluvial origin, covering areas

from 1 to 3 miles wide on both sides of the streams. The interstream area is a yellow hardpan or clay. In the lower lands the clay has become leached, leaving the surface material a lifeless buckshotty clay land known as "glades." The soil is very poor and but little of it is under cultivation. Water stands on some parts of this land for several months of the year. The character of the strata found at Walnut Ridge is shown in the following well record at that place:

Well record at Walnut Ridge.

	Feet.
Yellow to white clay	16
Fine sand	4
Hardpan similar to surface stratum	6
Fine black sand	5
Red sand, coarse	5
Coarse sand and gravel down to 65 to 70 feet.	

The white clay land extends eastward from Walnut Ridge to Sedgwick, on Cache River. The country to a line within 3 or 4 miles of Cache River, is marked by a rolling surface, with an occasional abandoned water channel.

The following is the general record of the strata in wells at Sedgwick:

General section of wells in Sedgwick.

	Feet.
Soil and clay	3– 6
Hardpan	3– 5
Black sand, water bearing	25–50
Hardpan or clay	2– 3
White sand, water bearing, to 65 feet.	

Just east of Sedgwick there is an area of lowland depressed 6 to 10 feet below the general level, marking the present limits of Cache River bottom, which is about 1 mile wide.

West of Walnut Ridge the country is mostly sandy, except the clay ridge on which Portia is situated, but over all the sandy region the older clay loam appears at the surface in places and forms the subsoil beneath the alluvial sand.

The following is a section of the strata in the east bank of Black River, at Cloverbend, about 9 miles south of Powhatan:

Section in bank of Black River at Cloverbend.

	Feet.
White buckshot clay, very hard when dry	3
Reddish tinted clay, very hard when dry, becoming sandy at base.	3
Reddish stratified sand, rather fine	3
Light-colored gray sand, stratified; coarser than the above	3

The sand is said to extend down to a depth of at least 50 feet below the surface.

The country west of Black River rises 200 feet or more above the bottom lands east of the river. The rocks belong to Cambro-Ordo-

vician series, and are composed of heavy-bedded, dark-colored limestone and of sandstone which is doubtless the equivalent of the St. Peter sandstone in southwest Wisconsin and Missouri.

CLAY INDUSTRY.

In Lawrence County there is but one plant in the Quaternary area that is engaged in the manufacture of clay products. This is Moore & Co.'s brick plant at Walnut Ridge, where common soft-mud bricks are made.

The surface white clay, to a depth of 6 feet, is used for making the bricks. The clay is tempered and molded in a Monarch pug mill, dried in covered racks, and burned in up-draft kilns. It requires three to four days for drying and ten to twelve days for burning. A light fire is kept under the bricks for five to six days, and a hot fire for about the same length of time. Wood is used exclusively for fuel. The bricks are dried and burned without checking. Wheelbarrows are used to convey the green bricks from the molds to the racks and the dried bricks from the racks to the kilns The bricks have a shrinkage of about one-eighth of their volume. The output of the plant is about 1,500,000 bricks per annum. The market for the bricks is Walnut Ridge and the surrounding towns.

There are two common mud-brick plants in the hard-rock district, one at Black Rock and the other at Imboden. The clay used at Black Rock is the yellow or reddish clay, doubtless of the same age as the yellow loam that occurs on top of Crowleys Ridge. The plant at Imboden uses the residual clay of the older rocks.

LEE COUNTY.

GENERAL GEOLOGY.

Lee County is crossed near its center by Crowleys Ridge, which extends in a north-south direction. In the northern part of the county L'Anguille River has cut through Crowleys Ridge and joins St. Francis River about 6 miles southeast of Marianna. North of this L'Anguille River flows in the flat lands on the west side of the ridge and parallel to it. The eastern portion of the county is low bottom land, largely built up of deposits of St. Francis and Mississippi rivers.

The typical calcareous loess forms the top and sides of Crowleys Ridge in Lee County. On the lower slopes on the west side of the ridge there is a kind of terrace or second bottom which is several feet higher than the flat, wet lands farther west. This terrace is very regular in elevation and extends entirely along the foot of the ridge except where it has been cut away by streams. The soil of this second bottom or bench is a light brown or yellow loam, the reworked product of the loess, and is well adapted to the manufacture of bricks.

The country between Marianna and the Lonoke County line is a rolling plain cut into north-south ridges, with low, wooded depressions. The surface of many of these low ridges is a clay loam similar to the surface material on the terrace adjacent to Crowleys Ridge.

CLAY DEPOSITS.

Only one analysis has been made of the surface clays of Lee County, the sample being a reworked product of loess found at the foot of Crowleys Ridge at Marianna. The bricks made from this clay are of a deep-red color, and form a good, strong building brick.

Analysis of reworked loess soil from near Marianna, in sec. 24, T. 2 N., R. 3 E.

[Dried at 110°–115° C. R. N. Brackett, analyst.]

Silica (SiO_2)	75.46
Alumina (Al_2O_3)	10.29
Ferric oxide (Fe_2O_3)	7.07
Lime (CaO)	1.00
Magnesia (MgO)	1.36
Potash (K_2O)	.74
Soda (Na_2O)	.82
Phosphoric acid (P_2O_5)	.30
Loss on ignition	3.18
	100.22
Air-dried sand	72.40

This material is of chocolate-brown color and fills the bottoms and ravines of the region east of Marianna. It seems to be a rearranged and highly ferruginous variety of loess, agreeing with ordinary loess in all other particulars.

CLAY INDUSTRY.

A plant for the manufacture of common building brick was established in Marianna about 1890. It is at present run by O. C. Sutton & Co. The bricks are made from the red surface clay. The clay is tempered and molded in a steam machine having a capacity of 25,000 to 30,000 bricks a day. The bricks are dried by the rack and pallet system, in covered sheds. It requires about seven days to dry the bricks sufficiently for setting in the kilns. Wood is the fuel and the bricks are burned about nine days. Three up-draft clamp kilns are used. About half a cord of wood is consumed in burning a thousand bricks. The size of the bricks is $8\frac{3}{4}$ by $4\frac{1}{8}$ by $2\frac{1}{4}$.

LOGAN COUNTY.

GENERAL GEOLOGY.

The rocks of the northern half of Logan County belong to the upper coal-producing part of the Carboniferous, while those of the southern half of the county, except the top of Magazine Mountain, lie below the coal. The general geology of the county is like that of Sebastian, Franklin, Johnson, and Pope counties, and the clays and clay shales are very similar to if not identical with those of the counties named.

CLAY DEPOSITS.

CLASSES OF CLAYS.

For convenience of presentation the clays of the county may be classified as follows:

1. Carboniferous clays and clay shales associated with the coal and interbedded with the hard rocks.
2. Buckshot clays or brick loams, found in the uplands.
3. Terrace or second-bottom clays, found along Arkansas River.
4. River-bottom clays of the flood plains of the large streams.

These will be taken up in the order in which they are enumerated.

CARBONIFEROUS CLAYS AND SHALES.

Many of the clays associated with the coal beds of Logan County are fire clays. Some of these beds are only a few inches thick and of limited areal distribution, but it is to be expected that many fire-clay beds of workable thickness will be found associated with the coal. Such clays underlie the coal in the NE. ¼ NE. ¼ sec. 10, T. 7 N., R. 26 W., at the coal opening of H. M. Nichols. This clay is soft, dark blue, streaked with yellow, and only from 6 to 8 inches thick. The miners report that it is not a constant bed. At Wall's slope, in the NE. ¼ NW. ¼ sec. 15, T. 7 N., R. 26 W., a similar clay lies beneath the coal bed, but the mine being full of water, its thickness was not determined.

On the north side of the NW. ¼ NE. ¼ sec. 34, T. 8 N., R. 26 W., two beds of clay are exposed in the channel of a small stream. The upper bed is a dark-brown clay about 3 feet thick; the lower bed is of a lighter yellowish color. Only about a foot of the lower bed is exposed, but it is probably not less than 7 or 8 feet thick. The lower bed is said to have been used as a fire clay. A sample of this lower bed has been analyzed:

Analysis of clay from sec. 34, T. 8 N., R. 26 W.

[Brackett & Smith, analysts.]

Silica (SiO_2)	88.66
Alumina (Al_2O_3)	5.73
Ferric oxide (Fe_2O_3)	2.55
Lime (CaO)	Trace.
Magnesia (MgO)	Trace.
Potash and soda (K_2O, Na_2O)	.81
Loss on ignition	2.25
	100.00
Water at 110°–115° C	1.33
Sand in clay dried at 110°–115° C	17.94

Clays of this class are widely distributed over Logan County, and these examples do not fairly represent them either in thickness or importance. The Carboniferous clay shales are so abundant, so thick, and so widespread in Logan County that only a few typical areas will be mentioned.

In the southwest corner of the county the line between Logan and Scott counties crosses Jennings Hill. The alternate series of sandstones and shales forming this hill is described under the heading "Scott County." The same beds extend from Jennings Hill toward Booneville, a distance of 5 miles. The most important shale of this group underlies the town of Belva, in Scott County, but it crosses into Logan County in the NW. ¼ sec. 30, T. 5 N., R. 28 W., runs northeastward for 5 miles, and swings westward along the valley of Petit Jean Creek. This shale is 200 to 400 feet thick at Belva. Below this shale are two beds of sandstone and a thinner bed of shale, followed below by a thicker bed of shale.

A thick deposit of shale near the top of the Atoka formation covers a large area in Logan County and extends also into the adjacent counties both east and west. It ranges in thickness from 400 to nearly or quite 2,000 feet. It is generally of dark color, and although it is usually a clay shale it is at some places sandy. Starting in the southwest corner of the county near Golden City, this shale and its accompanying beds of coal form the surface rock along the upper parts of the valley of Brashy Branch and extend down Fletcher Creek toward the town of Booneville, and thence down the valley of Petit Jean Creek to Magazine. West of Booneville the same shale runs through the northern tier of sections in T. 5 N., R. 28 W., to Barber post-office. East of the town of Magazine the outcrop of this shale divides, one arm of it passing south of Magazine Mountain and underlying the northern part of the northern tier of sections across T. 5 N., R. 25 W., and the southern tier of the township just north of it. The same shale lies along the

south base of the range of mountains connecting Magazine Mountain with Mount Nebo in Yell County. Northeast of the town of Magazine these shale beds run northeastward for about 7 miles and then bend abruptly westward to the gap between Brushy Mountain and Calico Mountain. From this point they extend both east and west, with narrower outcrops. The outcrop to the east extends around the north base of Magazine Mountain and then around the base of Huckleberry Mountain, Three Knob Mountain, Spring Mountain, and Mount Nebo. Where the shale beds run around the north sides of the bases of these mountains they are either nearly horizontal or have a gentle southward dip and pass beneath the mountains, to appear again to the south of them. North of the mountains the rocks are folded, passing over an anticline and then dipping northward. The shale therefore appears again north of the anticlinal fold across the entire east-west length of Logan County.

Starting in Yell County northeast of Mount Nebo the same shale underlies Dardanelle Ridge and extends along the south side of its western continuation in Pine Ridge as far as Wildcat Mountain, around which it passes, and runs along the north side of Brushy Mountain until it joins the outcrop in the gap east of Brushy Mountain. Another area of this shale lies between the village of Prairie View and Shoal Creek Ridge, in T. 8 N., R. 24 W. It is only about 5 miles long and less than 2 miles wide. The length of the outcrop of this great body of shale in Logan County thus aggregates fully 150 miles.

In Logan County there is a shale associated with the coal found near Blaine post-office and the village of Shoal Creek and extending thence eastward in Yell County. This same shale horizon runs along the south side of Snake Ridge in T. 8 N., R. 24 W.

The shales in the rolling country at Paris and farther west, to the county line as well as farther east, about Spielersville and Ellsworth, and farther north, to Roseville, belong to an overlying series of rocks associated with the upper coal beds. On the south side of Short Mountain these shales and the coal dip northward and pass completely beneath that mountain, rising to the surface again on the north side. On the sides of Short Mountain thick beds of shales are exposed. The geology of Little Short Mountain is the same as that of Short Mountain. The rocks pass beneath it, so that these two mountains stand in synclinal folds, whose beds are largely composed of clay shales.

It is evident that the Carboniferous clay shales cover an enormous area in Logan County. Unfortunately, no practical tests have been made of these shales, but in so far as the appearance of the materials can be depended upon they are almost everywhere

available for the manufacture of paving brick, sewer pipe, and common earthenware, while many of them are true fire clays. With the exception already mentioned (pp. 128–129) no chemical analyses have been made of these clays. The analysis made, however, bears out the theory that the clays are workable, although they are not now utilized.

BUCKSHOT OR PRAIRIE CLAYS.

The clays found in the prairies are chiefly the altered edges of the shale outcrops. These clays have been used for the manufacture of building bricks, but the small iron nodules scattered through them cause the bricks to burn dark brown or spotted. The bricks are almost invariably strong and exceedingly durable, but they have not an attractive color.

In the neighborhood of Paris the clays are principally prairie soils, disintegrated blue shales, and the shales and clays associated with coal beds. Probably the most extensive of the prairie clay deposits is that of Hegwood Prairie. In the E. ½ SE. ¼ sec. 1, T. 7 N., R. 26 W., this prairie soil is yellow, contains a considerable quantity of iron nodules, and has an average depth of 2½ feet. In the NW. ¼ SE. ¼ sec. 1, T. 7 N., R. 26 W., a well 21 feet deep passes through yellow prairie soil 3 feet thick, which rests immediately on blue argillaceous shales of the coal-bearing rocks. In the NE. ¼ sec. 11 and NW. ¼ sec. 12 of the same township and range the yellow soil is somewhat deeper, but its general characteristics are the same. In the SW. ¼ SW. ¼ sec. 6 and the NW. ¼ NW. ¼ sec. 7, T. 7 N., R. 25 W., brick earths of the same yellow color are found, having an average depth of 3 feet. On the road along the south base of Short Mountain and in the SW. ¼ sec. 3, T. 7 N., R. 26 W., the blue shales appear in several places in a ditch on the south side of the road. These shales are 4 feet thick and are completely disintegrated where exposed. Similar clays occur in the valley about Booneville, in the upper bottoms of Sugar Creek, Petit Jean Creek, Revilee Creek, Shoal Creek, and other streams. None of these are utilized in Logan County.

TERRACE CLAYS ALONG ARKANSAS RIVER.

Clays similar to those found in the river terraces near Arkansas River at Fort Smith and at Argenta occur along the south side of Arkansas River in Logan County. These clays are generally sandy and of a reddish color, but wherever they have been tried they have been found available for the manufacture of fairly good building bricks. From Roseville a band of this red sandy clay forming a terrace or second bottom winds about the foothills south of the river bottoms. This terrace is crossed by the Roseville-Paris road just

south of Short Mountain Creek. The clay of this terrace is similar to that at Argenta.

Chocolate-colored plastic clays are associated with these terrace clays. Thus far no use has been found for these chocolate clays.

RIVER-BOTTOM CLAYS.

The clays of the Arkansas River bottoms are pockety and of uncertain distribution. They are not likely to be of economic importance, though some of the lenticular masses may occasionally contain pottery clays.

LONOKE COUNTY.

GENERAL GEOLOGY.

Most of Lonoke County lies within the Quaternary area of the State. The country is so flat and unbroken that there are almost no natural exposures of the rocks east of the St. Louis, Iron Mountain and Southern Railway. The extreme northwest corner of the county is in the lower Carboniferous (Mississippian). This includes, however, only the part of the county lying west of the St. Louis, Iron Mountain and Southern Railway, an area of only 55 square miles. The geology in this Paleozoic corner is an eastward continuation of that of Faulkner County. The same beds that outcrop in the southeast corner of Faulkner County pass through the Paleozoic part of Lonoke County to a point where they are overlapped by the Coastal Plain beds near the present location of the St. Louis, Iron Mountain and Southern Railway. The rocks of the lower Carboniferous here consist of alternate beds of sandstone and shales, all of them folded. The ridges through this region are usually of sandstone and run almost due east and west. The shales are parallel with the sandstones and occupy nearly all of the valleys, and in many instances they also form the lower slopes of the ridges.

The Bayou Meto anticline, starting between Preston and Mayflower, in Faulkner County, runs due east toward the town of Austin, Lonoke County, passing through the northern tier of sections of T. 4 N., R. 10 W. North of this anticline as far as Cypress Bayou the rocks all dip northward, and south of it they all dip southward as far as the Cato syncline, which passes through sec. 30, T. 4 N., R. 10 W. These dips of the rocks should be borne in mind in any attempt to utilize the clay shales of this area.

CLAY DEPOSITS.

The clay shales, like those of other parts of the State, vary considerably in character. Some of them are so sandy that it is difficult to determine whether they should be considered clayey sandstones

or sandy shales; others contain but little sand, and are sufficiently refractory to be regarded as fire clays. The shales are in places decomposed along their outcrops, but for the most part they are too hard to be pugged as they come from the ground. Analysis of some of these shales shows them to be suitable for the manufacture of paving brick, sewer pipe, fire bricks, or other refractory goods, but they will require to be pulverized.

The character and thickness of these shales, their proximity to the railroad, and the topography of the region are all favorable to the development of important clay industries in this section of Lonoke County.

In addition to the shales there are widespread beds of loam over the slashes or bottoms of Cypress Bayou, Magness Creek, and Wattensas Bayou. The loams are well adapted to the manufacture of common building bricks. In places they contain some buckshot clays, and are therefore not suitable for making high-grade finishing bricks. The bands of buckshot or iron nodules occur here and there at a depth of from 1 to 4 feet from the surface.

The wells at Austin and Cabot penetrate fossiliferous Cretaceous sediments, which outcrop in a few places west of these towns.

What has been said of the Beebe, Kensett, and West Point clays of White County is generally applicable to the clays along the railroad at and near Holland, Cabot, Austin, and Ward.

Two wells near Cabot show the presence of the light-colored clay.

At Neeley & Neeley's gin house in the village of Cabot a well 116 feet deep has the following section:

Section in well at Neeley & Neeley's gin house, Cabot.

	Feet.
Red and sandy clays	39
Calcareous clay (Cretaceous)	1
Marl (Cretaceous)	6
Carboniferous shale to the bottom of the well	70
	116

A well near the center of the NE. ¼ SW. ¼ sec. 25, T. 4 N., R. 10 W., passes through the following beds:

Section in well in sec. 25, T. 4 N., R. 10 W.

	Feet.
Soil	2
Red clay	10
Sandy clay	16
Calcareous clay (Cretaceous)	1
Marl (Cretaceous)	8
Carboniferous shale at bottom.	
	37

The clay here marked "red clay" is mottled red and gray, resembling very closely that underlying the low Quaternary country at different places.

The average well section at Lonoke, as reported by J. C. England, is as follows, the section being that of an open well:

Average section in wells at Lonoke.

	Feet.
Red clay	5– 6
White clay grading into sand	5– 6
Bluish, mucky, sticky clay.	
Quicksand, all the way from	30–45
Tough clay.	

Wells that reach to a depth of 70 to 80 feet get into gravel. A specimen of this gravel was brought to the office of the Arkansas Survey. It is composed mainly or entirely of waterworn chert pebbles, about the size of a hazelnut, and coarse quartz sand.

The average depth of bored wells at Lonoke is 70 to 85 feet. The deepest well reported is at J. C. England's place and is 107 feet deep.

CLAY INDUSTRY.

Chaplin & England's brickyard.—In the NE. ¼ SW. ¼ sec. 19, T. 2 N., R. 8 W., bricks were once made at the yard of J. P. Chaplin and E. W. England from a mixture of about 18 inches of the top yellowish prairie soil and about the same thickness of a brown iron-stained earth underlying the prairie soil. The bricks are hard and showed a tendency to melt when raised to a high temperature in the kiln. Those that were burned hard have a brown color and are very much spotted with dark, almost black marks. In bricks burned near the center of the kiln the color is a dark cherry red, the spotting is not so prominent, and in many of the bricks the spotting is not visible at all. There was not much loss on account of breaking in the burning. The bricks were machine made.

Harrison Brick Company.—This is the only plant now in operation in the town of Lonoke. It is quite likely, though it is not an assured fact, that this plant is the successor to the Chaplin & England plant. The Harrison plant was established in 1903, and is engaged in the manufacture of common building brick. It has an output of 25,000 bricks a day. The bricks are made from the red surface clay, molded in a steam machine, dried in the open air, and burned in up-draft clamp kilns. When the weather is favorable the bricks will dry sufficiently in three days to stand setting in the kiln. The bricks are burned with wood. About eight days are required to complete the burning. Two kilns are in use, each having a capacity of 175,000.

Wylie's plant.—There is also a brick plant at Cabot, on the St. Louis, Iron Mountain and Southern Railway. It is operated by I. C. Wylie. No further particulars concerning this plant were learned.

MILLER COUNTY.

GENERAL GEOLOGY.

Miller County is entirely within the Tertiary-Quaternary area. The beds everywhere penetrated by wells are Tertiary. Some of them contain marine fossils and others plant remains. Prof. William Moseley, at one time teacher at Texarkana, reports that a fossil palm was found in a well near Texarkana.

CLAY DEPOSITS.

Over the flooded regions of Miller County the soils are in some places alluvial, in others boggy slashes, and in others buckshot clays. The clays of the surface slashes are at many places leached clear of iron by the action of organic acids and carbonic acid, so that these clays are available for the manufacture of the coarser grades of pottery. This leaching, however, is a surface phenomenon, and such clays are nowhere more than 3 or 4 feet deep.

The nature of the surface, with the exceptions just mentioned, has nothing to do with the existence or nonexistence of pottery clays in the stratified beds below. The presence of such beds is seldom indicated by natural agencies in a flat region, where erosion is very slight, so that the existence, thickness, and character of clay beds must usually be determined by testing augers or pits, by digging wells, or by other artificial means.

The higher Tertiary lands about Texarkana occupy T. 15 S., R. 28 W., and a little of the adjoining territory. It is within this area, and principally in the northern tier of sections, that the pottery clays are worked. The occurrence of these clays on the north side of this higher region and the general southeastern dip of the Tertiary rocks of this area suggest that the pits now worked are at or near the northern outcrop of the Tertiary pottery clays and that these same beds dip beneath Texarkana. At what depth they lie beneath that city, however, can be determined only by ascertaining the dip of the strata.

Clay is obtained in a series of small openings in the west side of the SE. ¼ sec. 5, T. 15 S., R. 28 W.

The section exposed is as follows:

Section in sec. 5, T. 15 S., R. 28 W.

	Feet.
Iron-stained sandy clay	3
Whitish blue clay	5
Yellowish sandy clay at bottom.	

The middle bed of 5 feet is a pottery and fire-brick clay. The lower yellow sandy clay was tried for brickmaking purposes, but owing to some defect in the work rather than to the material used the attempt was unsuccessful.

The clay burns to a solid cream-colored body. It admits of both a salt and "Albany slip" glaze. Fire bricks made from this clay are of a light color.

The following are the analyses of these clays:

Analyses of clays from sec. 5, T. 15 S., R. 28 W.

[Sample dried at 110°–115° C.]

	Sandy clay at the bottom.	White clay used for pottery.
Silica (SiO_2)	74.76	75.99
Alumina (Al_2O_3)	13.96	16.12
Ferric oxide (Fe_2O_3)	3.44	1.35
Lime (CaO)	.51	1.45
Magnesia (MgO)	1.10	
Potash (K_2O)	2.28	
Soda (Na_2O)		
Loss (H_2O)	3.95	5.09
	100.00	100.00
Sand in air-dried specimen	3.33	.75
Water at 110°–115° C.		1.08

CLAY INDUSTRY.

Kind of clay used.—There are two brick plants and one stoneware pottery in Miller County. The clay used for the manufacture of fire brick and stoneware comes from the Tertiary clays, which are doubtless of the same age as those used at the Benton pottery, situated in sec. 9, T. 15 S., R. 28 W. In one of the pits clay was formerly obtained for the manufacture of stoneware. A sample of clay from this pit was analyzed:

Analysis of clay from sec. 9, T. 15 S., R. 28 W.

Silica (SiO_2)	74.85
Alumina (Al_2O_3)	17.20
Ferric oxide (Fe_2O_3)	1.12
Magnesia (MgO)	1.13
Loss on ignition	5.70
	100.00
Sand in air-dried specimen	3.44
Water at 110°–115° C.	1.53

Texarkana Brick Company.—At the plant of the Texarkana Brick Company, established in 1902, dry-pressed bricks are made from a semishale or clay. These bricks are molded in a Boyd dry-press machine and burned in up-draft clamp kilns. Five kilns are in use, each of which is 23 by 59 by 14 feet, inside measurements. Wood and oil are used for burning. The bricks are water-smoked for about ten days without wood and then a hot fire is kept up for about ninety hours. Oil is used for making the hot fire. The size of the green bricks is $8\frac{7}{8}$ by $2\frac{3}{8}$ by $4\frac{1}{4}$ inches. The bricks have a shrinkage of about

one-sixteenth after burning. The output of the plant is 20,000 bricks a day.

Steven brick plant.—No data have been obtained concerning the brick plant of Anthony W. Stevens, located in Texarkana.

Interstate Pottery Company.—The plant of the Interstate Pottery Company is located at Texarkana. The clay used is the Eocene (Tertiary) clay similar to that used near Benton by the Eagle Pottery Company. Jugs, churns, and jars are made.

MISSISSIPPI COUNTY.

Mississippi County occupies the northeastern corner of the State and is bordered by Mississippi River. The entire county is low and is subject to overflow by the river. The lowest lands are covered with water throughout the year. There are many large lakes in the southern, western, and northern portions of the county. Some of these lakes, such as Big Lake and Tyronza, are several square miles in extent. Levees along the entire Mississippi front are necessary to keep out the flood waters in the spring of the year. The highest land in the county is along Mississippi River, which by repeated overflows has deposited its greatest load on lands nearest the main channel. The westward slope of the country is shown by the fact that many small streams head near Mississippi River and flow westward and drain into Tyronza River and Pemiscot Bayou.

Much of the surface of the county is composed of alluvial deposits of silt, sand, and finely divided clay. In places, however, beneath the alluvial sand there is a yellow clay loam which greatly resembles the yellow clay loam of the prairies west of Crowleys Ridge and the narrow strip of clay land on the east side of the ridge. In a few places the yellow loam forms the surface soil.

At some distance back from the streams and abandoned water courses the country becomes flatter and is now largely covered with water for several months in the year. This land in the interstream areas is a gray buckshotty clay land, covered with a dense growth of sycamore, gum, and cottonwood, with more or less maple, willow, oak, hickory, black oak, elm, and ash. In the buckshotty clay area there are no signs of old stream channels.

At Blytheville there is a brick and tile works plant which makes a common brick from the yellow surface clay loam. The buckshot clay could likewise be tempered with sand and utilized for making common brick.

NEVADA COUNTY.

The geology of Nevada County is like that of Dallas and Ouachita counties, to the east and north, like that of southern Hempstead County, to the west, and like that of Columbia County, to the south.

In Nevada County, however, no large streams cut deep into the soft strata as the Ouachita cuts into those in Ouachita County, so that good exposures of the clay beds are rare and little or nothing is known about them. The strata of this county are nearly horizontal but dip slightly toward the southeast, and therefore a good clay bed found anywhere in the county will probably lie deeper beneath the surface as one follows it southward.

Records should be made of clay beds passed through by wells, for a promising clay found in a well may come to the surface at some point farther northwest. It is not likely that good pottery clays will be found close to the St. Louis, Iron Mountain and Southern Railway, but valuable and abundant brick clays may be found near that road. The best pottery clays and clays available for refractory purposes will be found about the central and southeastern part of the county.

Only one establishment in Nevada County is engaged in the manufacture of clay products, Longston Brothers' common-mud brick plant, located at Emmet, with an office at Sutton.

OUACHITA COUNTY.

GENERAL GEOLOGY.

The geology of Ouachita County may be regarded as typical of the southern portion of the State. The surface is underlain entirely by rocks of Tertiary age except where they have been removed by denudation and the valleys filled with Quaternary alluvium or residuary accumulations. The Tertiary rocks are usually not very hard; they are clays, sands, lignites, and gravels, and these four at many places grade into one another, forming sandy clays, clayey sands, lignitic clays, and all other possible combinations. At some places the sands are indurated, forming hard quartzites; at others they are but loose sands; while in color they range through the browns, yellows, grays, and reds.

Though local dips may be seen, most of the rocks lie in horizontal or approximately horizontal beds, so that they may readily be traced from one locality to another.

The Tertiary beds have been cut by Ouachita River, which has washed out a wide valley. This valley is bordered on the west by a rather abrupt escarpment, in which the Tertiary beds outcrop, especially at points where the river hugs its right bank, as at Camden, Newport Landing, and Millers Bluff.

In Camden a steep-sided ravine having walls 40 feet high is cut in the soft sandy clays by the stream.[a] A large part of the exposed surface of these clays was at one time covered with an abundant

[a] The section exposed on the Ouachita at Camden is given in Ann. Rept. Geol Survey Arkansas for 1888, vol. 2, p. 50.

efflorescence of green vitriol (ferrous sulphate) derived from the clays. This green vitriol causes the peculiar taste of the water found in many of the wells at Camden.

The character and disposition of the Tertiary beds at Camden may be taken in a certain sense as typical of the geology of Ouachita County. The strata there exposed extend beneath the whole county, but in a more or less modified form. This variability of the strata interrupts, of course, the continuity of the clay deposits and of whatever else there may be of economic value in these beds. The sandy clays, for example, in their horizontal distribution give place to pottery clays, and pottery clays give place to brown coal, and brown coal gives place again to clays or sands or some of the other beds so common throughout the county.

In some places the beds are deeply eroded and broad valleys are formed in them, so that the strata for several miles have been washed away, clays, sands, coals,[a] and all. The valley of the Ouachita is itself an example of such erosion. The road from Lester station,

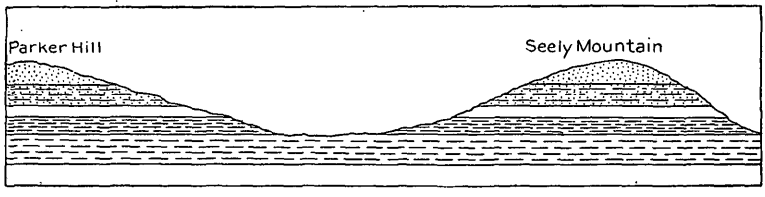

FIG. 12.—Section of Parker Hill and Seely Mountain, Ouachita County.

on the Camden branch of the St. Louis, Iron Mountain and Southern Railway, to Camden passes over a sharp ridge called Seely Mountain, which rises about 200 feet above the level of the Ouachita bottoms. About 4 miles northwest of Camden the same road ascends Parker Hill, which is geologically a repetition of Seely Mountain and which has the same elevation, the two being separated by a broad valley which has been cut out by the ordinary process of erosion. The profile section in fig. 12 will make plain the relations of these ridges to each other.

These details of general structure are given for the purpose of showing how the distribution of clays in Ouachita County is determined by the geology of the region.

CLAY DEPOSITS.

The region in which the brown coals occur is a promising one in which to seek valuable clays both for the manufacture of pottery and for fire clays.

[a] The Geological Survey of the State has data for a report on the coals of Ouachita County, and the United States Geological Survey has published a report on this subject by Mr. Joseph A. Taff in Twenty-first Ann. Rept., pt. 2, 1900, pp. 319–329.

In the S. ½ SE. ¼ sec. 2, T. 12 S., R. 18 W., on a small stream called Sandy Branch, is an exposure of material that has received considerable attention. It has the appearance of being a very sandy, compact, nonplastic, whitish cream-colored clay. It has usually been regarded as a fire clay, but the percentage of water of crystallization contained in the material when freed from sand shows it to be a kind of kaolin.

