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## MAPS.

Maps showing geology and elevations.
Showing agricultural features.
Showing deposition of gravel beds.

# LETTER OF TRANSMITTAL.

Professor JOHN R. PROCTER, *Director:*

SIR: I have the honor to transmit herewith my report on that portion of Kentucky lying between the Tennessee and Mississippi rivers, and known as the Jackson Purchase.

The report embraces:

1. A description of the general topographical, geological, economic and agricultural features.

2. A chapter on antiquities.

3. A description of each of the seven counties included in the region.

The report having, for the most part, been prepared before the organization of all of that part of Ballard county south of Mayfield creek into the new county of Carlisle, it would have required much time and labor to revise the work with reference to that county; then, too, the maps that accompany the report were already engraved and published, and to have made new ones would have entailed a very heavy expense upon the Survey. Under the circumstances, therefore, reference to the county of Carlisle is omitted.

It gives me pleasure to say that in my field work I have met with every encouragement on the part of the citizens of the region, many of whom gave me very material assistance. Among these may be mentioned Mr. W. F. Bradshaw, Dr. S. C. Caldwell and Capt. Golay (U. S. Engineer Corps), of Paducah; Mr. Lilley, of Birmingham, and Mr. Ed Brown, of Buffalo Landing.

The Survey is also indebted to Mr. W. Taylor, Superintendent, and Karl Langenbeck, Ph. D., Chemist of the Rookwood Pottery, Cincinnati, for tests made with more than thirty samples of clays sent from the Purchase counties. The specimens of crude "biscuit ware" and of beautifully

decorated ware, have been presented to the Survey museum, and have been the object of great admiration on the part of visitors.

To Prof. Wetherby, of Cincinnati, the Survey is indebted for determinations of shells from the Loess bluffs; to Mr. Angelo Heilprin for that of Tertiary fossil casts from near Paducah, and to the U. S. Geological Survey for identification of fossil flora from the clays and clay-stones of the Tertiary of Kentucky.

With assurances of my high appreciation for the cordial assistance and uniform courtesy which I have received from yourself and from the officers of the Survey,

I am, very respectfully,

R. H. LOUGHRIDGE, *Assistant Geologist.*

He failed to give credit to Dr. Peter for the great number of Chemical Analyses reported here (P)

# JACKSON'S PURCHASE.

The country embraced between the Mississippi, Ohio and Tennessee rivers, and the Tennessee State line on the south, and covering an area of about 2,340 square miles, is commonly known as "Jackson's Purchase," from the fact of its having been purchased from the Chickasaw Indians by Gen. Andrew Jackson, a commissioner appointed on the part of the United States to make a treaty with them.

The history of the purchase, so far as I have been able to ascertain from records and other sources, is as follows:

The Legislature of Kentucky, for the session of 1817, recognizing the right and title of that region as belonging to the Chickasaw Indians, memorialized Congress to purchase the lands from the Indians This was acceded to, and Gov. Isaac Shelby for Kentucky, and Gen. Andrew Jackson for Tennessee, were appointed commissioners by the President. They met with the Indian Council at King's Mountain. The Indians, however, had so strong an animosity toward Gov. Shelby that they refused to treat with him, and Jackson was obliged to conclude the treaty in his own name, promising, on the part of the United States, to pay $20,000 annually for fifteen years. The treaty was signed on October 19, 1818.

The following Legislature of Kentucky, recognizing the fact that the State had "recently come into possession of a large additional territory," passed an act for the survey of the line between this State and Tennessee.

The Purchase region became then a part of Livingston and Caldwell counties, but in 1821 was formed into Hickman county; the same act also outlining three other counties which should be organized so soon as the population justified it. Calloway was formed in 1822, Graves in 1823, and McCracken in 1824.

In 1842 Marshall county was cut off from Calloway, and Ballard from Hickman, and in 1845 McCracken and Fulton were organized from Hickman.

The Purchase now embraces the seven counties above enumerated, and had in 1880 an aggregate population of 96,348 persons, a little over one-half of whom were males. The number of voters in 1880 was 21,588.

In 1830 the population of the Purchase was 14,163, which was more than doubled in the next decade; the county of Graves receiving the largest accessions. Each succeeding census shows a continued increase in population.

Graves took the lead among the counties in 1850, and has kept that place to the present time, her population numbering 24,138. McCracken ranks next, 16,262, nearly half of whom are included in the city of Paducah.

The surface of the country is very generally rolling, and more or less broken and irregular from the many streams and small tributaries that have deeply cut their way into it. The broad areas of comparatively level uplands occupying the water-divides in various parts of the region, are themselves quite generally grooved with ravines and gullies along the borders of the streams, the light brown loam soil being easily borne away during washing rains. On the large creeks and rivers the country is generally very deeply eroded, forming "breaks" or a broken and rough country. Such is especially the case along the north and east borders of Mayfield creek.

The most broken portions lie along the Tennessee river on the east, through Calloway and Marshall counties, and along the Mississippi river bluffs from the State line northward to the town of Hickman. There are, however, no prominent high points in any part of the region other than those that represent the remnants of what was once a broad plain, and whose summits are no higher than the general level of the country.

ELEVATION.—The altitude determinations, as given on the map accompanying this report, were made chiefly with an aneroid barometer. The readings being frequently repeated and corrected for weather changes, with the low-water determinations made by the United States engineers between New Madrid and Paducah to serve as a base, it is believed



that the elevations as given are approximately correct. Back-water from the Paducah flood in 1883, along the various streams, also furnished points from which to check barometer readings.

*Low Lands.*—Between Cairo and Hickman the Mississippi river has a fall of sixteen feet. The low-water mark of the river at Hickman is 256 feet above the sea; the wide bottom lands, subject to yearly overflows, being estimated to be about 295 feet, while the old depot of the N. C. & St. L. R. R. is 301 feet. The bluffs rise 160 feet higher, that portion of the town being 461 feet above the sea. The town of Columbus, further up the river and located on its bank, has an altitude of about 309 feet, while above it the bluffs rise abruptly for 125 feet.

From Cairo to Paducah the Ohio has a rise of fourteen feet, low-water mark at the latter place being 286 feet. Above this, as shown by the river gauge, the banks rise fifty feet, the town of Paducah having an altitude of 341 feet above th sea.*

The Tennessee river, so far as can be ascertained, has a fall of about fifteen feet from the Tennessee State line to Paducah. Its eastern bank is at the immediate foot of Subcarboniferous limestone and flint bluffs, while on the west the hills lie from one-half mile to one mile from the bank. The bottom land proper is an extremely narrow belt (too much so to be marked on the map) subject to annual overflows. The rest of the valley is mostly above overflow, and the central portion is higher than that near the hills, which is usually occupied by a slough or creek. From its border, the hills rise rather suddenly to elevations of from 160 feet on the south to 100 feet on the north.

Clark's river has scarcely any bottom land, but is bordered on the west by a broad and level valley, an extension of the Ohio river valley, as far south as Carter's Mill or Kaler Post-office, a distance of nearly twelve miles in a direct line from

* The elevation of Paducah, as given by the C. O. and S. W. R. R., and published in the Dictionary of Altitudes of the United States Geological Survey, is 484 feet—the error extending also eastward for all the railroad stations in the Purchase region.

its mouth. Back-water from the Paducah overflow reached to Lyle's Mill, showing a fall of about fifty feet to low-water at Paducah. On the East Fork of Clark's river the back-water reached to within three miles of the bridge at Benton.

Mayfield creek, emptying into the Mississippi river, is bordered by broad bottom lands to almost its source. There is a fall of about sixty feet in the river from near Mayfield to Blandville, to which back-water from Mississippi floods reaches through a distance of only seven miles. On the north the uplands rise abruptly to 120 feet above the creek; but on the south they rise more gradually for several miles before they reach the same elevation as on the north. An exception to this feature occurs at the junction of Mayfield and Mississippi bottoms, where the high bluffs that face the latter river have been cut in two by Mayfield creek, and present abrupt points both on the north and south.

There is a difference of between thirty and forty feet between the levels of the waters of Mayfield creek and Clark's river at the points where they come nearest each other, viz.: Boaz and Kaler, a distance of four miles.

Obion creek and Bayou de Chien are each bordered by wide and low bottoms, subject to overflow. Back-water from Mississippi river floods reaches up the former to a point east of Columbus; and on the Bayou de Chien to a little above the mouth of Little Bayou de Chien.

Uplands.—The highest elevation of the entire region is along the dividing ridge from Pilot Oak, in Graves county, eastward to Lynnville, and thence southward to the Tennessee line, south of Murray, where an altitude of 600 feet is reached; this then passes south-eastward towards the Tennessee river east of Paris, in the State of Tennessee.

The next highest portion of the Purchase region, that lying about 500 feet above sea level, occurs on the south-east, forming a broad section from the Tennessee line northward for about ten miles, and westward beyond Crossland; embracing, also, the narrow water-divide that farther north reaches westward by Lynnville and Pilot Oak and separates the head waters of Mayfield, Obion and Bayou de Chien from those



which flow south into Tennessee; other northerly extensions reach to Farmington and Kirksey. The surface presents broad and comparatively level plateaus west of the Blood river, not so much furrowed by erosions as are the lower elevations of the Purchase, though small streams are numerous. East of Blood river the country is very broken and hilly, the streams having cut deeply and broadly into the loam and gravel material.

The third plateau of from 450 to 500 feet chiefly lies immediately north of the one just mentioned, reaching to Benton, in Marshall county; while westward two long narrow arms pass, the one south-west to the Tennessee line south of Feliciana, and thence east to Crossland; the other northward for ten or more miles, and thence north-westward nearly to Woodville, and on a course toward the Grand Chain of the Ohio; its northward trend forms the summit of the dividing ridge separating the waters of the Mayfield creek and West Fork of Clark's river, rising abruptly from the former, but immediately sloping towards the latter. The contour is highest to the southward, where it gradually rises to the higher elevations.

Another plateau of the same elevation occurs on a high bluff bordering the Mississippi river, from Hickman south into Tennessee, presenting a very abrupt face toward the west, and sloping eastward from its immediate edge.

There is very little room for doubt that it once continued not only westward over the region where now the Mississippi river flows, but northward to Illinois, to be subsequently cut away by erosions.

At the Tennessee line the plateau falls gradually eastward for several miles, but in the region of Hickman it is narrow, and its eastern side is rather abrupt.

Between the Bayou de Chien and the Obion the upland has receded eastward beyond the bluff plateau, and it is only after passing to the north of the latter stream that we again find it, but then with an elevation but little above the main upland. The bluff northward has a north-west trend which again brings it toward the high plateau region, and its elevation increases to 430 feet at Chalk Banks and Columbus, which

points are five miles east of a direct north and south line from Hickman. The bluffs here also have a gradual eastward slope, the highest points being on the immediate brows of the abrupt face.

Between Columbus and Chalk Banks (two miles below) the bluffs recede to the eastward, and have a much lower elevation. Still northward toward Wickliffe and beyond, the elevations are less and less as the bluffs bend to the eastward or away from the supposed line of high plateau.

At Hickman the bluffs seem to have been cut away by eroding floods, whose course was from the north-west, acting at the same time upon the entire line of bluffs from Cairo southward.*

The fourth area, embracing elevations of from 400 to 450 feet, forms a diagonal stretch of country from near the Tennessee river on the north-east to near Clinton on the south-west, extending also to the north-west on the north side of Mayfield creek, and embracing the narrow bluffs along the Mississippi river from Mayfield creek to Columbus, and southward, and also a broader region on the south-west near the Tennessee line.

The lowest uplands, with elevation of from 350 to 400 feet, embrace the flats or valley lands along the Tennessee and Ohio rivers, and a broad region reaching from Mayfield creek southward to the Tennessee line.

The former differ greatly from the latter, and will be separately described elsewhere.

The surface of the latter is uneven from erosions by numerous streams.

The deep trough-like depressions in the western portion of the plain, would seem to have been caused by the debouchement of the rapid and deep current of the Mississippi river into the embayment in their south-westerly course, before its momentum was checked.

The north side was apparently deeply eroded by impact of the Ohio river current.

* Crowley's ridge in the Mississippi river bottom in Arkansas, with its altitude 150 feet above the river, is doubtless a relic of the plateau.



Drainage.—A dividing ridge, lying nearly east and west along the Tennessee State line, forms the Purchase region into a water-shed; the Tennessee on the east, flowing northward, the Ohio on the north, flowing westward, and the Mississippi river on the west, flowing southward, receiving almost the entire drainage water, the area drained south into the State of Tennessee covering only about eighty-five square miles.

The respective areas drained by each river are approximately 850 square miles into the Tennessee, 250 square miles into Ohio, and 1,150 square miles into the Mississippi direct.

The general course of all of the larger interior streams is to the north and north-west; those entering the Tennessee river on the east flowing almost parallel with it for many miles before turning east.

*Tennessee Basin.*—The north and south basin of the Tennessee, omitting that of Clark's river, is narrow, not exceeding twelve miles in its greatest width within this State; its area is about 350 square miles. The only tributaries of note are Blood river, in Calloway county, which, rising in Tennessee, flows northward ten miles and turns abruptly to the east, with a width of about twenty-five feet; Jonathan's creek, rising in the northern part of Calloway, flowing north for twelve miles, turns east three miles to the Tennessee Valley, and again north to the river; and Big and Little Bear creek, the former lying within the valley, the latter in the hills, but both uniting and emptying into the river. These streams are narrow, and have but narrow bottom lands on either side.

Cypress creek, another tributary, rises near Briensburg and flows northward until it reaches the river flats, when it turns westward for six miles, parallel with the general course of the Tennessee river throughout. Its bottom lands, before reaching the valley, are very broad, presenting, during certain seasons of the year, an almost impassable cypress swamp several miles in width. After entering the valley there is scarcely any bottom land along the creek.

*Clark's River Basin.*—This stream, with its two forks and

tributaries, drains an area of about 500 square miles. The head waters of each fork are near together; thence the West Fork flows nearly northward and the East Fork eastward for nine miles, the latter then bends northward and north-westward by Murray and Benton, uniting with the former about five miles in a due course from the junction with the Tennessee river. The main river is narrow, flows between steep banks, and has but little true bottom land, being bordered by a broad flat valley region. Each of the forks has, on the contrary, from one-fourth to one-half mile of well-timbered bottom land.

*Ohio Basin.*—The area drained by streams running into the Ohio direct is about 250 square miles, embracing the country south of the river, almost to the bluffs of Mayfield creek.

The streams are mostly very small, and have very little bottom land. Massac, Clanton and Humphrey's creeks are the largest, the latter two uniting just before emptying into the river. Shawnee creek, south of Humphrey's creek, while flowing west into the Ohio bottom lands, turns immediately southward with a slough-like channel to the Mississippi river at Wickliffe.

*Mississippi Basin.*—The main drainage streams of the Mississippi Basin are Mayfield, Obion and Bayou de Chien.

An interesting feature connected with the Mayfield and Bayou de Chien is, that they drain very little of the country on the north of their banks; and that the north bluffs of the Ohio and Mayfield creek are high and precipitous, while on the south of each the country rises very gradually for many miles before assuming the elevation of the north bluffs.