This bed is exposed inconspicuously at three or four places on Sandy Branch, at the base of the hills that form the western limit of the immediate valley of Ouachita River. Most of the outcrop is concealed by débris that has fallen down from the hills above, but it has been opened sufficiently to show its relation to the overlying beds and to expose a thickness down to the water of Sandy Branch of 12 feet, but without discovering the total thickness of the deposit.

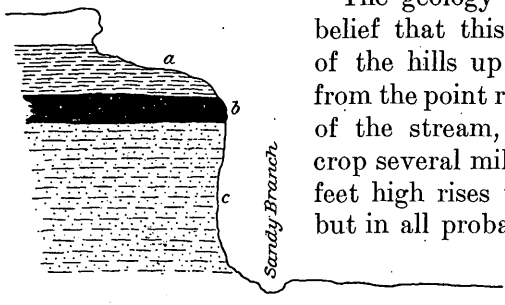

FIG. 13.—Section on Sandy Branch, near Ouachita River, Ouachita County. *a*, Plastic clay; *b*, brown lignite; *c*, sandy kaolin.

The geology of the region leads to the belief that this material lies at the base of the hills up and down Sandy Branch from the point referred to and on both sides of the stream, probably forming an outcrop several miles long. A hill nearly 100 feet high rises to the west of the outcrop, but in all probability places may be found at which there is no considerable covering to the bed. At the exposure referred to a bed of brown lignite[a] about 3 feet thick overlies the clay, and above this is a bed of plastic clay, the thickness of which is not exposed.

Fig. 13 is a section at this locality.

The following is an analysis made by the St. Louis Sampling and Testing Works of a sample said to have been taken from this kaolin bed. It was kindly furnished by Dr. A. S. Garnett, of Hot Springs, who had the analysis made in August, 1889:

Analysis of kaolin from Sandy Branch.

Silica (SiO_2)	66.25
Alumina (Al_2O_3)	25.35
Sesquioxide of iron (Fe_2O_3)	.22
Lime (CaO)	.26
Magnesia (MgO)	Trace.
Alkalies	.84
Water and loss	7.32
	100.24

[a] As a rule this lignite is considerably thinner on the outcrop than inside.

The following is an analysis of a sample of material said to have come from "Red Hill," made in 1882 for Walter Hamilton, of 120 William street, New York City, by A. Guyard, chemist. The material seems to be the same as that found in the Sandy Branch exposure.

Analysis of kaolin from Red Hill.

Silica (SiO_2)	70.40
Alumina (Al_2O_3)	18.40
Peroxide of iron (Fe_2O_3)	1.25
Titanic acid (TiO_2)	.05
Manganese (MnO)	Trace.
Lime (CaO)	.55
Magnesia (MgO)	.25
Alkalies	Trace.
Sulphuric acid (H_2SO_4)	.25
Water (H_2O)	8.75
Loss	.10
	100.00

A sample collected by the State Geological Survey of Arkansas (through Arthur Winslow, assistant geologist) at the Sandy Branch locality was analyzed by the Arkansas Survey. The label with this specimen says it comes from the NW. ¼ SW. ¼ sec. 2, T. 12 S., R. 18 W. Whether it came from that locality or from the one on Sandy Branch, the material is the same.

Analysis of kaolin from sec. 2, T. 12 S., R. 18 W.

[Brackett & Smith, analysts.]

Silica (SiO_2)	76.21
Alumina (Al_2O_3)	16.00
Ferric oxide (Fe_2O_3)	.75
Lime (CaO)	Slight trace.
Manganese and alkalies (by difference)	1.06
Water on ignition (H_2O)	5.98
	100.00

Anyone examining this material is impressed by the fact that it contains a large percentage of sand, though, of course, samples can be selected that are comparatively free from sand. In order to determine the nature of the material when freed from the greater part of the coarse sand, a sample of it was washed. The following is the analysis of a sample of the washed material, the sand being deducted from the silica and the composition recalculated:

Analysis of washed kaolin from sec. 2, T. 12 S., R. 18 W.

Silica (SiO_2)	28.47
Alumina (Al_2O_3)	48.00
Ferric oxide (Fe_2O_3)	2.25
Magnesia (MgO), Alkalies	3.18
Water (H_2O)	17.84
	99.84

This shows that this material is simply a sandy kaolin and not an ordinary clay, in the chemical sense of that term.

After the sand is removed by washing it is available for the manufacture of pottery and also as a refractory material. As a fire clay it will be spoken of elsewhere in this report. The quantity of this kaolin in the vicinity of the locality described above seems to be very large. Mr. Winslow observed the following section in the NE. ¼ SW. ¼ sec. 2, T. 12 S., R. 18 W., under a bluff very like that observed by the writer on Sandy Branch:

Section in sec. 2, T. 12 S., R. 18 W.

	Ft.	in.
Sand and clay	6	
Decomposed lignite		8
Gray clay	1	6
Decomposed lignite	1	6
Sandy kaolin	12–15	

At this place also the full thickness of the bed is not seen.

It is reported from several places in sec. 36, T. 11 S., R. 18 W. At one point the former exposure is said to have recently been concealed by a landslide; at another place it is said to be 4 feet thick, and has been used for whitewash.

In the SW. ¼ NW. ¼ sec. 36, T. 11 S., R. 18 W., at the house of Jack McKinzie, the following section was passed through in digging a well:

Section in well in sec. 36, T. 11 S., R. 18 W.

	Feet.
Clay	2
Lignite	2½
Gray clay with sand	3+

There are thin beds of pottery clay on a branch of Wolf Creek at the mouth of a lignite drift in the NE. ¼ NW. ¼ sec. 14, T. 12 S., R. 18 W. These beds are only a few inches thick, and therefore too thin to be of any practical value. Inside the drift they are only 6 or 8 inches thick. It is possible that these beds may be thick enough in this neighborhood to render them valuable. The clay itself is of fair quality, as the following analysis of it shows:

Analysis of clay from NE. ¼ NW. ¼ sec. 14, T. 12 S., R. 18 W.

[Sample dried at 110°–115° C. Brackett & Smith, analysts.]

Silica (SiO_2)	79.42
Alumina (Al_2O_3)	13.35
Ferric oxide (Fe_2O_3)	2.17
Lime (CaO)	Trace.
Magnesia (MgO), Potash (K_2O), Soda (Na_2O)	Trace.
Loss on ignition (H_2O)	5.38
	100.32
Sand in air-dried specimen	9.48
Water at 110°–115° C	3.72

In burning, this clay becomes a light gray and loses 9.68 per cent of its weight.

The following is the section exposed at the Sulphur Spring coal drift, at the base of the hill near the house of the superintendent of the Ouachita Coal Company's mines.

Section at Sulphur Spring coal drift.

	Ft.	in.
1. Yellow sand	15	
2. Thinly laminated sands and clay	7	
3. Sand		2
4. Buff pottery clay	1	6
5. Lignite	5	
6. Clay with fossil leaves	6+	

No. 2 of the above section is made up of interstratified half-inch beds of sand and pure clay, with fragments of vegetation scattered through them, in which form it can not be utilized. No. 4 is a good clay and might be utilized if the bed were thicker. Near the mouth of the drift it is somewhat stained with iron, but will not be found so stained farther in the hill. No. 6 is said to have been penetrated 6 feet in digging a sump in the coal mine, but at this depth it was not passed through. The leaf impressions in this clay are very abundant and fresh.

Mr. Winslow reports the following section from the old mine half a mile from the Ouachita River, in the NW. ¼ NE. ¼ sec. 12, T. 12 S., R. 18 W.

Section in old mine in NW. ¼ NE. ¼ sec. 12, T. 12 S., R. 18 W.

Sand on surface.	Ft.	in.
1. White sandy clay	3	
2. Chocolate sandy pottery clay	3	
3. Yellow and white sand	8	
4. Bluish-gray clay with sandy seams	8	
5. Carbonaceous shale		6
6. Lignite	5–6	
7. Gray clay not penetrated at	3	

No. 2 of the above section is a massive chocolate-colored clay that does not crack on drying. It seems to be available for the manufacture of both pottery and fire bricks. No. 7 is a tenacious pottery clay containing an abundance of well-preserved impressions of leaves. This bed strongly resembles the lower leaf-bearing bed of Atchison's pits at Perla switch, Hot Spring County, used for the manufacture of fire bricks.

The clays mentioned in this section are not being utilized for any purpose, although a company is said to have under consideration the question of erecting brick and sewer-pipe works in the neighborhood.

Mr. Kennedy reports also that at drift No. 1 on the Beach tract, within 200 feet of the county road, under the brow of a sandy hill,

in the NE. ¼ NW. ¼ sec. 29, T. 12 S., R. 18 W., there is a bed of pottery clay about 2 feet thick overlying the lignite. The upper 6 inches of this clay is of a yellowish color; the lower 18 inches is bluish gray. Both portions contain a large amount of very fine micaceous sand. The gray portion seems to be a fair potter's clay.

Wells bored at Henry C. Bell's place on sec. 4, T. 13 S., R. 18 W., passed through an aggregate of 17 feet of clay and 4½ feet of lignite. The order of their arrangement could not be ascertained.

A well put down at Wilson Carter's gin in the NW. ¼ NW. ¼ sec. 15, T. 12 S., R. 19 W., has the following section:

Section in well at Wilson Carter's gin.

	Feet.
Sand	15
Clay	5
Lignite	4½
Clay.	

Mr. Kennedy reports a drift in the NW. ¼ NW. ¼ sec. 15, T. 12 S., R. 18 W., with 3 feet of blue-gray clay above and below a 3-foot lignite bed.

Near Dempay's mill, in the S. ½ SW. ¼ sec. 25, T. 12 S., R. 18 W., the road descending from the hills to the flood plain of Ecore Fabre Creek passes over some light-gray sandy clays that appear to be available for pottery. From this point the highlands that border the right side of the Ouachita Valley follow a zigzag course through secs. 25, 24, 13, 12, 11, 1, and 2 of T. 12 S., R. 18 W., and still farther north it passes through secs. 36, 35, 25, 26, 34, and 33, T. 11 S., R. 18 W., and returns to secs. 4 and 5 of T. 12 S., R. 18 W. The clay outcrops follow in and out around the sides of these hills, though as a rule they are concealed by the earth and humus that have accumulated upon them. Outcrops of the same beds may be traced in the same way about the headwaters of Wolf Creek and of Ecore Fabre Creek.

South of Ecore Fabre Creek the Lester-Camden road rises to higher ground in the NW. ¼ NW. ¼ sec. 1, T. 13 S., R. 18 W. In these higher lands good pottery clays crop out locally in gullies and in the bluffs, but for the most part the outcrops are concealed by débris from the overlying beds. In the SW. ¼ NW. ¼ sec. 1, near Joshua Lester's house, this clay is exposed on the hillside just west of the road. The section shows 2 or 3 feet of sandy clay with 2 feet (exposed) of pink sandy potter's clay beneath it. This clay contains fossil leaves.

Mr. Lester's house is in the NE. ¼ SW. ¼ sec. 1, T. 13 S., R. 18 W. Just across the road west of his house, and about 200 feet from it, there is a 3-foot bed exposed; above it the soil is streaked with red, and contains thin bands of limonite; below it are red sandy clays, over 15 feet of which are exposed.

The sections exposed in Seely Mountain and in Parkers Hill, south of Lester, on the road to Camden, show very sandy beds, with no available pottery clays. These clays appear to lie at a lower level, and to wind in and out about the hills toward their bases.

In the city of Camden there is a small pockety bed of pottery clay, in places 3 feet thick, on the west side of the Missouri Pacific Railway, on California street.

The Arkansas Company, an organization with an office at Lester, Ark., owns a large part of the lignite and clay lands between the Camden branch of the St. Louis, Iron Mountain and Southern Railway and Ouachita River in T. 12 S., R. 18 W. This company put down a deep well at the center of sec. 12 of that township and range. Dr. A. S. Garnett, of Hot Springs, Ark., kindly furnished a copy of the record of this well, which shows the various clay beds and their thicknesses.

Record of well at the center of sec. 12, T. 12 S., R. 18 W.

	Feet.
Common clay	25
Blue fire clay	15
Coal (lignite)	5
Fire clay	15
Quicksand	60
Decomposed clay	5
Sand	30
Hard clay	30
Coal (lignite)	5
Hard clay	15
Sandy clay	110
Coal (lignite)	5
Sand and clay	50
Quicksand	100
Sand and clay	75
Hard clay	15
Coal (lignite)	10
Clay and sand	50
Coal (lignite)	2
Quicksand	175
Rock and sand	55
Total depth of well	852

From what has been said of the exposures known, it will be seen that pottery clays are to be looked for in the lower portions of the hills that skirt the Ouachita Valley. The steepness of these hills on the west side of the river gives rise to a great number of natural exposures of the clay beds, but the same beds may confidently be looked for on the east side of the river and in the gentler slopes of that side of the valley, though they are there farther from the stream.

It is noticeable also that good clays are at some places associated with the Tertiary coals or lignites of this region. Thus the lignite, which usually attracts attention more readily than clays, serves to a certain extent as a guide in searching for valuable clays.

CLAY INDUSTRY.

Notwithstanding the fact that Ouachita County is remarkably well supplied with potter's clays, no clay industry is known to exist in the county at the present time, and the only plant that has existed, and of which information could be had, was a pottery located about 8 miles south of Camden and about 2 miles from Ouachita River, on the farm now belonging to Mr. Thomas Patton (Camden post-office). The clay is said to have come from one of the stratified beds of the hillside. The pottery has not been in operation since the breaking out of the civil war.

PHILLIPS COUNTY.

GENERAL GEOLOGY.

The southern half of Phillips County is covered by the alluvial deposits of Mississippi and White rivers. The northern half is broken by Crowleys Ridge, which has its southern terminus at Helena, on Mississippi River. West of the ridge is a series of much lower ridges, or low swells, which have a general north and south direction. These smaller ridges are broken by streams and intervening depressions.

The elevation of the lowlands in the southern portion of the county is but a few feet above the water in Mississippi River. The elevation of the depot at Helena is 194 feet above sea level. The highest point on the top of the ridge at Helena is 198.9 feet above the zero gage. The elevation of the zero gage is 148.85 feet above sea level. The top of the ridge is therefore 347.75 feet above sea level, and about 150 feet above the lowlands to the west.

The bluffs along the south end of the ridge in the vicinity of Helena give good exposures of Tertiary and Quaternary strata. The loess covers the top and sides of the ridge here as at most places throughout the State. The rearranged product of the loess covers the older underlying strata, which are seen at only a few places.

At the west end of Cherry street in Helena, and along the bluff to the south, there is a bed of iron-stained pebbles, which greatly resemble the pebbles of the Lafayette formation. The top of the pebble bed stands at an elevation of 205 feet. Immediately above the bed of pebbles comes about 10 feet or more of orange-colored loam. Overlying the loam is an apparent soil zone, having a maximum thickness of 10 feet. This is present in many places, but it is at others absent. The remaining part of the bluff is composed of typical calcareous loess, containing numerous land shells.

In places where recent excavations have been made the loess is distinctly stratified. Viewed from a distance it has a general stratified appearance, but when more closely inspected many more faint lines of stratification can be seen.

At the big spring 2 miles north of Helena, on the east side of the ridge, 80 feet of variegated sands, clays, and lignitic clays are exposed in the deep ravine just north of the spring. The iron-colored pebbles and overlying orange-colored loam, seen at the foot of the bluff on Cherry street in Helena, comes above the 80-foot section of variegated sands and clays at this spring. The top of the bluff is covered with loess.

Along the western edge of Crowleys Ridge in this county there is an apparent terrace from one-half to 3 miles wide. It has a uniform elevation 20 to 30 feet higher than the plain to the west.

A section in a gulley 1½ miles east of Southland shows strata of the character found in the terrace west of the main ridge.

Section of terrace 1½ miles east of Southland.

	Feet.
Stratified dark clayey loam	4
Thin, laminated, argillaceous sand, with small, irregular concretions of iron oxide	4
Yellow argillaceous sand	2

CLAY DEPOSITS AND INDUSTRY.

The principal brick clays of Phillips County are the loess and rearranged loess found on the top and sides and at the foot of Crowleys Ridge. Bricks could be made from the upper loam of the terrace along the west side of the ridge and also from the clays that form the surface of Pine and Hickory ridges. So far, however, the brick industry of the county is limited to the city of Helena.

The plant of the Straub Brick Company is located on the southwest side of the town, at the foot of Crowleys Ridge. The capacity of the plant is 36,000 bricks a day. The bricks are made from the loess, which has been slightly reworked and mixed with the underlying clays. It requires a greater amount of care to make good bricks from this clay than from ordinary clay. The loess is a very fine, silty, calcareous loam, lacking plasticity, and it is very easy to get too much water in the pug mill. It is found to be more profitable to make soft-mud brick in the summer, and dry-pressed brick in the fall and winter.

The bricks are dried in the open air by the pallet and rack system. Most of them are burned in up-draft kilns. Only one down-draft kiln is used.

PIKE COUNTY.

GENERAL GEOLOGY.

The geologic age and character of the deposits in the southern part of Pike County encourage the hope that valuable beds of kaolin exist there. These beds, however, must be sought within the Mesozoic area and not in the region of hard Paleozoic rocks to the north.

In a general way the northern border of the Mesozoic rocks in Pike County passes from Antoine just north of Wolf Creek post-office, Brocktown, and Murfreesboro, and south of Royalston, passing into Howard County where the county line crosses Muddy Fork of Little River. North of this line it is useless to look for kaolin in commercial quantities in Pike County.[a]

CLAY DEPOSITS.

It has been known for several years that kaolin exists in Pike County, but the only plant of any kind in the county that is engaged in the manufacture of clay products is a small brick plant at Nathan.

Some fine specimens of kaolin were exhibited at the exposition held at Little Rock in the summer of 1887. These specimens were labeled "Pulaski County," but they must have come from the Vaughn Creek beds, in Pike County. At least no such kaolin is known in Pulaski County.[b]

The kaolin beds of Vaughn Creek have been examined by the State Geological Survey at the pits opened in the NW. ¼ SW. ¼ sec. 19, T. 8 S., R. 24 W., near S. D. Hanna's house. The locality is known in the surrounding country as "the chalk bank." Its discovery seems to have been due to the fact that pieces of kaolin were torn out by an uprooted tree. The material has been used to some extent through the country for school chalk.

The kaolin lies in horizontal beds in the tops of the hills that skirt the right bank of Vaughn Creek. These hills are low and are covered with an abundance of waterworn pebbles and cobblestones of Pleistocene age. In the valley of Vaughn Creek, about 75 feet below the summit of the kaolin-bearing ridges, lignites of the Trinity beds (lower Cretaceous) have been found in digging a well at Mr. S. D. Hanna's, in the SE. ¼ NW. ¼ sec. 19, T. 8 S., R. 24 W. The stratigraphic position of the koalin would admit of its belonging either to the lower Cretaceous, the upper Cretaceous, or to the Tertiary. In the absence of other evidence it is therefore impossible to say to which of these horizons it belongs. It is believed that the beds are of Cretaceous age, but this can not be stated as anything more than an opinion based on observations of the topography and stratigraphy of the Cretaceous beds farther west and south.

The accompanying section (fig. 14) is exposed in one of the old prospecting pits dug on the kaolin. It is impossible to say whether this kaolin bed represents the full thickness of the deposit in Pike County. A few other smaller holes have been dug in the immediate vicinity, but as they are all within 100 feet of this one and were dug

[a] The Mesozoic rocks of Pike County are shown on the map of that region accompanying vol. 2 of the report of the Geological Survey of Arkansas for 1888.

[b] In 1890 these specimens, still labeled "Pulaski County," were on exhibition at the rooms of the State Department of Agriculture at Little Rock.

to strike the same deposits, they throw no light on the nature of the beds except at this one place.

The broken bed *cl* of the section appears to be the remains of a bed of kaolin from which a part of the constituents has been removed by decomposition. The larger fragments, when broken parallel with the bedding, show a great many obscure and small plant impressions, resembling those made by blades of grass. None of the forms seen are recognizable, however. The upper part of the bed marked *ka* in the accompanying section contains a little grit in the form of grains of fine quartz sand. It also shows a great many indistinct and fragmentary impressions of plants. These plant impressions are very small and none of those found are determinable. The lower part of the bed *ka* is pink in color, and contains besides many small white

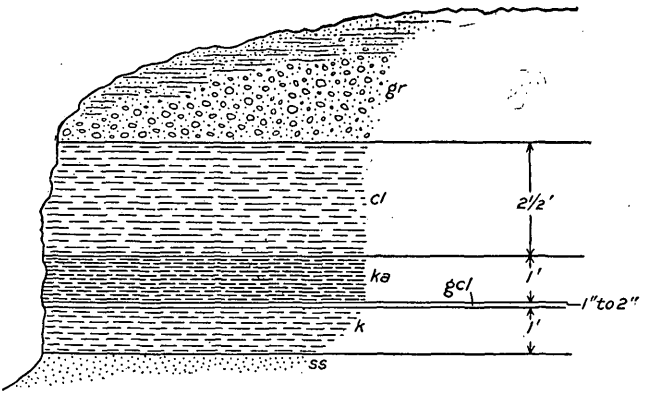

FIG. 14.—Section of kaolin deposits on Vaughn Creek, Pike County. *gr*, Lafayette gravel; *cl*, impure clay; *ka*, pink kaolin with white specks; *gcl*, granular, white streak of clay; *k*, white kaolin, iron-stained joints; *ss*, yellow sand.

spots about the size of a pin's head. These spots are kaolin like the rest, and retain their white color, distinct from that of the rest of the material, even after firing and glazing.

In sec. 19, T. 8 S., R. 24 W., and in sec. 24, T. 8 S., R. 25 W., the following record of the order of the beds is reported by Mr. E. C. Buchanan, of Little Rock:

Section in secs. 19 and 24, T. 8 S., Rs. 24 and 25 W.

	Ft.	in.
Earth and gravel	2	3
Kaolin with sand and red streaks		6
Kaolin and sand	1	6
Kaolin with streaks	1	6
Pinkish sand	1	8

Other pits show the same order, but in some of them the clean kaolin is thicker.

Mr. Buchanan, after having spent some time in examining the kaolin deposits of Pike County, wrote the following general conclusions regarding them:

The beds are from 3 to 9 feet in thickness and are very variable in color. Shafts only a hundred feet apart exhibit considerable differences in the sections. The following is a typical section as near as such a section is possible:

Typical section in Pike County.

	Feet.
Sand and gravel	3–25
Sand varying in color, but generally reddish or pink, with thin sheets of iron oxide	4
Kaolin, solid, pale yellow to white, with red or yellow streaks	3– 9
Sand	3+

The colors found in one shaft were not always the same as those in an adjacent one. The largest area of kaolin found in one body covered about 10 acres. The greatest depth at which the kaolin was found was 25 feet.

So far as these deposits have been examined they appear to be rather lens-shaped beds of limited distribution. Some of these beds cover only half an acre; others cover an area of 8 or 10 acres. Mr. Buchanan is of the opinion that the entire kaolin area probably does not exceed 350 acres. These lands lie in secs. 19 and 30, T. 8 S., R. 23 W., and in secs. 23, 24, 25, and 26, and probably in secs. 35 and 36, T. 8 S., R. 24 W.

The more massive beds of kaolin contain no evidence of its derivation beyond its sedimentary origin. The kaolin contains, as one might expect, fragments of quartz, but not enough to affect the value of the material for economic purposes. It has a conchoidal fracture, but within the stratum there are no bedding or lamination planes. In the beds above and below it there are evidences that the accompanying strata were deposited in water, a bed of sand underlying and a bed of less pure kaolin overlying it. There can be no doubt, therefore, of the sedimentary origin of the Pike County kaolin.

It is worthy of mention that no exposures of feldspathic rocks are known anywhere in this neighborhood. The nearest large exposure is at Magnet Cove in Hot Spring County, 50 miles distant, but as the Pike County kaolin is Cretaceous it can have no genetic relation to the Magnet Cove rocks, for the latter are probably of post-Cretaceous age; certainly they are not pre-Cretaceous, and could not therefore have supplied the material for this kaolin.

The Pike County kaolin is different in physical characters from any other kaolin thus far found in the State. It is not plastic in its natural condition, but has a hardness of about 1.5 in the mineralogical scale, being easily scratched with the nail. When dry it adheres strongly to the tongue, but it can not absorb enough water to render it plastic, even when left submerged for weeks. In the pit, where it

is thoroughly soaked with water, it is brittle and breaks with a splintery conchoidal fracture. When dry and rubbed with the hand it takes on a satin-like gloss. Ground to a fine powder and wet, it forms a nonplastic or but partially plastic mass.

A sample of this kaolin that had been left to air dry for several months and then submerged in water cracked to small angular pieces with plainly audible snapping sounds, very much as if it had been a piece of hot glass. Within five minutes the breaking had ceased, and though the kaolin remained in water for several days, it showed no further signs of being affected by it.

The fact that this kaolin does not soften in water like clay is a disadvantage, for it would need to be ground and washed before it could be used in the manufacture of fine pottery. A sample of it has been put to a practical test by being fired and glazed in one of the New Jersey potteries. It stood this test in a very satisfactory manner.

Below are given analyses of both the upper pink and the lower white kaolin of the section given on page 149. The locality is in the NW. ¼ SW. ¼ sec. 19, T. 8 S., R. 24 W. These analyses may be compared with those of well-known kaolins in the table on pages 236–237.

Analyses of kaolins from Vaughn Creek.

[Dr. T. C. Van Nuys, analyst.]

	Upper bed.	Lower bed.
Silica (SiO_2)	48.87	47.39
Alumina (Al_2O_3)	36.51	34.67
Iron (ferric) oxide (Fe_2O_3)	.98	2.31
Lime (CaO)	.19	.32
Magnesia (MgO)	.25	Trace.
Potash (K_2O)	.....	.20
Soda (Na_2O)	.....	.39
Water	13.29	13.89
	100.11	97.17
Water at 110°–115° C.	.....	1.00

At the pit from which the sample of the lower bed was taken the kaolin is much fractured, and iron-charged waters have infiltrated along these fracture lines and stained them a deep brown color, though the material still holds together compactly. When a mass removed from the bed is struck hard, it breaks along these fractures. The iron stain seriously injures the kaolin, probably rendering it worthless for fine ware. It is evident, however, that the iron has been leached from the waterworn gravels, sands, and clays that cover the surface of the ground and has been redeposited in the only part of the kaolin it could easily penetrate—that is, along these crevices. If, therefore, kaolin available for the manufacture of the finer grades of porcelain exists in commercial quantities in the neighborhood of the Vaughn Creek pits, it should be looked for at places where it will have a covering thick enough to protect it from infiltration of iron-charged waters from the surface.

The analyses of this kaolin show that except for the stains referred to above it is sufficiently pure for the manufacture of fine porcelain ware. It seems to be well adapted also for paper finishing. It also has high refractory properties, and in case it can not be found free from the impurities that would injure it as a china clay, it is still available for the manufacture of a high grade of fireproof articles.

Prospecting for kaolin that lies in horizontally stratified beds, as do these of Pike County, is a very simple matter and will not be expensive unless one happens upon thick deposits of the Pleistocene waterworn material that covers the surface of the ground. The accompanying diagram (fig. 15) is intended to show the method of occurrence of the kaolin with reference to the waterworn gravels of that region.

A vertical section cut through these beds would show that they have some such relations as those indicated in the diagram. The kaolin lies in a horizontal bed, *ka*, and the sands, *ss*, clays, *cl*, etc., associated with it, are also horizontally bedded. These beds have been worn away from above and the great body of kaolin originally deposited has been removed. What remains is fragmentary and,

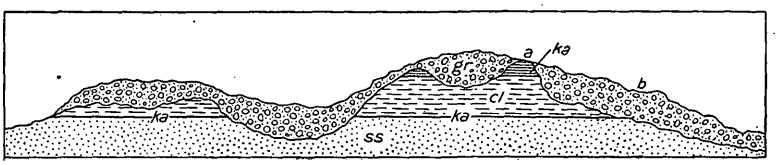

FIG. 15.—Section of kaolin beds in Pike County.

in the vicinity of the Vaughn Creek pits, at least, lies in the hilltops, but over the worn surface gravel beds, *gr*, have been spread out, covering the greater part of the surrounding country. This gravel varies greatly in thickness. At some places it is almost entirely wanting or is represented by only a few pebbles, while at others it has a thickness of 30 feet or more. It is at many places impossible to foresee the thickness of this gravel covering, for, as will be realized from the diagram, the thickness at *a* would give a miner no clue whatever to the thickness of the same deposit at *b*, and vice versa.

The horizontality of the kaolin beds makes prospecting for them simple and cheap. It is only necessary to ascertain the elevation on the hillside at which the bed is to be exposed, judging from the elevation at which it occurs at known localities, and then to dig a trench up and down the face of the hill so as to crosscut the bed. This trench should pass entirely through the waterworn gravels and uncover the underlying beds. If the kaolin bed were perfectly horizontal such a trench would not be necessary, for a pit could be opened directly on the bed, but its position varies somewhat, and this variation makes the trench necessary.

It will be seen from the foregoing that whether or not considerable quantities of kaolin are to be expected in the region west of Vaughn Creek in Pike County depends on the topography of the country. If the hills are all lower than the point at which the outcrop is found, near Mr. Hanna's, the kaolin has all been washed away. If the hills are higher and their height is not due to the great thickness of the gravel bed, the kaolin may reasonably be expected to outcrop on the hillsides. In broad and flat-topped hills, with kaolin outcropping around the margins, prospecting may be done by boring with testing augers on the hilltop. If the boring is in a depression it will not be necessary to bore through so great a thickness.

There is a very widespread and a very erroneous impression among a certain class of miners that mineral deposits grow thicker and better as one goes deeper. In the case of this kaolin, other things remaining the same, the material will improve as the cover thickens, but this is simply because the thicker cover prevents the infiltration of iron into the kaolin. Whether the beds thicken or not can not be predicted, but in view of the sedimentary origin of the deposit it is reasonable to suppose that they will not vary greatly in thickness.

In the SW. ¼ NE. ¼ sec. 24, T. 9 S., R. 24 W., a bed of kaolin is said to have been discovered in digging a grave about the year 1874. This point is said to be on the top of a sandy hill or bench about 30 feet above the "bottoms" of Little Missouri River.

POINSETT COUNTY.

GENERAL GEOLOGY.

The topography of Poinsett County is very similar to that of Cross County on the south and Craighead on the north. The eastern half of the county is a low, flat country, which is traversed by St. Francis River. A large area in the northeastern part is covered by shallow lakes, which were caused by the general sinking of the land during the earthquake period of 1811–12. Crowleys Ridge extends across the county in a north-south direction just west of the center. The country west of the ridge is a flat slash land sloping to the south and west. The elevations along the St. Louis, Iron Mountain and Southwestern Railway, in the western part of the county, are from 7 to 24 feet higher than corresponding points in the same latitude along the St. Louis and San Francisco Railroad in the eastern part of the county.

The Tertiary sands and clays outcrop in deep ravines and in roads along the sides of Crowleys Ridge, in the vicinity of Harrisburg, and doubtless at other places on the east side of the ridge. The top of the ridge at Harrisburg is 107 feet (barometric reading) above the

elevation of the town at the foot of the ridge. The following is a section of the hill along the road leading east from the town:

Section of Crowleys Ridge at Harrisburg.

	Feet.
Yellow clay (Columbia) on top of ridge	30
Stratified sand, variegated in color, interbedded with gray joint plastic clay	65
Unexposed detritus to foot of hill	12

A record of one of the wells in the town at the foot of the ridge gives the following section:

Section of well in town of Harrisburg.

	Feet.
Red to yellow clay, with some gravel	40
Blue gumbo clay free from sand, with small vein of water on top	25
Very fine red dry sand, which caves badly	40
Dark-blue or slate-colored sandy clay, containing small fragments of leaves, shells, and rotten wood; gives bad odor to water	50
Blue sand, water bearing	30

CLAY DEPOSITS.

The surface clay, which is 40 to 50 feet thick at foot of the ridge at Harrisburg, is only about 10 feet thick at L'Anguille River, 4 miles west of town. It changes from a reddish yellow at the foot of the ridge to white at L'Anguille River. In places it forms buckshot soil.

The surface yellow clay on the top and sides of the ridge, and also the surface clay in the lowlands as far west of L'Anguille River, are well suited to the manufacture of common wet or stiff-mud and dry-pressed bricks. The blue Tertiary clay that outcrops well up on the side of the ridge would, with proper manipulation, doubtless make an excellent face brick. The following analyses are made from brick clay at Harrisburg, Poinsett County:

Analysis of brick earth from the surface, Harrisburg.

[Dried at 110°–115° C. Brackett & Smith, analysts.]

Silica (SiO_2)	81.79
Alumina (Al_2O_3)	9.37
Iron oxide (Fe_2O_3)	4.03
Manganese (MnO)	Trace.
Lime (CaO)	.31
Magnesia (MgO)	.38
Potash (K_2O) (by difference)	.86
Loss on ignition	3.26
	100.00
Air-dried sand in air-dried clay	30.92

Brick earth at depth of 4 feet, Harrisburg.

[Dried at 110°–115° C. Brackett & Smith, analysts.]

Silica (SiO_2)	81.37
Alumina (Al_2O_3)	8.52
Iron (Fe_2O_3)	2.88
Manganese (MnO)	1.01
Lime (CaO)	.44
Magnesia (MgO)	.50
Potash (K_2O), Soda (Na_2O) (by difference)	2.40
Loss on ignition	2.88
	100.00
Air-dried sand in air-dried clay	28.08

Analysis of clay from an old clay pit at Harrisburg in sec. 25, T. 11 N., R. 3 E.

[Sample dried at 110°–115° C. R. N. Brackett, analyst.]

Silica (SiO_2) (free and combined)	75.93
Alumina (Al_2O_3)	11.05
Iron oxide (Fe_2O_3)	6.10
Lime (CaO)	.67
Magnesia (MgO)	.76
Potash (K_2O)	.72
Soda (Na_2O)	63
Phosphoric acid (P_2O_5)	.20
Loss on ignition	4.56
	100.62
Air-dried sand	37.62

The large amount of iron oxide and small amount of lime will give a deep red colored product.

The following analysis was made from the loess brick clay which came from the top of Crowleys Ridge, a short distance north of Spencer Creek, in Poinsett County:

Analysis of loess from Crowleys Ridge north of Spencer Creek.

[Dried at 110°–115° C. Brackett & Smith, analysts.]

Silica (SiO_2)	85.83
Alumina (Al_2O_3)	7.50
Ferric oxide (Fe_2O_3)	2.66
Manganese (MnO)	Trace.
Lime (CaO)	.32
Magnesia (MgO)	.35
Alkalies (by difference)	1.16
Loss on ignition	2.18
	100.00
Air-dried sand in air-dried soil	64.80

There is a striking similarity in the appearance of surface clay on top of Crowleys Ridge at Spencer Creek and the yellow clay that

occupies the surface of the country between Crowleys Ridge and L'Anguille River, west of Harrisburg. The similarity is made more evident by comparing the analysis of the loess above given and the one following.

Analysis of upper layer of the "buckshot land" from Harrisburg, sec. 25, T. 11 N., R. 3 E.

[R. N. Brackett, analyst.]

Silica (SiO_2)	87.50
Alumina (Al_2O_3)	6.10
Iron oxide (Fe_2O_3)	2.69
Lime (CaO)	.63
Magnesia (MgO)	.36
Potash (K_2O)	.38
Soda (Na_2O)	.65
Phosphoric acid (P_2O_5)	.13
Loss on ignition	1.95
	100.49
Air-dried sand	77.48

CLAY INDUSTRY.

Common wet-mud bricks are made by W. P. Lancaster and J. B. Huey at Harrisburg. The product is made from the reworked Columbia or loess, which is 8 feet thick. The clay is tempered in soak pits, molded by horsepower machinery, dried on pallet and racks, and burned in up-draft scove kilns. The plant has a capacity of 8,000 bricks a day. Five to six days are required for drying, and ten to twelve days for burning. The green bricks can not be taken from the molds and placed in the sun immediately.

POPE COUNTY.

GENERAL GEOLOGY.

A part of Pope County and all of the other counties farther west along Arkansas River lie within the area of the Carboniferous coal-bearing rocks. The coal-bearing rocks in these counties do not differ greatly from those in Conway, Faulkner, White, and Pulaski counties farther east, where coal is not present, but the presence of the coal beds adds another factor that must be taken into account in dealing with the clays and clay industries.

The coal-bearing rocks in Pope County and the counties to the west are folded like those of the region to the east and southeast; in places these folds are sharp, in others they are gentle. The clay shales are interbedded with sandstones and with coal. As a rule they are compact where they lie under other beds, but where they have been exposed for a long time to the weather they become soft and plastic. In color they vary from almost black through various shades of gray,

and weathering, become gray, yellow, or red. Among these clay shales that are associated with the coal seams the refractory clays are found.

In Pope County the sandstones usually cap hills or form ridges, just as they do in the counties farther east and south, while the shales as a rule underlie the valleys.

The sandstone ledge that forms the abrupt edge of Carrion Crow Mountain from Atkins to Galla Creek is widespread in western Arkansas, and was called by the Arkansas Geological Survey the Hartshorne sandstone, from Norristown Ridge, southwest of Russellville. This bed passes around the north side of Carrion Crow Mountain and forms the low hills from 2 to 4 miles north of Russellville. It also forms the rim of Tucker Mountain, from 4 to 8 miles north of Russellville, and crosses Illinois Creek to form the escarpments of Illinois Ridge, west of that stream. South of Tucker Mountain the rocks are bent into a trough or synclinal fold, and the Hartshorne sandstone bed is tipped up on edge to form Ouita Ridge.

The same bed of sandstone, after passing southward beneath the Ouita coal basin, comes to the surface again to form Norristown Mountain and Dardanelle Ridge and also Reeds Ridge, northeast of the ferry at Dardanelle. Special attention is called to this particular bed of sandstone because it furnishes the key to the structural geology of Pope County.

No workable coal is known in Pope County below the Hartshorne sandstone, though there is a bed 18 inches thick below it in Carrion Crow Mountain. The coal of the Ouita basin and that of the Shinn mines, south of Russellville, overlie it. If the Ouita bed existed about Carrion Crow Mountain it would be on top of the mountain, not on its flank. The Ouita coal bed lies south of Ouita Ridge because the sandstone dips southward, forming a basin or trough whose southern edge is Dardanelle Ridge. The Shinn mines lie north of Reeds Ridge because the sandstone of that ridge dips northward.

Important beds of shale and fire clay lie both above and below the Norristown sandstone. The shale above the Hartshorne sandstone has been called the Spadra shale, because it occurs typically at the Spadra coal mines. The Ouita coal bed at these mines and the same bed at the Shinn mines is in the Spadra shale, near its base. The Spadra shale is mostly a clay shale, though it is usually more sandy toward the top, and varies in thickness from 100 to 500 feet. The shales on the top of Carrion Crow Mountain belong to this set of beds. They everywhere accompany the Ouita coal bed and dip as the coal dips. Starting at Illinois Creek in sec. 29, T. 8 N., R. 20 W., these shales cover the whole area lying between Ouita Ridge and Dardanelle Ridge and west of Norristown Mountain. Below the Ouita coal bed—

that is, between the coal and the Hartshorne sandstone—lie 3 to 5 feet of fire clay and shale.

Below the Hartshorne sandstone there is a thick deposit of shale. The relations of this bed to the Hartshorne sandstone are well shown in the following section of Carrion Crow Mountain just north of Atkins:

Section of Carrion Crow Mountain.

	Ft.	in.
Hartshorne sandstone	45–180	
Shale	180–190	
Coal		18
Shale	160–200	

This shale can be traced throughout Pope County, in which it everywhere underlies the Hartshorne sandstone. It lies along the upper flank of Carrion Crow Mountain and of Tucker Mountain. Where Mill Creek cuts through Ouita Ridge it is well exposed below the Hartshorne sandstone to a thickness of about 300 feet.

This shale is underlain by a sandstone, and this in turn by still another shale. This last shale underlies the town of Russellville. The overlying sandstone does not seem to exist in the vicinity of Russellville, or if it does it is thin and unimportant. The great thickness of shales between the town of Russellville and Norristown Mountain therefore extends up to the lap of the Atoka formation. These shales probably have a thickness of 200 to 400 feet in the vicinity of Russellville. They form the lower flank of Carrion Crow Mountain, and the thin bed of coal there exposed is in these shales. They are well exposed on the Russellville-Dover road just south of Baker Creek and also along the west side of the same road along the base of Tucker Mountain. Buck Mountain, in T. 9 N., R. 19 W., is made of this shale, and in that mountain it has a measured thickness of 375 feet. Iron Ore Mountain, in T. 8 N., R. 18 W., is also made up principally of this shale.

CLAY DEPOSITS.

No analyses or tests have yet been made of the clay shales of Pope County. Where valuable shales are closely associated with workable coal beds, or even with coal beds which alone are not workable, it sometimes becomes economically possible to mine the coal and some of the shale together, with a view to utilizing the latter. There is no doubt that there are in Pope County enormous quantities of shales available for the manufacture of paving bricks, sewer pipe, and fire-clay goods. The occurrence of such raw materials in connection with abundant, excellent, and cheap coal and the cheap and convenient transportation afforded by Arkansas River afford highly favorable conditions for the building up of important manufacturing industries.

Material suitable for brickmaking covers a large area around Atkins, extending from W. H. Murphy's old brickyard at the base of Carrion Crow Mountain, in the SW. ¼ SE. ¼ sec. 20, T. 7 N., R. 18 W., eastward over several sections. This material varies much in depth, while at some places its continuity is broken by small gravel ridges.

On the line between the SW. ¼ NW. ¼ sec. 4 and the SE. ¼ NE. ¼ sec. 5, T. 7 N., R. 18 W., and over the greater portion of these lots, there is a fine light-colored clay about 4 feet thick. It is almost white in color, although there are spots of brown here and there toward the eastern side of the area.

Analysis of clay from sec. 5, T. 7 N., R. 18 W.

[Brackett & Smith, analysts.]

Silica (SiO_2)	90.49
Alumina (Al_2O_3)	5.22
Ferric oxide (Fe_2O_3)	1.38
Lime (CaO), Magnesia (MgO), Potash (K_2O), Soda (Na_2O)	Trace.
Loss on ignition	3.12
	100.21
Fine sand specimen	30.53
Water at 110°–115° C	1.60

In the NE. ¼ SE. ¼ sec. 26, T. 7 N., R. 19 W., there is an area of about 10 acres containing a soft brown and blue argillaceous shale, showing an exposure of 2 feet in the side of a creek. These shales are very soft and can readily be worked into a clay for the manufacture of fire-clay goods.

The clays around Russellville vary in color from a yellowish brown to an ashen white, according to the position of the material in the bed. In general the surface clay is darker than the underlying material. This difference in color varies in different places. In secs. 8 and 9, T. 7 N., R. 20 W., the upper clay is yellowish brown and varies in depth from 1 foot on the southern side of these sections to 3 feet along the bank of the creek that flows northeastward past Russellville. The lower division of this clay as exposed in the bank of the creek is pale yellow, almost white, and contains a great quantity of nodules of iron.

This buckshot clay rests immediately on the dark-blue argillaceous shales of the coal-bearing rocks and varies in thickness from 1 foot to 5 or 6 feet. On the slight ridge immediately south of Russellville, in the NW. ¼ sec. 9, it is not more than 1 foot thick, but in the land along the creek and between the Little Rock and Fort Smith Railway and the Dardanelle Railway it shows a thickness of 6 feet.

A short distance north of Russellville the thickness is reduced to 3 or 4 feet.

In area this clay covers secs. 4, 5, and 9 and the greater portion of sec. 8, T. 7 N., R. 20 W. It is also scattered through secs. 10, 11, 12, 13, and 14 of the same township and range. At Galla Creek station on the Little Rock and Fort Smith Railway, in sec. 19, T. 7 N., R. 19 W., it appears as a dark-yellow clay.

CLAY INDUSTRY.

Common bricks are made by the Mena Brick Company at its plant 2 miles southwest of Mena from a thin bed of clay overlying the shale. The clay is partly residual, since it contains many fragments of shale. The clay is first run through a Success crusher, then through a pug mill of the same make, and finally through a stiff-mud machine. About 4,000 bricks are made daily. The machine is run by a 40-horsepower engine. Usually 10 men are required to run the plant—two men in the pit, two feeders (one to temper the clay), one sander, two off-bearers, and two truckers. About one-half of the time is employed in molding and one-half in burning.

Another plant belonging to the same company is located 1½ miles from Mena, but it will probably be sold and removed to De Queen.

There is a brick plant at Russellville, known as the Russellville brick works, but nothing further is known concerning it.

There is a small brick plant at Atkins, with a capacity of 5,000 to 6,000 a day. The bricks are made by hand and burned in common scove kilns. It requires from two to five days for drying and ten to twelve days for burning. The bricks are made from the residual clay of the Paleozoic rocks. The size of the molds is 9 by 4 by 2½ inches; when burned the bricks measure 8½ by 3⅝ by 2¼ inches.

PRAIRIE COUNTY.

GENERAL GEOLOGY.

The southern half of Prairie County lying west of White River is level prairie land. The part that lies north of township 2, with the exception of a small area around Desarc, is chiefly wooded "slash land." The soil of the country east of White River is entirely alluvial, and the surface stands but a few feet above the low-water mark in White River.

Throughout the county White River has formed a bluff of varying height along its west bank. At Devall Bluff the level of the prairie land west of the river is 25 to 40 feet higher than the high-water mark in the river. The elevation of the depot at Devall Bluff is 186 feet, or about 7 feet lower than the depot at Helena.

The strata west of White River are of late Quaternary age. The surface material of the prairie land is a reddish clay loam or gray buckshot clay. On the higher ridges, where water does not stand for any great period, the surface clay and subsoil is a red clay very similar to the second-bottom or terrace clays along the west side of Crowleys Ridge in Lee and Phillips counties. In the low slash lands, which are covered with water for several months during the year, the surface clay was doubtless originally the same kind of material as that on the prairie lands. But the iron oxide of the prairie soils has been segregated into small limonitic concretions, which have received the local name of buckshot. The soils of the slash lands are therefore more or less leached and have a white to grayish color.

The character of the strata found in wells and in the bluff at Devall Bluff is shown in the following sections:

Section of bluff at Devall Bluff.

	Feet.
Yellow clay loam, in places buckshoty	10
Stratified reddish sand, very fine grained	8
Red plastic clay to bottom of gully	3

The yellow surface clay is used here for making brick. In the prairie land at Tollville, 6 miles southwest of Devall Bluff, the following well record was obtained:

Record of well at Tollville.

	Feet.
Yellow clay	3
Hardpan, gray clay	10
Reddish clay grading into a gray sand	20
Very fine quicksand, supplying water	10
Red clay	50
Soft gray clay	4
Gravel and sand; source of water	(?)

Over much of the prairie region there are numerous small spheroidal mounds which are rarely more than 2 feet high and 50 feet across the base. They are different from the larger mounds of undoubted human origin. The origin of these mounds has been a great mystery to all those who have studied them. By some they are thought to have been built by Indians, others have considered them to have been built by ants, and still others have attributed their origin to natural agencies, as winds and waves.

CLAY INDUSTRY.

Common building bricks are made at Devall Bluff. The Devall Bluff Brick and Tile Company manufactures a stiff-mud side-cut brick. The bricks are made from the red surface clay. They will check when

dried too rapidly, and therefore have to be dried in covered sheds. The bricks are burned with wood in up-draft kilns. The capacity is 5,000 bricks a day. The output of bricks is largely governed by the local demand. They can not compete with bricks made at Little Rock, where convict labor is used in the yards.

PULASKI COUNTY.

GENERAL GEOLOGY.

The northwestern edge of the Tertiary beds crosses Pulaski County 2 or 3 miles northwest of the Iron Mountain Railway and keeps about parallel with it from Little Rock toward the southwest. Northwest of this Tertiary margin the rocks of the county are much folded, and are either Silurian or Carboniferous, while toward the south and east they are nearly horizontal and are Tertiary and Quaternary. The granites or syenites of the Fourche Mountain region are of earlier age than the Tertiary sediments to the south and east. They furnish the kaolins of Pulaski County, and have also probably been the source of much of the valuable clays of this and of adjoining counties.

CLAY DEPOSITS.

DISTRIBUTION.

But little is known of the details of the distribution of the clays in the extreme southern part of the county. South of the Fourche Mountain region the land is low and flat, and it is to be expected that ordinary brick clays are spread over that part of the county in great abundance. In the immediate vicinity of Fourche Mountain there is much pisolitic kaolin.

Pulaski County clays are best exhibited in the southwestern part of the city of Little Rock, and extend thence southwestward to the town of Alexander, on the Iron Mountain Railway and on the county line. Anywhere along this Tertiary margin a section drawn from the Paleozoic region on the northwest toward the southeast would show approximately the same geologic structure.

FOURCHE MOUNTAIN DISTRICT.

The feldspathic rocks of Pulaski County cover a total area of 8 or 9 square miles, all in the vicinity of Fourche Mountain, near Little Rock. White clays are found over this same area at various places. They also occur in the township next west, in the vicinity of Mabelvale, where no feldspathic rocks are known at the surface. The surface exposures are in secs. 5 and 9, T. 1 S., R. 12 W., and secs. 2, 10, 11, and 12, T. 1 S., R. 13 W.; and clays have also been found in wells in secs. 25, 26, 35, and 36, T. 1 N., R. 12 W.

In the NE. ¼ and the NE. ¼ NW. ¼ sec. 9, T. 1 S., R. 12 W., the exposures of clay occur on the middle Pine Bluff road about a quarter of a mile south of the end of the turnpike. It is exposed along both sides of the road for a distance of about 300 feet, and again in the road leading from the main road to D. Rausch's house for about 250 feet. At these exposures the clay where it is first seen has a dark pearl color and comes out in angular blocks that are somewhat stained with iron. Nothing is known of the depth or extent of this material, but it is probable that it will be found clearer of iron stain at no great distance below the surface, for the iron that coats many of the blocks has been washed into the crevices from the overlying surface sands. Small surface fragments seem to show that it extends to the middle of sec. 8, the section next west of that in which these exposures occur, and also into sec. 10 on the east. In the NW. ¼ NW. ¼ sec. 8 it is said to have been cut in a well at a depth of 14 feet. About 100 feet north of D. Rausch's house clay mingled with syenite bowlders is exposed at the surface. A light-gray clay is also reported from the W. ½ NW. ¼ sec. 15, T. 1 S., R. 12 W., but the locality has not been examined.

A well in the NW. ¼ NE. ¼ sec. 2 of this township is said to have penetrated white clay at a depth of 27 feet. A small exposure is also reported at the corner between secs. 3, 4, 9, and 10. Mr. E. C. Buchanan reports an outcrop in the SW. ¼ SE. ¼ sec. 3, T. 2 S., R. 13 W., similar to that found in sec. 9. Samples of this kaolin from the road near the middle of sec. 9 were analyzed and subjected to various practical tests in order to determine its availability as a china clay.

Analysis of Pulaski County kaolinite from sec. 9, T. 1 S., R. 12 W.

Silica (SiO_2)	46.27
Alumina (Al_2O_3)	38.57
Iron (ferric) oxide (Fe_2O_3)	1.36
Lime (CaO)	.34
Magnesia (MgO)	.25
Potash (K_2O)	.23
Soda (Na_2O)	.37
Water	13.61
	101.00
Water at 110°–115° C	1.57

It will be seen that the percentage of iron in this clay is rather high. Samples were tested by practical potters at Trenton, N. J., with the following results: The body of the crude clay burns a beautiful white, but a great number of rusty brown specks are scattered over this white ground, the largest of them one-sixteenth of an inch in diameter. This clay cracks in firing, but not enough to prevent its use for fine pottery if it were available in other respects. The iron in this clay

seemed at first to offer a serious impediment to its availability, but some of the material was ground and thoroughly mixed and made into a paste and tested by firing. The samples came from the furnace in a much better condition than the crude clay—that is, it was free from the rusty brown specks—but the iron had only been evenly distributed through the mass, and the result was that the sample came out with an ivory color instead of pure white. It takes the glaze well and is regarded by the potters as available for such wares as do not require a pure white body.

The clay at this locality (middle of sec. 9) as it comes from the ground is not plastic, nor is it soft enough to admit of its being taken out with a spade or shovel, but it is so hard as to require crushing. It comes out in angular blocks of various sizes; it is readily cut with a pick and has an earthy fracture. It is at first of a dark-pearl color, but upon drying takes on a cream color. The blocks from near the surface are covered with more or less iron stain, but this coating is readily removed, and it probably does not extend to any considerable depth.

Wells dug in secs. 25 and 26 and 35 and 36, T. 1 N., R. 12 W., disclose the existence of clay at various depths. At a small stream in the orchard near William Tarpley's house, in the NW. ¼ NW. ¼ sec. 36, a well 16 feet deep shows the following section:

Section in well in sec. 36, T. 1 N., R. 12 W.

	Ft.	in.
Gravel and sand	5	
Iron ore		2½
Joint clay	3	
Kaolinite	8	
Syenite (?) at bottom.		
	16	2½

In another well, 18 feet deep, on the top of the hill north of the well just mentioned, in the same orchard and nearer the house, no clay was found. The following is a section of this well:

Section in well near William Tarpley's house, in sec. 36, T. 1 N., R. 12 W.

	Feet.
Waterworn pebbles	6
Joint clay	8
Sandstone	4
Syenite at bottom.	
	18

These two wells are not more than 200 feet apart and the difference of elevation between their mouths is about 30 feet. It is evident that these clay beds are irregular in shape and thickness.

The clay found in Mr. Tarpley's well is very soft and almost milk white in color. Small patches of iron stain appear in places.

The following is an analysis of this clay:[a]

Analysis of clay from Tarpley's well.

Silica (SiO_2)	45.28
Alumina (Al_2O_3)	37.39
Iron (ferric) oxide (Fe_2O_3)	1.71
Lime (CaO)	1.83
Magnesia (MgO)	.29
Phosphoric acid (P_2O_5)	.06
Water, after having been dried at 110° C.	13.49
	100.05

In the NE. ¼ SE. ¼ sec. 35, T. 1 N., R. 12 W., on the farm of J. M. Dickinson, a well 48 feet deep gives the following section:

Section of well in sec. 35, T. 1 N., R. 12 W.

Thin gravel at top.	Feet.
Red clay	16
White clay	1
Yellow pisolite (bauxite ?)	6
White clay	25
	48

Water was obtained before the last body of clay was passed through. Its actual thickness in this well is, therefore, not known.

In Mr. Dickinson's yard, about 100 feet east of this well, another well shows clay at 23 feet. In the latter well the yellow pisolite appears at 16 feet and the 1-foot band of white clay seen in the 48-foot well is absent. The following is a section of this well:

Section in well at house of J. M. Dickinson.

Thin gravel at top.	Feet.
Red clay	16
Yellow pisolite (bauxite ?)	6
Kaolinite in bottom	1
	23

The difference in elevation of the mouths of these two wells is not more than 4 feet. The specimens of clay obtained from the 48-foot well are of grayish-white color and show iron stains on the surface. There are signs of clay at the fork of the roads in the NE. ¼ sec. 26, but no systematic search has been made to ascertain whether it occurs in quantity or of a quality that will render it valuable.

In the neighborhood of Sweet Home station, in sec. 25, T. 1 N., R. 12 W., several wells are said to have passed into a white pipe clay, probably the white clay found in the village half a mile west of the station.

[a] This analysis was made by Mr. W. R. Cravens under the direction of Dr. T. C. Van Nuys, professor of chemistry at the University of Indiana.

Those who may seek for clay in the Fourche Mountain district should bear in mind that it is not likely to be found on the hilltops, but rather in the lower grounds, where the rocks are kept constantly saturated with the acid waters by which decomposition is produced. It is surmised that places favorable to the formation of clay beds may be found in the northern part of sec. 3, T. 1 S., R. 12 W.

It should be added that at several places the lower portions of the bauxite beds of Pulaski County grade into clays.

MABELVALE DISTRICT.

The Mabelvale district lies about halfway between the Fourche Mountain district, south of Little Rock, and the Saline County district. No feldspathic rocks have been observed in the immediate neighborhood of Mabelvale, but a band connecting the Fourche Mountain and the Saline County areas would embrace Mabelvale. This fact and the existence of bauxite seem to suggest the probability that syenites exist not far beneath the surface in the vicinity of Mabelvale. The clays in this district are all more or less pisolitic, and are believed to be simply the kaolin varieties of bauxite. Their chemical composition, however, seems to suggest the possibility that some of them may be available as china clays.

On the middle of the east side of the NW. ¼ sec. 10, T. 1 S., R. 13 W., about 150 yards south of the west end of the railway siding at Mabelvale station, on the St. Louis, Iron Mountain and Southern Railway, there is a deposit of bauxite which merges into pisolitic clay, the two covering about 25 acres. The material outcrops at many points, but it is concealed for the most part by a thin covering of sand and pebbles and nodules of sandy limonite. The covering becomes gradually more abundant toward the higher ground and thins out on the margins of the knolls. But little is known of the actual area covered by the clay. A well said to have been dug 92 feet deep at the house of J. W. Hopkins, within 300 feet of the western outcrop, is reported to have penetrated 8 feet of soil and then "soapstone," or gray clay, all the rest of the way.

The following analysis shows the character of the clay from the Mabelvale locality:

Analysis of pisolitic clay from SE. ¼ NW. ¼ sec. 10, T. 1 S., R. 13 W.

[Brackett & Smith, analysts.]

Silica (SiO_2)	45.20
Alumina (Al_2O_3)	37.60
Iron (ferric) oxide (Fe_2O_3)	3.00
Lime (CaO)	.89
Magnesia (MgO)	Trace.

Potash (K_2O)	0.06
Soda (Na_2O)	.69
Water (loss on ignition)	13.54
	100.98
Very fine sand	.25
Water at 110°–115° C	.62

This contains a large amount of iron, but it is probable that material found at greater depth will contain less iron than that nearer the surface.

White pisolitic clay is also exposed in the NE. ¼ NE. ¼ sec. 10, less than half a mile southeast of the railway station. This material crops out in the road. Just south of the road, about 15 paces from it, a well was at one time put down, and the following is reported as the section passed through:

Section in well in sec. 10, T. 1 S., R. 13 W.

	Feet.
Yellow clay soil (dug)	3
Pisolitic clay (dug)	14
Pisolitic clay (bored)	14
	31

The clay was not penetrated at this depth, so that its total thickness is not known. This well record is also said to bear out the suggestion that the clay becomes softer and cleaner as the depth increases. The extent of this deposit is not known, but it probably does not exceed 5 acres.

The analysis given below shows that this material contains less iron than the sample taken near Mr. Hopkins's place, in the same section.

Analysis of pisolitic clay, NE. ¼ NE. ¼ sec. 10, T. 1 S., R. 13 W.

Silica (SiO_2)	48.05
Alumina (Al_2O_3)	38.92
Iron (ferric) oxide (Fe_2O_3)	1.19
Lime (CaO)	.58
Magnesia (MgO)	.45
Potash (K_2O)	.18
Soda (Na_2O)	.28
Water (loss on ignition)	10.86
	100.51
Water lost at 110°–115° C	.46

Another deposit, which shows in the form of bauxite at the surface, but which will probably be found to contain a pisolitic clay a short distance below the surface, occurs in the SW. ¼ SE. ¼ sec. 2, T. 1 S., R. 13 W., and nearly or quite on the line between secs. 2 and 11, the greater part of it lying between the forks of the road at this point. The total area covered by this deposit probably does not

exceed 4 acres. Where this material is exposed at the surface it is pisolitic, hard, and iron stained. A well sunk in it showed that it resembles the other deposits of this region in being softer and whiter below the surface. The surface fragments have been used somewhat for building chimneys and for setting boilers, to which purposes its fireproof qualities make it well adapted.

In the SE. ¼ SW. ¼ sec. 12, T. 1 S., R. 13 W., loose fragments of pisolitic clay are scattered over the surface and a few small exposures are visible. There are no means, however, of knowing the nature or extent of this deposit, but if this kind of clay proves to be valuable it would be worth while to prospect at this place.

The following is the record of a well dug at Mabelvale, in the NE. ¼ NE. ¼ sec. 10, T. 1 S., R. 13 W., in the yard of Mr. A. W. Norris:

Section in well at Mabelvale.

	Feet.
Yellow surface clay	5
Reddish clay	1
Dove-colored joint clay or "soapstone" clay with occasional "iron pots" and some manganese streaks	16
Ferruginous sandstone	2
Black clay in the bottom.	
	24

The dove-colored clay of this section is soft and unctuous, and is popularly known as "soapstone." The "iron pots" (hollow masses of iron ore, some a foot in diameter, resembling waterworn cobbles) found in this bed are so large and so sparsely scattered through the bed that they can not seriously interfere with the use of the clay.

This clay bed is probably widespread in the neighborhood of Mabelvale, lying at or near the surface. It was passed through in digging the well in the public square at Mabelvale. The section of this well given below is a sort of average made up from several reports, which disagree somewhat in minor details, but not in any essential features.

Section of well in public square at Mabelvale.

	Ft.	in.
Yellow surface clay	5	
"Soapstone clay"	10–15	
Ferruginous sandstone	2	
Black clay	10	
Limestone		8
Black clay	10	

The following analyses give the composition of the "soapstone" clay bed. No. 1 is an average sample from the well at Mr. Norris's house. The analysis was made by the Geological Survey of Arkansas. No. 2 was sent for analysis by McCarthy & Joyce, of Little Rock, to

Prof. W. B. Potter, of St. Louis. A copy of the analysis was kindly furnished by Mr. Norris.

Analyses of "soapstone" clay, from well of A. W. Norris, NW. ¼ NE. ¼ sec. 10, T. 1 S., R. 13 W.

	1.	2.
Silica (SiO_2)	65.27	60.79
Alumina (Al_2O_3)	18.75	19.73
Oxide of iron (Fe_2O_3)	7.34	5.94
Lime (CaO)	.81	.37
Magnesia (MgO)	1.26	.72
Potash (K_2O)	1.10	1.93
Soda (Na_2O)	.81	
Loss on ignition (H_2O)	6.88	10.77
	100.22	100.25
Water lost at 110°–115° C	9.46	.....
No sand.		

This clay is convenient to transportation and well adapted to the manufacture of paving bricks, sewer pipes, and probably fire bricks. The beds are horizontal, and at points where the surface is somewhat lower than at Mr. Norris's can be reached without much stripping.

The following sections of wells in the vicinity of Mabelvale, although evidently imperfect and unsatisfactory, are given for what they are worth. All references here are to T. 1 S., R. 13 W.

V. L. Cochrane, in the SW. ¼ NW. ¼ sec. 11, reports "17 feet of fire clay and red clay." The so-called fire clay is possibly the same as the buff clay in Mr. Norris's well.

Mr. Rowland, on the NW. ¼ SW. ¼ sec. 11, reports "22 feet of fire clay and red clay." This section without doubt exposes the same beds as does that given by Mr. Cochrane near the blacksmith shop.

Mr. Rowland also reports, from the SW. ¼ NW. ¼ sec. 11, "13 feet of fire clay and yellow clay, with from 2 to 4 inches of ferruginous sandstone interbedded."

Mr. S. E. Emerson, in the NE. ¼ NE. ¼ sec. 11, reports the following well section:

Section of well in NE. ¼ NE. ¼ sec. 11, T. 1 S., R. 13 W.