Mayfield creek rises in the southern central part of the region, flows northward to within twelve miles of the Ohio river, and turns quite abruptly west to the Mississippi. Its basin, covering an area of 390 square miles, is, south of Mayfield, quite wide, but narrows at Mayfield and northward to but four or five miles, while in its westerly course it receives the drainage waters of a large scope of country on the south.



The divide between these two parts of the basin lies just east of Kansas, Pottsville and Anytime, but is low and scarcely perceptible. From the east and north the creek receives very little drainage, the high bluffs being often the summit of the water-divide. These bluffs border the bottom land from the Mississippi river bottoms east and south nearly to Mayfield, with an elevation of about 120 feet. They then become lower and less abrupt. On the south the lands rise gradually from low and rounded bluffs for many miles, reaching, at Milburn and Fancy Farm, the elevation of the bluffs north of the creek.

The main tributary is Little Mayfield creek, which rises near Mayfield and unites with the main stream near Blandville. Wilson's creek is another tributary. Mayfield and Little Mayfield creeks have wide and well-timbered bottom lands.

The Obion creek drains a basin of about 250 square miles, with head waters near those of Mayfield creek; it flows north-west into the southern part of Ballard county, and abruptly turns west and south-west into the Mississippi river not far above Hickman. It has comparatively large tributaries on each side. Its banks are steep and regular, and the stream is not very wide.

The Bayou de Chien, the last important stream of the region, also has its head waters in the south and central part of the Purchase region, and has a general westerly course to the Mississippi river. Its basin covers an area of 165 square miles. The tributaries are Cane, Little Bayou de Chien, Big Mud and Snapneck creeks. The creek enters the Mississippi about a mile above the town of Hickman, or one and a half miles below the mouth of the Obion.

There is little doubt that these two streams were once united a little westward from their present mouths, and flowed southward near the line of bluffs and independent of the river, through what are now wide sloughs, and through Reelfoot Lake into the Obion river, many miles south in Tennessee, and thence to the Mississippi river. Not more than thirty years ago there was a wide slough and bottom land west of the preseht town of Hickman, where now the

river has its most rapid current, and the mouths of the Obion and Bayou de Chien were within 300 yards of each other. The Morrow slough, in its course through the bottom and in the continuation of its channel through the lake and southward, resembles very much the channels of the creeks.

TRANSPORTATION.—The three rivers that form the three sides of the Purchase region afford splendid and regular transportation facilities for the contiguous country, and at all seasons of the year, unless blocked with ice in winter. The smaller streams in the interior are not at all navigable, and, except for logging, they play no part in the transportation problem.

There are also several railroads which run through the region, and afford to the central and western sections additional facilities.

The C., O. & S. W. R. R., connecting Paducah with Louisville, runs south-westward via Fulton to Memphis, and thence to the great south-west. The Illinois Central system, reaching to Chicago on the north and New Orleans on the south, enters the region at Cairo and passes out at Fulton. The M. and O. R. R., reaching from Mobile northward, enters the State at Jordan, and runs to Cairo; a branch of two miles length, from South Columbus to Columbus, connects with the St. L. and Iron Mt. R. R.

Hickman is connected with Nashville by the N. C. & St. L. R. R. The above roads cross each other at different points southward in Tennessee. Hack lines (daily), carrying United States mails, connect Paducah with Benton, and on alternate days with Blandville. Murray has a daily line to Paris, Tennessee, and on alternate days to Mayfield. There are daily mails between Mayfield and Columbus via Fancy Farm, Milburn and Arlington; also between Wickliffe and Blandville. Merchandise is brought to Murray from the Tennessee river by wagons. The roads over most of the region are in winter almost impassable.



## GEOLOGICAL FEATURES.

The Purchase region occupies an interesting geologic position almost at the extreme northern extension of what was once a bay or arm of the ocean, reaching northward from the extreme south, and whose waters washed the Paleozoic shores on the east and west. The northern shore line of the embayment extended across the southern part of Illinois, beginning below the mouth of the Cumberland, at New Liberty on the east, and reaching south-westward parallel with the Ohio river and but a few miles from it, until at a point about fifteen miles north of Paducah it turned sharply westward to within fifteen miles of the Mississippi, when it bent south-west to the river at Santa Fe, opposite Commerce on the Missouri shore. The Tennessee river marks what was then the eastern side of the embayment, while on the west the shore line was twenty or thirty miles beyond the present position of the Mississippi.

Within the region the following geologic formations have been observed. They are given in the order of position, beginning with the most recent or topmost:

ALLUVIUM (of river and creek bottoms).

QUATERNARY.

*Brown loam;* surface loams of uplands.

*Loess;* grey silt of Mississippi bluffs.

*Port Hudson* (Hilgard's Louisiana); stiff dark and bluish clays with calcareous concretions, under the river alluvium, and overlaid in the Ohio valley by micaceous loam.

*Stratified Drift;* rounded chert and quartz gravel interstratified with coarse sand, the whole more or less stained and cemented with iron oxide.

TERTIARY.

*Lagrange* (of Safford's Tennessee); stiff plastic clays, variegated in color and interstratified with whitish sand, and holding impressions of leaves.

*Lignitic;* blackish arenaceous clay and clay-stone, with leaf impressions and beds of lignite and lignitic peat.

*Porter's Creek* (of Safford's Tennessee); massive and jointed clays (locally called "soapstone"), somewhat micaceous, blackish when wet, dark grey when dry.

*Hickman* (provisional, of the Hickman bluff); siliceous clay-stone over a thick bed of buff-colored clays.

CRETACEOUS.

*Ripley;* black clay in very thin laminæ, separated by fine white and highly micaceous sand; beds of sharp angular white and yellow micaceous sand, 100 feet thick.

SUBCARBONIFEROUS.

*Lower* (or *silicious*, of Safford's Tennessee); heavy limestone beds intercalated with dark flint layers.

DEVONIAN.

A region or belt of massive quartzose sand-rocks has been referred provisionally to this formation.

The above, beginning with the oldest, will be considered separately in the following pages.

NATURE OF THE BORDER.—The geologic formations that formed the bluffs around the embayment in Missouri, Illinois and Kentucky are entirely of the Paleozoic, beginning with the Calciferous and Potsdam on the extreme west, and terminating with the Subcarboniferous on the east.

In Missouri the Lower Silurian formed the ancient shore line, the Calciferous and Potsdam being exposed from the Arkansas State line north-eastward, passing under the Trenton before reaching the river below Cape Girardeau. The dips have not been ascertained. In Illinois the Trenton rocks are exposed along the Mississippi river as far south as Santa Fe, and are overlaid on the east by a narrow belt of the Cincinnati, which in turn pass under a broad region of the Upper Silurian still eastward; and reaching to Cache river we find the Devonian quartzite sandstones and shales occupying a belt some six or eight miles in width, its course from the north being turned south-eastward, near the old shore line, in the direction of Caledonia on the Ohio river. The series of the latter as given in the Illinois Report (vol. iii., p. 22) comprise black slates associated with



cherty siliceous limestone, which pass into a compact brittle flint rock and overlie a white quartzose massive sandstone; beneath this are the Oriskany beds of cherty silico-magnesian limestone.

The Subcarboniferous overlies the Devonian to the eastward, and extends to the Ohio river above the mouth of the Cumberland, and southward to New Liberty. Its dips are generally to the northeast; a belt of the coal measures appears in the northern part of Pope county.

In Kentucky, the Paleozoic south of the Ohio begins with disturbances in the strata, producing a number of faults in Livingston county, and, according to Mr. Norwood, have a strike varying N. 30° to 50° E., and an easterly dip. The St. Louis limestone forms the western wall of the fault, while on the eastern side, and forming the hanging wall, is a hard massive quartzose sandstone, which Mr. Norwood thinks is of the Chester, though resembling the Devonian rock mentioned above as occurring in Illinois.

At the distance of a mile south of Smithland another sandstone outcrop, with an exposure of about fifty feet thickness, forms a low and sharp ridge trending N. 10° E., the rock dipping to the east. While the age of this latter sandstone has not been definitely ascertained, there is but little doubt that it is of the Devonian series; not only because of its strong lithological resemblance to the sandstone north of Cairo, but from the fact that the direction of its strike places it almost in the line of disturbance that brought up the Devonian in Hardin county, Ill. The Grand Chain of the Tennessee river, located about one mile below Haddock's Ferry, south of Smithland, is a high ledge of dark flinty rock strata fifty feet thick, and stands twenty-five feet above low water. It reaches out for 150 or more yards from the Livingston county shore in a S. 30° W. course. The ledge is very irregularly bedded, and dips at a high angle to the south-east. Some parts of the flinty mass are bent over to the west, and in places overlap other flinty layers. The rocks doubtless belong to the siliceous or Lower Subcarboniferous, and have been uptilted by the same force that brought up the sandstone. This appears to be an east-

erly anticlinal of that apparent uplift that extended northward beyond Smithland. A bluff of thinly bedded sandstone, seemingly of the Chester, crops out in the north bluff of the Tennessee river opposite the mouth of Cypress creek, below the Grand Chain.

Southward, along the eastern side of the Tennessee river, no extended observations have been made; but, so far as known, no other formation than the Lower Subcarboniferous appears anywhere until at a point beyond the southern limit of the Kentucky Purchase region, where Prof. Safford reports the exposure of Lower Silurian beds along the river. The high bluffs opposite Birmingham, Marshall county, are made of alternate layers of dark flint and limestone, the former predominating towards the north, with a dip towards the south.

Paleozoic Shelf.—The eastern side of the embayment shows evidences of there having been two Paleozoic shore lines, the oldest one at the beginning of the Cretaceous, the other further eastward at the beginning of the Quaternary period.

From the eastern bluff of the Tennessee river, whose Subcarboniferous rocks rise over 100 feet above the valley, there extends westward a broad shelf of siliceous limestone at a much lower elevation, and covered by Quaternary gravel and brown loam. The western edge of this shelf must have been the original shore line of Cretaceous and Tertiary seas, for upon it no strata earlier than the Quaternary have been observed. This edge seems to have been abruptly beveled off, for Cretaceous sands and clays, appearing immediately westward, have been penetrated to a depth of a hundred feet and no older rocks reached.

This shelf reaches from the Tennessee line, where its width is about a mile, as exposed in creek beds, northward beyond the Tennessee river, into Livingston county, where it widens to about three miles. In southern Illinois it underlies the Quaternary beds westward to the southern prolongation of the Devonian and Silurian along the Mississippi river. (Illinois Reports, vol. iii.) In Kentucky, the Tennessee river evidently separated this narrow Paleozoic shelf from the main land,



cutting deeply into the rocks in its northward course, and probably with the width of the present valley. Turning westward it found its way to the embayment basin, probably just south of its present bed, below what is now a flat valley region, for there seems to be an entire absence of limestone to quite a depth in this region, between the outcrops of that rock on the brow of the hills, one mile south of Calvert City, and that of the flinty, uplifted strata which forms the so-called "Chains" at and below Haddock's Ferry (a little west of north of the former), which extend very far out into the river and twenty-five feet above low-water. The current of the river has, since then, worn away the northern bank, confining itself to that side, and allowing the deposition of Quaternary Port Hudson material where once the river flowed. The long strip of Paleozoic rocks on the west of the Tennessee river had, therefore, the form of a peninsula, reaching from the extreme south in the State of Tennessee northward to Livingston county.

The Chains, composed of such hard flinty masses and offering such resistance to the wearing effects of the flowing waters, do not seem to have extended southward very much beyond their present limit, for otherwise they would have formed an obstruction which would have prevented the wearing away of the upper river bed, and we would not find at the present day so small a fall in the river between the Tennesse line and Paducah.

The geologic formations whose outcrops extended across the basin at the time of its formation, were doubtless the Silurian, Devonian, and Subcarboniferous, and perhaps the Carboniferous. No outcrop or remnants of the Silurian divisions are visible between its line of exposure along the northern shore line in Illinois, east of the Mississippi river, and that on the south-east in the beds of the Tennessee river just south of the Tennessee State line, except those occurring just east of Cache river, Illinois, not far from Villa Ridge Station. (Illinois Report, vol. i, page 414.) Here the so-called "Clear Creek Limestone" series of Upper Silurian are exposed. The erosion of this central and western part of the embayment basin seems to have been

very energetic, and to have progressed deeply; no Silurian fragments have been observed in the gravel deposits.

The Devonian belt, on the other hand, embraces a series of harder rocks, among them the "Onandaga Quartzite Sandstone" of the Illinois Report, which seems to have withstood, to some degree, the wearing effects of the waters, for at a number of points we find large masses of the rock emerging from Quaternary gravels.

## DEVONIAN.

The rocks of the Devonian dip to the north-east, and the south-east trend of the belt in Illinois, just before reaching the old shore line, would, if prolonged into the Purchase region, pass a few miles south of Paducah and on into Tennessee. It is reasonable to suppose that this geologic formation was once prominent along this line, even after the removal of the softer rocks, for there are now massive quartzite sandstones exposed at a number of points between Illinois on the north and Tennessee on the south-east, and apparently in place.

In the Illinois portion of the basin, the exposure of the sandstone beneath the Tertiary and Quaternary deposits have not been largely observed; but in Kentucky there are a number of such exposures, and though there may be some doubt as to their age, yet from their position in the direct line of Devonian outcrop, and their strong resemblance to the Onandaga sandstone, I have without much hesitation referred them to that formation. The rock is white, massive and quartzose, sometimes so friable as to crumble to sand by a blow from a hammer, and at other points extremely hard. No fossils have been found. The locations have not been designated upon the map that accompanies this report because of this uncertainty, and because they are mostly overlaid by Quaternary deposits. Some of the rocks seem to be in place, forming regular beds of unknown thicknesses, while others appear as immense fragments or remnants of broken-down strata, sinking so deeply in the earth that it has been impossible to ascertain upon what they rested. Some of these fragments have been removed



from place, and lie buried in the Quaternary gravel, their edges and surfaces being greatly water-worn. The most northwesterly exposure of these rocks occurs at Palestine Church, about three miles south of Metropolis, or seven northwest of Paducah. There are here four large masses, lying in a north and south line from each other, three of them near together, their surfaces on a level with the marshy flats in which they lie. The other lies in front of the church, and has recently been dug up. Its surface is smooth and rounded.

Southward from this, at Massac P. O., there are loose fragments of quartzose sandstone, a foot or more in thickness, and three or four feet square on their surfaces, buried in the gravel beds. Their surfaces are worn smooth, and the edges are rounded, the evident effects of transportation to westward from the line of Devonian outcrop, the removal probably occurring at the time of gravel deposition. In the ravines around this place beds of sand rock overlie the gravel, and have also been struck in the digging of wells, but they are of a different character from those described.

Another locality along the line of the Devonian is on the place of Mrs. Flournoy, four miles south-west of Paducah. Here the quartzite appear in immense masses, and do not show signs of transportation. They lie along the bed of a small branch, and are protruding from the ground. One of the rocks has an exposed thickness of ten feet, its top surface measuring twelve by twenty feet. It is massive in structure, composed of fine and sharp grains of sand, in part graduate into a hard quartzite, and in part so friable as to easily pulverize beneath the blow of a hammer. Other masses are found in the vicinity over an area of 25 acres, and always at a lower level than the Quaternary gravel. Wells sunk within 300 yards of these exposures pass through Quaternary material and the black clay of the lower Eocene at depths of thirty feet, or ten feet lower than the level of the quartzite.