	Feet.
Red clay	3½
Gray "fire clay and black clay"	20
Gray clay	18

These gray clays and so-called fire clays are probably the same as the buff clays passed through in Mr. Norris's well. If this supposition is correct, these sections show that the buff clay is a widespread bed, underlying all the higher grounds east and southeast of Mabelvale, and probably a much wider area still, while it is cut out in the low grounds along the streams. Should there be a demand for these clays they will be found most accessible in sec. 3 and on the lower grounds about the bases of the ridges, where they are not obscured by a covering of gravel and sand and soil.

LITTLE ROCK DISTRICT.

BRICK CLAYS

The folded Paleozoic rocks pass beneath the city of Little Rock, and on these folded beds rest the Tertiary clays and sands of the southwestern part of the city. It should be observed also that these Tertiary beds are nearly horizontal, that they thin out toward the north, and that similar beds underlie the region south of Fourche Mountains.

At several places in the city of Little Rock the folded Paleozoic rocks may be seen standing almost on end. The famous "little rock" itself, on which rests the south end of the railway bridge at the foot of Main street, is a folded and wrinkled Paleozoic bed.

Only a few paces south of the river bank these older beds are not exposed, but the surface is made up of loose materials. One of the best sections seen near the center of the city was exposed when the excavations were made for the foundations of the Masonic Temple, on the corner of Fifth and Main streets, in June, 1890. The section exposed was as follows:

Section in excavation for Masonic Temple at Little Rock.

	Feet.
1. Mottled red clays with chert pebbles, becoming more sandy at the base	7–9
2. Reddish-brown clayey sand with brown chert pebbles	2–3
3. Red, gray, and white mottled plastic, sandy clay with a few large and angular sandstone fragments at the top of the bed (exposed)	3

The upper surface of No. 3 is irregular, as if it had been eroded before the overlying beds were laid down upon it. These are probably the overwashed portions of the Tertiary series, the equivalents of which on the Atlantic seaboard are called the Appomattox formation. These rehandled beds of mottled clays, sands, and gravels are found at the surface in nearly every part of the city. They are well exposed in the cuts, even on the top of Capitol Hill, in the vicinity of the school for the blind, and at many other places. Below these gravelly beds lie the undisturbed Tertiary strata, which in and about Little Rock consist chiefly of limestones, shales, or clays, and sands.

Mr. C. E. Siebenthal, while in the employ of the Arkansas Survey, collected many data regarding the geology of southwestern Little Rock. He is of the opinion that there are four pretty constant and well-defined beds in the series of sediments resting upon the Paleozoic rocks. These are, beginning at the base, (1) yellow calcareous clay or marl; (2) dull gray fossiliferous limestone; (3) soft, dark unfossiliferous shale; (4) olive-green clay, probably derived by weathering from No. 3. Above this type section are found various combinations of sands and gravels and soil.

Of these beds the ones of interest in connection with the subject of clays are the shale bed (No. 3) and the olive-green clay. The green clay is well exposed on the Seventh street pike, between West Spring street and West Sherman street, where it rests upon upturned Paleozoic rocks, which are exposed at this place. The following exposures and well records show the depth of the shales and clays at various points in the city:

Section in D. T. Coffman's well, at northwest corner Eighteenth and West Sherman streets, Little Rock.

	Feet.
1. Soil, gravels, and white clay	16
2. Soft shale, yellow above, blue below	14

West of the railway the olive-green clay is exposed in the road cut near the Catholic cemetery, in the gullies south of the cemetery, in the gully west of the hospital, and in another gully about 500 feet southwest of the hospital. It is also exposed in the bed of the branch just east of the hospital, and also toward the top of the ridge to the east.

The following is the record of a well put down west of the railway, about 300 feet northeast of the center of the south side of sec. 8, T. 1 N., R. 12 W., as reported by Mr. Siebenthal.

Section of well in sec. 8, T. 1 N., R. 12 W.

	Ft.	in.
Gravel and sand	6	
"Mulatto" clay	8	
Gray clay		10
Yellow clay	10	
Gravels and sandy clay	8	

East of the railway near the center of sec. 16, T. 1 N., R. 12 W., there are several exposures of the shale and of the olive-green clay. On the east slope of the ridge that runs along the east side of sec. 16 this same green clay is exposed here and there. It is exposed also in the gullies beside the road leading southwest from the Arch street pike, in the SW. ¼ sec. 15.

A well on the east side of the Arch street pike, 200 feet south of the northern edge of sec. 15, passed through soil, gravel, yellow clay, and tough blue clay, and got water at 27 feet in gravel. This clay bed is probably the same as that exposed in the gully on the slope of the hill below, where the road turns southwest from the Arch street pike.

A well at the southeast corner of Arch and Twenty-third streets passed through 8 feet of gravel and sandy clay and 10 feet of yellow and blue Tertiary clay. This is doubtless the same blue clay bed again.

At the end of the ridge east of the Rapley house and north of Pettifer's brickyard the olive-green clays are well exposed to a thickness of 40 to 45 feet. The olive-green clay and dark shale were found in

wells and cisterns dug about Cumberland, Rock, Twentieth, and Twenty-first streets.

The following records were gathered by Mr. Siebenthal:

A well at Fifteenth and May streets passed through the Tertiary shale.

A well near the northwest corner of Thirteenth and Jones streets passed through 10 feet of soil and gravel and 18 feet of shale.

A well 14 feet deep at Fourteenth and Marshall streets passed through dark shale most of the way.

A well at the southeast corner of Twenty-seventh and Wolfe streets passed through 10 feet of gravel and sandy clay and 20 feet of dark Tertiary shale.

A well on Mr. Robert's place, Twenty-second street, between Commerce and Sherman, passed through 19 feet of soft Tertiary shale, and two other wells in adjoining lots to the east penetrated 60 feet of the same soft shale.

A well at the corner of Sixth and College streets passed through 30 to 35 feet of dark Tertiary shale.

A well bored by the Cotton Belt Railway Company on Rector avenue between Third and Fourth streets passed through the following:

Section in well of Cotton Belt Railway Company, Rector avenue, Little Rock.

	Feet.
Soil	12
Dark Tertiary shale	20
Paleozoic shale	29
Sand (?)	6

A well on Ninth street opposite the arsenal is reported by the digger to have the following section:

Section on Ninth street near the arsenal, Little Rock.

	Feet.
Soil and clay	20
Tertiary shale	8
White gravel	4

These facts and others not here given lead to the belief that the Tertiary clays follow the brow of the hill where the Arch street pike descends the slope about the middle of sec. 15, encircle the narrow valley that heads about the corner of Nineteenth and High streets, pass around it, and thence extend southward along the slope of the hill that runs along the east side of sec. 16, return northwestward along the valley through which the Iron Mountain Railway passes, appear again in the vicinity of the hospital on the west side of the railway, and thence around the hills west of the hospital. Of course, it is understood that these beds are nearly horizontal and that they pass right through the hills mentioned and have their edges exposed only on the slopes of the ridges. Almost everywhere, however, the

outcrops are concealed by the soil and surface materials that have fallen down over them.

The elevation of the outcrop varies somewhat, but it lies for the most part between 260 feet and 302 feet above sea level.

In and near the city of Little Rock there are only a few places at which the clays can now be worked advantageously. This condition is due to the value of the land for building purposes, and not to any defect of the clays themselves. In spite of this it is possible that there may be places in the southwestern part of the city where the clays could be worked, while the nearness to market and to transportation would be in favor of such an enterprise.

On the south side of the river there is a brownish-yellow brick earth similar to that which forms the surface in sec. 28, T. 2 N., R. 12 W., overlying the other clays in different places west and south of Little Rock.

Between the high shaly hills on which the asylum for the insane and the reservoir of the city waterworks have been erected and the river there is a narrow strip of this same brownish-yellow clay. It lies in a long, narrow belt between the hills and the bottom land of the river. At Ward's old brickyard this brick loam rested directly upon a red sand. The section is as follows:

Section at Ward's old brickyard, Little Rock.

	Feet.
Brick earth removed at other places in the same belt	2
Stiff, hard red sand	4
Light iron-gray or yellowish sand	5

Between the point where the St. Louis, Iron Mountain and Southern Railway crosses Sixteenth street and the outcrop of the blue shales and quartz ledge at Nineteenth street a small deposit of this brownish-yellow brick earth appears to have been laid down in a sort of pocket among the shales, with its opening toward the south. The yellowish loam here has a depth of about 3 feet.

Another small deposit of the same material is found on the corner of Rector avenue and Eighteenth street. Here the brownish-yellow loam has a thickness of 2 to 3 feet. It is underlain by a bluish pebbly clay, mixed with sand. A well bored through this clay shows it to have a thickness of 19 feet. It is underlain by sandy clay. The underlying sandy clay is seen in the bottom of a small stream that runs along the south side of the old Bragg brickyard. The clay covers only a small area, most of it lying between gravel ridges.

On Arch street between Twenty-fourth and Twenty-sixth streets, at C. W. Clark's old brickyard, the brick clay was about 2 feet thick before it was exhausted, and was underlain by a stiff, bluish-red, streaked clay containing pebbles, which is said to be underlain by gravel.

The greater portion of a well close to Clark's yard, 23 feet deep, passed through gravel, below which lay black mud. Another well, 16 feet deep, does not reach the black mud, but ends in the gravel.

JOINT CLAYS.

The next clay below the brownish-yellow brick clay is a stiff, hard clay having a tendency to break into small cuboidal fragments when exposed to the air. Its tendency to break is the chief objection to its use for manufacturing purposes. Ware containing any of this "joint" clay, as it is called, is likely to break in drying.

This joint clay varies somewhat in different places as regards color, having a blue or red tint according to its position, but the color has no apparent effect on its texture or its tendency to break when exposed to the drying action of the atmosphere. It appears to be very persistent, being found in nearly every opening in the district that passes through the upper beds. It is not confined to the brownish-yellow brick-earth area, but underlies the chocolate clay and some of the gravels.

In the district north of the river this joint clay is red and is seen in the stream running through the small bayou on the north side of Big Rock, where it underlies 2 feet of chocolate clay. In the wagon road near the Fort Smith crossing of the St. Louis, Iron Mountain and Southern Railway it varies from 3 to 5 feet in thickness and overlies a red sandy clay. In Mr. Vestal's portions of secs. 26 and 27, T. 2 N., R. 12 W., it lies near the surface. In the NE. ¼ NE. ¼ sec. 17, T. 2 N., R. 11 W., the clay underlying the brownish-yellow loam is very compact.

In the NE. ¼ NW. ¼ sec. 21, T. 2 N., R. 11 W., the clay underlying the brownish-yellow loam is a whitish-yellow and blue mixed sandy clay 20 feet thick and rests upon 12 feet of mottled clay.

On the south side of the river a blue clay underlies the other clays at most places where deep cuttings have been made. This clay, which lies just below the brownish-yellow surface clay, is a light-blue iron-stained clay containing quantities of pebbles and sand and nodules of limonite.

The underlying clay on the corner of Rector avenue and Eighteenth street is bluish gray and contains pebbles. At this place it is 19 feet thick. It is also seen in the bank of a small stream a short distance south of this place.

At C. Clark's old brickyard the brick earth is also underlain by this light-blue sandy clay. This same blue clay extends southward over the ground formerly used as a brickyard on the south side of Twenty-fifth street.

In the banks of the small stream that runs through the cemetery and westward across the Sweet Home turnpike, close to the Confederate soldiers' cemetery, there is a heavy deposit of a stiff, red joint clay.

On the Arch street turnpike a little west of the place where the new road joins the turnpike a bed of blue and red mottled joint clay is exposed in a gully washed out by the rain.

For practical purposes these joint clays are not in much demand. Their tendency to "joint" or break up into small blocks whenever exposed to the weather makes their use difficult for any purpose except with great care, and even then no reliance could be placed upon them if worked alone.

If judiciously mixed with other clays they might be used for some classes of ware. A mixture of the stiff red clay and the brownish-yellow surface clay has been successfully used for making flower pots. A few lengths of drain tile, turned upon the potter's wheel, dried and burned very satisfactorily.

CHOCOLATE CLAYS.

The chocolate clays are found only in remnants or patches in various parts of the district.

At the union depot in Little Rock the chocolate clay forms the surface of the flat bottom of the cove in which the depot is situated. It has here a thickness of 2 to 3 feet.

In the small valley formed by the stream crossing the Sweet Home turnpike and skirting the southern side of the gravel ridge in the SE. ¼ sec. 11, T. 1 N., R 12 W., the chocolate clay is found on both sides of the stream and has a thickness of from 1 to 2 feet. On the hill at the tollgate between this stream and Fourche Bayou, about one-half mile from the place just mentioned, the same bed of chocolate clay appears.

The following section shows the relation of the clays at this hill:

Section at hill at tollgate.

	Feet.
Chocolate clay	3
Red clay	6
Blue clay.	

In Big Rock Bayou, in sec. 21, T. 2 N., R. 12 W., chocolate clay 2 feet thick overlying a blue clay occupies the greater part of the bottom lands around the bayou.

A partial analysis of the clay northwest of the union depot at Little Rock shows the following constituents:

Analysis of chocolate-colored clay northwest of union depot, Little Rock.

[J. P. Smith, analyst.]

Silica (SiO_2)	70.05
Alumina (Al_2O_3)	14.56
Ferric oxide (Fe_2O_3)	6.20
Lime (CaO)	.74
Magnesia (MgO)	1.12

Potash (K_2O)	Not determined.
Soda (Na_2O)	
Loss on ignition	4.45
	97.12
Sand, very fine, but some coarse particles	11.83
Water at 110°–115° C	4.48

When the chocolate clay is washed, it makes a smooth paste of uniform color. This may probably form a good base for the manufacture of some classes of terra-cotta ware, but great care must be taken to see that it is dried at a uniform rate over all the work, as otherwise the clay has a tendency to break into small blocks.

A portion of the chocolate clay found in the valley at the union station was washed, and the slip so formed was allowed to stand for some time. The surplus water was filtered off and the whole was allowed to stand for two weeks. On drying it formed a smooth-surfaced even-textured clay and retained its characteristic chocolate color.

BOTTOM CLAYS.

The bottom lands that lie along Fourche Bayou and form Fourche Island are overlain in many places by a dark-bluish clay. On drying this clay becomes ashy gray and exhibits patches of iron or rust stains. When wet the clay is tough and plastic, and in drying it becomes hard and shows a tendency to crack where exposed to the heat of the sun.

An exposure of this clay is seen in the stream along the track of the St. Louis, Iron Mountain and Southern Railway, near the point where that road crosses Fourche Bayou, in the NE. ¼ SE. ¼ sec. 17, T. 1 N., R. 12 W. In this stream the clay bed is about 4 feet thick and extends along the railroad for nearly a quarter of a mile. It is also shown at various other places in the cuttings throughout the bottom lands.

This clay is comparatively free from sand and when wet is very tough. When worked properly it may be used for making a good grade of pressed front or ornamental bricks and may possibly be utilized for the manufacture of ordinary drain tile. In appearance and texture, as well as in position and apparent origin, this clay greatly resembles the clays of the bottom lands of Terre Noir and Bradshaw creeks, which were formerly used in the manufacture of bricks and drain tiles by Maj. Jesse A. Ross at his brick and tile factory near Arkadelphia.

In working this clay considerable attention will have to be paid to its proper mixing and tempering, and also to the drying of the bricks or tiles after they have come from the machine.

This clay will work better and easier if dug in the fall and worked over during the winter preparatory to its final tempering and manufacture in the following summer. The low-lying position of the pits will require the clay that is to be thus worked to be removed to a

higher situation, where it will be beyond the reach of the overflow of the bayou during the late winter and early spring rains. It will be an advantage to house the clay in covered pits, where it can be protected from excessive wet and where at the same time it will not become too dry for working. If it contains a considerable quantity of its natural moisture, less work will be required in mixing and grinding and a much better final article will be produced.

Like the other clays found in the bottom lands of the State, this clay holds a considerable percentage of water, and at the same time it parts with the water very slowly. For this reason it will be necessary to work this clay in as dry a condition as possible. The slow parting with its combined water renders the drying of the bricks and tiles made of this or similar clays a rather long process and one which must be very carefully attended to. Such clays can be best dried under cover, in sheds so constructed that, as far as possible, a uniform amount of air and heat will be allowed to come in contact with the newly made bricks or tiles and strike them as equally as possible. At some seasons of the year, and for reasons given above, an artificial drier may probably be the most advantageous. Probably the drier may be economically used at all times, as clays of this class can not be dried in the air sufficiently to be ready for the kiln within fifteen to twenty days. Great care must be taken that the bricks or tiles are sufficiently dry before they are placed in the kiln. If not thoroughly dry when put into the kiln, the bricks will crack and the tiles have a tendency to split longitudinally.

M'ALMONT DISTRICT.

West of the village of McAlmont, in the center of sec. 16, T. 2 N., R. 11 W., on the line of the St. Louis, Iron Mountain and Southern Railway, and in the NE. ¼ NE. ¼ sec. 29, T. 2 N., R. 11 W., the railway crosses a bank of clay running in a northwest-southeast direction. The northern boundary of this field begins near Tremble Lake, in the SW. ¼ SW. ¼ sec. 9, T. 2 N., R. 11 W., and passes northeastward, curving gently round it until it crosses the St. Louis, Iron Mountain and Southern Railway 1 mile north of McAlmont. It there crosses the Memphis wagon road and, turning somewhat abruptly, comes west, crossing the wagon road to Galloway, a short distance east of McAlmont. The bank then curves round toward Ink Bayou. It follows the edge of the bayou for some distance and again crosses the public road and railway in the SE. ¼ sec. 20, T. 2 N., R. 11 W. This area is overlain to a great extent by a brighter colored loam than that found in the old brick field around Argenta, and from appearances it seems capable of making a finer brick.

This bank is not altogether composed of yellowish loam. North of McAlmont the loam gives place to a stiff clay, which changes in color from bright red to drab and dark red as it approaches the outer point of the area comprised within the above limits. This clay, although differently colored, is apparently of the same nature. It is plastic, greasy to the touch, and works smoothly. Each color works into the other, forming a perfectly homogeneous mass. A well bored through the red clay in the SE. ¼ SE. ¼ sec. 9, T. 2 N., R. 11 W., shows it to have a thickness of 12 feet and that it rests upon fine sand.

In a ditch along the side of the railway and between it and the Memphis wagon road three beds are exposed. These clays are red, drab or gray, and bright red. The red clays at the bottom do not appear to have the same texture as the others. Where exposed to the air these clays become dried and show a tendency to break up into small pieces, somewhat in the same style as the joint clay, but when wet they are stiff and tenacious.

This clay bank follows the same general course as that just mentioned. It begins at Clear Lake, and from that point a mulatto sand succeeds it to the Galloway road at McAlmont. West of McAlmont the face of the bank becomes somewhat paler in its upper division. The light-colored material forms no great proportion of the bank, and in the many cuttings made by the small streams and rain the red clay is seen everywhere underlying it. Where the bank is crossed by the public road west of Buchanan's the light-colored and mulatto soils appear to be wanting in the face and are confined to the middle level of the country, and form a terrace, the edge of which is seen on the road a short distance west of Buchanan's, where it overlies a red silty sand and has a depth of 3½ feet. It, however, gradually disappears toward the west, and at the old graveyard on the Little Rock and McAlmont wagon road, about 2 miles east of the lower railroad bridge over Arkansas River, it is replaced by this red sand. The underlying clays in this field are not easily determined.

CLAY INDUSTRY.

The various kinds of clays found in Pulaski County have already been discussed. They include the kaolins of Fourche Mountain, pottery clays, clay shales suitable for the manufacture of paving bricks and fire bricks, and the more common surface clays suitable for the manufacture of common building bricks. Common brick clay is the only clay in the county now used, and Little Rock the only place where it is manufactured into bricks.

There are at present three brick plants in Little Rock engaged in the manufacture of brick. One of the largest plants is the Arkansas Brick and Manufacturing Company, established in 1897. The plant is well equipped with modern machinery for molding, drying, and

burning. Stiff-mud and dry-pressed bricks are made. The stiff-mud bricks are molded in a Chambers machine and the dry-pressed bricks in a Ross-Keller dry press. The bricks are dried in a Standard drier and burned in Swift's patent up-draft grate kilns. It requires forty-eight hours to dry and eight to ten days to burn the bricks. Ten kilns, 72 feet by 24 feet inside measurement, are in use. The output of the plant is 150,000 stiff-mud and 25,000 dry-press bricks a day.

ST. FRANCIS COUNTY.

GENERAL GEOLOGY.

St. Francis County is divided into three natural subdivisions—(1) the eastern, or St. Francis River bottom; (2) the central, or Crowleys Ridge; and (3) the western, or the prairies.

The St. Francis River bottom is a flat area which is but 212 feet above sea level at Madison, on St. Francis River. East of this the country rises somewhat. The elevation of Forrest City, on the west side of Crowleys Ridge, is 251 feet. East of the ridge the surface material consists entirely of alluvial sand and silt.

The Chicago and Rock Island Railroad, which runs from Memphis to Little Rock, crosses Crowleys Ridge at Forrest City. The following interesting section is shown along the railroad from Madison, on St. Francis River, to Forrest City:

Section of Crowleys Ridge at Forrest City.

	Feet.
Loess (unstratified)	10
Dark loam, a phase of the loess	3
Yellow clay loam, a phase of the loess	10
Loess unstratified, containing irregular lime concretions	6
Stratified loess, bedding brought out in narrow bands by yellow iron-oxide coloring, containing many small land shells, also many round lime concretions of all sizes up to that of a base ball, the whole bed becoming more and more sandy toward the base	16
Hidden	2–3
Gravelly sand, streaked yellow with iron stain and cross-bedded	3–4

Still farther east, at a lower elevation than the base of the above section, the following section was obtained:

Section 1¼ miles east of Forrest City.

	Feet.
Loess (unstratified)	10
Dark loam, a phase of the loess	3
A reddish-yellow phase of the loess	6
Loess, indistinctly stratified	15
Yellow clay loam	3
Fine drab argillaceous sand	3
Coarse gravel (Lafayette)	5
Gray sand, cross-bedded in places and elsewhere interstratified with thin layers of light-drab clay	2
Dark to black sand, very fine, containing lignite, the dark color being due to carbonaceous matter	2–3

On the east side of Crowleys Ridge, near the mouth of Big Crow Creek, and also in the bed of the creek about one-half mile from its mouth, there is a series of calcareous marine deposits containing numerous Tertiary fossils, which belong either to the Jackson or Claiborne horizons. The collections which have been made contain about an equal number of Jackson fossils and of fossils of Claiborne age. While the exact horizon may be somewhat doubtful, the fossils prove conclusively that the strata belong to the lower Tertiary beds.

The fossils found in the strata along Big Crow Creek, east of Forrest City, have made it possible to determine the age of the older strata along Crowleys Ridge. The ridge is, therefore, a remnant of the old Tertiary plain which once extended unbroken from the foot of the Paleozoic hills in eastern Arkansas eastward to the present bluffs east of Mississippi River.

CLAY DEPOSITS.

The clays of St. Francis County are the common brick clays found along the top and sides of Crowleys Ridge and the yellow clay loam of the prairie country west of the ridge.

Crowleys Ridge throughout the county is capped with loess, which is found in different phases. In the railroad cut east of Forrest City there are no less than four different varieties of the loess. In places it is a buff to gray nonstratified mass, containing a large percentage of lime concretions and land shells. Both above and below lie beds of stratified loess, which in places is a reddish-yellow clay loam, containing little or no lime carbonate and free from shells. The yellow clay loams of the loess are much better adapted to brick manufacture. The bricks burn to a solid red and are much stronger and stand more heat than bricks made from the calcareous loess.

The country west of the ridge has a surface covering of yellow clay similar to the yellow clay of the loess, but of much later age. In places its thickness ranges from about 15 feet at the western edge of St. Francis County to 40 feet or more near the foot of Crowleys Ridge.

The persistency of the surface clay is shown in the following well sections:

Section of well at Palestine.

	Feet.
Red clay	12–14
Quicksand	12–14
White clay	6– 8
Heavy gravel	12

Section of well at Brinkley, about 3 miles west of St. Francis County.

	Feet.
Yellow clay	12
Yellow sand	17
Blue mud	1
Quicksand	6
Hard clay	25
Coarse gravel	(?)

The yellow surface clay which occurs so extensively over the prairie region west of the ridge forms in places the limonite buckshot land.

Below are given three analyses of the brick clays from St. Francis County:

Analysis of loess soil from Crowleys Ridge, at Forrest City.

[J. P. Smith, analyst.]

Silica and insolubles	76.30
Ferric oxide (Fe_2O_3) / Alumina (Al_2O_3)	16.86
Lime (CaO)	1.00
Magnesia (MgO)	1.22
Potash (K_2O)	.54
Soda (Na_2O)	.89
Phosphoric acid (P_2O_5)	Trace.
Loss on ignition	2.83
	99.64

Analysis of buckshot clay from Goodwin Prairie, 4 miles northwest of Goodwin station.

[J. P. Smith, analyst.]

Silica (SiO_2)	82.52
Alumina (Al_2O_3)	7.50
Iron oxide (Fe_2O_3)	4.32
Lime (CaO)	Trace.
Magnesia (MgO)	.40
Potash (K_2O)	.52
Soda (Na_2O)	.63
Manganese (MnO)	Trace.
Phosphoric acid (P_2O_5)	Trace.
Loss on ignition	3.64
	100.34
Water at 115° C	7.82

The following sample was taken from the material about a newly dug well about 4 miles northeast of Goodwin station, on the railway:

Analysis of hardpan from Goodwin Prairie.

[J. P. Smith, analyst.]

Silica (SiO_2)	84.04
Ferric oxide (Fe_2O_3)	3.70
Alumina (Al_2O_3)	6.32
Lime (CaO)	.34

Magnesia (MgO)	Trace.
Potash (K_2O)	0.91
Soda (Na_2O)	.80
Manganese (MnO)	Trace.
Phosphoric acid (P_2O_5)	.00
Loss on ignition	3.32
	99.43
Water at 115° C	1.40

CLAY INDUSTRY.

The only clay product manufactured in the county is common building brick, made from the loess by the Choctaw Brick and Tile Company, of Forrest City. The clay is hauled from the pit to the machine by a team and scraper, mixed in a steam pug mill, and molded in a Chambers end-cut, stiff-mud machine. The bricks are dried by steam, which requires one to two days. They are burned in up-draft kilns, having a capacity of 200,000 bricks. Wood is used as fuel. The plant has a capacity of 20,000 bricks a day.

SALINE COUNTY.

GENERAL GEOLOGY.

Saline County has within its borders rocks of two widely different geologic ages. The northwestern portion of the county is covered with Paleozoic shales, sandstones, and novaculites, much folded or standing on edge, and intersected by a vast number of quartz veins; while the southeastern part is of soft and usually uncompacted and horizontally bedded Tertiary sands, clays, and gravels, except in parts of T. 2 S., R. 14 W., where eruptive rocks come to the surface. The line separating the Paleozoic and Tertiary areas runs through the county in a northeast-southwest direction. The St. Louis, Iron Mountain and Southern Railway follows the dividing line approximately parallel with and from 1 to 4 miles northwest of it. The region of Paleozoic shales and sandstones to the northwest was the dry land forming the shores during Tertiary times, when the sands and clays that lie to the southeast were being deposited in the waters which at that time covered all southern and eastern Arkansas.

CLAY DEPOSITS.

DISTRIBUTION OF THE CLAYS.

In the northern and western parts of the county pottery clays are not likely to occur in abundance. They may possibly be found in occasional local pockets, where the clay shales have decayed, or in "slashes," where the water has leached out local accumulations; but the great pottery clay beds lie south and east of the old shore line re-

ferred to above. In the river bottoms also, especially along Saline River, the immediate surface soil includes here and there "buckshot" clays, which furnish rather poor pottery clays.

CLAYS ABOUT BENTON.

The clay pits opened in the vicinity of Benton have aided a comprehension of both the general and detailed structure of this part of the State. These pits are all in T. 2 S., R. 15 W. The sections which they represent are here given in detail, beginning with the Hicks pit in the NE. ¼ NE. ¼ sec. 12.

HICKS CLAY BANK.

The Hicks clay bank, formerly known as "the old Leach bank," was the first clay deposit opened in the neighborhood of Benton, and for several years was the only source of supply for pottery clays at that place. Early in 1889 the old pit was reopened by Mr. J. Howe, and the clay was mixed with clay from other pits for use in his pottery. It is not used by itself in any of the potteries.

Section at the Hicks pit.

	Feet.
Sandy soil, capped with novaculite gravel	2
Sandy clay, with scattered pebbles; particolored and more sandy below	7
Drab potter's clay	20

The bottom of this clay had not been reached by the operations in progress at the time it was visited. The clay at different points of the pit varies in the amount of sand it contains. It is pinkish brown when first dug, but as it dries becomes light gray with a faint pink tinge. It has a slightly sweetish taste. It is wanting in body and will not burn to a solid stoneware. Only the Albany slip-black glaze can be used with it, all attempts hitherto made at salt glazing having resulted in failure owing to the inability of the ware to bear a sufficiently high heat. When subjected to a white heat it cracks and breaks in the kiln, and the pieces escaping destruction in this way are liable to air check in cooling. It may be very profitably manufactured into open ware, however, such as pots, churns, crocks, and milk pans, or into any article in which the liquid contents are not allowed to stand long. Unglazed ware made from this clay is very porous, and when glazed ware made of it cracks or chips so as to expose the body of the vessel it is found to be very absorbent, so that it can not be employed for ware that is to be used to hold liquids for any great length of time.

THE RHODENBAUGH CLAY BANK.

The Rhodenbaugh bank is in the SW. ¼ NE. ¼ sec. 12, T. 2 S., R. 15 W., about one-fourth mile south of the Hicks pit. A depression between this and the Hicks bank is filled with waterworn gravel.

The sections at the two pits are practically the same, and the beds are the same, but there is a slight difference or local variation in the character of the clays themselves.

Section at the Rhodenbaugh clay bank.

	Feet.
Thin sandy soil with fine gravel	1
Ferruginous gravel with abundant coarse sand; clayey below	5
Light-drab potter's clay, the lower 2 feet of which is blue containing red patches of iron	10
Fine white sand	1½
Novaculite gravels, conglomerated	3
	20½

Below the pottery clay is a bed of brownish-yellow waterworn, novaculite gravel, much of which is cemented into a conglomerate. Near the upper surface or top of the 10-foot bed of clay there is a streak of black material 2 inches thick. The 2 feet of blue clay constituting the base of this bed contain numerous impressions of leaves and stems of plants and red patches. This 2-foot layer of clay is not used in the manufacture of pottery but goes to the waste bank with the gravel. This blue clay might, if mixed with sufficient quantity of sand, be used for the manufacture of bricks. Bricks as a rule do not require the same degree of firing as stoneware, and the red material, if mixed properly, will be an advantage rather than a detriment to it, as it would serve to color the whole mass. This clay is rejected by the potters because the ware must be subjected to a prolonged white heat before it will take the glaze necessary to produce a marketable product, and under the high temperature required the red clay, which is highly charged with iron, would melt or turn black and make the ware unsightly and unfit for market. Great care must therefore be exercised to prevent any of this material from being mixed with the clean pottery clay.

The clay from the Rhodenbaugh bed is fine grained and of close texture. When moist it has a pinkish-brown color, which it loses on drying. Although sometimes used without any mixture the proprietors of the pit consider it very much improved by the addition of a little sand. The sand adds to the body and in burning enables the ware to take a hard finish. It will take either the Albany slip glaze or the salt glaze.

The bed of clay found in Rhodenbaugh's pit covers about 8 acres and thins out toward the south within a short distance of Rhodenbaugh's house.

The following is the section exposed in a well 36 feet deep in Rhodenbaugh's garden, in the NW. ¼ SW. ¼ sec. 12. The well does not strike the clay, although it penetrates the Tertiary and reaches Paleozoic rocks below. The mouth of the well is doubtless at a point below the clay bed.