Between Mrs. Flournoy's and Paducah, on the hills bordering the flat valley region, another outcrop of the sand rock occurs, while within a mile of the town, on the west, south-

west and south, numerous and large isolated fragments lie embedded in the land, having evidently been brought by some strong flood. The most interesting point of exposure in this part of the Purchase, however, occurs south and south-west of Paducah, over a distance of several miles, lying nearly east and west. The most easterly outcrop is on the place of Mr. Byers, a little to the west of the Mayfield and Paducah road, on Island creek. The eastern, north-eastern and southern sides of the hill are here covered with large masses of the quartzite, to an elevation of seventy-five feet, and the rock also forms in part the bed of the branch. It has all the characteristics of the Devonian sandstones described above, though seemingly entirely free from fossils. The rocks in the branch lie in close proximity to layers of soft micaceous sandstone, well charged with Eocene fossil casts, and standing almost vertically, about fifty feet thick, and with a strike nearly north and south. The quartzites are overlaid by twenty feet of Quaternary gravel and loam. A well on the south-west, about 100 yards distant, dug to a depth of fifty feet, struck the blue Eocene Tertiary clay at twenty feet.

Westward from this point the quartzite is again found on the place of Mr. Smith, one mile distant. It here is also exposed in several places in the banks of the branch, and below about twenty feet of loam and gravel. The rocks are massive and broad, having an exposed depth of several feet; one rock has an apparent dip of 20° S. 30° W., but this may be merely local. All have their surfaces more or less stained with iron. Still south-westward, about a mile, the rock is again exposed in the bed of another branch, forming an almost solid ledge of fifty feet or more of exposed length, and with an undetermined thickness.

The above are the chief exposures of the sand rock in this part of the Purchase region, though small fragments were picked up two miles south of Hard Money, in Graves county. In the southeastern portion of the region the quartzose sand rock is most largely developed, especially around Murray and in the hills bordering the Tennessee Valley west of Buffalo Landing.



The Murray exposures are in and near the road north of the town, in the woods a mile south-west, and on the brow of the hills facing Clark's river to the right of the road south of town. The rocks in the two latter localities are very large, and do not show evidences of transportation. Some of them outcrop but little below the surface of the uplands, and others lie as much as twenty or thirty feet lower; their upper surfaces are, in some instances, much abraded and worn, but their edges are sharp; they vary in size from ten to as much as 300 square feet on the upper surface, or with an area of twenty by fifteen feet and several feet in height. These outcrops are many feet above those near Paducah. Black Tertiary joint clays ("soapstone") form the bed of the river here, and are exposed in the bluffs of streams north of town.

East of Murray quartzite sandstones again appear over a large area, in broken or isolated masses, a mile or more north of the Buffalo and Concord road, and three miles west of the river, or some six miles north of the Tennessee State line. Some of the lower rocks at the base of the hill seem to be in place, and are about fifty feet below the upper exposures. They are all massive, and their upper part is surrounded by gravel and loam, which also covers them to a depth of thirty to forty feet. The base of the gravel bed is more or less cemented with iron oxide, portions of the conglomerate being occasionally found attached to the quartzites. In one instance the cementing material had penetrated the sandstone for several inches in a band two inches thick, coloring it at first black, and hardening the mass for half an inch, when it graduates into the lighter grey of the rock. This color line is regular and horizontal, and is seen upon the sides of a number of the rocks.

Another outcrop of the same quartzite occurs a mile or more northwest of this group; its elevation is above the beds of Subcarboniferous limestone that outcrop along the base of the hills bordering the river valley, and would indicate a Chester horizon for the quartzites of this region. This is further strengthened by the southerly dip of the Lower Subcarboniferous limestones and flint beds opposite Birmingham,

which would bring the Chester beds down to the general level of the country. But the rocks are much whiter and far more quartzose than the Chester beds that cap the hills in Livingston county, or that appear in the eastern part of the State; then, again, although the southerly dipping Subcarboniferous limestones form so high and prominent bluffs along the east bank of the river at Birmingham, we find, a few miles to westward on the sides of the hills along the west border of Little Bear creek, a large outcrop of these quartzites at a much lower elevation than the limestones. It is, therefore, most reasonable to conclude that one of the faults observed by Mr. Norwood at the mouth of the Cumberland, extended far southward through this region, and that the quartzites east of Murray and those of Little Bear creek and Cumberland river were all brought up by that disturbance and are of probable Devonian age. The Murray exposures are separated from them by a broad trough, whose depth below the sand rocks is at least 200 feet, now filled in with Cretaceous and Quaternary material.

## SUBCARBONIFEROUS.

This formation, which borders the embayment in Illinois also, is exposed beneath the Quaternary along a number of streams in a narrow belt on the west side of the Tennessee river. A notable outcrop occurs in the bed of the Ohio river, on the Illinois shore, forming what is known as the Grand Chain. The exposure here embraces layers of siliceous limestone, holding dark flinty masses. The fossils observed were crinoid stems, Spirifer Linneatus, etc. The beds belong to the Lower Subcarboniferous, and are exposed along the river bank in low water seasons for a distance of about a mile. The limestone is overlaid by alluvium, and in the bluffs of the river by masses of white decomposing chert and white siliceous earth, with a vertical exposure of ten feet. There are a number of these chert outcrops, the first appearing about fifty yards up the river from the limestone, each outcrop having a length of about 100 feet, rounded off at the ends and separated from each other for a distance of seventy-five or one hundred yards by later or Quaternary deposits.



The chert pieces are sharply angular and large, their surfaces frequently half decomposed into the white siliceous earth. The beds are, in places, cemented almost into a conglomerate. They are very similar to the siliceous beds occurring a few miles west of Birmingham, in Marshall county, and at Brandon's Mill, in Calloway county. Quaternary gravel of the stratified drift overlies the chert, and is in turn covered by the brown loam. The bluffs of the Illinois shore of the Ohio show no other exposure of rocks older than the Tertiary until above the mouth of the Tennessee river. The Little Chain below Joppa is formed by masses of Quaternary pebble conglomerate lying in the bed of the river.

There are no bluffs on the Kentucky shore of the Ohio; the low flats come to the river and show only later Quaternary deposits from Cairo eastward until the Cretaceous clays appear at Paducah; passing thence up the Tennessee river, the first outcrops of Paleozoic rocks are reached at Barber's Landing, where a bluff of sandstone, probably of the Chester series, appears on the Livingston county shore, and is said to be in the bed of the river nearly across to the southern shore. It is exposed for fifty yards along the river and for forty feet in height, the whole capped by ten feet of Quaternary gravel in large pieces, the lower portion in places cemented with iron oxide and accompanied by some thin sheets of hematite. The sandstone is softer than the quartzite of the Paducah region.

The extreme upper rock is about twenty feet long, its surface very smooth, and its upper edges highly rounded for eight inches by the action of flowing water, probably during the Quaternary period, at which time the gravel was also left upon it. The upper ledges of the sandstone are thick and massive; those below are thin-bedded, more broken, and contain in places much pyritous nucleii, which, on weathering, decompose into yellow and red ferruginous spots. There are, also, numerous small impressions of what appear to be calamites. The rocks very generally dip towards the north-east. In the edge of the water a mass of the rock ten feet thick and fifty feet long lies on edge, dipping nearly east. How far below the water it reaches, or whether other

rocks in the bed of the river have the same feature, could not be ascertained.

On the opposite or southern side of the river, the valley shows no outcrop of the sand rock, the Quaternary deeply covering every thing.

Going up the river, and passing the massive and long out-crops of uptilted Subcarboniferous flint rock, dipping southeasterly and forming the Tennessee Grand Chain described above, we find, just above Haddock's Ferry, other masses of dark flinty material forming another small shoal; it outcrops on the southern shore above low-water at the ferry itself. Limestone ledges, similar to those of the Grand Chain of the Ohio river, are exposed in the small streams eastward of the ferry on the northern shore. From this point southward the Subcarboniferous rocks are found along the beds of streams or on their bordering hill-sides, and generally at a much lower elevation than the summits of the rock strata east of the Tennessee river, thus forming a kind of shelf around the embayment basin; its western edge being the old Cretaceous shore line, as mentioned on a previous page.

The most northerly outcrops of the limestone in Marshall county occur in the bed of a branch one mile east of Calvert City, and a short distance south of the railroad, at about twenty feet below the level of the valley. Again, east from this, it is exposed on the northern brow of the uplands bordering the valley one mile south-west of Gilbertsville at a point called "Limestone Hill." The rock is associated with some flinty layers, and is covered by a heavy Quaternary deposit.

Southward, along the base of the hills facing the valley of the Tennessee, there are only chert and flint debris in small quantities, until beyond the junction of the two Bear creeks, where we find the hill-sides along Little Bear covered with masses of this debris to a height of seventy-five feet above the creeks. No limestone has been found, though lime-sinks are abundant two miles to westward. The chert is sharp and cellular, and, immediately south of these sinks, occurs in large fragments, covering the hill-sides almost



to their very tops, and with very little overlying Quaternary loam. Southward the cherty material disappears in the bed of Little Bear creek, before reaching the road leading from Birmingham to Palma.

Four miles west of Birmingham, at Mrs. Stone's, on the head waters of Buckhorn creek, is exposed the white siliceous earth from decayed chert, similar to that at the Grand Chain of the Ohio, and also to that at Brandon's mill, east of Murray, in Calloway county. It is also found near Birmingham, but overlaid, as usual, by heavy Quaternary material. The outcrop at Mrs. Stone's is the most westerly appearance of the Subcarboniferous in this part of the Purchase region.

Limestone appears in ledges along the base of the hills west of Birmingham, or just south of the Benton road, and extends for one-half mile south. Limekilns have been erected here. The rock has been reported also to occur in the deep gullies a little westward.

These cherty strata seem to be the lowest of the Lower Subcarboniferous, their position being either under the Waverly or forming a part of it. The southerly dip that belongs to the beds in the hills opposite Birmingham has not been observed in the more westerly outcrops, though it doubtless exists, for on going south, the cherty masses are not very prominent along the hills bordering the valley, until near the Calloway county line, where they again appear, forming possibly the south side of a synclinal basin. These masses continue southward beyond Blood river, followed by the appearance of still lower limestone beds in the southern portion of Calloway county, and finally by the Silurian uplift, just beyond the State line in Tennessee. In the southern part of Marshall county the hills bordering the valley at Aurora, and also on Jonathan creek at the crossing of the road leading to Fairdealing, are quite cherty, the flinty layers also appearing in the bed of the branches of Clear creek on the Olive road. These are the most westerly outcrops of the formation; no limestone could be found. Southward to Blood river, in Calloway county, the hill-sides that face the river valley are covered with the cherty masses

to elevations of one hundred feet, the extreme summits of the hills being capped with Quaternary drift and loam. To westward the exposures are lower in elevation, appearing only in beds of streams. South-west from Highland the last outcrop of the formation is at the first crossing of Ledbetter creek, on the road to Shiloh. At other crossings westward in the same valley no exposures occur.

This western shore line, on approaching Blood river in its southerly extension, bends to the westward, and its sharp chert appears at the foot of the hills facing Little Sugar Tree creek at the crossing of the Newburg and Murray roads, and ten feet above the bed of the creek, or forty above the valley of the Tennessee. Thence to Newburg the chert beds are exposed on the hill-sides, and near the river are as high as seventy-five feet above the valley—a rise eastward of thirty feet in about three miles. On the north side of Wild Cat creek, about three miles due south of the Little Sugar Tree exposure, and a little more than a mile west of Blood river, the hills are covered, for thirty-five feet from their base, with the chert fragments overlaid by Quaternary gravel, conglomerate and loam. To westward the chert suddenly disappears, giving place to Cretaceous sands.

No other Subcarboniferous chert exposures have been seen on the east of Blood river, this shore line bending from Wild Cat creek very sharply nearly eastward, passing a mile south of Brandon's mill in a south of east course to the small tributaries of the Tennessee river, in whose beds the chert appears at a distance of from two to three miles from the river. The chert masses reach almost to the tops of the hills that face Blood river, and cover their sides southward to Pine Bluff. The top of the exposure is about one hundred feet above the valley at Pine Bluff. White siliceous earth from decomposing chert occurs in a number of places, separating the layers and inclosing half decomposed pieces. These Blood river hills are very broken and rough. Southward, along the hills facing the river to Buffalo Landing, the chert is seen on the hill-sides from the base to elevations of fifty feet, but westward it is only seen along the beds of the small streams, and associated with the whitish siliceous



earth. Thence to the Tennessee State line limestone beds appear at the base of the hills, outcropping twenty feet at Mr. Edward Brown's on Shannon creek, and at other places to the site of old Fort Hindman, within a short distance of the river, where the exposure is nearly one hundred feet in height.

The limestone at Mr. Brown's is fine grained and quite free from fossils or siliceous matter, while at Fort Hindman there are intercalated bands and inclosures of dark flinty masses, with geodes and Subcarboniferous fossils. There is much shale in the lower portion of the bluff. Above the limestone are twenty feet of chert and loam, the Quaternary gravel appearing on the higher hills back from this. The fort is just north of the mouth of Cypress creek, along whose bed the limestone is exposed to a half mile beyond the crossing of the Murray and Paris road. It is here overlaid by a little loose chert. Westward from Brown's the limestone outcrops in the bed of Shannon creek, a mile beyond the old iron furnace.

There is a gradual rise in this strip or peninsula of the Subcarboniferous, from its exposure near Calvert City south of the Tennessee State line, and the rocks have been abruptly beveled off on the west by either a faulting and sinking of the region, or from the wearing away of strata by the great currents of the four great rivers—Tennessee, Ohio, Cumberland, and Mississippi—that rushed through this region as a gateway from the immense denudation of the country east, north and north-west.

The form of the embayment, however, would seem to preclude the latter supposition, for the basin reached northward beyond the mouths of the three first named rivers, with a long, narrow neck separating it from the Ohio, while its extension eastward from the (then) mouth of the Mississippi placed that portion out of the reach of these currents.

To what depth this beveled edge reaches is uncertain, but certainly for a hundred feet, for wells sunk to that depth within a short distance from it did not reach the bottom of the Cretaceous.

*Carboniferous* rocks appear to be entirely absent from the Purchase and adjoining territory.

## CRETACEOUS.

The long belt of Cretaceous clays and sands, that extends westwardly from Flint river (west of Macon, Georgia) across Alabama, and turns north-westward through north-west Alabama and north-east Mississippi, and northward through Tennessee, reaches the Kentucky State line in a belt of about ten miles in width; thence it borders the Subcarboniferous region, with about the same width northward through Calloway and Marshall counties, bending north-westward in the latter county into McCracken county, and across the Ohio river into Illinois. At no point in the State has the formation been found directly covering the Subcarboniferous shelf; but, on the contrary, it does not rise quite as high as the old shore line, and abuts against it, the Quaternary drift and loam covering both formations.