Section of Rhodenbaugh's well.

	Feet.
Waterworn gravel	12
Black clay, breaking up in flakes	4
Stiff, tenacious blue clay	20
Paleozoic sandstone at the bottom.	
	36

A well is reported to have been dug at Bernard Fiste's place, near the middle of the north side of sec. 13, about three-fourths of a mile east of Rhodenbaugh's pottery. In this well a pottery clay bed was struck at a depth of 45 feet. The bed is said to be 15 feet thick here and of dark color. The clay, which has been tested, retains its dark color after burning. Its occurrence at this place throws much light on the distribution of the pottery clays about Benton.

WOOSLEY CLAY BANK.

The Woosley clay bank is in the NE. ¼ sec. 1, on both sides of "the old military road" leading northeastward from Benton. The clay is 5 or 6 feet thick, but it thins out at the margins of the bed, which covers about 1½ acres. About 400 feet east of Mr. Woosley's house the following section is exposed in an abandoned clay pit:

Section at Woosley's clay pit.

	Feet.
Brown pebbly, iron-stained clay	4
Red sandy clay	6
Blue clay with red patches	2
Pottery clay	5
Grayish sand	4
	21

The following section is reported by Mr. Kennedy:

Section of pit at Woosley's pottery sheds.

	Feet.
Hard grayish sandy clay	4
Pottery clay	5
Light-grayish sand	6
Bluish joint clay at base.	

Mr. Woosley has opened another clay pit on the west side of the SW.¼ NW. ¼ sec. 1. The beds exposed are as follows:

Section in SW. ¼ NW. ¼ sec. 1, T. 2 S., R. 15 W.

	Feet.
Red sandy clay	4
Pottery clay	4

The well section at Woosley's pottery, reported by Call, is interesting as showing the relations of the potter's clay of his pit to the underlying blue joint clays of Eocene age. The section should be considered in connection with that at Womack's pit, in the village of Benton.

Section of well at Woosley's pottery.

	Feet.
Gravelly and clayey sand	4
Potter's clay, becoming sandy below	10
Stratified blue or black joint clay	45

The well ends in the joint clay without penetrating it. Probably the clay is precisely equivalent to that found in the Benton well sections.

The section at Woosley's pit, as observed by Professor Call in June, 1891, is given below.

Section at Woosley's clay pit.

	Feet.
1. Light gravelly and sandy soil	1
2. Gravel bed, with much coarse sand	3
3. Red sandy clay with occasional pockets of clay	8
4. Snuff-colored potter's clay, upper foot containing pockets of red sand, lower 4 feet a bright-yellow potter's clay	12
5. Fine white sand with some clay	12
	36

The sands from No. 5 of this section were mixed with clays from No. 4. The pottery made of this combination was a well-bodied light-yellow ware with a metallic ring, and took a good glaze. Only a portion of this clay was worked and the pit was then abandoned by its owner, who now uses clay from a bed 500 feet north of Davis's pottery and west of the military road.

In appearance and in general structure the clay taken from Woosley's bed is like that found in the other clay deposits near Benton. It is light pinkish brown when moist and dries to a faint pink color. In working and burning it has the reputation of being, next to that from Rhodenbaugh's bed, the finest clay in the district. It burns to a solid stone body and takes both salt and Albany slip glaze.

DAVIS CLAY BANK.

The L. R. Davis pit (formerly Herrick & Davis) is in the NW. ¼ SE. ¼ sec. 2, on the northwest side of the old military road. The following section in a pit near the west end of the bank shows the relations of the several beds:

Section at the L. R. Davis clay pit.

	Feet.
Waterworn gravel	3
Red clay	4
Potter's clay	11
Ferruginous sandstone at the bottom.	

Nearly the same section is exposed in a well 50 feet deep a little east of the east end of the pit. In the well section the gravel is thicker and the red clay somewhat thinner, while the potter's clay remains the same.

Below is given the section of a well at Mr. Herrick's house, east of Davis's clay pit, in the NW. ¼ SE. ¼ sec. 2, T. 2 S., R. 15 W.

Section of Herrick's well.

	Feet.
Waterworn gravel	4
Brown pottery clay	11
Coarse, white, sharp sand	25
Waterworn, iron-stained gravel	10
	50

The potter's clay thins out and disappears south of the road and about 50 yards south of Davis's pottery sheds. The clay burns to a white or cream color and may be glazed by both salt and Albany slip glaze.

HENDERSON CLAY BANK.

S. M. Henderson's bank is in the NW. ¼ NE. ¼ sec. 2, T. 2 S., R. 15 W., and underlies a brownish sandy gravel 3 feet in thickness and a blue sandy clay containing bright patches. This sandy clay is of variable thickness, but it averages about 3 feet. Beneath this bed lies the potter's clay, with a thickness of 14 feet. The color of the clay varies with the depth in the pit, ranging from light blue or pinkish on top to almost black at the base. The lower strata contain impressions of leaves and stems of plants. This clay burns to a stone body that readily takes both the Albany slip and the salt glaze.

About 300 feet east of Kirkpatrick's house a well at his brickyard shows the pottery clay to have a covering of 15 feet.

At Kirkpatrick's, on the west side of the NE. ¼ NE. ¼ sec. 11, a well 20 feet deep penetrates gravelly, sandy clay and ends in the potter's clay beds.

This bed is probably continuous eastward over the bottoms along the creek. Its dip is southeast, as is indicated by the occurrence of a similar bed in a well section three-fourths of a mile farther east, in the NE. ¼ NE. ¼ sec. 23, T. 2 S., R. 15 W., which is without doubt an extension of the same deposit.

Search has been made for these beds at various points in ravines and gullies along the hillside south of the Iron Mountain Railway depot at Benton, but none were found.

WOMACK CLAY BANK.

A stiff, dark, lead-colored clay appears in the town of Benton on the west side of Market street and between that point and the "old military road," in the NW. ¼ SW. ¼ sec. 11, T. 2 S., R. 15 W. The clay is at least 30 feet thick, as seen in the section given below (by Call), but its total thickness has not been ascertained. It gets darker as it is penetrated deeper.

Section at Womack's clay pit, Benton.

	Feet.
Soil, sandy and gravelly	2
Gravel and coarse sand, highly ferruginous	6
Conglomerate; sand and fine gravel cemented with iron oxide	½
Blue or lead-colored joint clay, with scattered nodules of iron pyrites	30½
	39

The clay found in this pit occurs in the bottom of a dozen or more wells in the village of Benton. A well digger who had put down nearly all these wells exhibited a mass of clay from the bottom of one well (which stratum he said was reached in all wells attaining a depth of 40 feet or more) containing marine shells (*Turritella carinata*) of Eocene (Tertiary) age.

In certain portions of the pit, near its middle line, occasional nodules of iron pyrites occur. Mica scales abound in the cleavage planes and rarely crystals of selenite are seen.

The clay from Womack's pit is too stiff to be worked in ordinary pugs, and must be crushed by special machinery. A sample brought to the office of the Arkansas Geological Survey by Mr. Womack was somewhat streaked with iron, some of which seems to have infiltrated along the rootlets of plants.

This clay taken alone is not a distinctively good potter's clay, and ware made from it is not equal to that made from the clays of any other Benton pit. It gives a heavy body and cool cracks when salt glaze is employed. It is mixed with clay from Hicks's pit in the proportion of equal parts of each, and in this way makes a very fair gray pottery. It is highly probable that with some experimenting a method could be hit upon that would make it possible to utilize this fine bed of clay to better advantage. If no better use be found, it might be available for making vitrified bricks.

OTHER CLAYS NEAR BENTON.

In the southeast corner of the SW. ¼ NW. ¼ sec. 13, T. 2 S., R. 15 W., near Mrs. Butler's house, a well 65 feet deep passes through a bed of dark potter's clay 30 feet thick.

Section of well near Mrs. Butler's.

	Feet.
Red clay	4
Sand	24
Potter's clay	30
Waterworn gravel	7
	65

In the NW. ¼ SW. ¼ sec. 13 a well 800 feet south of Mrs. Butler's, just west of the road, is 20 feet deep but does not penetrate the potter's clay bed. The mouth of this well is about 15 feet above the mouth of Mrs. Butler's well.

Section in sec. 13, T. 2 S., R. 15 W.

	Feet.
Red sandy clay	3
Joint clay	4
Blue sand	13
	20

In the NE. ¼ SE. ¼ sec. 13, T. 2 S., R. 15 W., at Bennett's pottery, a well 20 feet deep has the section given below.

Section of well at Bennett's pottery.

	Feet.
Soil	5
Clay	2
Red sandy clay	12
Blue sand at bottom.	

The well section at Mrs. Butler's and at other points south of the railway, taken in connection with the other observations, throws light on the distribution of the clay beds about Benton and throughout the region south of Benton. The relations of these sections to one another can be best shown by the profile given in fig. 16. This

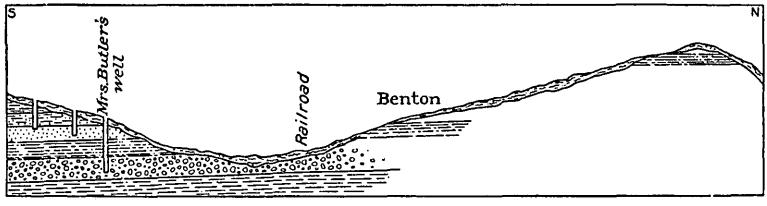

FIG. 16.—North-south section at Benton, showing relations of the clay beds north of the railway to those south of it.

section shows why pottery clay was not found either in the well south of Mrs. Butler or in that at Bennett's pottery. If these wells were carried down 25 feet deeper they would enter the bed penetrated at Mrs. Butler's.

On the hills west of Mrs. Butler's, at a point in the W. ½ sec. 14, but not precisely located, a well is reported with the following section:

Well section in sec. 14, T. 2 S., R. 15 W.

	Feet.
Clay and gravel	10
Clay with sand streaks	20
Sand	4

It seems probable that the sand found in the bottom of this well is the top of the sand bed that overlies the potter's clay, and that if the well were carried down 20 feet deeper it would enter the clay.

Mr. T. C. Hopkins also found an exposure of weathered potter's clay on the south side of the little stream about a quarter of a mile south of the Benton depot. This is about where one would expect to find the outcrop of the great bed on the south side of the valley.

The elevations were observed (by aneroid barometer) at Mrs. Butler's and at the various clay pits north of the railway for the purpose of determining whether the clay pits were all upon the same bed, and to ascertain the dip of the beds.

Elevations of the pottery clay beds near Benton.

	Feet.
Rhodenbaugh's pit	340
Hicks's pit	350
Davis's pit	420
Woosley's pit	440
Bed in Mrs. Butler's well	325
Bennett's pottery	340
Henderson's pit	380

These elevations show that the beds have a gentle dip to the east and south and that the Rhodenbaugh, Hicks, Davis, Woosley(?), and Henderson pits on the north side of the railway track are in all probability on a bed of clay identical with the bed cut in Mrs. Butler's well. The slight differences of the clays found in the various pits are of a character that usually occurs in any deposit in passing from one point to another. The thinness of the beds and their irregularities are no doubt produced by the greater erosion to which the northwestern or landward edges of these soft beds have been exposed.

The Woosley bed appears to be higher than the others and to be only the small fragment of a bed which once overlay the region south of Woosley's, but which has all been removed by erosion except this remnant and its possible southward extension, which is to be looked for in the hilltops south of Mrs. Butler's well.

The beds opened north of the railway (except Woosley's) appear to be all parts of the same deposit, and in all probability the clay may be found in a long outcrop that will connect the Hicks, Henderson, Davis, and Rhodenbaugh banks with the well at Mrs. Butler's.

The sections and records given above relate only to the beds exposed in the immediate neighborhood of Benton. Most of the clays of these beds have been tested in one way or another. There is no reason for supposing that the valuable clay beds are confined to this locality, but the geology leads us to conclude that just as good deposits exist in other parts of the county. With a view to ascertaining as much as possible regarding the distribution of the potter's clays in the surrounding country the following observations are brought together here:

About the center of the SE. ¼ SE. ¼ sec. 3, T. 2 S., R. 13 W., there is a bed of clay on Robert Bigg's place that deserves special attention. The geologic observations at this locality were kindly furnished by Mr. E. C. Buchanan, of Little Rock, who made two trips to examine it, and who collected the sample whose analysis is given below. The

clay outcrops at several places in the SE. ¼ SE. ¼ sec. 3. The outcrops are in a series of small gullies, from 2 to 7 feet deep, draining south and southeast and northeast. The section exposed is as follows:

Section at the Robert Bigg place.

	Ft.	in.
1. Sandy clay and gravel	2	6
2. Reddish clay	2	
3. Cream-colored clay	5	
4. Reddish sandstone		½
5. Cream-colored clay	10	

Mr. Palmer, who lives at the northwest corner of SE. ¼ sec. 3, says that he dug a pit 3 feet at the lowest part of the exposure of No. 5 without reaching the bottom of that bed. The beds seem to be horizontal.

The clay of the bottom bed (No. 5) has a conchoidal fracture, and is cream colored when first dug out, but on exposure to the sun it becomes nearly white. Beds of No. 3 and No. 5 are apparently about the same, but are separated by the thin layer of sand rock.

A well 55 feet deep, dug by Mr. Palmer at the point indicated, starts about 20 feet below the level of the clay and for that reason does not penetrate the bed. The clay is thus confined in this locality to the tops of the low hills, and the total area underlain by it here is about 20 acres. It is probable, however, that the same bed occurs in the surrounding hills, especially toward the east. The same bed is exposed at the spring just south of Mr. Bigg's house, where fragments of lignite overlie it.

The composition of No. 5 of the section at Robert Bigg's place (SE. ¼ SE. ¼ sec. 13, T. 2 S., R. 13 W.) is given below.

Analysis of clay from the Bigg place.

[L. R. Lenox, analyst.]

Silica (SiO_2)	63.29
Alumina (Al_2O_3)	18.19
Iron (Fe_2O_3)	6.45
Lime (CaO)	.31
Magnesia (MgO)	2.44
Manganese (MnO)	Trace.
Potash (K_2O)	.56
Soda (Na_2O)	Trace.
Water (loss on ignition)	9.47
	100.71

In the low ground about 2 miles southwest of Alexander, on the St. Louis, Iron Mountain and Southern Railway, potter's clays of a buff color are exposed in the ditch by the railroad. This exposure is at the foot of the railroad grade that descends from the summit next north of Bryant to Crooked Creek, and is 1¼ miles from Bryant. Again, potter's clay is reported on the railroad near Bryant, a short distance

southwest of the station. The well sections at Bryant, however, do not show satisfactorily that such clays exist there. The well at the Commercial Hotel, about 50 paces south of the railroad, and 22 feet deep, has hard clay in the bottom, but it is not known whether it is a potter's clay. Another well, 22 feet deep, a quarter of a mile northeast of the station, has lumpy clay in the bottom, but it is probably not a good potter's clay. In the NW. ¼ sec. 24, T. 1 S., R. 15 W., a well 15 feet deep has 10 feet of pipe clay in the bottom. Nothing is known of its value. In the SE. ¼ sec. 13, same township, a well 30 feet deep has 10 feet of "joint clay" in the bottom.

At Zuber post-office, in the NE. ¼ sec. 5, T. 1. S., R. 15 W., there are two wells. One in a depression struck black shale 4 feet below the surface, and one on the slope above the sawmill struck black shale at a depth of 20 feet. In the débris from the latter are numerous lumps of potter's clay, resembling that at Benton.

In the NE. ¼ NW. ¼ sec. 36, T. 2 S., R. 16 W., at Mr. Cliff's, a well passed through the following section:

Section of Cliff's well.

	Feet.
Red clay and sand	4
Clay with fossil shells	20
Decayed limestone	2

The clay referred to was not seen by the writer, but it is possible that a portion of the bed, at least, may be available for pottery.

Clay beds, somewhat mottled on their exposed surfaces, occur in the NW. ¼ SW. ¼ sec. 19, T. 2 S., R. 15 W., but the Paleozoic rocks are exposed on the lower side of the hills that slope to the north in this quarter section. In the SW. ¼ sec. 20, of the same township, a well 25 feet deep penetrates beneath the topmost 4 feet an 18-foot bed of light-colored potter's clay containing streaks of sand near the bottom.

A well 40 feet deep in the middle of the east side of sec. 3, T. 3 S., R. 16 W., is said to be dug entirely in red and white pipe clay, through which there is a single black streak. No evidence was found of clay farther south in Saline County than where it is cut in this well. It should be remarked, however, that no well sections were found farther south. The surface is covered with fine quartz and novaculite gravel, which seems to form the slope of the hill on the south side of the small creek in sec. 10, T. 3 S., R. 16 W. In the NE. ¼ sec. 14 of this township 16 feet of clay is also reported in a well. This is in Hot Spring County.

Between the county line and Traskwood and thence northward on the Traskwood-Benton road for more than 4 miles the well sections show only sand or very sandy clays.

On Crooked Creek in the SW. ¼ NE. ¼ sec. 15, T. 1 S., R. 14 W., about three-fourths of a mile west of Collegeville, there is an exposure of blue, white, and variegated shales.

Section on Crooked Creek.

	Feet.
1. Surface gravel and humus	3
2. Sandstone	1
3. Blue and white shales having a talcose or soapy touch	2
4. Light-colored shales, drying white and chalky	1
5. Blue clay.	

All these shales have a greasy feel and very much the same appearance in fracture and splitting. No. 4 of the above section was analyzed with the results given below.

Analysis of shale from Crooked Creek.

[Brackett & Smith, analysts.]

Silica (SiO_2)	82.45
Alumina (Al_2O_3)	11.80
Iron (ferric) oxide (Fe_2O_3)	.80
Lime (CaO)	.31
Magnesia (MgO)	.25
Alkalis (by difference)	1.60
Water (loss on ignition)	2.79
	100.00
Water at 110°–115° C	.21

The air-dried material contains 27.37 per cent of fine sand.

The following table brings together the analyses of all the pottery clays examined from the different clay banks at Benton, except that called kaolin on pages 196–197.

Analyses of clays from Benton, Saline County.

	Rhodenbaugh.	Davis.	Henderson.	Hicks.	Woosley.	Womack.
Silica (SiO_2)	72.44	69.95	71.09	65.79	64.49	66.23
Alumina (Al_2O_3)	18.97	22.34	19.86	23.92	23.86	22.31
Iron (ferric) oxide (Fe_2O_3)	1.59	1.44	1.81	1.94	2.11	2.12
Lime (CaO)	.18	Trace.	.11	.23	.31	.92
Magnesia (MgO)	Trace.	.08	Trace.	Trace.	Trace.	Trace.
Potash (K_2O)	1.35	1.28	1.45	1.15	.11	.04
Soda (Na_2O)	.91	.18	.81	1.08	1.82	1.59
Water (H_2O)	5.39	5.98	5.67	7.07	8.11	7.38
	100.83	102.25	100.80	101.18	100.81	100.59
Water at 110°-115°C	1.55	2.34	1.96	1.80	2.37	7.27
Sand	.26	.46	3.13	2.72	.19	.....

GENERAL CONCLUSIONS.

That Benton is well supplied with excellent clays for the manufacture of the common grades of stoneware and pottery is a fact established by the experience of many years. The clays there used, however, have a much wider distribution throughout the southern and eastern parts of the county than seems to be suspected. They have been found at Bernard Fiste's place, west of Rhodenbaugh's pottery, while the great bed cut in Mrs. Butler's well in sec. 13, T. 2 S.,

R. 15 W., is simply the southward continuation of the beds opened north of the railway. The bed extends around the hills to the south, the outcrop being in the faces of the hills that look toward Saline River. It is exposed on nearly all the hillsides on the old military road running northwestward from Benton, probably extending to and beyond the borders of the county.

In the broad bottoms on the west side of Saline River the "buckshot clay" lies beneath the surface soil and good clays are not to be expected here in such localities within easy reach.

The Tertiary hills west of the Saline begin about the middle of the SE. ¼ sec. 20, T. 2 S., R. 15 W. The Tertiary clays encircle these hills north of the railway and west of the river, and the potter's clays will probably be found about the bases of these hills in the vicinity of Traskwood, on both sides of the railway. The geology of the region favors the supposition that the potter's clays occur also within the drainage of Hurricane Creek, in the southeastern part of the county.

Those who are in search of pottery clays in Saline and adjoining counties should bear in mind that such clays are at many places associated with leaf and other plant impressions and not often associated with marine shells. Many of the Saline County clays that are now regarded as but poorly or not at all adapted to the manufacture of common pottery need only more careful study and experimenting to make them available. That a clay can be used unmodified, just as it comes from the pit, is a mere accident, and while it is a fortunate one, we should not be satisfied to allow an industry to depend on it.

VARIETIES OF KAOLIN.

SALINE COUNTY KAOLIN.

The syenite area of Saline County lies in secs. 35 and 36, T. 1 S., R. 14 W., and in secs. 1, 2, 9, 10, 13, 14, 15, 16, 20, 21, 22, 23, 24, 25, 26, 27, 34, and 35, T. 2 S., R. 14 W. The margins of the crystalline rocks are covered by the Tertiary and Pleistocene deposits, which make up the remainder of the county southeast of the railway in Saline County.

The kaolins found in Saline County are of three varieties—(1) a compact variety, derived directly from feldspathic rocks by decomposition; (2) a pisolitic variety, found associated more or less intimately with the bauxite deposits, and (3) a claylike variety of sedimentary origin, found at Benton.

The first two of these varieties are not readily separable and will here be considered together.

COMPACT AND PISOLITIC KAOLIN.

Kaolin exists in secs. 9, 10, 14, 15, 16, 21, 22, 23, 26, T. 2 S., R. 14 W., and probably in other places. The deposits in sec. 16 seem to be extensive, for kaolin is found here and there almost all over that section. In the SE. ¼ SE. ¼ sec. 16, T. 2 S., R. 14 W., it is exposed on the eastern side of a ridge, where it rests on syenite. This deposit has never been bored through and its thickness is unknown. Messrs. Nethercut, the proprietors, have quarried it on a small scale for building material. The coarser matter is used for building the outsides of chimneys and the finer is employed for lining flues and hearths. In carrying on these quarrying operations the material was penetrated to a depth of 15 feet near the upper edge of the deposit, but the kaolin had not been passed through.

In the NE. ¼ SW. ¼ sec. 16, 80 or 100 yards west of Mr. Sol. Nethercut's house, an excavation 8 feet in diameter and 15 feet deep was made for the purpose of testing the thickness of the kaolin, but the undertaking was abandoned before the bed was cut through. At Mr. Sol. Nethercut's house, near the northwest corner of the NW. ¼ SE. ¼ sec. 16, a well 18 feet deep shows a face of 10 feet of kaolin in the bottom of the well. This does not indicate the thickness of the deposit at this place, as the digging was stopped before the kaolin was penetrated.

Kaolin also overlies the syenite at many places in the SW. ¼ SE. ¼ sec. 16, T. 2 N., R. 14 W.

On the north side of the NE. ¼ sec. 16 there is a large deposit of kaolin which extends across the line into sec. 9. This kaolin varies somewhat in appearance in different positions. That on the eastern side of the SE. ¼ SE. ¼ sec. 16 is of two kinds. One bed is white or grayish white, having small specks and streaks of a gray material scattered through the white ground and occasional patches of iron stain. The other contains fewer gray patches, but is of a pale pinkish or brownish tint. The pink-tinted kaolin generally overlies the gray mottled material.

The deposits on the bank of the stream in the NE. ¼ SW. ¼ sec. 16, as well as those in the diggings and wells in this division of the land section, have generally a white, chalky appearance. It does not show so much iron staining or gray specks as the material found in the SE. ¼ SE. ¼. sec. 16.

The deposit found in the NE. ¼ sec. 16 and the SE. ¼ sec. 9 is a white and gray streaked material very similar to the lower gray-streaked bed in the SE. ¼ SE. ¼ sec. 16.

Analyses of kaolins from sec. 16, T. 2 S., R. 14 W.

	NW. ¼ SE. ¼.	SE. ¼ SE. ¼.
Silica (SiO_2)	45.62	44.97
Alumina (Al_2O_3)	34.18	38.87
Iron (ferric) oxide (Fe_2O_3)	4.05	1.34
Lime (CaO)	.20	.25
Magnesia (MgO)	Faint trace.	Faint trace.
Potash (K_2O)	.53	.20
Soda (Na_2O)	.54	.34
Manganese (MnO)	.17	Strong trace.
Water	13.82	14.37
	99.11	100.34
Water at 110°–115° C	1.46	5.51

The distribution of pisolitic kaolin in this district is probably nearly the same as that of bauxite, and the map accompanying Dr. C. W. Hayes's report on Arkansas bauxite[a] shows the distribution of bauxite and of crystalline rocks in Saline County so far as they are known. As in the other bauxite areas, the pisolitic kaolin is to be sought well below the surface, where it is probably of better color, softer, and freer from iron than nearer the surface.

TERTIARY KAOLIN AT BENTON.

Beds of kaolin that are formed by the decomposition of feldspar are commonly irregular and pockety in form, owing to the irregularity with which the feldspathic rocks decay. After the rocks have decomposed, however, the kaolin is liable to be washed away, and when it settles to the bottom of a body of water it will be spread out in horizontal beds like other sediments. It seems probable that some, possibly all, of the sedimentary kaolins are formed in this way.

At Benton two beds of kaolin are associated with the Tertiary deposits. One of these is exposed on the north side of the stream in the SW. ¼ SW. ¼ sec. 36, T. 1 S., R. 15 W., on the slope of a hill about 600 feet northwest of Howe's pottery and at intervals along the face of the hill for several hundred feet. It is about 9 feet thick and looks like a firm white clay. Above it is 6 feet of coarse, indurated red sand, and above this is a thin sandy soil.

The association of this bed with the pottery clays and its attractive appearance have led to attempts to utilize it for making the ordinary coarse pottery usually manufactured at Benton, but as it requires treatment different from that given the common pottery clays, its use for this purpose was soon abandoned.

[a] Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 3, 1901, Pl. LXI.

Analysis of Tertiary kaolin from Benton.

[R. N. Brackett, analyst.]

Silica (SiO_2)	48.34
Alumina (Al_2O_3)	34.58
Iron (ferric) oxide (Fe_2O_3)	1.65
Lime (CaO)	.81
Magnesia (MgO)	Trace.
Potash (K_2O)	.44
Soda (Na_2O)	1.26
Loss on ignition (water)	12.94
	100.02
Water at 110°–115° C.	2.20

It is to be hoped that other efforts will be made to turn this bed of kaolin to account. It should be remembered that no kaolin can be used just as it comes from the pit; each one requires a treatment of its own, and he who experiments with this variety until he understands how to treat it will probably be well rewarded for his trouble. It must not be expected, however, that a kaolin that contains so high a percentage of iron will burn white. If mixed with a poor sandy clay it will probably make an excellent pottery clay.

CLAY INDUSTRY.

Eagle Pottery Company.—The plant of the Eagle Pottery Company is located 1½ miles northeast of Benton. It has a capacity of 800 to 900 gallons daily. Four turners are employed, some of whom turn 300 gallons a day. Twenty-two pounds of clay are used in a 5-gallon vessel and 6½ pounds in a 1-gallon vessel. The smaller the vessel the more clay is used per gallon.

The ware is burned in a rotary up-draft kiln. Forty-eight hours are required to burn the ware. Twelve cords of wood, mostly pine, are used to each kiln.

The principal vessels made are jugs, crocks, jars, and churns, which contain from 1 to 5 gallons each. The unglazed ware burns to a beautiful light buff color. Arkansas slip is used.

The clay used by this factory is obtained in two places. The purest and best clay comes from a pit on the roadside one-half mile south of the kiln, between the kiln and Benton. When fresh the clay has a chocolate color, but becomes white when dry. It is plastic, free from grit or sand, and very similar in appearance to the clay from Holly Springs, Miss. It occurs in large lenses and is overlain by Lafayette sands and gravel, which in places rest directly on the clay. In some places the stratified sands of the Tertiary intervene between the clay deposits and the Lafayette. The clay, therefore, belongs to the older Tertiary sands and not to the Lafayette. Leaf impressions in the clay are reported to be of frequent occurrence.

The second locality from which clay is obtained is at the pottery. This is a dark-blue stratified clay containing more or less sand. An equal amount of clay from the two localities is used in making the ware.

Benton Brick Manufacturing Company.—Bricks are made by the Benton Brick Manufacturing Company from a surficial deposit that lies above the Lafayette gravel beds. It is a very sandy brick clay composed of about one-third clay and two-thirds sand. The clay is hauled from the pit to the pug mill in wheelbarrows. The pug mill is run by horse power. The bricks are molded in a hand mold and taken to a shed, where they are dried in air without artificial heat. When the bricks are sufficiently dried they are wheeled to a rotary up-draft kiln and burned. The plant employs eight men and has a capacity of 5,000 bricks a day. Five days and nights are required to burn the brick and 20 cords of wood are used to the kiln—10 cords of pine and 10 of oak. The clay makes bricks of poor quality.

SCOTT COUNTY.

GENERAL GEOLOGY.

The geology of Scott County is like the geology of those parts of Sebastian County that lie below the coal. The coal-bearing beds enter Scott County only through the parts occupied by the Poteau Mountains. So far as the clays alone are concerned, however, the coal is of but little importance, for there is an abundance of excellent clay shale in the rocks below the coal.

The rocks of Scott County are all more or less folded, and the denudation that has removed much of them has left the usual ridges of sandstone dominating the valleys cut in the shales.

In the northern part of the county there are long, winding sandstone ridges with shale valleys parallel to them. Coops Prairie, already mentioned under Sebastian County, is half in Scott County, Coops Ridge swinging around the east end of it. Bluff Ridge, starting a mile south of the eastern end of Coops Ridge, runs a little north of east for 4 miles, to the toll bridge, then turns northward for 2 miles, and then swings eastward, crosses Washburn Creek one-half mile above the point where that stream enters Petit Jean Creek, and thence continues eastward and southward until it goes nearly around Jennings Hill. Between Jennings Hill and Bluff Ridge there is another ridge of sandstone that completely encircles Jennings Hill, though it is twice cut by Petit Jean Creek.

These ridges of sandstone are mentioned only for the purpose of directing attention to the shale beds that accompany them, for the valleys between are made up for the most part of shales which are here argillaceous and there sandy. Washburn Creek, just north of Pine Log Ridge, in the extreme northern end of Scott County, flows along

one of these shale valleys. East of the mouth of Washburn Creek this same shale valley continues past Barber post-office into Logan County. South of Pine Log Ridge another long but narrow valley crosses this end of the county. Still farther south is Bluff Ridge, already mentioned. The valley south and east of Bluff Ridge is a remarkable one. Geologically it begins on the headwaters of Little Petit Jean Creek, southwest of the toll bridge, passes northward by way of Crow post-office, then turns eastward to the mouth of Washburn Creek, extends down Petit Jean Creek to the point where it cuts through Bluff Ridge, and there swings southward and westward past the town of Belva. Here it forks, one part passing westward toward Crow, the other swinging southward and eastward, where it runs along the north base of the Poteau Mountains. Everywhere throughout this valley are shales, some of them clay shales and others more or less sandy. Another shale valley runs completely around Jennings Hill.

The Poteau Mountains themselves are made up of shales and sandstones that are higher in the geologic series than the rocks of the lower lands both north and south of them. Near the base of the southern slopes of Poteau Mountain there is a series of parallel ridges and valleys. These ridges are of sandstone again and the valleys between are in shales. Beginning at the Indian Territory line in sec. 31, T. 3 N., R. 32 W., one of these shale valleys passes just north of Gipson post-office and just north of the town of Cauthron, and so on eastward to the valley of Self Branch, 5 miles north of the town of Waldron. South of the Poteau River the region both north and south of Walker Mountain is made up of a series of sandstone ridges and shale valleys. The sandstones predominate here, however, and the shales do not form such thick beds as they do north of the Poteau Mountains or in the region about and south of Waldron.

The town of Waldron stands in a broad shale valley which passes 4 or 5 miles east of the town and then bends northward and westward and swings back so as to form one of the set of valleys parallel with Poteau Mountain along its south side. A mile south of Waldron is a sandstone ridge that extends a few miles farther west and bends northward, ending in a low, hooked ridge about 2 miles west of the town. East of Waldron this same ridge continues for several miles along the north side of the upper part of Poteau Creek. South of this sandstone ridge is a broad shale valley through which runs Haw Creek and the headwaters of Poteau Creek. South of this is a series of parallel ridges of sandstone, the most prominent of which are Piney Mountain and Ross Mountain. The shales interbedded with these sandstone beds are not very thick, but many of them are available for the manufacture of clay goods. One of the most prominent of these valleys is that along which Ross Creek flows. This is a shale valley about 11 miles in length.

CLAY DEPOSITS.

Over the whole of the valley regions of Scott County ordinary brick clays occur in the form of loam or buckshot clays. In many places this brick loam is from 2 to 6 feet thick. It is often high in iron, however, and the brick made of the clays containing much iron are likely to be covered with dark brown or black spots, and the bricks as a whole usually have a dark color. These clays are especially abundant in the upper bottom lands of Poteau River, from the point where it enters Oklahoma up to and east of Waldron. They occur also along Black Fork of Poteau, along Ross Creek, and in the broader parts of the valley of Fourche La Fave River. North of Poteau Mountain similar clays are found in the upper bottoms of all the streams, but especially in those of Petit Jean Creek and its principal tributaries, and along Little Washburn Creek.

No establishments of any kind in Scott County are engaged in the manufacture of clay products.

SEBASTIAN COUNTY.

CLAY DEPOSITS.

CLASSES OF DEPOSITS.

So far as the actual development of the clay manufacturing interests are concerned Sebastian is one of the most important counties in the State. This development could not have taken place, of course, if the geology of the county had not been favorable to the building up of the clay industries; but the fact should not be overlooked that so far as geology alone is concerned several counties in the State are as well provided with valuable clays and clay shales as is Sebastian County.

The geologic structure of Sebastian County admits of clays and clay shales occurring (1) as shales in place in the uplands of all parts of the county; (2) as residuary clays in the uplands derived by disintegration from the Paleozoic shales; (3) as clays in the "second bottoms" or the elevated Pleistocene terraces that follow the general course of the river bottoms; (4) as clays in the alluvial deposits of the river bottoms.

SHALES.

The rocks of Sebastian County all belong to the Carboniferous, except the clays and alluvial deposits along the Arkansas River bottoms. There is but little variation in the older rocks of this county. They consist of sandstones, shales, fire clays, and coal. It has already been pointed out in the chapter on general geology that the sandstones and shales were originally deposited in water as horizontal beds of sediments, and that vegetation growing in marshes

afterwards became coal. Subsequently all these beds have been pressed into folds, lifted into dry land, and in many places worn away.

The sandstones are in some places coarse enough to be considered grits or conglomerates, while the shales in places grade over through sandy shales to fine sandstones. The coal is confined to the upper portion of the Carboniferous rocks in Sebastian County, but the clay shales cover a larger area than the coal.

The sequence of the rocks varies from place to place owing partly to the fact that the folding and erosion of the beds has left one set of beds at the surface at one place and another set at another. Moreover, the horizontal variation of the beds or the grading of fine sediments into coarser ones results in a variation in the sequence of the beds, especially when the sections considered are several miles apart.

In the process of denudation (the weathering and breaking up of the rocks and their removal by streams) the shales decompose, readily forming clays, while the sandstones, as a rule, are more resistant. The result is that the valleys are usually cut in the shales, while the sandstones are left capping the hills if the beds are horizontal or forming long winding ridges if the beds are folded. In Sugar Loaf Mountain and in Jennings Mountain the beds are nearly horizontal, and these mountains are capped with sandstone, while in the long, narrow ridges, like Long Ridge, just north of Jenny Lind; Sand Ridge, running from Hackett City to Greenwood; Nigger Ridge, southwest of Huntington, and Devils Backbone Ridge and the other parallel ridges south of Greenwood, the resisting beds are sandstones that have been thrown into folds and then eroded. Inasmuch as the clay shales are interbedded with the sandstones the valleys curve with and follow the ridges, and it is in the valleys that the shales are usually found. At some places the shales are decomposed into soft, plastic pottery clays, as noted later, but more frequently they are compact, or fissile, breaking up under the influence of the weather into small, angular fragments.

One of the most important manufacturing interests of the State is based on the clay shales of the coal-bearing rocks of Sebastian County, which are used in the manufacture of paving bricks. This industry began under circumstances not without interest. In 1889 the citizens of Fort Smith had under consideration the paving of their streets, and the State geologist of Arkansas received a letter from Harry E. Kelley, the chairman of the paving committee, asking his advice in regard to the best clay of the region about Fort Smith for the manufacture of paving bricks. The State geologist visited Fort Smith and examined the clays and clay shales near that city. He found that attempts had been made to manufacture paving bricks from the sandy clays and loams of the river terraces, but these bricks were, of course, too soft to be available for paving streets. It was pointed out

to the committee that the clay shales in the vicinity of the city were well adapted to the manufacture of paving bricks. This opinion was supported by analyses made by the State Geological Survey, and later by practical tests made by brick manufacturers.

The following letter was addressed to the paving committee after the examination:

DEAR SIR: At the request of the paving committee of your board of commerce I have made a cursory examination of the material in the immediate vicinity of Fort Smith with a view to ascertaining its availability for the manufacture of paving brick.

The clays and clay shales about Fort Smith available for the manufacture of bricks, tiles, pottery, etc., belong to two distinct geologic ages. To the newer division belong the yellowish, reddish, and dove-colored loams, clays, and sandy clays which underlie almost all the plain upon which the city of Fort Smith is built.

The bricks now made at Fort Smith are made either from the uppermost of these beds or from a mixture of this and the one just beneath it, as is now practiced at Pendle & Morrison's brickyards.

In some of the deeper hollows there are later deposits of chocolate-colored clay which by the admixture of organic matter has been changed to a deep black soil at the surface. An analysis of a similar clay from near Dardanelle is given below.

The other class of material which is available for the manufacture of pottery, bricks, tiles, etc., is a clay shale belonging to the Carboniferous series of rocks. These shales are interstratified with sandstones and other rocks of the coal measures and are probably widely distributed through Sebastian and adjoining counties. The clay said to have been taken from Crawford County to the brickyards of Pendle & Morrison for testing is simply a disintegrated clay shale. The light-colored and mottled clays overlying the sandstones of Harding & Boucher's quarry, a couple of miles south of Fort Smith, are also disintegrated clay shales. An extensive exposure of such shales, however, occurs much nearer the city. On the public road leading south from Fort Smith and about 600 feet south of the crest of what is popularly known as Nigger Hill the ditches beside the road have exposed a thickness of 10 or 15 feet of friable clay shales. This shale bed is capped by a stratum of sandstone, but its base is not exposed. It will be found to extend around the hills on both sides of the road, and there can be no question of its great abundance both at the locality mentioned and in the continuation of the bed around the sides of the hills.

Following is an analysis of the clay shale from Nigger Hill, in the vicinity of Fort Smith:

Analysis of clay shale from Nigger Hill.

[Specimen dried at 110°–115° C. Brackett & Smith, analysts.]

Silica (SiO_2)	58.43
Alumina (Al_2O_3)	22.50
Ferric oxide (Fe_2O_3)	8.36
Lime (CaO)	.32
Magnesia (MgO)	1.14
Potash (K_2O)	2.18
Soda (Na_2O)	1.03
Sulphur (S)	.16
Loss on ignition	6.87
	100.99
Sand in air-dried specimen	25.72
Water at 110°–115° C	3.37

The clay shales spoken of as cropping south of the city would, of course, have to be ground before they could be used for the manufacture of either pottery or bricks, but in view of the nature of these clays, the ease with which they can be dug and ground, and the extent of the beds, it would seem very desirable that thorough practical tests should be made of this material and of its availability for making pottery, tiles, retorts, fire bricks, and paving bricks. It will doubtless be found necessary to mix with this material a certain proportion of the sandy clays so abundant all about Fort Smith, but a practical brickmaker can readily determine these proportions by a few trials.

I do not think there can be any doubt about the formations spoken of above furnishing excellent material for the manufacture of paving bricks, pottery, tiles, etc. * * *

Trusting that these clays and clay shales may receive from our citizens the attention to which they are justly entitled, I remain,

Very respectfully,

J. C. BRANNER, *State Geologist.*

The analyses showed the shales to be available for the manufacture of paving bricks, and practical tests bore out these results and predictions.

Samples of the shale were also sent for testing to the Brick and Terra Cotta Manufacturing Company, of St. Joseph, Mo., and the results obtained were favorable.

Specimens were also taken from the property of the Oak Park Land Company in the SE. ¼ NW. ¼ sec. 35, T. 9 N., R. 32 W., and shipped for testing to the Tennessee Brick Manufacturing Company, at Memphis. The following letters were received by Mr. May in regard to these tests:

MEMPHIS, TENN., *August 10, 1889.*

N. MAY, Esq.: In regard to the manner in which the bricks were made from the samples of Fort Smith clay or shale, will say: Each sample was separately pulverized, pugged, and molded by hand, the oldest and most crude method known for making bricks. With proper appliances for making and burning it would produce a brick not surpassed anywhere in the country for strength and durability and suitable for any purpose where the best bricks are required. It will admit of rapid drying without cracking.

Very truly, yours, HARRY MCCUE, *Superintendent.*

MEMPHIS, TENN., *August 13, 1889.*

Mr. NOEL MAY.

DEAR SIR: The tests that I have made of the new Fort Smith brick show very excellent results. The samples made of mixed clay are the best. The unmixed-clay samples are very good building brick, suitable for sewers and foundations, strong, dense, and heavy. They will be durable in any position.

The samples made of mixed clay, the two kinds being combined in about equal quantities, show remarkable strength and toughness. I made the percussion test on three samples and at the same time on one of the West Virginia brick, same as we used on North and East Court streets. The Fort Smith samples were fully equal, and I think rather superior, to the West Virginia, showing less abrasion and less granulation.

I hope you will continue your experiments in mixing varying quantities of the different clays until you have the strongest. Then you will have a superior paving brick.

Truly, yours, R. S. MILLER.

By the month of November, 1889, W. A. Doyle was using the Nigger Hill clay shales at Fort Smith in the manufacture of paving bricks. The business succeeded from the outset, and there was soon built up at that place a large and prosperous business in the manufacture of paving and building bricks from the shales.

Two analyses are here given of the Fort Smith clay shales, and for purposes of comparison analyses of the well-known Carboniferous shales of Akron, Ohio, and of Cheltenham, Mo., are added.

Analyses of clay shales.

[Specimens dried at 110°-115° C. Brackett & Smith, analysts.]

	Fort Smith.		Akron, Ohio.	Cheltenham, Mo.
	Harding & Boucher's quarry.	W. A. Doyle's paving-brick kiln.		
Silica (SiO_2)	57.10	58.43	60.05	54.92
Alumina (Al_2O_3)	23.74	22.50	20.00	22.71
Iron (Fe_2O_3)	8.18	8.36	6.82	9.81
Lime (CaO)	.53	.32	.52	.52
Magnesia (MgO)	1.04	1.14	.45	2.59
Potash (K_2O)	1.53	2.18	1.79	3.16
Soda (Na_2O)	.87	1.03	1.60	.62
Sulphur (S)	.....	.16	1.95	.....
Loss on ignition	7.21	6.87	6.96	5.88
	100.20	100.99	100.14	100.21
Sand	.12	25.72	29.12	2.04
Water at 110°-115° C	4.24	3.37	1.25	2.69

These Carboniferous shales outcrop at many places in the vicinity of Fort Smith and, indeed, in all parts of Sebastian County.[a] They are exposed at W. A. Doyle's paving-brick factory between Towson and Wheeler avenues, Fort Smith; at Harding & Boucher's quarry in the northeast corner of the SW. ¼ sec. 28, T. 8 N., R. 32 W.; and immediately across the Texas road from Harding & Boucher's quarry, on the railway track running through the SE. ¼ sec. 20 and the NE. ¼ SE. ¼ sec. 29 of the same township and range. They are also seen in a railway cut on the lands of the Oak Park Company in the SE. ¼ NE. ¼ sec. 35, T. 9 N., R. 32 W. At all these places the shales have disintegrated and formed a clay. A well on the Adams lot, in the NE. ¼ SW. ¼ sec. 15, T. 8 N., R. 32 W., shows a section of this clay 10 feet thick. At Harding & Boucher's quarry the clay formed from the disintegrated shale has a thickness of 6 feet, and in the railway cut through secs. 20 and 29 a thickness of 3 feet is visible. The analysis of the Harding & Boucher shales is given above.

There are exposures also in the banks of a small stream near Nowland's spring, in the NE. ¼ NE. ¼ sec. 34, T. 9 N., R. 32 W. In the SW. ¼ NE. ¼ sec. 9, T. 8 N., R. 31 W., near the center of the section, and in the SW. ¼ SW. ¼ sec. 7, T. 7 N., R. 31 W., and in a cutting on the Little Rock road in the SW. ¼ SE. ¼ sec. 15, T. 8 N., R. 32 W., similar shales are exposed. In these sections the shales are overlain

[a] The notes on the occurrence of shales about Fort Smith are by William Kennedy.

by grayish-brown sandstone, and retain their shaly character in a greater or less degree according to the protection given to them by the overlying sandstone.

In the section at Nowland's spring the bluff is protected by a covering of grayish-brown sandstone about 4 feet thick. The shales immediately under the sandstone are black, hard, and somewhat arenaceous. Thin beds of iron-stained quartz run throughout the upper 10 feet of the shales. Below, where they are exposed to the action of the waters of the stream, the shales form a soft, blue clay-like material. These blue shales are about 4 feet thick and overlie a series of soft black shales.

In the bluff overlooking Arkansas River in the SW. ¼ NE. ¼ sec. 19, T. 8 N., R. 31 W., near the center of the section, the covering is a heavy bed of brownish sandstone 7 feet thick. The shales beneath are light yellow for 5 feet immediately below the sandstone, and 3 feet of soft black shales are exposed below the yellow.

The quantity of talus along the bluff is so great that the shales are almost everywhere covered up. In the section shown at the end of the bluff in sec. 19 the sandstone projects about 7 feet beyond the underlying shales.

The following is a section at the end of the bluff in the SW. ¼ NW. ¼ sec. 19, T. 8 N., R. 31 W.:

Section in bluff of Arkansas River.

	Feet.
Brownish, heavily bedded sandstone	7
Soft, friable, yellowish shale, with whitish streaks in the upper division	5
Black shale somewhat harder than the yellow, and containing some red streaks	3
Talus covering black shales to the level of the river	150

A section in the SW. ¼ SW. ¼ sec. 7, T. 7 N., R. 31 W., gives the following:

Section in SW. ¼ SW. ¼ sec. 7, T. 7 N., R. 31 W.

	Feet.
Sandstones	7
Yellow shales, soft where exposed and forming dark yellow clay	4
Black shales	10
Sandstones	5
Blue shales	70
Black shales.	

The black shales lying at the base of the bluffs in sec. 19, T. 8 N., R. 31 W., and in secs. 24, 26, 34, 35, 27, and 28, T. 8 N., R. 32 W., on the north side of Massard Prairie, and in sec. 6, T. 7 N., R. 31 W., on the southeast side of the prairie, are the same beds, and they pass under Massard Prairie in an almost horizontal position. These shales are also seen at a few places where Massard Creek and one or two smaller streams have cut down through the overlying yellow prairie soil.

Wherever the shales are exposed they rapidly disintegrate and form a stiff clay, having approximately the colors of the shales from which the clay has been formed.

The following is a section at Doyle's paving-brick factory:

Section at Doyle's paving-brick factory.

	Feet.
Red sandy clay containing waterworn pebbles in considerable quantities	2
Blue and black shales interstratified and inclosing some thin beds of red arenaceous shale	25
Sandstone at the base.	

In this section the gravel and clay overlying the shales have partially obstructed the work of disintegration, so that the shales have not yet completely disintegrated. The softer blue shales have for the most part disappeared in the clay, but the harder black and red shales still remain in their shaly form, although somewhat soft and easily crushed.

Wherever the shales have been exposed by the removal of the overlying sandstones and gravel they readily lose their shaly character and assume the condition of a plastic clay, having the color and position in the series of the shales from which they are derived.

At Harding & Boucher's quarry, 1½ miles south of Fort Smith, in the northwest corner of the SW. ¼ sec. 28, T. 8 N., R. 32 W., the surface material consists of about 6 feet of disintegrated shales, which rests on the sandstone of the quarry. These shales have disintegrated and formed a gray mottled clay. In the lower part of the bed the disintegration is not always complete and fragments of shale are scattered through the clay. Analyses of these clays and shales are given below.

The shales exposed along the Missouri Pacific Railway track through the SE. ¼ sec. 20, T. 8 N., R. 32 W., are in the same disintegrated and clayey condition as those seen higher up the hill at Harding & Boucher's quarry.

Analyses of argillaceous shales from Fort Smith.

[Specimen dried at 110°–115° C. Brackett & Smith, analysts.]

	Nigger Hill.	Harding & Boucher's quarry.		
	1.	2.	3.	4.
Silica (SiO_2)	58.43	57.10	65.12	42.12
Alumina (Al_2O_3)	22.50	23.74	19.05	18.84
Ferric oxide (Fe_2O_3)	8.36	8.18	7.66	26.35
Lime (CaO)	.32	.53	.34	.28
Magnesia (MgO)	1.14	1.04	.31	.74
Potash (K_2O)	2.18	1.53	1.23	1.10
Soda (Na_2O)	1.03	.87	.85	1.85
Sulphur (S)	.16			
Loss on ignition (water)	6.87	7.21	6.12	8.77
	100.99	100.20	100.68	100.05
Sand in air-dry specimen	25.72	76.40	21.88	None.
Water at 110°–112° C	3.37	4.24	4.79	3.19

The Nigger Hill shale is from the paving-brick kiln of W. A. Doyle, on Towson road, Fort Smith; the other three are from Harding & Boucher's quarry in the northwest corner of the NW. ¼ sec. 28, T. 8 N., R. 32 W. Sample 2 is from the gray clay about 3 feet below the surface; sample 3 is from the yellow mottled with red; and sample 4 is from the undecomposed shale next to the sandstone beneath.

It is not possible to specify all the places at which clay shales available for the manufacture of bricks, sewer pipe, and similar products may be found in Sebastian County. They are associated with the coal at many places in the coal mines. Many of the clays that lie immediately beneath the coal are available as fire clays.

A specimen of gray clay from KcKenna's quarry, near Hackett City, was sent in by Mr. Ed. McKenna. The analysis is given below.

Analysis of gray clay from McKenna's quarry, at Hackett City.

[Material dried at 110°–115° C. R. N. Brackett, analyst.]

Silica (SiO_2)	54.13
Alumina (Al_2O_3)	30.69
Ferric oxide (Fe_2O_3)	3.15
Manganese oxide (MnO)	Trace.
Lime (CaO)	.63
Magnesia (MgO)	.94
Potash (K_2O)	.49
Soda (Na_2O)	2.01
Loss on ignition	8.54
	100.58
Water at 110°–115° C	4.82

At the Hartshorn coal mine, 4 miles south of Fort Smith, is a bed of dark-gray shale 4 feet thick. A sample was sent to the Survey by Mr. W. A. Doyle, of Fort Smith, and analyzed, with the results given below. The relation of this shale to the coal at the mine is not stated.

Analysis of shale from the Hartshorn coal mine.

[Material dried at 110°–115° C. R. N. Brackett, analyst.]

Silica (SiO_2)	70.83
Alumina (Al_2O_3)	17.49
Ferric oxide (Fe_2O_3)	3.64
Magnesia (MgO)	.91
Potash (K_2O)	.25
Soda (Na_2O)	1.72
Loss on ignition	4.95
	99.79
Water at 110°–151° C	.76

The region about Mansfield may be taken as a type of the topography and geology of most of the country south of Fort Smith. The

accompanying section (fig. 17), by Professor Purdue, shows the general character of the geology and the relation to each other of the shales and sandstones of the region. There are long parallel ridges of sandstone with shale valleys between. The shales are at some places so interbedded with sandstones that they are hardly available for manufacturing purposes on a large scale, but for the most part they form beds of enormous thickness and of a composition suitable for making paving bricks, sewer pipe, and fire-clay goods. Just north of Mansfield the heavily shaded area in the section represents the clay shales used by the Choctaw Pressed Brick and Terra Cotta Company.

One-half mile south of the town an almost unbroken ridge, known as Coops Ridge, incloses a small circular valley. The ridge is made up of sandstones that dip southward on the south side and northward on the north side; in other words, Coops Ridge surrounds a small anticlinal valley, called Coops Prairie. Inside of this valley are thick beds of clay shales that are probably available for the manufacture of various kinds of clay goods. The valley between Coops Ridge and the town of Mansfield is more than a quarter of a mile

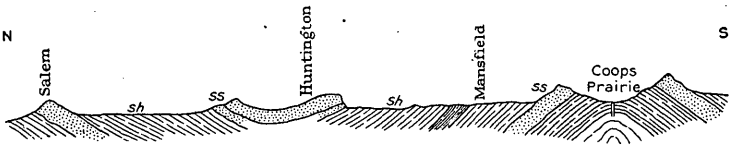

FIG. 17.—North-south section showing structure and relative positions of the shales and sandstones from Coops Ridge to Salem. *sh*, Shale; *ss*, sandstone.

wide and is cut in shales that extend westward to Cherokee Prairie and then swing back eastward around the south side of Coops Ridge and form the broad, open valley that lies about the village of Fuller, in Scott County, and extends a mile east of it, and then swing westward again and around to Mansfield. North of Black Jack Ridge is another shale valley not more than a quarter of a mile wide that extends from James Fork, 4½ miles west of Mansfield, northeastward past Mansfield 4 miles, and swings westward past the town of Dayton, which stands in the shale valley. Another shale valley parallel in the main with the last one mentioned begins a mile south of Liverpool post-office and runs northeastward parallel to and just south of Nigger Ridge, crossing Cherokee Creek a mile south of the town of Huntington, and about 2½ miles farther east it swings northward and then westward about 4 miles, when it turns due northward and extends for 5 miles or more along the east base of Devils Backbone Ridge. This same bed of shale can be traced for many miles along the base of this ridge past Burnsville post-office into the eastern edge of Sebastian County.

This description is doubtless sufficient to show that the clay shales of Sebastian County are widespread over the entire county, and that the beds are of great thickness. The value or availability of each bed has not been determined, but such tests can be made practically whenever it becomes necessary to consider the location of a manufacturing plant, and a brief examination of the geology should show the distribution of the materials.

POTTERY CLAYS.

It has already been pointed out that the shales of this region break up or decompose under the influence of the weather, forming plastic clays. Such clays are available for the manufacture of paving bricks and sewer pipe, or for pottery. Clays thus formed are about the only ones used for the manufacture of pottery in the upland regions of Sebastian County.

The only pottery clay that was used in Sebastian County in 1889 came from the S. ½ SE. ¼ sec. 27, T. 7 N., R. 30 W. An examination of the geologic structure of the region in which it is found affords evidence of its origin and suggests where other and similar clays may be found in this county.

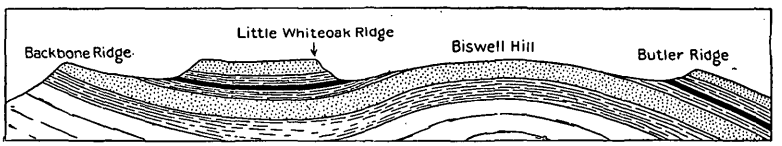

FIG. 18.—North-south section through Biswell Hill.

The place at which this clay occurs is at the north base of Little White Oak Ridge. This ridge runs southwestward toward Greenwood and northeastward past Auburn post-office, where it curves westward, merges into Butlers Ridge, runs northwestward and ends at Butlers Knob, in sec. 10 of this same township and range. To the west of Biswell Hill it appears again, striking away to the west and southwest, where it is known as Tennessee Ridge. The rocks of this line of ridges dip away from Biswell Hill on all sides, and a north-south section through Comby's clay pits would expose the rocks as they are shown in the section below.

A section across Little White Oak Mountain, Biswell Hill, and Tennessee Ridge would display practically the same structure as that shown above. This structure explains the origin of the Comby clays and suggests at the same time that similar clays may extend along the northwest side of Little White Oak Ridge, the southwest side of Butlers Ridge, and the south side of Tennessee Ridge.

The example cited above is given for the purpose of illustrating the general features of the geologic structure of Sebastian County and

to show the origin of the residuary pottery clays rather than to explain the presence of clay at a single locality. Throughout the entire county the rocks are thrown into folds and eroded, and wherever the argillaceous shales are exposed to decomposing agencies they have been changed into plastic clays.

In searching for the clays, or the clay shales from which they are derived, one must keep in mind the structural features of the region and the agencies by which the clays are produced and modified. It should not be forgotten, however, that sedimentary rocks frequently change in character in passing along the outcrops, so that what is a sandstone at one place may be an arenaceous shale at another and an argillaceous shale at a third locality.

The upland clays of Sebastian County are confined to the region of Paleozoic rocks. These clays, however, are not all produced by decomposition directly from the argillaceous shales. Some of them have been washed into the valleys and, mingled with the residual rocks of the region, have formed "buckshot clays" by precipitation within them of the iron carried in solution by percolating waters. The method by which these clays are formed is described in Chapter II of this report. These "buckshot clays" are not available for the manufacture of pottery, but they are used more or less for making bricks.

COMBY'S CLAYS.

The clay formerly used at Comby's pottery is a light-yellowish surface clay, found in a low-lying piece of ground in the S. ½ SE. ¼ sec. 27, T. 7 N., R. 30 W., where it has a depth of about 2½ feet. The mode of origin of this clay has already been described.

Analysis of Comby's pottery clay.

[Brackett & Smith, analysts.]

Silica (SiO_2)	81.61
Alumina (Al_2O_3)	10.52
Iron (ferric) oxide (Fe_2O_3)	2.70
Lime (CaO)	.32
Magnesia (MgO)	.40
Potash (K_2O)	.66
Soda (Na_2O)	.57
Manganese (MnO)	Trace.
Water (H_2O)	3.95
	100.73
Water at 110°–115° C	3.86
Fine sand	18.43

The ware from this clay is of poor quality and consists chiefly of such articles as are in local demand, such as churns, jugs, crocks, and jars. No other kinds of ware have been manufactured. It can not be said that this clay has been so tested as to establish or disprove its availability for the manufacture of pottery.

Close to the kiln and on the same quarter section there is a small deposit of stiff light-blue clay which has been turned for pottery, but without success. When this blue clay was used alone the ware made from it cracked in drying. A mixture of this and a pale-blue, almost white, sandy clay from the NE. ¼ NE. ¼ sec. 7, T. 6 N., R. 30 W., has also been tried with some success. The results, however, were not altogether satisfactory and the work was abandoned.

The pale-blue sandy clay from sec. 7, T. 6 N., R. 30 W., outcrops at several places along the side of a small hill and in the bottom and banks of a small stream that crosses the wagon road leading from Greenwood to Charleston. Mr. Comby tried this clay alone for the manufacture of pottery, but with the appliances at command he did not succeed. When mixed with the surface clay from the SE. ¼ SE. ¼ sec. 27, T. 7 N., R. 30 W., the results were fairly successful.

GLAZING MATERIAL.

Mr. Comby tried a black silt found on the bottom lands at the mouth of Vache Grasse Creek for glazing purposes. It is said to have served the purpose of a slip, but not much reliance can be placed upon the experiment. Analyses of this river deposit and of the Albany slip have been made by the Arkansas Geological Survey.

Analysis of Vache Grasse and Albany slip.

[Brackett & Smith, analysts.]

	Vache Grasse slip.	Albany slip.
Silica (SiO_2)	70.95	58.05
Alumina (Al_2O_3)	12.24	14.86
Iron (ferric) oxide (Fe_2O_3)	4.73	6.76
Lime (CaO)	1.90	6.61
Magnesia (MgO)	.97	3.08
Potash (K_2O)	1.14	1.18
Soda (Na_2O)	.66	.80
Water (H_2O)	7.01	7.41
	99.60	98.75

PRAIRIE CLAYS.

Over the whole of the upland portion of Sebastian County the soils are derived by decomposition from the rocks. The materials are shifted somewhat—washed down from the slopes and spread over the valleys—and are afterward more or less leached and altered by secular weathering. This process produces what are popularly known as "buckshot clays" of the prairies and slashes. These clays are not specifically mentioned as characteristic of this county, but as they are derived chiefly from the shales they are mentioned under this general head.

The whole of sec. 3, the greater part of sec. 2, the SE. ¼ sec. 4, the NE. ¼ NE. ¼ sec. 10, and the NW. ¼ sec. 11, T. 8 N., R. 32 W., are

covered with a yellowish buckshot clay, or prairie soil, containing considerable quantities of iron nodules about the size of a pea. The section in the banks of a small stream running through sec. 3 shows a thickness of about 3 feet of this clay.

In sec. 4 of the same township and range a similar yellow loam overlies a deposit of dark-red clay. In the W. ½ NW. ¼ sec. 35, T. 9 N., R. 32 W., a band of chocolate clay about 4 feet thick lies between the two yellow divisions of the exposed clays. The chocolate clay forms the surface for some distance and then passes under a heavy bed of yellow clay.

The surface soil of Massard Prairie is a yellow clay or prairie soil, having a general thickness of about 4 feet. This clay rests on the dark-blue or black shale which is seen at the base of the different sections exposed in the bluffs on the north and south sides of the prairie. A section from the bank of a small creek in the SW. ¼ SE. ¼ sec. 1, T. 7 N., R. 32 W., may be taken as a representative section of this prairie.

Section in SW. ¼ SE. ¼ sec. 1, T. 7 N., R. 32 W.

	Feet.
Thin covering of humus at surface.	
Yellow (almost orange-colored) clay containing nodules of iron in its lower division	4
Black or dark-blue shales, broken into kidney-shaped pieces at base.	

Where the soil has been washed off the surface the ground is covered with the nodules of iron in the shape of gravel.

In the NE. ¼ SE. ¼ sec. 19, T. 8 N., R. 31 W., the surface soil is red clay, and in the S. ½ sec. 29, on the south side of Massard Creek, a yellow clay overlies the coal in some of the openings.

In the NW. ¼ SW. ¼ sec. 29, T. 8 N., R. 31 W., near Massard post-office, a dark-red clay covers the small hill lying to the southeast of the prairie.

Nothing has ever been done to demonstrate the usefulness of these clays for any purpose. There is little doubt, however, that many of them might be profitably used for the manufacture of ordinary building bricks, and for this purpose the clays found on Massard Prairie and on the prairie-like district of secs. 2, 3, 4, and 10, T. 8 N., R. 32 W., will probably be much better adapted for making a hard, solid brick than the red earth found close to Fort Smith and used at present. It may be safely said that these clays will, with proper treatment, make as good and as strong a brick as can be found anywhere else throughout the valley of Arkansas River.

TERRACE CLAYS.

Over the lowlands near Arkansas River, in some places extending back inland for several miles, generally in the form of terraces, there is a system of unconsolidated deposits which are probably of Pleisto-

cene age. The material forming these terraces are yellowish, reddish, and lead-colored loams, clays, sands, and gravels. They lie in horizontal beds, but have been cut and more or less mutilated by erosion over the whole surface and by streams that cross them to enter Arkansas River. These Pleistocene deposits cover most of the plain on which the city of Fort Smith stands, and the peninsula extending northeastward toward Van Buren, where fragments of them occur here and there along the river east of Fort Smith. The clays of this series are exposed in what may be regarded as a typical section along the railway near the Ketcham iron works and at other points south of the city. The uppermost bed is a yellowish clay, in some places more or less mottled and in others containing small, friable nodules of iron. Although its characteristic color is yellow, this bed is in some places ashen gray and in others bright red.