The four divisions in Mississippi designated by Prof. Hilgard as Eutaw, Tombigbee Sand, Rotten Limestone, and Ripley, successively disappear from the belt in its course northward through Tennessee, the last or highest in the series alone reaching the Kentucky State line.

In lithological features the Kentucky beds can scarcely be distinguished from the oldest of the above Cretaceous series (Eutaw), and had the belt not been traced across Tennessee, and its distinct separation from the latter been clearly remarked by Prof. Safford, I would have referred these beds to the lowest instead of the uppermost group, chiefly because of the entire absence of fossils, which so strongly mark the Ripley beds in Mississippi and southern Tennessee.

The formation in Tennessee is supposed to be not less than four hundred or five hundred feet in thickness. "It is mostly made up of stratified sands; occasionally an interstratified bed of dark slaty clay, ten to thirty feet thick, is met with, but more frequently a sandy bed laminated with clayey leaves." (Report of Tennessee, page 418.)

In Kentucky the same features characterize the Cretaceous formation, but the beds are separable into the two distinct divisions of *sand beds* and finely laminated *micaceous clays;* the first occurring chiefly in the southern, and the last in the northern portion of the belt, both hidden by Quaternary material, and only exposed in the hill-sides and in the beds of the streams.



*Sand Beds.*—These exposures are more general toward the south of Calloway county, where Beechy creek and Blood river and their tributaries have easily carved out for themselves deep and broad valleys, which are still in places quite sandy. These sand beds are well exposed in a deep ravine at the cross-roads two miles east of New Concord, on the road to Buffalo Landing. The sand is partly white, and in part colored yellow with iron oxide, and is very highly micaceous. The grains are very sharp, and their quickly polishing power on silver coins has given rise to the belief with some persons living near, that it contains mercury.

There are other exposures of the sand beds southward in the same valley. The whole is capped on the side of the hill with the thinly laminated clay beds, which dip N. 10 E. at a small angle. The thickness of the beds is not known, but must be one hundred feet at least. A well on the place of Mr. McChristian, in the valley of one of the Beechy forks, and but a little west of the edge of the Subcarboniferous, was dug sixty-five feet in the micaceous sand, at which depth water was obtained, but the bottom of the sand not reached.

The abundant flow of water indicates that an impervious stratum of probably Subcarboniferous limestone or of chert layers, is not far below.

The formation extends west of Blood river, exposed along the streams, though often hidden by debris from the hills. The bottom lands of McCulloch creek, on the State line, are generally covered with deep white sands derived from the Cretaceous, while in a well on Mr. Witherspoon's place, located on the hills above the creek, the white, sharp and micaceous sands were struck at about twenty feet, and penetrated fifty-four feet before water was found. White pipe clay overlies the sand in a bed about two feet thick. Over this are eighteen feet of Quaternary material. Tertiary clay occurs a mile or more north of this.

*Micaceous Clay.*—Northward the exposures are not deep, and are mostly of the dark sandy micaceous clays that ac-

company the Cretaceous formation in Tennessee. The beds are, however, not very marked, and it is often difficult to distinguish them from the lignitic Tertiary clays that overlie them to westward. The entire absence of fossils from the Cretaceous in Kentucky, and their occurrence in but one locality in the Tertiary of the State, makes the determination of the age of any strata dependent entirely upon lithological resemblances and continuities.

The relation between the laminated blue clay and the sand beds is well seen at what is locally known as the "sand hill" on the north edge of the bottoms of Clark's river, two miles north of Benton. The hill is covered with masses of Quaternary gravel and gravel conglomerate, while, at its base by the roadside, is exposed beneath the gravel the following:

| | |
|---|---|
| 1. Light blue, plastic and micaceous clay | 2 to 4 feet. |
| 2. Blue micaceous clay in thin laminæ, which are separated by very fine and white micaceous sand | 5 feet. |
| 3. Irregular bed of iron-stone, in places concretionary and rounded | 1 to 2 inches. |
| 4. White micaceous sand, colored yellow to red in upper two feet —in thin layers, and separated by thin leaves of stiff, plastic greyish clays—all dipping at slight angle S. 70 E. This is exposed five feet, and is covered at a lower level by fifteen feet of debris to the bottom lands | 20 feet. |

In the sand bed are a few concretionary nodules of ferruginous sandstone, similar to those in the Cretaceous beds in McChristian's well, mentioned above. In a well in the town of Benton the thinly laminated and micaceous clays were penetrated at twenty or thirty feet from the surface.

Tertiary black clays are found to westward from Benton, while northward from town the sandy micaceous clay beds of the Cretaceous occur in the hill strata and in the banks of some creeks. At Dishman's old mill, on the edge of the bottoms of Clark's river, just south of Oakland P. O., the clays were reached at a short depth below the surface, and are highly pyritous.

An interesting locality is in the bottoms of Cypress creek, just north of the railroad tank, near Cypress P. O. There is here a small area of land higher than the surrounding

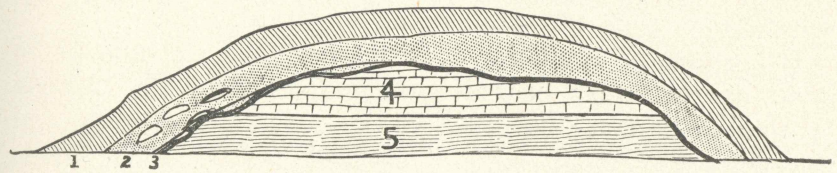


bottoms, in the bluffs of which is exposed the following section:

| | |
|---|---|
| 1. Yellow loam | 4 feet. |
| 2. Coarse gravel | 3 feet. |
| 3. Iron-stone layer | 2 inches. |
| 4. Angular white sandstone in thin layers separated by shaly clay | 2 feet. |
| 5. Shale, white and yellow | 2 feet. |
| 6. Thinly laminated micaceous black clay with laminated fine micaceous sand to water's edge | 8 feet. |

This is an isolated point, and the ends of the outcrop have been rounded off, evidently before the Quaternary, as the material of that formation, the gravel and loam, are bedded on it.

SECTION NORTH OF LITTLE CYPRESS P. O.




1. Brown loam. 2. Gravel bed. 3. Ferruginous sandstone layer. 4. Micaceous sandstone with clay seams. 5. Micaceous and sandy black clay.

The currents that flowed across this region, carving out the flats or valley of the river, seem to have failed to entirely remove the Cretaceous and Tertiary beds, and we here find what was then an island, having a base of Cretaceous clay and a capping of what is apparently a Tertiary sandstone. Then came the Quaternary era, in which the gravel, and finally the loam, was superimposed upon these beds. On the opposite side of this isolated bluff, and at its foot, is a ledge of the sandstone dipping north-west, which has evidently been undermined and fallen in. To eastward of it, in the bed of the creek, is a miniature anticlinal of the same rock. One of the large masses incloses round lumps of black clay, probably of the Tertiary formation.

On Clark's river the Cretaceous clays have been penetrated in borings near what is known as "the old fish trap," a few miles from Paducah, and are also exposed in the banks three miles above the crossing of the railroad. They again appear

in the banks of the Ohio at Paducah, the tunnel for the water-works having been excavated in them. This is probably very near the western limit of the formation, as on the south and west the heavy Tertiary clays are found. In the well of the water-works the Cretaceous is overlaid by forty-three feet of Quaternary gravel and loam.

In Illinois, the sandy shaly clays and micaceous sands, occurring in the county of Massac (Illinois Geological Survey, vol. i, pages 447–451), are undoubtedly a continuation of the Cretaceous beds of Kentucky. The "white micaceous shaly sand," so frequently mentioned, is especially characteristic of the formation in Tennessee and Kentucky. It forms a narrow belt north-westward from Paducah, its beds exposed in the banks of streams and in wells off from the Ohio river; also in the hills that border the river just west of the Pulaski county line (page 447), and thence westward.

The course of the Ohio, after entering the embayment region, has evidently been largely influenced by the material of this formation. Cutting its way south-westward through the Quaternary material, it reaches the Cretaceous above Paducah, and thence cutting through that formation to the heavy plastic clay just south-west of Paducah, its course is immediately turned north-westward through the easily yielding sands of the Cretaceous, until again it is thrown south-westward by the Subcarboniferous barrier at the Grand Chain, and enters the Tertiary.

## TERTIARY.

This formation reaches from the Cretaceous belt, just outlined, westward to the Mississippi river, being exposed in many of the beds and banks of streams and in the bluffs adjoining them, where the hill-side debris has been removed. Quaternary material covers the formation upon the hills to a depth of from ten to twenty feet.

There is a little fall in the surface of the Tertiary beds from the eastern border westward to the bluffs of the Mississippi at Wickliffe, Columbus and Hickman, while along the Tennessee State line they are nearly one hundred feet higher than those occurring northward in the hills south of Paducah; the difference between the outcrops near Murray and that of the same belt of black clay in the hills south-west of Paducah being about ninety feet. The only perceptible dips occur in the Mississippi river outcrops, where alternating beds of white sand and clay are inclined to the north-east and east.



The divisions of the Tertiary represented in Kentucky are of the lowest of the formation, viz: the Lower Eocene or the northern lignitic of Hilgard's Mississippi report, and the Porter's creek and bluff lignite of Safford's Tennessee report, together with the Lagrange or extreme upper group of clays and sands which have been, by Prof. Safford, placed as a Tertiary division, though having strong Quaternary features.

While the lignitic of Mississippi is the oldest of the formations thus far observed, there is in Kentucky a series of beds that seem to underlie even the lignitic, and are provisionally termed the *Hickman* group, from their prominent occurrence in the bluffs of the Mississippi river at the town of that name.

The Eocene subdivisions represented and described are, beginning with the upper,

Lagrange group (of Safford's Tennessee).
Lignitic (Safford's Porter's Creek and Bluff lignite).
Hickman (provisional).

The upper Mississippi divisions of the Eocene, viz: Vicksburg, Jackson and Claiborne, are not represented either in Tennessee or Kentucky.

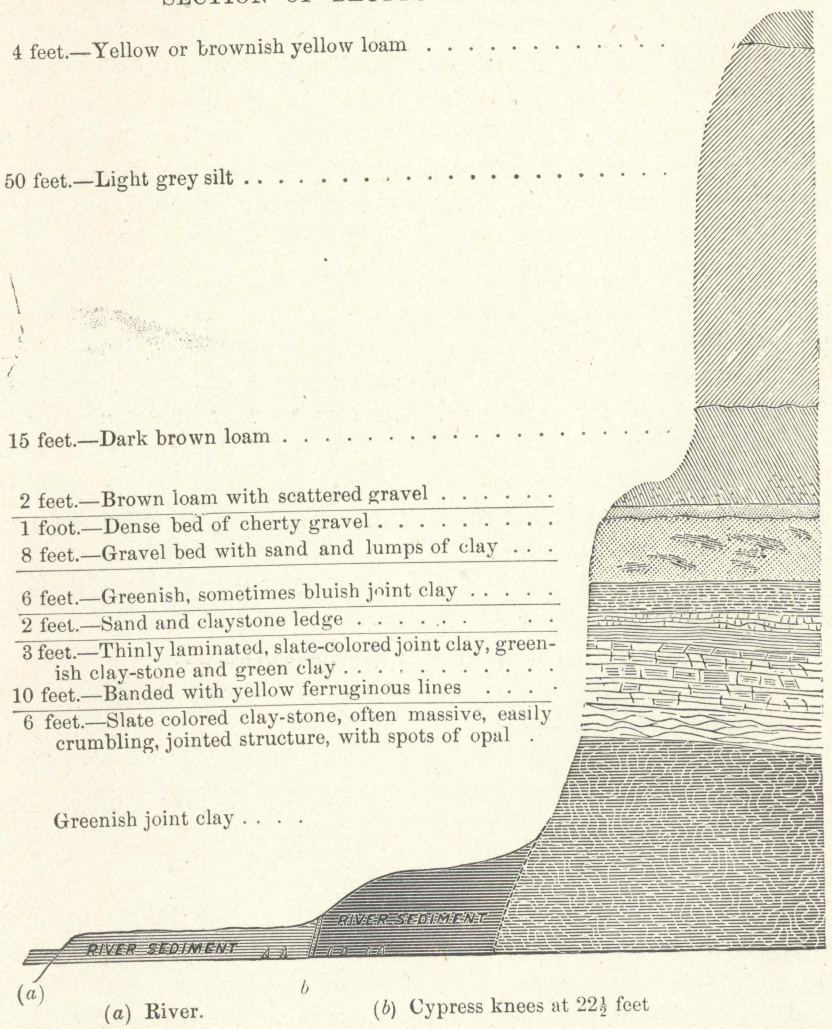
### HICKMAN GROUP.

The strata referred, under this name, to a geologic group other than the rest of the Eocene, are exposed in the bluffs bordering the Mississippi bottom from Hickman south into Tennessee. Their position, with reference to other Eocene divisions, has not been positively ascertained, but there is very strong evidence that they are older than the lignitic.

These exposures are embraced in a belt of country five miles west of a line running south from the lignitic outcrops at Columbus, and both of the formations have an apparent slight easterly and north-westerly dip, which would carry the Hickman beds much below those of Columbus.

As exposed in the bluffs at Hickman, the group shows the following section:

SECTION OF BLUFFS AT HICKMAN, KY.




(*a*) River. (*b*) Cypress knees at 22½ feet

Going eastward, the clay-stone of the above section is exposed along the bluffs for a few hundred yards, and apparently in very nearly horizontal beds. The underlying clays appear in the bed of the creek a mile east of this, but the clay-stone seems to have been removed by that denudation which took place probably at the beginning of the Quaternary. The clay-stone mentioned above is highly siliceous in



places, and holds dark opalescent masses which break easily. These were observed only in the point of the bluff between the pump factory and the river. The clay-stone disappears in the bluffs south of town.

Going south from Hickman, the green clays outcrop along the bluffs as far as Mr. Carpenter's on the east of Reelfoot Lake, just beyond the State line. The bluffs here are about one hundred and sixty-five feet high, rising quite abruptly from the bottom lands. At their base an exposure shows the following section beneath the grey silt and gravel:

| | |
|---|---|
| Blue fetid clay at fifty feet above the river bottom | 2 feet. |
| Ledge of solid clay-stone | 1 foot. |
| Soft grey sandstone, with yellow streaks | 6 inches. |
| Greenish or drab clays | 45 feet. |

The green clay was penetrated in a well on the south of town within the eastward curve that the bluff makes, and about two hundred and fifty yards from its foot. The section presented was as follows:

| | |
|---|---|
| Loam | 6 feet. |
| Greenish or drab clay | 5 feet. |
| Blue plastic clay, micaceous and fetid with small pieces of lignite | 8 to 10 feet. |
| White sand to water | 8 feet. |

The above well was sunk in the flat bottom land of the river. The water is unhealthy, probably charged with Epsom salts.

The green clay spreads easily where disintegrated from its jointy nature, and has probably thus been deposited, during the Quaternary, over what seem to be Port Hudson beds.

No wells have been dug to such a depth that we can ascertain the thickness of this group, or the character of the material underlying it. To westward on the Missouri shore, the nearest bluff exposure is that of "Clay Bluff;" so that we have in the Hickman series either beds synchronous with the lignitic Columbus beds, but free from the dark organic matter because of their distance from the shallow Tertiary shore line, or of beds *older* than the Columbus.

The following analyses have been made of the sand rock found in the Hickman beds:

No. 1440. *Soft sandstone* from the bluff at Hickman, Fulton county, fifty feet above low water. A whitish, porous and friable siliceous rock; adheres to the tongue. Only slightly plastic when powdered and rubbed up with water. Burns of a light buff color.

No. 1441. *Soft sandstone* from Chickasaw Bluff, eight miles south of Hickman, Fulton county. Bed ten feet thick, similar to the preceding.

No. 1442. *Soft sandstone* from Chickasaw Bluff, near the base; eight miles south of Hickman, Fulton county. A dull light-yellowish grey, porous, soft sandstone; adheres strongly to the tongue. Composed of minute rounded quartoze grains, with a whitish cement.

ANALYSES OF SOFT SANDSTONES, FULTON COUNTY.

| | Hickman. | Eight miles S. of Hickman. | |
|---|---|---|---|
| | No. 1440. | No. 1441. | No. 1442. |
| Silica | 81.060 | 89.160 | 94.060 |
| Alumina and iron oxides | 13.609 | 7.809 | 3.129 |
| Lime carbonate | .560 | .380 | .380 |
| Magnesia | .139 | .086 | .173 |
| Phosphoric acid | .051 | .051 | .051 |
| Sulphuric acid | .844 | .707 | .981 |
| Potash | .231 | .115 | .230 |
| Soda | .021 | .080 | .124 |
| Water expelled at red heat | 3.600 | 2.400 | 1.600 |
| Total | 100.115 | 100.788 | 100.728 |

The analyses show these sandstones to be somewhat gypseous and clayey, the clay holding also potash, soda, magnesia and phosphoric acid.

The Hickman rock possesses this clayey feature to a high degree, but southward the sandstones are more and more



sandy, and at the State line have less than one fourth of the amount of clay.

LIGNITIC GROUP.

This, the next lowest division of the Eocene, embraces the two groups of Safford's Tennessee, viz: Porter's creek and bluff lignite, which he supposed were separated by his Lagrange beds, but which are in reality one and the same bed, as shown in the bluff of the Ohio on the Illinois shore at Caledonia, as well as by the continuity of the belt on the east, north and west of the Purchase region.

The belt, designated on the map by a bright yellow color, enters from Tennessee with a width of about ten miles, passes northward through the middle of Calloway county, soon bends to the north-west, through the south-west corner of Marshall, and passes diagonally, through the center of McCracken and the northern part of Ballard county, into Illinois, in the region of Caledonia, following a parallel course with that of the Cretaceous already outlined.

Southward, along the Mississippi river bluffs, its first outcrops occur two miles north of Wickliffe, Ballard county, and in the bluffs between Wickliffe and Fort Jefferson, reaching eastward seven miles to Blandville, and southward to Laketon on the M. and O. R. R. Thence to Columbus the bluffs are composed largely of alternating layers of sands and pipe clays which belong to the higher Lagrange group; but at Columbus, and a mile above, and also at Chalk Bluff, two miles south, the greatest exposures of the Lignitic beds occur, and are apparently the last of the series in this direction, for the bluffs southward to the Obion and Bayou de Chien recede and become lower eastward from the river, and the beds disappear beneath the Quaternary deposits.

In Tennessee the group appears again in the Chickasaw bluffs at Randolph, on the Mississippi river, with an exposed thickness of ninety feet, and near Memphis, where there are but twenty feet exposed. (Tennessee Geological Report, page 429.)

The *material* of the group comprises—*First.* A lower heavy bed of massive joint clay, black when wet, but drying to a lead-grey color, and on exposure to air crumbling to a fine

shaly mass. This is the Porter's creek group of the Tennessee series. It is popularly called "soapstone." Along the Mississippi river bluffs the clays, while dark and somewhat jointy, are more sandy than those on the eastern side of the region. *Second.* An upper bed of dark sandy clays, holding two layers of lignite, each varying from two to four feet in thickness, the topmost being about five feet from the surface of the formation. This upper or lignitic portion of the group, while, perhaps, at one time continuous from the Mississippi river eastward nearly to the Cretaceous, has now almost disappeared on the east, outcropping only on Panther creek, six miles east of Mayfield, in Graves county. On the west, however, in the neighborhood of Wickliffe, the lignite beds reach for three miles to north and south, and for seven miles eastward to Blandville. Elsewhere in the Purchase counties they have not been observed.

The lignitic group is everywhere covered by heavy beds of gravel and loam, rendering its examination, or even a knowledge of the character and extension of its beds, dependent entirely upon such exposures as have been made by streams, gullies, and by well-digging and boring. The following section shows the character of the series comprising the group:

SECTION OF THE LIGNITIC GROUP.

| | |
|---|---|
| Dark sandy clays | 3 feet. |
| Lignite bed | 4 feet. |
| Dark sandy clays | 5 feet. |
| Lignite bed | 3 feet. |
| Dark sandy clays | 3 feet. |
| Clay-stone, with fossil leaf impressions | 2 feet. |
| Dark sandy clay, the upper holding leaf impressions | 2 feet. |
| Micaceous sandstone, with fossil casts | 3 feet. |
| Black joint clay, changing to dark sandy clay | 100 feet. |

Beginning at the Tennessee State line on the south-east, and going northward in Calloway county, we find black joint clay exposed in the bed and bluffs of the East Fork of Clark's river at Paris bridge, one mile south of Murray, the county seat. The clay here is in strata, each jointed or



broken up into irregularly shaped blocks, the seams separating them being filled with yellow clay, whose coloring matter has been derived from the overlying clayey gravel beds. The clay forms a bed of about twenty feet; it is very brittle, and, when moist, cuts roughly with a knife. Its analysis is given in the chapter descriptive of the Purchase clays.

The clay outcrops again north of Murray, in the banks of the creeks and along the roadside, as described in the Calloway county report at the end of this volume. At Wadesboro its upper portion is so highly charged with iron as to make of it a good yellow ochre. This is exposed in the bed of the ravine just east of the main street, and is about ten inches thick. The jointy character of the clay is well shown.

To the westward, the clays sink far below the surface, and are covered by the sands and pipe clays of the Lagrange group. In a well on the place of Mr. Miller the clay was reached at a depth of about 130 feet, pieces of lignite being found also.

In Marshall county (northward) exposures of the lower dark joint clays occur about four miles west of Benton, and occasionally in the banks of the West Fork of Clark's river. The upper beds of lignite overlie them on Panther creek, a small stream west of the river, in Graves county, and six miles east of Mayfield. The lignite is very similar to that of Wickliffe, to be mentioned below. The bed is about six feet thick, the upper and lower portions black, and holding pieces of lignitized wood, the central portion being of a dark brown color, and very light, fine-grained and compact—more of a lignitic-peat in character. Its analysis, given in full in another chapter, shows 69.40 per cent. of ash, and 26.47 per cent. of combustible matter. It is overlaid by a bed of somewhat micaceous grey sandy clay, eight feet thick, and similar to that at Columbus.

The above bed of lignite is the only one exposed in the eastern belt of the group, and outcrops for about fifty feet along the creek. It was again exposed on the branch about a mile northward. It contains numerous leaf impressions.

North-westward from Benton the lignitic formation is exposed at a number of points south from the river, and

also in the bluffs of West Fork, at Lyell's mill, near Symsonia. At this latter place the black joint clay has an exposed thickness of eight feet, under two feet of soft micaceous sandstone, here free from fossil casts — which is overlaid in turn by three feet of the same black joint clay. On the hills above the creek forty feet of Quaternary gravel and loam cover the Tertiary.

Going down the river, the same clays form the immediate steep bluffs at a number of points as far north as the old fish-trap ford, four miles above the railroad crossing. Borings made at this point showed the underlying micaceous sandy clays of the Cretaceous. Here the exposure at the water's edge is the stiff joint clay, changing above to a dark micaceous sandy clay, eight feet in all, and capped with the micaceous sand-rock, two feet in thickness, in which no fossils could be found; over this occurs another bed of the black clay.

The lower joint clay bed is very brittle, cuts very smoothly with a knife, the chips crumbling readily. The transition to the dark sandy clay above is sudden. These lower beds are penetrated by seams of the micaceous sandstone, often crossing each other, as if that rock material, on being deposited, had filled broad cracks in the clay strata. Some were as much as three inches in width, running east and west, and exposed for twenty-five feet. The upper sandstone ledge is horizontal, and in every respect is the same as that found at Lyell's mill and already mentioned.

To westward, the formation is next exposed in the foot of the hills that border the broad flats of the Ohio. On the road leading south from Paducah, and at points three and four miles distant, fine exposures are had in the deep washes by the side of the road.

There is a broad valley on the south of Eden's hill, and on rising from this valley, going southward, the most northern of these outcrops is seen. The next exposure is about one mile farther south, or on the south side of this hill, consisting of twelve feet (exposed) of lignitic joint clay, below four feet of micaceous sand-rock, in which are large numbers of casts of Lower Eocene fossils; about thirty feet of Quaternary gravel and loam overlie the bed. The strata seem to dip slightly to the north.



The laminated sand-rock is again exposed a mile south, on the eastern edge of the hill of hard Onandaga quartzite at Mr. Byers'; its outcrop is about fifty feet thick; the strata are in an almost vertical position, and have a north and south strike. It is in the bed of the creek, and may have fallen in at some time by the undermining action of water, though it is not broken up and its bedding is very regular. Casts of fossil shells were also found here. Its surface is about five feet below that of the outcrops on the north side of this valley, in the section just described. On the west side of the hill of quartzite, and but a short distance from this sand-rock, a well, when dug, struck blackish joint clay at about fifteen feet, and penetrated it for thirty-five or forty feet without passing through it.

An interesting feature connected with the micaceous sandstone is, that it seems to have been confined to the *east* of the line marking the exposures of quartzite.

The fossil casts found here have been determined by Prof. Heilprin, of the Philadelphia Academy of Sciences, to comprise the following:

Nucula (in all probability *N. ovula*).
Leda protexta.
Leda Costata (?)
Mysia ungulina.
Turritella Mortoni.

The lignitic belt, turning thence to the north-westward, is not exposed, so far as known, except at Maxon's mill, and in wells at several points between Paducah and Woodville. Beyond this it has been cut through by the erosion that preceded the deposition of Quaternary Port Hudson clays and stratified drift and loam, which now fill the basin between Woodville and the Illinois bluffs of the Ohio, at Caledonia.

The Caledonia bluffs rise almost precipitously from the river shore to a height of about one hundred feet above low water. At the time of my visit there was about nine feet of water above the low-water mark, and at its edge was ex-

posed a bed of greensand (glauconite) with hyaline sand and dark clay. Above this are seventy-five feet of the dark joint clay, weathering to a grey shale, and similar in every regard to the clay beds of the lignitic, already described. On the western end of the bluff the upper part of this clay graduates almost imperceptibly into the dark sandy clay of the Columbus bluffs, with a thickness of about twenty feet. The bluffs here are lower.

SECTION OF CALEDONIA BLUFFS.

| | |
|---|---|
| Brown loam | 10 feet. |
| Silt or loam | 10 feet. |
| Gravel | 5 feet. |
| Dark sandy clay, indurated | 20 feet. |
| Dark joint clay, weathering into a grey shale and with cracks running S. 20 W. | 25 feet. |
| Greensand (glauconite) with hyaline sand; also some black sand and clay. | 2 to 4 feet. |

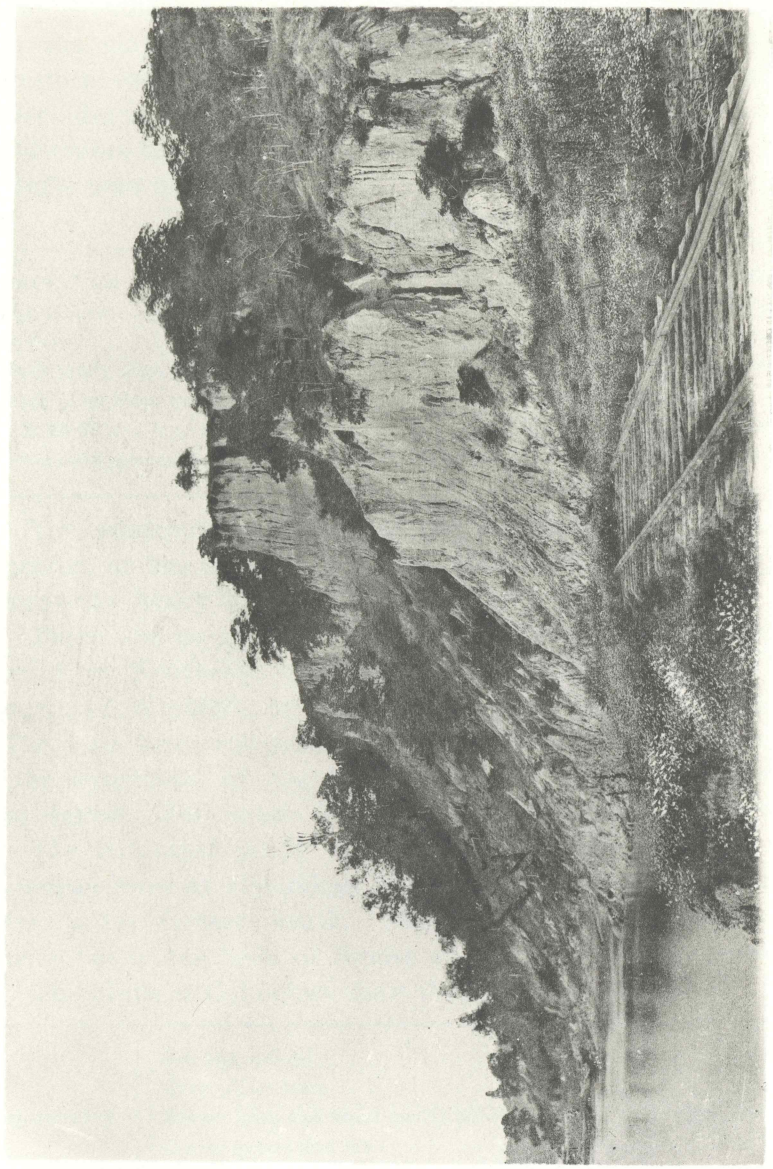
The micaceous sandstone of the Paducah series has disappeared, or has been merged into what seems to be its equivalent—the heavy bed of indurated sandy clay.

There are no lignitic exposures south-westward and southward in Kentucky, until Cane creek is reached, two miles north of Wickliffe, or about twelve miles south of Caledonia. The beds here exposed are the upper part of dark sandy clay (the equivalent of the joint clay) and its overlying stratum of lignite. The entire thickness shown is about ten feet.

The indurated sandy clay forms the bluffs along the Mississippi river at Columbus, and the so-called "chalk banks," two miles farther south. Dipping to the north-east, they pass below the beds of lignite at Wickliffe and elsewhere.