In the typical section just mentioned the next bed below the yellow clay loam is a dark-red clay which contains a good deal of sand and which is about 10 feet thick. Below it is a bed about 1 foot thick of deep-red to chocolate-colored clay, and below lies a bed of fine sand. The bottom of the sand is not exposed. The thickness and quality of these beds varies greatly; the yellow loam is entirely wanting in many places, having been removed by erosion, while the red clay may contain occasional beds of sand.

It can not be positively stated that pottery clays do or do not exist in these Pleistocene river terraces, but the nature of the beds seen is favorable to the occurrence in them of pockets of pottery clays. In these terraces or second bottoms extensive deposits of brick earth are found, both in Sebastian and in adjoining counties.

RECENT ALLUVIUM.

The Pleistocene terraces referred to above are distinct from the river-bottom silts. The latter stand at a lower level and are usually less brilliantly colored. No pottery clays are now known in the bottom, but it is possible that they may occur there. As a rule the alluvial deposits are silts and sands rather than clays, and such pottery clays as they contain will probably be found only in pockets.

CLAY INDUSTRY.

UTILIZATION OF THE CLAY SHALES.[a]

Although the clay shales of Fort Smith and of Sebastian County are suitable for the manufacture of sewer pipe, fire bricks, and pottery, nothing has been done thus far to utilize these shales for making such articles. The abundance of excellent raw materials, the proximity of the deposits to the coal fields, and the possibility of building

[a] The notes on the brick industries of Fort Smith are chiefly by William Kennedy.

up a larger trade in clay products in the South and Southwest ought to lead to the early development of such industries at some point in Sebastian County.

Chemical analyses of the argillaceous shales show them to be clays so far as their chemical composition is concerned. They have been changed, however, by pressure and time in physical appearance and character. The chemical composition of these clay shales of Sebastian and adjoining counties suggests the possibility of using them, when ground and washed, for the manufacture of the common grades of pottery. The clay shales have the average composition shown in the table below. For the purpose of comparing this with the pottery clays of the Tertiary region of the State (Benton, Perla switch, etc.) the average composition of the latter is given in an adjoining column.

Analyses of clay shales and of Tertiary pottery clays.

	Clay shales.	Tertiary pottery clays.
Silica (SiO_2)	58.91	68.20
Alumina (Al_2O_3)	22.21	21.79
Iron (ferric) oxide (Fe_2O_3)	7.64	1.77
Lime (CaO)	.53	.20
Magnesia (MgO)	1.37	.....
Potash (K_2O)	2.15	1.12
Soda (Na_2O)	.93	1.16
Water (H_2O)	6.64	6.44

The clay shales contain a somewhat higher percentage of the bases (iron, lime, magnesia, potash, and soda), elements which increase the fusibility of the material, and a lower percentage of silica. The higher percentage of iron in the clay shales would give the pottery made from it a dark color like that of sewer pipe, but this objection would not apply seriously to jugs and many other articles. The upper weathered portions of the beds can be ground more readily, while the already decomposed and plastic clays that usually cover the exposed surfaces of these shale beds may advantageously be mixed with the crude material.

BRICK PLANTS.

Paving bricks.—It is only since 1889 that the manufacture of paving brick has been carried on at Fort Smith. Mr. W. A. Doyle had the first contract for the paving of Garrison avenue, and 3,000,000 bricks were required for this purpose. The bricks were made from the disintegrated shales found on Towson road between Towson and Wheeler avenues. The shales were ground before pugging. For this purpose a Penfield crusher was used. The clay was then pugged in a No. 10 D pug mill, and the bricks were made in a No. 20 B Penfield machine having a daily capacity of 50,000 bricks. The machinery was driven by steam power. The bricks were end cut and dried in a

steam heated drying shed and burned in the ordinary open kiln. The fuel used was a mixture of coal and wood.

In drying these bricks part with their water very slowly, and it usually requires about six days to dry them sufficiently to be put in the kiln. The time allowed for burning is from ten to twelve days. When burned hard the outside bricks are dark brown and the inside bricks dark blue. In the kiln used at Fort Smith the outside bricks were bright red.

Clays formed by the disintegration of these shales shrink considerably in drying and burning. The bricks made at Fort Smith shrink about 1½ inches in the length of the brick (9½ inches), and the average settling of a kiln 36 bricks high is about 2 feet.

In setting the kiln it is necessary to set the rows close to one another in order to provide for the widening of the spaces between the rows of bricks due to the shrinkage.

There are at present three brick plants in Sebastian County. Two of these are in Fort Smith and the other at Mansfield.

The Choctaw Brick and Gas Company.—A plant was established in 1901 at Mansfield, in the southeastern part of the county, by the Choctaw Brick and Gas Company. Common building bricks are made from Carboniferous shale. The shale is pugged and molded in the Berg machine. The bricks are dried in sheds and nine to ten days are required to dry them sufficiently to place in the kiln. They are burned in up-draft and down-draft kilns, which hold from 50,000 to 250,000 bricks each. Five kilns are in use. The kilns are arranged to use coal and natural gas for burning, and about one-half ton of coal is consumed for each 1,000 bricks. The length of time for burning a kiln is about fifteen days. The shrinkage of the clay is about one-sixteenth. The output of the plant is 20,000 a day.

Plants at Fort Smith.—The two plants located at Fort Smith are the Fort Smith Paving Brick and Fire Clay Company, Louis Ismay & Brother, lessees, and a plant operated by John D. Carbaugh. Detailed information concerning these plants was not obtained.

The material used in the manufacture of the ordinary red building brick at Fort Smith occupies a district west of the city that includes the greater portions of secs. 9 and 16, the whole of fractional secs. 8 and 17, and the northwestern portion of sec. 20, as well as the SW. ¼ sec. 4, all in T. 8 N., R. 32 W. The SW. ¼ SE. ¼ sec. 34, T. 9 N., R. 32 W., also contains a red earthy clay from which bricks have been manufactured.

This brick earth is a stiff clay which is in places mixed with so much sand that the beds have the appearance of homogeneous deposits of sandy clay. It is, however, very irregular in its texture, varying within short distances from stiff clay to loose sand. Both sand and clay are of a red color, dark red when wet and pale yel-

lowish brown when dry and exposed for any great length of time. At Messrs. Bocquin & Reutzel's old location on the strip of land lying between Towson road and Wheeler avenue, Fort Smith, on the west side of the SE. ¼ sec. 17, T. 8 N., R. 32 W., the clay has a pale-yellowish, almost gray, color.

The average thickness of this mixed clay and sand varies considerably, but averages about 6 feet. A section taken close to the line between Oklahoma and Arkansas, near the bank of Poteau River, gives the following section:

Section near Poteau River.

	Feet.
Reddish-gray sand	2
Red clay	3–6
Red sand	6–8

The bottom of the red sand is not reached in this exposure.

In the district between Arkansas River and Poteau River, along Fourth street in Fort Smith, the red sand and clay have been penetrated to a depth of 12 feet. The sand and clay seem to be overlain by a course white river sand. In this district the clay also becomes much more sandy.

Bricks made from the brownish-yellow sandy material are soft and will not bear much rough handling. They are readily injured by rain, and ought to be dried under cover. In the kiln they will not stand a heat sufficiently high to make hard bricks without fusing. It is no uncommon thing for the arches to fall in, and when the kiln is opened the bricks forming the broken arches are found to be a fused mass of half-burned clay and dark-greenish slag. The result of this tendency to fuse is that the bricks must be burned soft and will not bear rough handling or resist the crushing strain imposed on bricks used in the erection of heavy structures. The loss through breakage in handling is also considerable, amounting in most yards to 15 or 20 per cent. When burned these bricks have a bright-red color, and when re-pressed for front or face bricks they are darker and have smooth faces and square corners. The color of bricks of this class is uniform and good.

The following analyses of this clay dried at 110°–115° C. show its composition:

Analyses of clay from Fort Smith.

[Brackett & Smith, analysts.]

	1.	2.	3.	4.	5.
Silica (SiO_2)	83.83	84.00	74.79	76.26	76.20
Alumina (Al_2O_3)	9.32	8.33	12.86	11.74	12.41
Ferric oxide (Fe_2O_3)	2.64	2.73	4.90	4.54	4.36
Lime (CaO)	.34	.27	.38	.39	.49
Magnesia (MgO)	.45	.35	.90	.79	.54
Potash (K_2O)	1.27	.83	1.73	1.28	1.21
Soda (Na_2O)	.85	.82	1.49	.98	.84
Loss on ignition (water)	2.40	2.81	2.91	3.82	3.75
	101.10	100.14	99.96	99.80	99.80
Fine sand	38.23	37.57	29.77	47.79	11.89
Water lost at 110°–115° C.	2.21	2.45	2.76	3.71	4.06

No. 1 is the lighter colored clay from the bank opposite Ketchum Iron Company's shop; No. 2 is the yellow clay overlying No. 3 at the Ketchum Iron Company's shop; No. 3 is the lower reddish clay at Ketchum Iron Company's shop (underlying No. 2); No. 4 is the red sandy clay from Messrs. Pendell & Morrison's old brickyard; No. 5 is an ashen-gray clay from the south end of the Fort Smith and Dardanelle Railway.

POTTERIES.

Comby's pottery.[a]—This pottery was situated in the SE. ¼ SW. ¼ sec. 28, T. 7 N., R. 30 W. The kiln was a small one, built of stone cemented with clay, and was half underground—the kind of kiln sometimes called "groundhog." It was not adapted to salt glazing, and the Albany slip or black glaze was used. Sometimes a little salt was thrown into the kiln, but it affected only the ware at the front of the kiln next the fire, and that not always beneficially. There was nothing to protect the ware from the ashes of the fire, and every time a fresh supply of fuel was added or the fire touched the lighter ashes were sent in a shower among the hot ware, to settle down on the articles in the process of burning to become fixed to them by the glaze. The result of this is that the ware, especially that portion of it next the fire, presents anything but a pleasing appearance. With such a method of firing, a good class of pottery could not be made even with the best of pottery clays. The poor results obtained at this pottery must be attributed for the most part to the methods employed in burning the ware, though it is in part evidently due to poor raw material or to the improper treatment of the clay.

[a] The notes and statistics of Comby's pottery were collected by Mr. Kennedy. The plant has gone out of business.

Caldwell's pottery.—A small deposit of bluish-white sandy clay mottled with red is found on the north side of a small creek in the SE. ¼ SE. ¼ sec. 10, T. 6 N., R. 31 W. This was at one time used to supply a pottery at Greenwood owned by Mr. Caldwell, but clay from this place has not been used for a number of years.

UNION COUNTY.

GENERAL GEOLOGY.

The strata underlying Union County consist almost exclusively of soft uncompacted clays, sand, brown coals (or lignites), and gravels of Tertiary age. The horizontality of these beds makes the geology comparatively simple. The clays are of various colors, exhibiting all the shades of brown, yellow, red, and gray. The highest beds of the county are those that cap the divide on which Eldorado stands. These beds are sandy clays and clayey sands, covered here and there by gravels of novaculite and quartz. From this elevated divide the surface of the county slopes away on all sides, the streams cutting deeper and deeper into the soft horizontal rocks. Along their banks, where bold headlands are left in the process of stream erosion, the stratification of the Tertiary beds is occasionally well exhibited. The best exposures, however, are in the river bluffs along the Ouachita at places where the river hugs the foot of the bluff closely, as at Camden, Newport Landing, Millers Bluff, Wilmington Landing, and New London. At Wilmington Landing the section exposed is typical of the geology of the entire highland region of the county.

The beds there exposed continue with some variation toward the west and underlie a large part of Union County, and in all probability underlie Columbia County also. In the deeper channels of the larger streams the beds of soft rocks are penetrated to greater depths and the entire section given on page 220 is exposed here and there, though generally only in fragments.

Where erosion has not been so powerful and so concentrated as in the immediate neighborhood of Ouachita River the stream channels are broader and their sides less abrupt, so that the clays and other beds have thinner coverings along the side valleys that extend inland from the river.

The lignites of Union County are of the same kind as those of Ouachita County. Aside from any direct use to which the coal may be applied, it serves as a guide in searching for clays, for the clays are at many places associated with the lignite, either overlying or underlying it. Persons acquainted with the geology of this county report that at many places a bed of clay 15 feet thick overlies the lignite. The clay beds at Wilmington Landing and at

New London Landing, on Ouachita River, overlie the lignite exposed in the river bluff at those places. This clay, however, is not everywhere valuable.

CLAY DEPOSITS.

In the neighborhood of Beach Creek, where it is crossed by the Mount Holly-Lisbon road, many small fragments of fine potter's clay are scattered through the sandy clays. These fragments are of no value in themselves, but their presence suggests the probability that they were derived from deposits of fine potter's clays in this neighborhood. Similar evidence of the presence of good clays are common at many points in both Union and Columbia counties. About Lisbon such clays are exposed in deep gullies, especially on the west side of the town, near Camp Creek, and also on Holmes Creek.

About 2 miles west of Lisbon, on the Lisbon-Mount Holly road, just west of the Rose farm, on the brow of a westward-sloping hill, 3 or 4 feet of dove-colored potter's clay is exposed by the roadside. The total depth of the bed, however, is not visible. In places this bed contains very thin laminæ of fine sand, which may prove injurious.

East of Lisbon the clays and sands are thinly laminated and interstratified, so that they are not available for the manufacture of pottery or fire-clay products.

Four miles west of Eldorado, on the road to Lisbon, there are some rather promising looking exposures, but so far as examined they contain too many streaks of sand to be useful. Further search in the vicinity is likely to discover good beds.

One and one-fifth miles west of Eldorado, on the Lisbon road, on the side of a hill facing westward, the following section is exposed:

Section near Eldorado.

	Ft.	in.
Yellow soil and clay at surface.		
Good pink clay with fossil leaves	1	
Gray, rather sandy potter's clay	4	
Pink sandy clay		8
Dull pink sands exposed	2	

The clays exposed by the Eldorado-Lisbon road, about 400 feet west of the first milepost west of Eldorado, are all or nearly all too sandy to be available for the manufacture of pottery.

Three miles east of Eldorado the road to Wilmington Landing passes over a bed of pink potter's clay containing abundant leaf impressions. On the south side of the road the bed is about 4 feet thick, but it is not exposed on the north side of the road.

About 1¼ miles southwest of Wilmington Landing, on the edge of the flat woods, some fair pottery clays are exposed by the roadside, but their thickness is not evident.

There are said to be some very fine clays on Lapile Creek in T. 18 S., R. 13 W., probably in sec. 9 or 10.

At Wilmington Landing the Tertiary beds are well exposed in the river bluff and in the gullies that furrow its sides.

Section of river bluff at Wilmington Landing.

	Feet.
1. Sand on hilltop	2
2. Sandy clay	5
3. Light-gray clay	2
4. Pinkish clay	3
5. White sand with some clay	9
6. Fat buff clay with some sandy patches and lignite	16
7. Tough, somewhat sandy, light-colored clay	7
8. Fat gray clay	6
9. White sand	3
10. Outcrop of brown coal	3
11. Fat dove-colored clay	3
12. Sands with clay laminæ	5
13. Pink sandy clays with fossil leaves	6
14. Sandy clays and sands	10
15. Concealed to the level of Ouachita River	10
	90

The hills one-eighth of a mile south of Wilmington Landing continue upward the section given above. It is approximately as follows:

Section south of Wilmington Landing.

Clays and clayey sands at the surface.	Feet.
Lead-colored and pink pottery clays	12
Sands	6
Chocolate-colored sandy pottery clays	4
Lignite	3

The horizontality of the Tertiary beds of the region and the outcrops of lignite along the bluffs and foothills of the region point to a wide distribution in Union County of the clay beds exposed in the section given above.

A specimen of the clay bed No. 6 of the Wilmington Landing section was analyzed.

Analysis of buff clay from Wilmington Landing.

[Specimen dried at 135° C. W. A. Noyes, analyst.]

Silica (SiO_2)	64.97
Titanic oxide (TiO_2)	.40
Alumina (Al_2O_3)	18.87
Iron oxide (Fe_2O_3)	5.26
Lime (CaO)	.63
Magnesia (MgO)	1.00
Potash (K_2O)	1.43
Soda (Na_2O)	.30
Water (H_2O)	7.43
	100.29

The large percentage of iron in this sample is probably due to infiltrations, the specimen having come from near the surface. Clay under cover will probably be found freer from this impurity and available for pottery ware and for other purposes for which basic clays may be used.

CLAY INDUSTRY.

But one plant in Union County is engaged in the manufacture of clay products—the Felsenthal Brick Company, at Felsenthal. The plant was established in 1904 for the manufacture of stiff-mud building bricks. They are made from the common surface red clay. The clay is tempered and molded in a Sword machine run by steam. The bricks are dried in a shed and burned in an up-draft kiln. Four kilns are in use, each having a capacity of 200,000 bricks. It requires six to ten days for the bricks to dry sufficiently to set in the kiln, and from six to eight days for burning. Wood is used as fuel. The plant has an output of 30,000 bricks a day.

The potter's clays of Union County are not utilized. There was at one time a pottery on what was formerly known as the "poor-house farm," sec. 34, T. 17 S., R. 15 W., a little more than a mile southeast of Eldorado. It was operated by Mr. Leonard as late as 1860, and was probably closed by the civil war. The pottery made is said to have been of ordinary grade. The clays used are reported to have come from the "slashes" and not from a bed in place in the hills.

There was another pottery in Union County before the civil war, about 4 miles below Wilmington Landing. The ware burned light gray and was of good texture. The clay came from the stratified beds in a bank. This pottery is no longer in existence.

There is no lack of clays in Union County for the manufacture of good pottery and of fire-clay goods. It is possible that valuable clays may cover as much as half of the total area of the county. Though analyses have not been made of all the varieties of clay found in Union County it may safely be assumed that the clays are similar to those of Ouachita County, many of which have been analyzed. Until recently there was a lack of prompt transportation, for there was no railroad in the county, but the railroad from Camden to Eldorado and other railroads lately completed now afford cheap transportation for any clay goods that may be manufactured from the fine clays along Ouachita River.

WHITE COUNTY.

GENERAL GEOLOGY.

PRINCIPAL FEATURES.

The part of White County lying west of the St. Louis, Iron Mountain and Southern Railway is made up chiefly of sandstones, grits, and shales belonging to the lower Carboniferous or Mississippian series. In the extreme northwest corner of the county, about Rosebud and Romance, these beds are very nearly horizontal, and the streams have cut through the steep-sided and rather narrow valleys. Here the harder beds of sandstone form broad, flat areas with rather abrupt edges. In the southwestern part of the county and in the region between Searcy and Griffin Springs the same series of beds has been greatly folded, so that the beds dip toward the south on one side of the folds and toward the north on the other. In the folded area the alteration of hard beds of sandstone with soft beds of shale has given rise to alternate valleys and ridges, for the resisting sandstones withstand weathering and form the ridges, while the beds of shale break down into soft, easily washed clays, which are carried away, forming the valleys. The relations of these interfolded shales and sandstones are of great importance to anyone studying the distribution of the clays and clay shales, for it often makes it possible to trace the same bed for many miles across the county.

In the region just north of the town of El Paso the parallelism of the sandstone ridges and shale valleys is a striking feature of the topography. These ridges and valleys begin a few miles west of Buble and some of them swing northward around Antioch Mountain and then pass nearly due west to the vicinity of Caldron Creek, just north of Conway, in Faulkner County. Similar ridges beginning just north of the town of Austin can be traced nearly to Palarm Bayou, south of Preston, in Faulkner County. The valleys parallel with these sandstone ridges are all cut in shales, and it is to these shales that attention is directed. Some of these shales are too sandy to be utilized, but others are well adapted to the manufacture of paving brick and sewer pipe, and some of them are good fire clays.

The geology of Round Mountain, in the extreme southwest corner of White County, has been examined for the purpose of determining the character of these shales. The geology of that particular hill is therefore given here in detail.

ROUND MOUNTAIN.

A great syncline or troughlike valley known as Cypress Valley extends from the vicinity of Beebe to Arkansas River west of Conway. In the middle of this synclinal, in White County, in secs. 5, 6, 7, and 8, T. 5 N., R. 10 W., stands an isolated table-topped hill known as

Round Mountain. This hill rises about 200 feet above the surrounding valley, and has in general outline, as seen on a map, the form of a dumb-bell.

The sections given in fig. 19, taken at the opposite ends of the mountain, and the north-south profile section in fig. 20 show that while Round Mountain contains some coal and is capped by sandstone it is made up for the most part of argillaceous shales.

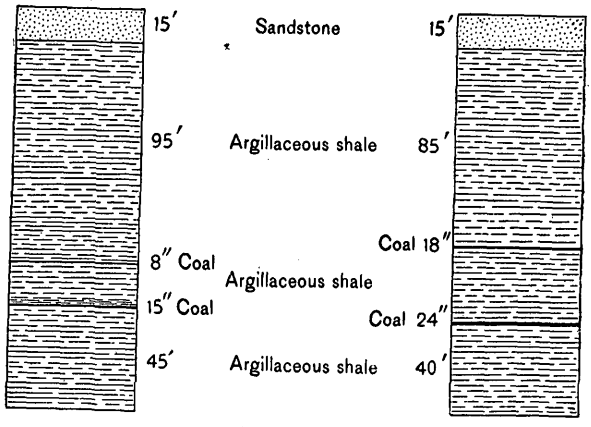

FIG. 19.—Sections of beds at Round Mountain.

The coal bed in section 2, fig. 19, was reported to have a thickness of 42 inches until 1892, when Mr. Charles Kantorowicz, of Little Rock, the owner of the Round Mountain property, engaged Capt. R. N. Scruggs to open the drift and definitely determine its thickness. The thickness here reported is that given by Captain Scruggs.

Where the shales near the base of the mountain have been covered by the débris from its sides they are already deeply disintegrated. The great body of the hill, however, is of compact shale, weathering

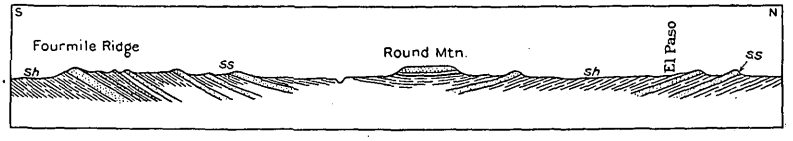

FIG. 20.—Theoretic north-south section through Round Mountain. *sh*, Shale; *ss*, sandstone.

in the usual way on exposure and breaking up in small prisms and cuboidal fragments. Much of this shale, possibly all of it, is available for the manufacture of fire bricks, sewer pipes, furnace linings, etc., and for road-paving bricks. The following are analyses of two samples of shales from Round Mountain and of two other similar shales from Missouri and Ohio, the analyses of the latter being introduced here for comparison:

Analyses of shales from Round Mountain, Ark., Cheltenham, Mo., and Akron, Ohio.

	Round Mountain.		Missouri.	Ohio.
	1.	2.	3.	4.
Silica (SiO_2)	64.04	57.12	56.86	60.05
Alumina (Al_2O_3)	21.55	24.32	28.07	20.00
Ferric oxide (Fe_2O_3)	5.01	8.21	5.03	6.82
Lime (CaO)	.59	.72	.27	.52
Magnesia (MgO)	.96	1.74	.32	.45
Potash (K_2O)	1.56	2.07	.11	1.79
Soda (Na_2O)	.80	.53	.96	1.60
Loss on ignition	5.94	7.58	10.88	6.96
Sulphur (S)	.14	.22	.....	1.95
	100.59	102.51	102.50	100.14
Water loss at 110°-115° C	1.36	1.75	3.84	1.25

1. From the bed of shale lying between the two coal beds exposed at west end of mountain. J. P. Smith, analyst.
2. From above uppermost bed of shale in the section. J. P. Smith, analyst.
3. From shale banks at Cheltenham, Mo. This is the material of which the Laclede Company manufactures its fire-clay goods. Brackett & Smith, analysts.
4. From Akron, Ohio; material used in the manufacture of sewer pipes, etc. Brackett & Smith, analysts.

A comparison of these analyses shows that the clay shales of Round Mountain are well adapted to the manufacture of fire bricks, sewer pipes, and such goods as are made of the similar clay shales at Cheltenham, Mo., and Akron, Ohio, as well as of paving bricks for roadways.

The coal in Round Mountain may perhaps be utilized in connection with the shales. At the west end of the mountain Mr. W. S. Brewer has opened a drift on a bed of coal which he reports to be 14 inches in thickness.

Immediately above the coal lies 20 to 24 inches of coal dirt or crushed bony coal. During and since the civil war Mr. Charles Kantorowicz's coal mine at the east end of the mountain was operated, but the drift has been abandoned since the spring of 1877, and the opening has been closed by the caving in of its sides. It was therefore impossible to examine the thickness of the coal bed at this place at the time it was visited. In 1892 Mr. Kantorowicz employed Capt. R. N. Scruggs to open the drift, and it was found that the coal was 24 inches thick 41 feet from the outcrop. Unfortunately it has not been possible to obtain a sample from the Kantorowicz mine, but analysis was made of a sample from Mr. Brewer's pit, which probably fairly represents the quality of coal of this lower and more important bed. The specimen was taken from the 8-inch bed high on the side of the mountain, and the coal is of good quality, as may be seen from the following analysis:

Analysis of Round Mountain coal.

[R. N. Brackett, analyst.]

Water	1.224
Volatile matter	10.298
Fixed carbon	78.119
Sulphur	3.149
Ash	7.210

Round Mountain is easy of access either from Beebe or Conway, Cypress Valley being well disposed for the location of a railway line.

Cypress Valley, especially the country about Round Mountain, abounds in good brick clays, while the region is well timbered.

There are other shale hills in the Cypress Valley syncline, the largest of which is about 7 miles east of Conway, Faulkner County, in secs. 11 and 14, T. 5 N., R. 12 W., in a hill which is also known as Round Mountain. The body of the hill is of dark argillaceous shale capped by sandstone. The rocks are identical in age and character with those of the White County section, except that thus far no coal beds have been found in the Faulkner County hill. This hill rises between 250 and 300 feet above the valley and is nearly a mile long.

In secs. 11 and 14 of the same township and range there is another shale hill that is identical in structure and character with the one just mentioned, though somewhat smaller and only about half a mile long.

CLAY DEPOSITS.

CLAY SHALES.

In addition to the localities specified above as containing large and accessible clay shale deposits, it should be remembered that the parallel valleys of White, Faulkner, and Conway counties are, for the most part, underlain by clay shales, many of which are available as refractory materials for various uses.

In the highlands the brick clays are most abundant in the shale valleys. The valley lying just northwest of Searcy and swinging north and northeast in the vicinity of Center Hill and opening into the Red River Valley east of Mount Pisgah may be taken as typical of those shale valleys of the county in which considerable deposits of brick clays have accumulated. In places these clays are spread out in thin beds for miles over the valley, in others the beds are from 10 to 20 feet thick, while in still other small areas they are entirely absent.

Along some of the larger streams, such as Red River, Big Indian Creek, and Bayou des Arcs, the bottom lands are largely buckshot clay with alluvial soil adjacent to the streams. In the immediate valley of Cypress Bayou good brick clays are abundant, especially about the headwaters of that stream and in the vicinity of Round Mountain, in T. 5 N., R. 10 W.

In the region of the lower hills the brick clays are at many places of great thickness. The following is a section of a well bored near Pangburn post-office, in the northwest corner of the county, in the NE. ¼ NE. ¼ sec. 10, T. 9 N., R. 8 W. This record was kindly furnished by Dr. F. L. Shaw, of Pangburn.

Section of well near Pangburn post-office.

	Feet.
Brick clay	16
Hard sandstone	4
Black shale	70
Hard blue sandstone	4

The western part of White County is mountainous, and on the highest elevations the brick clays, although not altogether wanting, are not so thick or abundant as in the lower lands.

TERTIARY AND QUATERNARY CLAYS.

From Cypress Bayou to Bradford the St. Louis, Iron Mountain and Southern Railway runs through White County just east of the line of junction between the Carboniferous hills on the west and the Tertiary and Quaternary deposits of the lower flat country to the east. This line divides the county into two sections which differ widely from each other in geologic age and in character. The clays of the two areas also differ more or less. Those of the hilly region are derived directly from shales by decomposition. The clays in the lowlands and valleys are the products of the erosion of the higher points, while the clays of the lowlands farther east are often horizontally stratified. Good brick clays are abundant in various parts of White County, especially along the line of the St. Louis, Iron Mountain and Southern Railway.

The Tertiary and Quaternary clays along the Iron Mountain Railway are, according to Mr. Kennedy, made up of two divisions. The upper division is a brownish-yellow sandy clay of very nearly the same texture throughout. In places it has a greater proportion of clay; in others it is nearly a sandy loam, while in still others it is a clean sand. It varies also in color from a brownish yellow to dark orange, or even red.

The second or underlying division is usually a dark-bluish clay, somewhat brownish when damp and weathering almost white when dry and exposed for some time. In some places this clay is of a reddish color, owing to the presence of a greater quantity of iron. Although this lower bed is somewhat lighter in places, it does not materially vary in texture or composition, and wherever found in the region as red, white, or blue clay it is essentially the same material, has the same qualities, and is available for the same uses. In comparing the well records in the district these variations in color have to be taken into consideration, for observers may report the same beds as having different colors.

These two deposits vary considerably in thickness in different parts of the county. The underlying bluish-white clay is persistent over the whole area, but the brownish-yellow clay, overlying the

blue, is by no means so extensive and is at some places altogether absent. In the Beebe district the brownish-yellow surface material varies from 3 to 6 feet in thickness. At Searcy it is 3 feet thick, while a mile west of Searcy, in a well, it is only 2 feet 6 inches thick, and it has the same thickness (2 feet 6 inches) at Judsonia.

Wells in the neighborhood of Kensett show that the upper clay there is very irregular in thickness, while in some of them it is wanting altogether. In the Briggs well, in the S. ½ NW. ¼ NE. ¼ sec. 16, T. 7 N., R. 6 W., it is 2 feet thick. On the road near Captain Moseby's house, about a quarter of a mile south-southeast of Moseby's gin house, in the NW. ¼ NW. ¼ sec. 15, T. 7 N., R. 6 W., it is 3 feet thick. At West Point an extensive area is altogether devoid of any such covering, while the railway from that place to Kensett shows it in various places to have a thickness of 2 to 4 feet.

Brownish-yellow clay or earth suitable for the manufacture of brick is found in spots throughout the area under consideration, but most of these areas are too small to be shown on a small map. These spots occur in rolls or on the tops of ridges, and may, as at Judsonia, occupy parts of secs. 8, 9, and 17. At Searcy the brownish-yellow earth extends over an area that is possibly a quarter of a mile wide and three-quarters of a mile long, occupying the small valley running west from the town of Searcy through the centers of secs. 10 and 9 and the middle of sec. 8, T. 7 N., R. 7 W. This area includes the best brick clays in this neighborhood.

The sections exhibited in the well borings from Cabot, Beebe, Kensett, and Judsonia, in a continuous line, as well as those along the lines from Searcy to West Point, show the persistence of the underlying bluish-white or bluish-brown clay. This clay is dark bluish brown when moist and gray when dry. The light-gray appearance is due to patches of pale-blue clay embedded in the mass. When exposed at the surface and allowed free contact with the rain these whitish or pale-blue spots become fluid and spread over the face of the cutting, giving the whole a light appearance. This clay contains also numerous patches stained with iron and some almost black. The following sections show the relations between the upper yellow loam deposits and the lower blue clays and sands:

Section in C. Essig's well, near Beebe.