The bluffs at Columbus show the following section:

| | | |
|---|---|---|
| Quaternary | Soil and subsoil | 3 feet. |
| | Gray silt or loam | 25 feet. |
| | Brown loam and small quartz pebbles | 4 feet. |
| | Coarse gravel and sand | 15 feet. |
| | Dense gravel bed | 20 feet. |
| Tertiary | Stiff variegated colored clay, with some sand layers | 15 feet. |
| | Dark sandy clays, with lignitic leaves, etc., in upper portion. | 50 feet. |
| | Covered with debris to water's edge | 15 feet. |



BLUFF AT COLUMBUS, HICKMAN CO., KY.



At the foot of the bluff, beneath the debris, there are variegated and white sands, but belonging to a more recent formation. The bluffs at the "chalk banks" show about the same bedding.

The beds in each are indurated, when exposed, into a greyish semi-sandstone. They contain much lignitic matter in the form of leaves and sticks of wood; descriptions of the former are given below. Between Columbus and the "chalk banks" there has been an extensive cutting away of the bluffs, the plain or bottom land on which Columbus stands reaching a mile eastward from the river.

These easterly bluffs are much lower than those that rise immediately from the water's edge—a feature of the entire bluff region southward into Tennessee and beyond. The grey lignitic clay outcrops in the bluffs north-east and east of Columbus in but few places, having, it would seem, been largely removed by some denuding agency before the deposition of the sands and clays of the succeeding or Lagrange division. This is to be observed prominently in the bluff immediately north of the town, where heavy beds of fine white sand, with interbedded stiff, plastic and variously colored pipe clay, rise from the river; while a short distance up the river, in the same bluff, the lignitic beds rise to the same height from the water's edge.

The same feature is seen at the "chalk banks," where the sandy clays are replaced on the northern end by the interstratified sands and clays of the Lagrange group. It is a question whether the entire distance between these two lignitic bluffs was not once occupied by the Lagrange, to be subsequently removed by currents.

The upper beds of lignite do not appear in these bluffs, nor at Randolph, Tennessee (Safford); but, as already mentioned, farther north-eastward, at Wickliffe and Blandville. Immediately south of the former, the Illinois Central Railroad has cut away a large portion of the beds at the base of the hills, showing a vertical section in which the stratum of lignite is seen in a long horizontal black or brown band, for many hundred yards. Its position is about thirty feet above the river bottom land, and within the upper part of the lignitic sandy clays.

Beneath this, at about ten feet, another bed is said to occur, though not exposed except in a culvert under the bed of the railroad, where it is said to have, at one time, caught fire and slowly burned for many months. I rather believe it to be simply a portion of the upper bed that has slid down from its original position, as the bluffs are thus constantly doing, much to the annoyance of the track hands.

The lignite stratum is about four feet thick, comprising a central portion of two feet of very finely divided, light, highly compact and brown lignite; and an upper and lower layer, a foot each, of black and fine lignitic matter, holding also leaves and sticks. The entire mass, and especially the central part, has the appearance of a bed of lignitic peat.

The following is a section of the bluff above mentioned:

| | | | |
|---|---|---|---|
| Quaternary. | | Grey silt or loam | 12 feet. |
| | | Brown loam with small gravel | 3 feet. |
| | | Rounded and angular chert gravel | 15 feet. |
| | | Coarse sand, in part red and in part hyaline | 10 feet. |
| Lagrange, | Tertiary. | Interstratified red and white clay and sand | 6 inches. |
| | | Dark massive lignitic clay | 5 feet. |
| Lignitic, | | Lignitic peat | 5 feet. |
| | | Massive dark sandy clays with leaf impressions, etc., to railroad track | 25 feet. |

The lignite is again found in the deep ravines and creek bottoms at a number of points, east of Wickliffe, to Blandville, seven miles distant. At the latter place it resembles in every respect the bed at Wickliffe, except that it is, in places, very highly pyritous..

At two miles west of Milburn, or twelve miles south of Blandville, there is an exposure of plastic and black lignitic clay, but at no other point have I been able to find any of the beds of the formation; on the contrary, the sands and clays of the succeeding or Lagrange group are penetrated in wells at sometimes even lower depths than the lignite, and outcrop occasionally in the banks of streams.

There is every reason to believe that the lignite beds extended eastward to the Cretaceous, covering almost the entire country, and that the period was followed by a rapid current



of water, which swept away the greater part of the formation, leaving the long line of clays on the east, the bluffs at Wickliffe and Columbus and intermediate points, as well as the lignite bed east of Mayfield and the isolated point at Milburn.

The fossil leaves described below were collected in the chalky banks of the Mississippi river near Columbus, Ky., by Dr. D. Dale Owen and L. Lesquereux. (The descriptions are taken from the American Journal of Science and Arts, 2d Series, XXVII.)

1. *Quercus virens* (Michx.), live oak. The leaves of this species are abundant in the strata. On this oak Michaux remarks that its range of habitat does not extend to more than ten to fifteen miles from the shores of the sea, in the southern States.

2. *Castanea nana* (Muhl.) Our leaf is somewhat narrower than generally found in this species, which now inhabits the pine barrens of the south.

3. *Ulmus alata* (Michx.) This species is also mentioned with some doubt. Our leaf is more pointed and its teeth shorter. It might be only a variety of *Ulmus Americana.* The only specimen is deficient.

With the above species there is another *Ulmus*, scarcely one inch long, ovate, with nervation and form of teeth of the genus which exactly resembles *Ulmus minuta* (Göpp) of the Upper Miocene. Perhaps it may be a variety of the following species. But it differs evidently in its simple teeth and the rounded base of the leaves.

4. *Planera Gmelini* (Michx.) This species grows now in the river swamps of Louisiana.

5. *Prinos integrifolia* (Ell.) Two leaves of this species were found in the "chalk banks." They agree in every point with the Prinos still living in Florida.

6. *Ceanothus "Americanus"* (L.) To this very variable and common species, I refer with some doubt two leaves, one large, regularly ovate-obtuse, with somewhat decurrent margins, the other oval-lanceolate, with rounded base. The nervation and serrature of the leaves are just alike and agree with *C. Americanus.*

7. *Carya olivæformis* (Nutt), pecan. Fruit and leaves in specimens. The geographical habitat of this species is still the same as of old.

8. *Gleditschia tricanthos* (L.) A few detached leaflets evidently belonging to the locust.

9. *Acorus calamus* (L.). Part of a broken leaf.

10. Some undeterminable catkins of Alnus or Betula.

*Clay-stone.*—The lignite beds are overlaid at Wickliffe by a fine light grey colored clay-stone rich in fossil leaves. The thickest bed, or what seems to be an accumulation of broken pieces of the stone, occurs in the bank of the creek southeast of the town, with a thickness of about ten feet, but elsewhere there is only a thin layer of it, and not prominently exposed.

During the lignitic period, this country between the Cretaceous shore line on the east and the western border was a sea-marsh, at first deep, but soon, on filling up with the dark sands, became shallow enough to support a rank vegetable growth, the leaves and stems of which, falling and sinking with the dark clays, were embedded in them.

The surface of the basin thus gradually rising, and at the same time filling up until it was little else than a peat bog, reached, as far as can be judged, from what are now the bluffs of the Mississippi river eastward to the present Clark's river, and southward from the Illinois shore to a little south of Mayfield. This peat was probably of moss, whose decay would result in the finely divided material that we find here. It is very compact, and almost entirely devoid of leaves and sticks, except in the upper and lower sections of the bed. Upon changing to lignite by age the peat proper became of a dark brown color, and with a thickness of about two feet. Leaves falling upon this peat formed, in the course of time, a lignitic mass of from three to six feet thick in all. Deeper water followed this period, and another bed of dark sands covered the peat, to be followed again by another shallow bog, and thus alternately to the end of the period. There are two or more of these lignite beds, and all are overlaid finally by two or more feet of dark sandy clays.



It is hard to arrive at any definite conclusion as to the condition of the region at the end of the lignitic period, or prior to the deposition of the succeeding Lagrange beds. The absence of lignitic strata within a broad belt reaching from the (at that time) mouth of the Mississippi eastward for many miles, and finally southward into Tennessee, indicates either that the river current swept far out into shallow gulf marshes and kept this belt free from the deposits of clay and vegetable matter, or that these deposits, covering the entire region, were in this belt removed by a strong and sudden current coming from the north-west, leaving a deep basin to be again filled by later deposits of an entirely different character, viz: the Lagrange group of sands and clays. This latter view is sustained by, *first*, the outlying remnants of the lignitic beds, one at Panther creek, six miles east of Mayfield, in Graves county, and another two miles west of Milburn, in Ballard county; while on the north of Mayfield creek the beds cover a large area, and are continuous from Blandville westward to the river bottom, its outlines forming a triangle whose apex is at Blandville, and its base reaches from two miles north of Wickliffe southward along the Mississippi bluffs to near Laketon. *Second.* By the very evident removal of the lower portion of the lignitic bluffs between Columbus and the Chalk Banks, and again between the latter and the Hickman bluffs, as already alluded to, and the filling up of the gap by the Lagrange beds. This presupposes the current of the Mississippi river to have been far westward of its present bed, or in a continuous course with the river far west of Cairo; a strong current then coming from the north-west must have cut its way by several channels through the lignitic marshes southward for many miles; one from the present site of Cairo eastward until it met the Ohio current and then turned southward; another reaching more southward, between the present Wickliffe and Columbus bluffs, cutting away the beds to Milburn, and also removing, in its south-easterly course, the lignitic beds between the bluffs at Columbus and those at Chalk Banks (two miles south), and on to the south of Milburn, leaving a small

outcrop of black clays two miles west of the latter place and joining the main current further southward. A portion of this current cut away a long portion of the river bluffs between the Chalk Banks and Hickman, leaving but a narrow belt of Eocene at the latter place, and affording a subsequent outlet for the waters of Obion and Bayou de Chien.

Within the territory thus outlined, as having been denuded of its lignitic beds, I have found nothing older than the Lagrange sands and clays, and these reaching to depths far below the level of the lignitic at Columbus.

### LAGRANGE GROUP.

This group, so named by Prof. Safford, in his Tennessee report, from its largely developed beds near the town of Lagrange, is referred by him to the Eocene, though no fossil shells have been found to verify his impressions.

The eleven specimens of fossil leaves from a thin local sandstone in the bottom of a railroad cut near Somerville, and the three specimens from the clays at Lagrange, Tennessee (Geol. of Tenn., pp. 425–6), indicate, according to Prof. Lesquereux, a Miocene or Upper Tertiary age for these beds. In Kentucky there are three distinct leaf-bearing beds, viz: the dark arenaceous Tertiary clays of the Columbus bluffs, described above, the Tertiary clay-stone of Wickliffe which is clearly associated with the lignite, and the fine plastic clays of Boaz Station, which resemble the Lagrange clays. The leaf-bearing sandstone of Somerville has not been observed in Kentucky.

The presence of fossil leaves in the Lagrange clays gives to them their only, and even then a doubtful, Tertiary feature, while in all other respects the beds strongly resemble the Quaternary deposits. Owing to this uncertainty as to age I have, in this report, placed the Lagrange beds provisionally in the Tertiary but above the Eocene division (a position higher than that given to them by Prof. Safford); though, from my observations in Kentucky, I am strongly inclined to believe, with Prof. Hilgard, that they are the lowest of the Quaternary stratified drift. The boring of an artesian well is being thought of by the citizens of Mayfield, and this, if done



to several hundred feet, may go far toward determining the true age of these interstratified beds of fine clay and sands.

Prof. Safford included in the group not only the leaf-bearing clays, but also the superficial beds of sands belonging to the Quaternary that spread themselves over the country southward; but I have here restricted the name Lagrange to the former, viz: the interstratified beds of white sand and light colored pipe clays that occupy a broad belt north and south through the central and western part of the region, between the eastern and western belts of the lower lignitic, and that occupy, as it were, a deep trough in that formation.

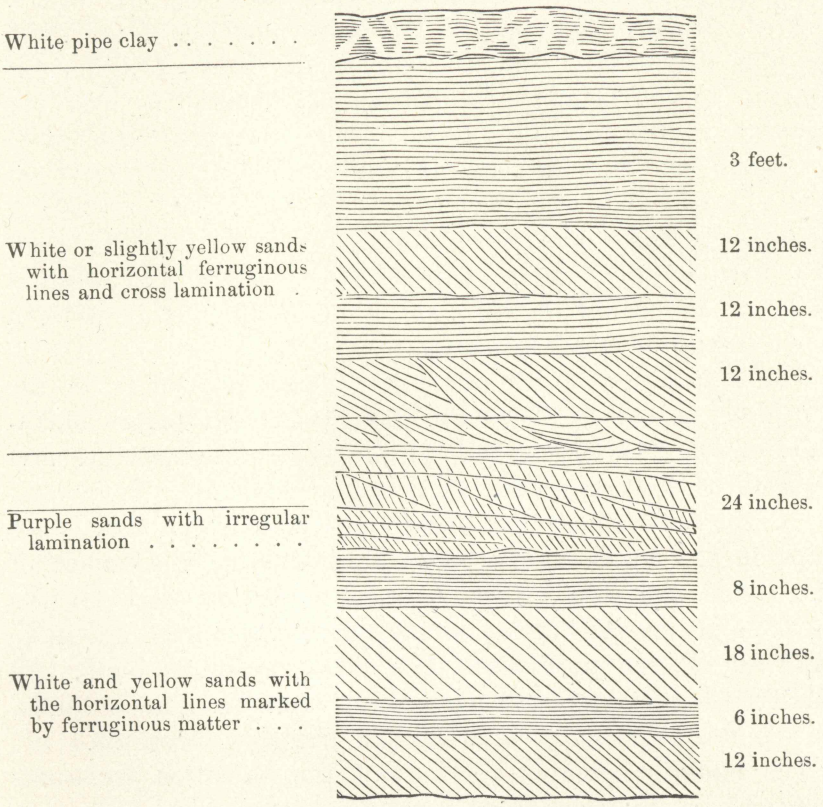
The belt has a width of about twenty-five miles on the south, as it enters the State from Tennessee, passes northward across Mayfield creek to the east of Blandville, and then turns westward with very narrow limits.

On the west, along the Missisippi river bluffs, it fills broad gaps in the lower lignitic beds, first between the mouth of the Obion and Chalk Banks, then northward between the latter and the Columbus bluffs; then, after passing these bluffs, it is seen northward to a little beyond Laketon, and finally between Cane and Humphrey's creeks, not in bluffs, but found occasionally in wells and outcrops in creeks.

The material forming the beds of the formation are sands and clays; the former predominate, and are usually made up of fine white non-micaceous sands, often stratified with other colored sands. The clays in some localities are highly gypseous, the fine needle-like crystals of which form clusters throughout the clay bed. This is specially noticeable at Mr. Hough's, four miles south-west of Paducah, on whose place the clay has a thickness of several feet. Again, at the foot of the hill south of Benton, Marshall county, it was observed in a thinner bed.