	Feet.
1. Surface clay	4
2. Bluish clay with dark-colored and iron-stained patches	10
3. Joint clay	20
4. Yellow sandy clay	14
5. Quicksand	7
	55

No. 1 of this section is used for bricks and No. 2 for drain tile.

In the W. ½ N. ½ NE. ¼ NW. ¼ sec. 8, T. 5 N., R. 8 W., a well dug by Mr. Parker gives the following:

Section in Parker's well.

	Feet.
Yellow loam	6
White joint clay	12
Red sandy joint clay with pebbles	35
	53

W. A. Ballou has a well at Beebe 20 feet deep, which shows—

Section in Ballou's well.

	Feet.
Yellow clay	3
Bluish clay	17
	20

Part of the upper division of the lower bed is dug and mixed with 3 feet of yellow clay for brick clay, and the articles so made burn better and are much harder than those made from the yellow brick earth alone.

That part of White County lying east of the St. Louis, Iron Mountain and Southern Railway has not been examined except at West Point. The general geology of the region, however, is inferred to be very nearly identical with that of Lonoke and Prairie counties. Good brick clays are likely to be found throughout most of the eastern part of White County. In the wet lands or slashes the limonite buckshot is found in the clays a short distance below the surface, and, as is well known, these nodules injure clays more or less for brickmaking purposes. The best brick clays of White County are found on the higher lands.

CLAY INDUSTRY.

The upper yellow clays are made into bricks at Beebe, Searcy, and Judsonia, and a mixture of the yellow and upper portion of the bluish clay is also used. The blue clay beneath was formerly also used by Mr. C. Essig at Beebe for the manufacture of drain tiles. The Beebe clay makes hard, solid bricks, but their color is not satisfactory and they can not therefore be used for facing and other purposes where ornamental or fine bricks are required. Their color when properly burned is a light gray, sometimes running into a dark cream, but they are not of a uniform shade. These bricks are well adapted for use in foundations where a sound, hard brick is required without regard to its roughness of appearance or poor color.

When the brownish-yellow upper bed is used alone the clay is worked in a very soft condition and in drying shrinks considerably and shows a tendency to warp. A mixture of the two clays forms a brick which, although coarse, is of good quality, and is less liable to

shrink or warp. The mixing of the clays, however, requires a great amount of care and time. The material of the lower bed must be dug up and allowed to lie for some time before it is incorporated with the upper clay.

If the clay were dug from the lower bed during the fall of the year and left exposed to the disintegrating influences of the rains and frosts of the winter and spring its texture for brick or tile making purposes would be materially altered and improved. By such treatment it would be pulverized, mellowed, and almost completely tempered, and with slight additional treatment could be manufactured into bricks of a bright-red color, more uniform than those made from the upper bed alone, and of better texture than those made either from the upper clay or from a mixture of the two.

As a material for the manufacture of drain tiles this winter-mellowed clay would serve a very good purpose. It would turn out a stronger tile than any at present used.

In May, 1905, Mr. J. Y. Woodson was operating a brick plant at Searcy, one-half mile west of the court-house. The yellow surface clay is used to a depth of 3 feet. The mud is pugged in a ring pit with a Raymond wheel run by horse power, and must be ground for one and one-half to three hours before it can be molded. In the summer, when the clay is dry, it requires 200 to 250 gallons of water to temper sufficient mud to make 1,000 bricks. In the winter it requires less than half that amount of water.

The bricks are common wet-mud bricks molded by hand and dried in racks in the open air. They are burned in up-draft kilns of 200,000 capacity. Wood is used for burning, and about three-fifths of a cord is used for each 1,000 bricks. The bricks require twelve to fourteen days for drying and six to eight days for burning. The plant is operated by six men and three boys, and the output is about 5,000 bricks a day.

WOODRUFF COUNTY.

GENERAL GEOLOGY.

The surface of the western half of Woodruff County is composed of the alluvial bottom lands of White and Cache rivers. The surface of the eastern half varies from a reddish clay to sandy prairie land, 25 to 30 feet higher than the bottoms of Cache and White rivers. The prairie area is cut into north-south ridges by Bayou de Vue, Buffalo Creek, Caney Creek, and other small streams. The most prominent of these ridges is Nubbin Ridge, which has a north-south trend through R. 2 W. The top of this ridge is 25 to 30 feet above the Cache River bottom to the west. The soil on Nubbin Ridge is much poorer than the rich alluvial soils of the bottoms to the east and west.

The geologic strata of the county belong to two distinct periods. The bottom lands are all alluvial sands, which are now being formed by the present streams. The prairie lands and ridges belong to a much earlier period in Quaternary time.

Where the railroad passes up to Nubbin Ridge from the bottom land just south of Colona the cut shows the following section:

Section of Nubbin Ridge near Colona.

	Ft.	in.
Soil		10
Reddish to yellowish-tinted loamy clay, containing buckshot concretions; practically impervious to water	2	2½
White sandy clay, sharply separated from the above by its lack of moisture, and grading down into a reddish resistant sand, and this to a purple loose sand	10	

The same order of strata that is given above is seen in the road a short distance west of Powell.

The typical prairie lands in the western part of St. Francis County extend westward into Woodruff County. The following section was obtained in wells at Hunter:

Section of wells at Hunter.

	Ft.	in.
Soil (a few inches) at top.		
Red clay, sticky and soft when wet	2	6
White clay		3–6
Hardpan (clay)	9–15	
Clay and yellow sand, very hard when dry	5	
Fine gray sand	5	
White sand	4	
Quicksand with some gravel, water bearing	3	
Hardpan	3	
Sand becoming coarser at bottom, water bearing	35–45	

CLAY INDUSTRY.

At present there is but one plant in Woodruff County where clay is utilized. This is a common wet-mud brick plant located at Cotton Plant. The bricks are made from the yellow loam which occurs in the prairie section of the county. There are no large towns in the county except Augusta, which is located in the alluvial sands of White River, so that the local demand for building brick is not great.

YELL COUNTY.

GENERAL GEOLOGY.

The general geology of Yell County is similar to that of Pope and Logan on the north and to that of Scott and Logan on the west. The clays therefore fall naturally into the same classes, namely, (1) Carboniferous shales and clays interbedded with the hard rocks in place; (2) brick loam and buckshot clays; (3) terrace clays along Arkansas River; (4) clays of the Arkansas River flood plains.

CLAY DEPOSITS.

CARBONIFEROUS CLAY SHALES.

In Yell County the great shale member at the top of the Atoka formation is again one of the most prominent and important of the Carboniferous rocks. This shale enters Yell County on the west, on the south side of Magazine Mountain 2½ miles west of Waveland, and extends along the south side of both Magazine and Chickahah mountains. At the east end of Chickahah Mountain it runs round the end and then, turning westward, extends along the base of the ridge until it joins the same outcrop around the base of Huckleberry Mountain. The same beds run entirely around Three Knobs Mountain, around Spring Mountain, and around Mount Nebo. The shale bed underlying the sandstone on the south side of Dardanelle Ridge is this same shale.

Shales lower in the geologic scale are exposed over a large part of Yell County. At Chickahah village and in the valley thereabout there are many exposures of such shales. At Danville shales are well exposed along Petit Jean Creek with a dip N. 60° W., varying from 20° to 24°. These shales extend over the flat valley for miles east of Danville. On the Rover road south of Danville and on the north side of Danville Mountain there are many exposures of clay shales interbedded with sandstones, and these alternations of shale and sandstone continue to the top of Danville Mountain. Along the road running from Danville to Ola, along the base of the mountain, the rocks are nearly all shales and all dip toward the north. At Ola, on the Choctaw Railway and just south of the railroad station, is a cut, 12 feet deep, in shales. A few hundred feet west of the station there is a large exposure of promising looking shales in the railroad cut. Along the road leading from Ola toward Dardanelle shales are exposed at many places for a mile or more, all of them dipping northward. Where the Ola-Dardanelle road crosses Petit Jean Creek the flaggy shales dip N. 80° E. at an angle of 14°. On the ridge a mile north of Dardanelle the red clay is underlain by fissile shale dipping north and passing beneath Dardanelle Rock.

BRICK LOAM AND BUCKSHOT CLAYS.

The brick loam or yellow and ashen buckshot clays cover a large area in the lowlands of Yell County; indeed, there is probably more clay of this kind in Yell than in any other county in the State. The clays are especially abundant and thick along Petit Jean Creek from the point where that stream enters the county, 3 or 4 miles southwest of Waveland, to the place where it empties into Arkansas River—a distance of about 50 miles. In places south of Dardanelle the yellow loam is exposed to a depth of fully 12 feet, yet the total thickness of the deposit is not visible.

The following are a few localities at which the brick loam has been noted: On the upper Dardanelle-Danville road 3 miles from Dardanelle, at a place where the road crosses the stream, the loam is 6 feet thick, with sandstone fragments at the base. It is a widespread deposit in the lower parts of the valley between Chickahah and Belleville and between Belleville and Danville. The valley soil about Danville is mostly the "buckshot" loam. In many of the low red-clay hills along Harris Creek several feet of yellow clay lies beneath the red clay, and waterworn pebbles beneath the yellow. At Johnsons Bridge, on the lower Dardanelle-Danville road 1 mile southwest of Dardanelle, the yellow loam is at least 12 feet thick. This exposure is especially interesting because it exhibits the relations of the chocolate clays of the river country. The following is the section:

Section at Johnsons Bridge.

	Feet.
Greenish-yellow loam with some waterworn cobbles	4
Chocolate clay with calcareous concretions and nodules	4–8
Yellow sandy clay with calcareous matter in crevices	12

The demarcation between the chocolate clay and the underlying yellow sandy clay is very clear at this locality. The lower bed is deeply scored by big gullies that are in places as much as 12 feet deep. The calcareous matter of the lower bed is derived from that of the chocolate clay by solution and redeposition, as is indicated by the fact that the concretions of the lower bed occur mainly in cracks and are not disseminated through the mass as they are through the chocolate clays.

The following section is an analysis of the lower yellow clay of the Johnsons Bridge section:

Analysis of the lower yellow clay at Johnsons Bridge, 1 mile south of Dardanelle.

[Specimen dried at 110°–115° C. J. P. Smith, analyst.]

Silica (SiO_2)	74.48
Ferric oxide (Fe_2O_3)	7.52
Alumina (Al_2O_3)	11.58
Lime (CaO)	.64
Magnesia (MgO)	.26
Manganese oxide (MnO)	.41
Potash (K_2O)	1.10
Soda (Na_2O)	.54
Loss on ignition	4.11
	100.64
Water at 110°–115° C.	1.83

TERRACE CLAYS ALONG ARKANSAS RIVER.

Certain clays and silts along Arkansas River are quite different from any found in the Paleozoic region away from that stream. Such are the loams used for the manufacture of common bricks at

Argenta and at Fort Smith. The same clays occur in Yell County in the second bottoms, usually well away from the river. But as the Yell County line follows this river for 28 miles, there is an abundance of this material in the second bottoms, especially between Dardanelle and the mouth of Petit Jean Creek. Over the pink and yellow clays that form most of these terraces lie patches of what the Arkansas Geological Survey has called chocolate clays. These chocolate-colored clays are very fine silts, and are extremely plastic and sticky when wet. When dried they often break up in small angular and conchoidal fragments and are sometimes called "buckshot" clays, not on account of the presence of the iron nodules that characterize the true "buckshot" loams, but because it falls to pieces in these small lumps about the size of a buckshot. These chocolate clays have thus far been found in the State only within the area subject to overflow by Arkansas River, and it has therefore been supposed that they are silt deposits made by that stream. The section at Johnsons Bridge just given shows that the chocolate clay is of later age than the yellow and pink loams of the second bottoms. The chocolate clay usually contains an abundance of lime nodules. The clay itself is also high in lime, as is shown by the following analysis:

Analysis of chocolate clay from Johnsons Bridge, near Dardanelle.

[Specimen dried at 110°–115° C. Brackett & Smith, analysts.]

Silica (SiO_2)	56.91
Iron (Fe_2O_3)	6.68
Alumina (Al_2O_3)	19.80
Lime (CaO)[a]	4.76
Magnesia (MgO)	.96
Potash (K_2O)	2.12
Soda (Na_2O)	1.05
Loss on ignition	9.57
	101.85
Water at 110°–115° C.	7.77

A qualitative examination of the nodules in the chocolate clay showed that they consist chiefly of lime carbonate, but they contain considerable iron and magnesium.

The chocolate clay overlying this yellow sandy clay at Johnsons Bridge and elsewhere in the neighborhood has been tried for brick-making, but without success. Indeed, it may be set down as a rule that the chocolate clay, wherever found in the State, is unsuited to brickmaking.

[a] Some of the lime is in the form of carbonate, but the carbonic acid was not determined.

ALLUVIAL CLAYS ALONG ARKANSAS RIVER.

The clays of the great flood plain of Arkansas River are confined to the river bottoms proper. They are for the most part extremely variable in character and thickness and hold out but little promise of being useful as clays.

CLAY INDUSTRY.[a]

POTTERY.

In the SE. ¼ SE. ¼ sec. 12, T. 6 N., R. 21 W., a deposit of light-bluish, red-streaked clay overlies the black shales to a depth of 3 to 5 feet. This same clay covers the greater part of the section. Some years ago it was worked as a pottery clay, and was manufactured into a strong, dark-red earthenware. When glazed the material used for the purpose was broken glass and soda, which gave the ware a peculiar greenish color. This clay may be suitable for sewer pipes or any ware requiring a strong plastic clay capable of burning to the verge of vitrification and taking a salt glaze.

In the E. ½ SE. ¼ sec. 11, T. 6 N., R. 21 W., soft blue argillaceous shales appear to underlie 3 feet of broken red shales and sandstones.

COMMON BRICKS.

In the NE. ¼ NE. ¼ sec. 1, T. 6 N., R. 21 W., bricks have been made from a light-yellowish sandy clay. This clay is about 2 feet thick and overlies a red clay. The red clay forms the surface soil in the northern part of the same section and also in part of the NW. ¼ NW. ¼ sec. 6, T. 6 N., R. 20 W. No bricks have been made in this yard since 1886. From the broken pieces of brick lying on the yard they appear to burn to a salmon color when soft, and when burned hard are gray and spotted with iron.

On lot 2 of the NW. ¼ SW. ¼ sec. 6, T. 6 N., R. 20 W., bricks were made some years ago by Messrs. Perry & Kimball and afterward by Mr. R. Smiley. A yellowish clay containing small white calcareous concretions was used for the manufacture of these bricks. This clay is unsuited for hand molding, and the bricks were made on a Hotchkiss machine. Owing to the stiffness of the clay and the tendency of the green bricks to crack when exposed to the sun, there was considerable difficulty in drying them until drying sheds were built. Under cover the bricks dried very slowly, but without much loss through breakage. In burning these bricks the firing was kept up for twelve to fourteen days. The shrinkage or settling in the kiln is said to have been considerable, but no reliable information could be obtained on the subject. The eye bricks showed a slight tendency

[a] The notes on the clay industries of Yell County were made by Mr. William Kennedy.

to vitrification and were of a dark metallic-blue color. The bricks were hard and apparently durable, some of them put down in a pavement twelve years ago being still sound. In the SW. ¼ SE. ¼ sec. 29, T. 6 N., R. 20 W., J. F. Nolan burned a few bricks in 1888. The earth used by him is of orange color. The bed is 2 feet thick and extends over an area of 30 acres. The bricks burned hard and range in color from a dark cherry-red to a light gray. The hard-burned bricks are spotted with dark iron stains. The loss at this kiln amounted to about one-third.

The only plant in operation in the county at the present time (1906) is run by William Murphy, at Dardanelle, for making common bricks. No further information concerning this establishment was obtained.

ANALYSES OF CLAYS.

In the table of analyses of pottery, fire, and other clays of Arkansas given on pages 236–237, certain typical clays of Ohio and Missouri are also included for purposes of comparison.

Analyses of pottery, fire, and other clays.

Laboratory No.	Location.	Silica (SiO_2).	Alumina (Al_2O_3).	Ferric oxide (Fe_2O_3).	Lime (CaO).	Magnesia (MgO).	Potash (K_2O).	Soda (Na_2O).	Loss on ignition.	Total.	Water at 110°–115° C.
	POTTERY CLAYS OF ARKANSAS.										
276	NW. ¼ NE. ¼ sec. 12, T. 2 S., R. 15 W	65.79	23.92	1.94	0.23	Trace.	1.15	1.08	7.07	101.08	1.80
277	NW. ¼ NE. ¼ sec. 12, T. 2 S., R. 15 W	72.44	18.97	1.59	.18	Trace.	1.35	.91	5.39	100.83	1.55
278	NW. ¼ SW. ¼ sec. 12, T. 2 S., R. 15 W	69.95	22.34	1.44	Trace.	.08	1.28	1.18	5.98	102.25	2.34
279	SE. ¼ sec. 2, T. 2 S., R. 15 W	71.09	19.86	1.81	.11	Trace.	1.45	.81	5.67	100.80	1.96
305	NW. ¼ NW. ¼ sec. 1, T. 2 S., R. 15 W	64.49	23.86	2.11	.31	Trace.	.11	1.82	8.11	100.81	2.37
[a]338	NE. ¼ NE. ¼ sec. 24, T. 4 S., R. 17 W	73.24	14.61	1.04		0.78			5.33	100.00	2.01
336	NE. ¼ SE. ¼ sec. 18, T. 13 S., R. 24 W	76.33	16.04	1.24		.99			5.40	100.00	2.23
339	NE. ¼ SE. ¼ sec. 18, T. 13 S., R. 24 W	73.87	17.38	1.64		1.46			5.65	100.00	1.92
337	W. ½ SE. ¼ sec. 5, T. 15 S., R. 25 W	75.99	16.12	1.35		1.45			5.09	100.00	1.08
[b]340	NE. ¼ NW. ¼ sec. 9, T. 15 S., R. 28 W	74.85	17.20	1.12		1.13			5.70	100.00	1.53
[c]328	S. ½ SE. ¼ sec. 27, T. 7 N., R. 30 W	81.61	10.52	2.70	0.32	0.40	0.66	0.57	3.95	100.73	3.86
329	SE. ¼ NW. ¼ sec. 36, T. 10 N., R. 32 W	67.64	21.57	2.48	.27	.62	1.63	.57	5.53	100.31	2.85
	FIRE CLAYS OF ARKANSAS.										
333	NW. ¼ NE. ¼ sec. 34, T. 8 N., R. 26 W	88.66	5.73	2.55		.81			2.25	100.00	1.33
334	Clarksville (in stream opposite college)	53.36	29.96	5.12	.30	1.16	2.69	1.03	7.90	100.52	3.90
[b]341	NE. ¼ SW. ¼ sec. 2, T. 12 S., R. 18 W	76.21	16.00	.75		1.06			5.98	100.00	
[b]342	W. ½ SE. ¼ sec. 5, T. 15 S., R. 25 W	75.32	16.75	.92		1.87			5.14	100.00	1.54
343	.....do	74.76	15.96	3.44	.51	1.10	2.28		3.95	100.00	3.33
344	NW. ¼ SE. ¼ sec. 18, T. 13 S., R. 24 W	72.48	18.24	1.52	Trace.		1.98		5.78	100.00	1.69
345	NE. ¼ NE. ¼ sec. 24, T. 4 S., R. — W	72.59	16.08	1.18	Trace.	.26	3.55		6.34	100.00	2.18
347	SW. ¼ NW. ¼ sec. 4, T. 7 N., R. 18 W	90.49	5.22	1.38					3.12	100.00	1.60
352	SE. ¼ SW. ¼ sec. 12, T. 10 N., R. 26 W	62.92	23.60	3.17	.23	.57	2.77		6.74	100.00	2.65
99	SW. ¼ NW. ¼ sec. 16, T. 9 N., R. 31 W	64.63	23.71	3.71	.31	.41	2.03	0.94	6.52	102.26	3.02
351	NE. ¼ NW. ¼ sec. 14, T. 12 S., R. 18 W	79.42	13.35	2.17	Trace.				5.38	100.32	3.72
286	Mabelvale station	65.27	18.75	7.34	.81	1.26	1.10	1.81	6.88	102.22	9.46
[d]110	Towson road, Fort Smith	58.43	22.50	8.36	.32	1.14	2.18	1.03	6.87	100.83	3.37
267	Iron Mountain Rwy., near Mount Ida wagon road	62.36	25.52	2.16	.51	.29	1.90	.66	5.32	98.72	1.99
[e]270	Faulkner County	64.04	21.55	5.01	.59	.96	1.51	.80	5.94	100.40	1.36
71	Harding & Boucher's quarry, Fort Smith	57.10	23.74	8.18	.53	1.04	1.53	.87	7.21	100.20	4.29
	NW. ¼ SW. ¼ sec. 28, T. 8 N., R. 28 W	65.12	19.05	7.66	.34	.31	1.23	.85	6.12	100.68	4.79
	SUNDRY CLAYS OF ARKANSAS.										
[f]51	Johnsons bridge	56.91	19.80	6.68	4.76	.96	2.12	1.05	9.57	101.85	7.77
174	Fort Smith	76.26	11.74	4.54	.39	.79	1.28	.98	3.82	99.80	3.71
[g]330	River deposit	70.95	12.24	4.73	1.90	.97	1.14	.66	7.01	99.60	4.19

343	W. ½ SE. ¼ sec. 5, T. 15 S., R. 28 W	74.76	13.96	3.44	.51	1.10	2.28		3.95	100.00	3.33
f 274	Union depot, Little Rock	70.05	14.56	6.20	.74	1.12	Not determined.		4.45	97.12	4.48
280	NW. ¼ sec. 30, T. 1 N., R. 11 W. (on railroad)	90.38	4.48	2.10	.16	Trace.	0.41	0.66	1.91	100.10	1.91
173	Railway at Ketchum Iron Co.'s works	83.83	9.32	2.64	.34	.45	1.27	.85	2.40	101.10	2.21
117	South end of railway to Dardanelle	76.20	12.41	4.36	.49	.54	1.21	.84	3.75	99.80	4.06
335	NE. ¼ SW. ¼ sec. 15, T. 1 S., R. 14 W	82.45	11.80	.80	.31	.25	1.60		2.79	100.00	.21
h 332	Albany (slip clay)	58.05	14.86	6.76	6.61	3.08	1.18	0.80	7.41	98.75	1.66
	CLAYS FROM OHIO AND MISSOURI.										
i 109	Carboniferous shales from Akron, Ohio	60.05	20.00	6.82	.52	.45	1.79	1.60	6.96	98.19	1.25
j 264	Carboniferous shales from Akron, Ohio	73.77	17.40	1.88	.49	.31	.61	1.55	5.41	101.42	1.10
311	Cheltenham, Mo.k	56.86	28.07	5.03	.27	.32	.11	.96	10.88	102.50	3.84
312	Cheltenham, Mo.k	54.92	22.71	9.81	.52	2.59	3.16	.62	5.88	100.21	2.69

a Pink clay.
b Slight trace of lime.
c Slight trace of manganese.
d Sulphur, 0.16.
e Sulphur, 0.14.
f Chocolate clay; brick clay.
g May be used as slip clay.
h Used as a slip for black glazing by all potters in the State.
i Sulphur, 1.95; used at Akron, Ohio, for the manufacture of sewer pipes.
j Sulphur, 0.08; pottery clay.
k Used by the Laclede Fire-Brick Manufacturing Company, St. Louis, Mo.: No. 311, for making fire bricks; No. 312, for making sewer pipes.

PRODUCTION.

There has been a steady increase in value of the clay products in Arkansas since 1899, as the following figures will show:[a]

Value of clay products of Arkansas 1899–1907.

Year.	Amount.	Year.	Amount.
1899	$339,142	1904	$696,582
1900	381,012	1905	643,956
1901	407,263	1906	532,194
1902	520,178	1907	536,286
1903	589,946		

The output and value of the various clay products of Arkansas for the year 1907 are summarized below. The number of operating firms reporting is 52.

Quantities and values of various clay products of Arkansas in 1907.

	Quantity.	Value.	Average price per thousand.
Common brick	68,463,000	$468,706	$6.85
Vitrified brick	.....	(b)	10.00
Front brick	1,010,000	11,940	11.82
Fire brick	.....	(b)	12.36
Drain tile	.....	5,160	.....
Earthenware and stoneware	.....	16,950	.....
Miscellaneous c	.....	33,530	.....
	.....	536,286	.....

a Statistics of the clay-working industries in the United States in 1904, by Jefferson Middleton.
b Included in "Miscellaneous" to avoid disclosing the operations of individual establishments.
c Includes vitrified and fire brick, hollow building tile or blocks, etc.

LIST OF CLAY WORKERS.

The following table gives a directory of the clay workers in Arkansas in 1906, together with the location of their plants and data concerning materials, processes, etc.

List of clay workers in Arkansas, 1906.

Location of plant.		Name of firm.	Material used.	Process.	Drier.	Kilns.		Product.
County.	Place.					Number.	Kind of draft.	
Arkansas	Stuttgart	H. C. Bruner	Surface loam					Common bricks.
Ashley	Hamburg	Nolley Bros						
Benton	Bentonville	Bentonville Brick and Tile Co.						Do.
	do	Thomas Haney	Surface clay	Wet mud	Open air		Up	Do.
	Rogers	J. E. Gelabert & Son	do	Hand	do	2	do	Common builders.
	Siloam Springs	W. S. Williams	Common clay	do	Sun		do	Do.
	Sulphur Springs [a]	David J. Young	Shale	Dry press	Air		Up and down	Face bricks.
Boone	Harrison	J. Samuel Tyson						
Bradley	Warren	Moore & Gannway						
Clark	Arkadelphia	W. A. Obaugh	Surface clay	Wet mud	Sun	2	Up	Common bricks.
	Bradshaw	J. A. Ross						
	Gurdon	N. R. O'Neal	Surface clay	Wet mud	Standard	3	Up	Common builders.
Clay	Pratt [b]	Pratt Brick Co						
Cleveland	Kingsland [c]	Leali Presser and Fire Brick Co.	Shale and surface clay.	Stiff mud and dry press.	Standard	7	Up and down	Fire and common bricks.
Columbian	Magnolia	McIntyre & Co	Red surface clay	Wet mud, handmade.	Sun	1	Up	Common bricks.
Craighead	Jonesboro	Barton Lumber and Brick Co.	Yellow clay	Soft mud and dry press.	Pallet and rack		do	Do.
	do	Jonesboro Brick Co	do	do	do		do	Do.
	do	Logan & Collins						
	do	Patrick Bros. Brick Co	Reworked loess	Wet mud	Pallet and rack		Up	Do.
	do	Sachs Brick and Tile Co	do	Wet mud and dry press.	Closed sheds with steam.		Down	Tile and common building brick.
Cross	Wynne	Wynne Brick Co	Yellow clay	Soft mud	Pallet and rack		Up	Common bricks.
Drew	Monticello	J. H. Blythe, Drew Brick Co.						
Faulkner	Conway	J. W. Firestone	Surface clay	Stiff mud	Shed	2	Up	Common builders.
Green	Paragould	Paragould Brick Co	Reworked loess	Solt mud and dry press.	Pallet and rack		do	Do.
Hempstead	Doyle	L. F. Huddleston						
	Hope	Hope Brick Works	Surface	Wet mud	Pallet and rack	3	Up	
	Spring Hill	Spring Hill Pottery Co	White Tertiary clay		Closed shed		Down	Stoneware.
Hot Spring	Malvern	Clark Pressed Brick Co.	Surface clay	Stiff mud and dry press.	Steam		Up	Common builders.
	Perla	Malvern Brick and Tile Works.	Plastic fire clay	Stiff mud	Direct-heat tunnel	4	Down (round)	Fire, paving, and white front bricks.
Howard	Center Point	M. C. Pope	Red surface clay	Wet mud	Open air		Up	Common bricks.
	Nashville	F. M. Buston						
	do	B. F. Hill						
Jefferson	Pine Bluff	O'Neal & Rogers						
	do	Pine Bluff Brick Co	Surface clay	Soft mud	Standard	5	Up	Common builders; also sand-lime bricks.
	Redfield	James H. Conley	Yellow surface clay	Wet mud	do	1	do	Do.

[a] Office at Fort Smith. [b] Office at Rector. [c] Plant to be removed to Little Rock.

List of clay workers in Arkansas, 1906—Continued.

Location of plant.		Name of firm.	Material used.	Process.	Drier.	Kilns.		Product.
County.	Place.					Number.	Kind of draft.	
Lawrence	Black Rock and Imboden.	Crouch & Courtney	Yellow surface clay.	Wet mud	Open air		Up	Common bricks.
	Walnut Ridge	Moore & Co	do	Soft mud	Pallet and rack		do	Common builders.
Lee	Marianna	O. C. Sutton	Reworked loess	do	do	3	do	Do.
Lonoke	Lonoke	W. H. Harrison	Surface clay	do	Open air	2	do	Do.
	Cabat	I. C. Wylie						
Miller	Texarkana	Interstate Pottery	White Tertiary clay		Closed shed		Down	Stoneware.
	do	Anthony W. Stevens						
	do	Texarkana Brick Co	Semishale	Dry press		5	Up	Common builders.
Mississippi	Blytheville	Blytheville Brick and Tile Co.						
Monroe	Brinkley	John C. Moshier	Yellow clay	Hand	Open air	2	Up	Common bricks.
Montgomery	Oden[a]	James & Robinson	Residual clay		Closed shed		Down	Stoneware.
Nevada	Emmet[b]	Longston Bros	Surface clay	Wet mud	Open air		Up	Common bricks.
Phillips	Helena	Straub Pressed Brick Co	Loess	Wet mud and dry press.	do		Up and down	Do.
Pike	Nathan	C. J. Polk	Residual clay	Wet mud	do		Up	Do.
Poinsett	Harrisburg	Harrisburg Brick Co	Reworked loess	Soft mud	Pallet and rack		do	Do.
Polk	Mena	Mena Brick Co	Residual clay	Stiff mud	do		do	Do.
Pope	Atkins	C. B. Wilson	Red surface clay	Hand	Open air	1	do	Do.
	Russellville	Russellville Brick Works						
Prairie	Devall Bluff	Devall Brick Co	do	Wet mud	Pallet and rack	2	Up	Do.
Pulaski	Little Rock	Arkansas Brick and Manufacturing Co.	Surface clay	Stiff mud and dry press.	Standard and open air.	10	Up (Swift's)	Do.
Randolph	Pocahontas	Jansen & Shannon						
	do	Joseph Schmidt	White and gray clay	Wet mud	Open shed	2	Up	Do.
St. Francis	Forrest City	Choctaw Brick and Tile Co	Loess	Stiff mud	Pallet and rack		do	Common building bricks.
Saline	Benton	Benton Brick Manufacturing Co.	Surface clay	Soft mud	do		Up and down	Common bricks.
	do	Eagle Pottery Co	White Tertiary clay		Shed		Down	Stoneware.
Sebastian	Fort Smith	John D. Carbough						
	do	Fort Smith Paving Brick and Fire Clay Co.						
	Mansfield	Choctaw Brick and Gas Co	Shale	Steam mold	Open air	5	Up and down	Common builders.
Union	Felsenthal	Felsenthal Brick Co	Red surface clay	Stiff mud	Pallet and rack	4	Up	Do.
Washington	Prairie Grove[c]	Terpening Brick and Tile Co	Surface clay	do	Closed shed	6	do	Do.
	Springdale	J. W. Carter	3 feet surface clay	Hand	Open air		do	Common bricks.
	do	E. T. Caulde	Red surface clay	do	do	2	do	Do.
White	Beebe	Beam & Tidwell	do	Soft mud	do		do	Do.
	Judsonia	Judsonia Brick Co	do	do	do		do	Do.
	Searcy	J. Y. Woodson	do	do	do		do	Do.
Woodruff	Cotton Plant	H. F. Doyle						
Yell	Dardanelle	William Murphy						Do.

[a] Office at Story. [b] Office at Sutton. [c] Office at Farmington.

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