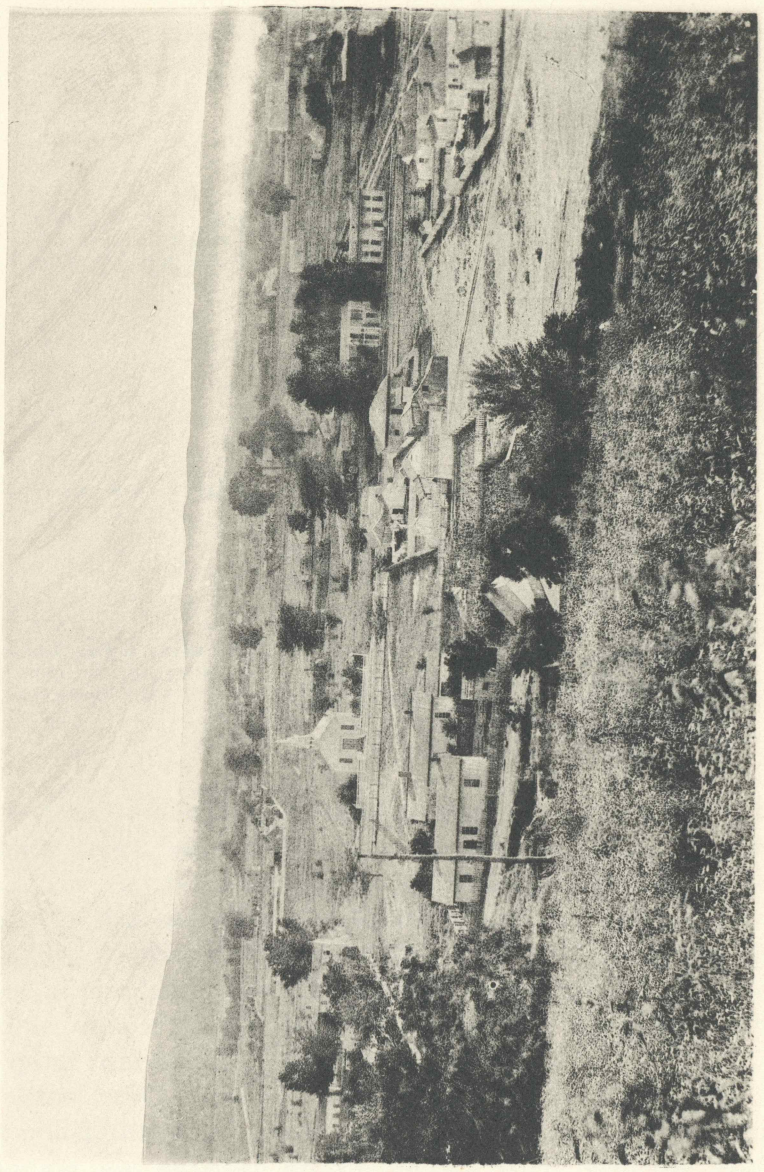
A strong point towards showing the Quaternary origin of the Lagrange group is the ebb and flow structure peculiar to the stratified drift, which is very prominently seen at Columbus in the bluffs north of the town. It forms the base of the high sand and clay bluff. The following sketch was made of the section. The laminæ mostly slope to the northeast as shown.

SECTION SHOWING IRREGULAR CROSS LAMINATION OF VARIEGATED SANDS AT COLUMBUS, KY.




The bluffs extending eastward or away from the river, with a south front, show this clay and sand stratification very well. The clay is deeply purple or reddish, varies from a few inches to two or three feet in thickness, the washing rains spreading it over the sides of the bluff and giving to the whole a purplish color. The entire series have a very perceptible dip of about ten degrees to the north-east. The overlying gravels, etc., are almost horizontal.

On the north side of Chalk Banks (two miles south of Columbus) the dark sandy lignitic clays of the foregoing formation are exposed at the water's edge, and the interstratified clays and sands of the Lagrange are well seen from the foot of the bluff to an elevation of twenty feet, overlaid by thick beds of gravel, etc. The clays are more or



PLAIN, EAST OF COLUMBUS, HICKMAN CO., KY. CHALK BLUFFS AND MISSISSIPPI RIVER IN THE DISTANCE.



less purplish in color, and are in beds a few inches thick, alternating with thicker beds of sand from two to four feet thick. The sand bed is sprinkled with fine clay particles. The strata dip to the north-east as at Columbus.

This formation furnishes chiefly the large beds of white and colored clays that bear so important a relation to economic geology. They are very variable in thickness, from a few inches to several feet. They will be further described in the chapter on Economic Geology.

Within the main belt of the formation, exposures to any depth are rather rare, as the material is easily removed, and the hill-side washings have very generally covered any outcrops. In deep wells, however, the strata are penetrated, and it is largely from this source that I have been enabled to trace the formation. As a rule, water is obtained either in or just below the gravel, the upper bed of the Lagrange series being a thick, impervious clay, which prevents the percolation of water.

In the northern part of Ballard county, between the Ohio river and Mayfield creek, wells are dug or bored to depths of from forty to sixty feet, those at Woodville being over one hundred feet in depth. It often happens that no water at all is found, because of the extreme thinness of the clay beds.

An excellent opportunity for studying the stratification of the Lagrange and later formations is afforded by the many railroad cuts along the line of the C., O. & S. W. R. R. from Paducah south to Fulton. Some of these cuts are deep and long. The first, at Bond's Station, shows only the loam and heavy beds of rounded gravel, not stratified. At Florence Station the first exposure of pipe clay is at the edge of and below the railroad track. It is highly plastic and variegated in color, several feet thick, and underlaid by a red sand. South from this the cuts usually show more or less clay beneath the gravel and loam, the gravel often cemented into a conglomerate. At about three miles from Boaz the following section appears:

| | |
|---|---|
| 1. Surface loam | 6 feet. |
| 2. Yellow clay and some gravel | 2 feet. |
| 3. Variegated clay holding a few small white quartz pebbles | 4 feet. |
| 4. Yellow sand | 3 feet. |

The clay No. 3 is plastic when wet, but indurated when dry, resembling the siliceous earth from decomposed Subcarboniferous chert.

A notable locality is in the long and deep cut one and a half miles north of Boaz. The clay, appearing at the base, has an exposure of several feet, and a purple tint. The nature of the overlying material is shown in a section given under the discussion of the gravel beds.

At Boaz, in an old field just north of the depot, the clays again appear near the surface, and at some distance from the bluffs. The bed is about three feet thick over a coarse sand. The upper half is of a purple color, the lower creamy white, and both contain well preserved impressions of leaves, some of which have been submitted to the United States Geological Survey for identification, the result of which will, I hope, appear in time to be added as an appendix to this report.

At Pryorsburg, a bluff to the east of town shows, beneath the superficial loam and a foot of gravel, the following strata:

| | |
|---|---|
| 1. Yellow ocherous clay, somewhat plastic, and changing downward into a purple and more compact variety, somewhat sandy . . . . . | 4½ feet. |
| 2. Highly colored purple joint clay, plastic and dipping to the northeast; in laminæ with a fine micaceous sand (resembles the upper Cretaceous beds) . . . . . | 5 feet. |
| 3. Light bluish, fine sandy clay (white when dry) . . . . . | 2 feet. |
| 4. Compact or indurated, very fine white siliceous earth. The grains are very sharp and about one thousandth of an inch in diameter; thickness probably . . . . . | 25 feet. |

The latter two beds resemble the lower portions of the Cretaceous as found in the eastern part of Calloway county, and seem to be an outlier of that formation. Nowhere else in this county have the same character of material been found as that of beds two, three and four.

There is an absence of the representatives of the lower lignitic Tertiary at this point; the Lagrange clays alone resting on what seem to be the Cretaceous.

The beds of white pipe clay are not confined to the central region, but reach eastward of the belt of lignitic clays, in somewhat isolated areas, and are not so much interlaminated with sands; they are also devoid of fossil leaves, so far as ascertained. In plasticity and other physical features, the clays



are similar to the true Lagrange beds; they overlie directly the black lignitic clays, as observed at Rufus Morris', three miles east of New Providence, Calloway county. The upper bed here has a thickness of about two feet, with two inches of white sand in its upper part, a few pockets of sand interspersed through the main bed, and is underlaid by a rather coarse ferruginous sand at its base.

On the Tennessee State line, a few miles south of this, the thinly bedded clays and sands are again seen in a ravine by the roadside, and beneath about twenty feet of loam and gravel. A westerly or W. 10 N. dip of the beds occurs in the eastern slope of the hill that rises from Concord, on the road to the south-east corner of the county. The clay is in layers of from three to eight inches thick. At Russell's pottery, six miles east of Murray, there is a thick deposit of these clays, local in occurrence, and utilized in the manufacture of pottery. Another local deposit occurs at J. T. Pugh's, three miles east of Palma, also at Scale and at Mr. Burradell's, north of Briensburg, in Marshall county.

At Bell City (or Howard's pottery), near the Tennessee line, several beds occur in the hill-sides. The upper parts of the clay hold purplish sand concretions. In the southern part of Graves county, three miles west of Lynnville, a massive and highly plastic clay shows, on a smooth cross-section, prettily banded lines. This clay is used at Pitman's pottery.

The sand beds of the series are seemingly thickest in the northern part of the belt, and become more and more interlaminated with clays as we go southward into Tennessee. The analyses and value of the various clays are given in the chapter on Economic Geology.

## QUATERNARY.

The Quaternary formation, as represented in this portion of the State, embraces the following divisions, beginning with the uppermost:

Brown loam of the table lands.
Loess or grey silt of river bluffs.
Port Hudson.
Gravel beds and stratified drift.

The formation overlies or caps the uplands of the entire Purchase region, and even extends eastward upon the lower highlands of the Subcarboniferous, between the Tennessee and Cumberland rivers, in Livingston county. The two middle divisions are limited in their occurrence to the neighborhood of the large streams, as will be noticed under their respective descriptions.

The several divisions are not conformable with each other, nor are they regular in their deposition or thicknesses. They only partially fill the immense Mississippi basin, whose rim on the east of the Tennessee river, on the north of the Ohio and west of the Mississippi river, is formed of the old Paleozoic rocks, the surface lying fifty to one hundred feet below the rim escarpments.

### GRAVEL BEDS.

The early part of the Quaternary period does not seem to have witnessed the deposition of its sand and gravel material in that stratified form that characterizes it in the more southern portion of the great Mississippi embayment basin, and to which the term *stratified drift* has been given; for we find in the eastern part of the Purchase region, along the Tennessee river uplands, beds in which no stratification appears, and which differ in character from that of the stratified drift. Other beds also occur that are unlike each of these, and which are also older than the stratified drift. The following divisions of the gravel beds are made for purposes of description, beginning with the uppermost:

Stratified drift.
Gravel conglomerate.
Ore region gravel.
Tennessee river gravel.

The upper three are characterized by the presence of fossils of the Carboniferous, the last by their entire absence.

*Tennessee River Gravel.*—At some period anterior to the deposition of the great mass of gravel that forms so prominent a feature of the Purchase region, beds of a white and well rounded, water-worn chert material were formed along



the border uplands facing the Tennessee river valley. They are entirely devoid of fossils, and were evidently derived from Subcarboniferous chert layers similar to those that occur throughout this border region, for they are permeated with the white siliceous earth that is found with the chert, the result of the decomposition of the latter *in situ*. The beds are not continuous, and have been observed in but few localities within the State, west of the river. They overlie directly the Subcarboniferous beds.

The most southerly point at which they have been observed, was in the south-eastern part of Marshall county, two miles north-west of Aurora, where they were thrown out in digging a well on the place of Mr. Alford. The well is in a branch valley, much below the level of the uplands, and higher than the river valley. As given by Mr. Alford, the following strata were penetrated:

| | |
|---|---|
| Brown loam | 5 feet. |
| Hard cement gravel* | 5 feet. |
| Loose cement gravel | 30 feet. |
| White chert river-gravel | 64 feet. |

The last was not passed through, and no water was obtained. The well had been dug many years before, and none of the cement gravel could be found, for examination and comparison with that of the stratified drift. It is more than probable that it belongs to the iron ore and conglomerate divisions, as given above. Angular chert of the Subcarboniferous occurs on the hills west of and high above this locality, and a few large rounded quartz pebbles or cobble-stones were found on the hill-sides on the north.

In Livingston county, on the east of the Tennessee river, this river gravel is found along the line of the C., O. & S. W. R. R., upon the hills, and forming deep beds in the cuts. In the Cumberland river valley or water-shed, they are overlaid by the beds of stratified drift.

The valley of the Tennessee is deeply covered with the micaceous clays of the Port Hudson group, and at no point beneath these have the beds of the river gravel been found.

* Locally called "cement gravel" from its tendency to form a conglomerate on exposure to the weather.

*Ore Region Gravel.*—This term is applied by Prof. Safford* to a large region of gravel deposits in West Tennessee, which contain large accumulations of iron ore, and are found upon the bluffs of the river and on the uplands on either side, extending westward for eight or ten miles. The beds are not continuous, occurring only in detached bodies. To what extent they occur in Kentucky, east of the Tennessee river, has not, as yet, been ascertained; but so far as the country west of the river is concerned, they are very limited, and confined to the near border of the bluffs facing the river.

The gravel resembles in character that of the stratified drift, in containing hornstone and fossils of the Carboniferous; but the stratification peculiar to the drift is wanting. The beds which are so prominent in Tennessee, seem to thin out in Kentucky, the only locality of importance being in the south-east corner of Calloway county, and but a few miles from the State line, where there are several heavy deposits, two of which each hold masses of iron ore. At one of the beds a furnace was operated many years ago, while from the other the ore has been shipped to furnaces elsewhere. The beds overlie the chert layers and limestone of the Subcarboniferous, as exposed in the adjoining bluffs, and are composed of fifteen feet of gravel, chert fragments, and clay. Crinoidal stems, large and small, occur in greatest abundance, while throughout the mass are found very many fine, almost microscopic crystals of pellucid quartz, in part of the smoky variety, and with both terminals perfect. The iron ore is partly in plate form and partly concretionary, varying from one to eight inches in thickness. Some masses are much larger.

A few miles north of these beds we find the large quartzose sandstones of an older formation (Onandaga?), with their upper portions embedded in this gravel. The latter is frequently cemented to the sides of the rock by iron oxide, the cementing line being quite horizontal, and the iron having, in places, permeated for several inches into the sandstone, producing at first a dark stain, which fades gradually toward the interior of the rock.

In other parts of the Purchase counties the presence of

* Geology of Tennessee, page 434.



this Quaternary iron ore marks the near occurrence of either Subcarboniferous chert layers, or of the hard quartzose sandstone, whose outcrops are found in a line extending north-westward from the above point, through the town of Murray, and through the southern and western parts of McCracken county, to the Grand Chain on the Ohio, and the Onandaga sandstone region of Illinois; for it is only at these points that it has been found in masses of any prominence.

*Gravel Conglomerate.*—In the south-east part of Calloway county there is a large area in which the gravel is cemented into a very firm and hard conglomerate, from five to ten feet in thickness. It underlies the surface loam upon the uplands east of Murray, between the East Fork of Clark's river and Blood river, forming an almost continuous ledge between these streams, and from the Tennessee State line northward, for twelve or more miles, becoming more and more broken up toward Hico and the southern part of Marshall county. It is found also at other isolated points, especially eastward and northward. The rock usually caps the beds of gravel, and, a mile south of New Providence, is seventy-five feet above the quartzose sandstone, which outcrops in the bed of a branch.

The rock is usually dark or blackish, the individual gravel well rounded, the interstices filled with dark sand, and the whole very strongly cemented together with iron oxide, making a conglomerate not readily disintegrated by exposure. The fracture of the rock is even, and directly through the gravel, as if the whole had been homogeneous in structure.

To the north-westward small fragments of it are found in the gravel beds of the stratified drift, one piece, found five miles south of Paducah, containing several cubic feet, its edges being somewhat water-worn, as if transported from a distance.

The conglomerate seems to have extended originally north-westward and northward, into Illinois, and to have been very generally disintegrated, for fragments are frequently seen, and in the bluffs at Joppa and Metropolis, on the Illinois shore, large beds outcrop in the bluffs and in the river. It is also confined almost entirely to that part of the region lying east of the line of the Onandaga quartzite occurrences, al-

ready described. Conglomerates, more recently formed, occur throughout the region of the stratified drift, but they lack that firmness and siliceous cement that characterizes the rocks just described. They also break unevenly, and the gravel is usually released, in its rounded unbroken state, from the cementing iron oxide.

Near Baltimore, five miles west of Wingo, Graves county, there is an exposure of conglomerate very similar in character to the above; it is in heavy ledges, fifteen feet thick, the gravel very coarse and red, and mixed with crinoidal stems.

On the upland bluffs of the East Fork of Clark's river, near its junction with the West Fork, the conglomerate again appears, covering an area of about three acres. It is massive and much broken up into large fragments.

A most interesting locality, showing how this massive and heavy bedded rock may be broken up by the undermining and removal of underlying sand beds, is to be seen at the crossing of Big Sugar Tree creek, six miles north-east of Murray, Calloway county, on the Newburg road. On either side of the creek valley, in the bluffs one-half mile apart, are huge ledges of the gravel conglomerate, fifteen feet thick, overlying seventy-five feet of white and reddish micaceous sands, belonging to the Cretaceous formation. Ten feet of brown loam caps the conglomerate, giving to the valley a depth of at least one hundred feet below the surface of the bordering uplands. Within this valley are very large masses of the rock scattered here and there, some standing nearly on edge, and others nearly horizontal, and giving to this large valley region, one-half mile wide and nearly the same in length, an appearance of wildness so unusual to this country, that it has received the name of "The Volcano" from Esquire Mahan, on whose place it occurs.

The locality furnishes a splendid illustration of how the surface of a country may suffer degradation, and its rocks be broken down, disintegrated and carried away, even when they otherwise could hardly be affected by weathering. This ledge of conglomerate was once evidently continuous from bluff to bluff, across this valley, and supported by the underlying bed of sand. At some time these sands were washed away, perhaps gradually, by some small stream from the north, that had found its way, by percolation through the bed; or possibly by heavier floods that have acted quickly and suddenly, not only in this, but also in other localities, bearing away gravel and conglomerate fragments to be deposited elsewhere. The sand being thus removed from beneath the conglomerate, there remained an immense cave over which the rock formed a natural covering, whose great thickness and compact structure held it up until the distance between the end supports became too great, or until some central column of sand was washed away, when the whole fell in, breaking up into immense fragments, many of which have since suffered disintegration, yielding great piles or mounds of gravel which still, in part, remain.



*The Stratified Drift.*—The material of this, the oldest division, reaches very nearly over the whole of the uplands of the Purchase, and overlies directly, or is spread over the Subcarboniferous, Cretaceous, and Tertiary formations.

Before the deposition of the Quaternary material the surface of the basin was made very uneven, by the wearing action of the currents of the three large rivers that poured their waters into it from the north-west, north-east and south-east, as well as by many other minor currents induced by these, in the then shallow sea or embayment. Thus were formed the valleys along these streams.

The Tennessee river, in its northward course, confined between the high walls of Subcarboniferous limestone, and suddenly deflected to the west, entered the basin at a point where Big Cypress creek now unites with it, in the northern part of Marshall county. The force of its current would naturally produce a trough to westward, and, united with the current of the Ohio river, which was also deflected from a southerly to a westward course by the limestone bluffs of Livingston county, a few miles east of the present site of Paducah, was amply sufficient to excavate the broad lowland region, known as the Ohio flats or valley, that reaches a little north of west for twenty-five miles, that river still skirting its northern border. The depth of this trough, where the

currents of the Ohio and Tennessee rivers united, viz: where Paducah now stands, was about forty-three feet below the present level, as shown in the well of the water-works. The depth is also greater here than to westward, where the force of the current was probably broken, as it cut through the Tertiary black and heavy joint clays below the Grand Chain, whose powers of resistance were much greater than the more sandy Cretaceous strata which it first met. It is also probable that additional resistance was afforded in the region of Grand Chain, by the Paleozoic limestones and sandstones, which even now rise above low-water level of the Ohio at that place. In this portion of the trough the lower edge of the Quaternary gravel is not more than thirty feet below the present country surface. On the south side of this trough the Tertiary and older beds rise many feet above the present level of the flats, thus giving to the original trough a depth of from fifty to seventy-five feet.

The width of the trough is from three to five miles, the outline of the southern border being irregular. At Paducah it reaches south for ten miles in a narrowing belt, and in an almost direct line with the course of the Ohio river where it enters the basin. A portion of the force of the current of this river, therefore, seems to have cut southward, as well as westward, through the Cretaceous clays, until it met the more intractable joint clays, and was deflected, along the foot of their bed, to north-westward. The wearing action was not very great, for we find the bed of the trough to be very shallow. The black joint clays are seen along the banks of Clark's river, from Lyell's mill, the extreme end of the trough, for several miles northward, and but a few feet below the level of the flats, while the same clays outcrop fifteen or twenty feet above that level, in the border hills near Hard Money, Florence Station, and south-west of Paducah.

It is more than probable that the Mississippi river, with its greater volume of water, had also excavated, southward, a still deeper trough in the Tertiary clays underneath the now broad bottom lands of Missouri. Along the border bluffs of Kentucky and Tennessee on the east, and in



those of Crowley's ridge of the Arkansas border on the west, the Tertiary clays rise as high as seventy-five or eighty feet above low-water of the river.

It is possible that the original corrosion occurred further west than the present course of the river, and that, since the deposition of the Quaternary beds, the river current has been rapidly cutting the eastern bluffs to their present outlines.

At the beginning of the time of the stratified drift, the general surface of the country within this basin was from one hundred to one hundred and fifty feet higher on the south-east, than on the west or north, the elevation above the present level of the sea being a little more than five hundred feet in Calloway county, falling to four hundred and fifty feet along the ridge east of Mayfield creek, and in the southern part of Marshall county to four hundred feet west of Mayfield creek to Milburn (or within a few miles of Columbus), and in the northern half of Ballard county, at Blandville, Hinkleville and Woodville (outside of the deep Ohio trough already mentioned), and to three hundred and seventy feet at Columbus and points south-east. At Hickman, and southward, the country again rose to about four hundred feet. These figures are the approximate altitudes of the base of the gravel beds above present sea level.

The *material* of the stratified drift comprises rounded or water-worn sands and coarse gravel, deposited in thin, alternating layers, or in thick beds which show more or less the stratified structure. The gravel is the most prominent feature of the beds, and is derived almost entirely from the chert beds of the Subcarboniferous, the fragments being rounded or having their edges worn off by attrition with each other in water during transportation, and varying in size from the fraction of an inch to several inches in diameter. Many small and prettily rounded white and colored quartz pebbles are found associated with the gravel, and are, doubtless, from the Carboniferous conglomerate, whose waste material from the degradation of the country is found very frequently in the interior of the State. There are found in the beds occasional large fragments of chert—

as much as a six-inch cube in size—whose edges do not show any traces of wear, and also fragments of gravel conglomerate that have evidently been broken from those larger masses, already described. In some localities the gravel is inclined to be soft, and easily crushed by the hand; but in general it is quite firm and hard, bearing a crushing weight of from one hundred and fifty to two hundred pounds, and much of it still more, when applied directly to the single piece. Hornstone is another constituent of these gravel beds, and varies in color from nearly white to red. They, too, are much rounded, but not so much so as the quartz pebbles.

Petrified wood, which is so characteristic of the Quaternary gravel in the States further south, and especially in Texas, is very seldom found here. A large piece, measuring a couple of feet in length and two by four inches in its cross section, was picked up near the Grand Chain in the Ohio river west of Paducah, and a few small pieces have been reported as having been found in gravel beds in other parts of the Purchase. Silicified Subcarboniferous fossils and fossil casts occur abundantly in the cherty gravel; crinoidal stems of many varieties and sizes being especially numerous, both in the loose state and in the gravel fragments. Next in occurrence are the lace-like favosites and spirifers. A trilobite cast was picked up from the gravel at Milburn, in south Ballard county.

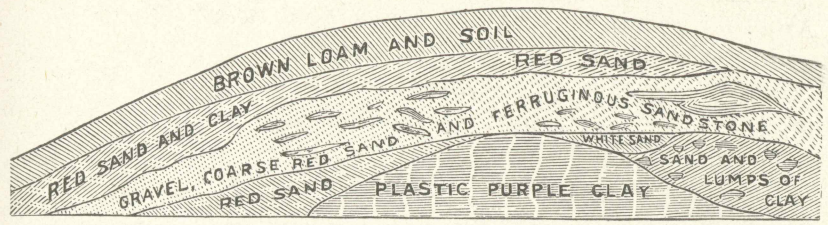
A prominent feature of these beds, and one which often gives to them an economic importance, is the presence of red oxide of iron which has permeated the mass, staining the gravel and sand a red color of various intensity, and very frequently, in combination with clay, forming a cementing material which, on exposure, produces a firm gravel conglomerate. The streets of Paducah are graded with this gravel, and are quite firm and compact, bearing up heavily loaded wagons.

Another result of this cementing property is seen in the massive red sandstones, found in several portions of the Purchase region where the gravel is absent.

For the examination of cross sections of the loam and gravel beds, and as showing the irregularities, both in material and



lines of deposition and relations to underlying clays, the various railroad cuts afford excellent opportunities. The following section is taken from a cut on the C., O. & S. W. R. R., one and a half miles north of Boaz, Graves county. The cut is about twenty feet deep and more than one hundred yards long:




Section of R. R. cut, 1½ miles north of Boaz; height 20 feet.

*Area Covered by the Stratified Drift.*—As has been already stated, the sand and gravel beds cover the entire Purchase counties, with the exception of the Tennessee river valley and that part of the Subcarboniferous highlands adjoining it on the west, whose altitude is above the general level of the gravel beds. Other exceptions are the bottom lands of the many streams which have been excavated since the deposition of the gravel, and now lie many feet below the latter; the deep gullies and ravines that have been washed out in the hill-sides bordering these streams often expose the gravel and sand.

So far as known, no gravel lies beneath that part of the Mississippi river bottom embraced in this State north of Hickman, the present bluffs having formerly extended much further westward, and been cut away subsequent to the deposition of the gravel. West of Hickman, near the foot of Island No. 8, gravel was found, in the borings of the Mississippi River Commission, to a depth of one hundred and seventy-one feet. Nearer the bluffs south of Hickman no examination of strata below the surface of the alluvium has been made.

*Deposition of the Gravel.*—The depth of the gravel beds throughout the Purchase region varies greatly, but is, within certain areas, quite constant. These different areas are shown on the accompanying map. The area of greatest depth, viz:

*thirty feet* and upwards, occurs on the south-east, in Calloway and south Marshall counties, with an additional smaller area on the uplands immediately east of Mayfield. The former of these has approximate diameters of about sixteen by eight miles, the longest lying in a north-west and south-east course.

Another belt in which the beds are from *twenty-five to thirty feet* in thickness, enters the State from Tennessee, passes north-westward, through the counties of Calloway and Marshall into the south-east corner of McCracken. It has an average width of about ten miles, except in Marshall county, where it spreads out abruptly on either side for five or six miles, again becoming very narrow to north-westward. Westward, along the north side of Mayfield creek to the Mississippi river valley or bottom, there is a very narrow belt of gravel of the same thickness, whose beds form precipitous bluffs and are well exposed. The belt was, doubtless, originally wider, and has been cut away by the encroachment of some strong current from the south, for we find on the south side of the creek a gradual rise from the bottom lands to southward, and an entire absence of beds of gravel more than three to five feet in thickness. The continuity of this narrow belt with the large area before mentioned is interrupted by beds of less thickness upon the high ridge that separates Mayfield creek and the West Fork of Clark's river. There may once have been a continuation of the narrow belt of deep gravel southward to Mayfield, where, on the east side of the creek, we now find the beds of from twenty to thirty feet thickness reaching eastward; and it is also possible that the narrow belt of gravel of about ten feet thickness, that extends a short distance northward from Mayfield along the west side of the creek, may be but a remnant from the degradation of this supposed heavy and continuous belt, for the supervening country is much lower than the gravel bluffs, and the now existing gap is but eight miles.

On the Mississippi river bluffs at Columbus, and two miles south, at the "chalk banks," there are other isolated areas of beds having a thickness of twenty-five feet; but elsewhere in this part of the Purchase region the gravel is much thinner.



Large areas of gravel, whose beds have a thickness of from *fifteen to twenty feet*, occur on the east of the heavier beds just described, reaching, in places, almost to the brow of the highlands facing the Tennessee river valley, and northward to the border of that valley at Calvert City, and ten miles westward. These beds are all on the highlands, and are often exposed in the deep washes and ravines. North-westward from Clark's river, to and beyond Paducah, beds of this thickness are found at a much lower level within the trough of the Ohio river, already alluded to, and thirty feet below the surface at Paducah, as shown in the well of the water-works. Within the region of flats south of Paducah, the beds are not so thick, and come nearer the surface, while westward, along the flats for several miles, and upon the highlands south-westward, beds of fifteen feet thickness are frequently exposed; west of Mayfield and Massac creeks, such thicknesses very rarely occur.

The gravel beds thin out to broad areas of from *ten to fifteen feet* thickness to the eastward, westward, and northward from the heavy deposits already described. Such beds are found in the eastern part of Marshall county in a narrow belt extending southward, widening to a width of several miles in south-east Marshall and north-east Calloway, and separated from the brow of the Tennessee river highlands by thinner deposits. In south Calloway, and thence in a belt from six to eight miles in width, extending north-west to Mayfield, in Graves county, there is a very large area of these beds, Harris Grove and Farmington lying near the south-west edge of the belt. Beyond Mayfield creek, upon a dividing ridge, the beds become thinner; but we find westward from Wingo, to and beyond Baltimore, another narrow region in which a thickness of ten feet is maintained. Going northward, on the east side of Mayfield creek, these beds occupy a narrow belt upon the bluffs from Hickory Grove and Boaz to Collierville; and again, still northward, within the Clark's river flats, and nearly to Massac creek, south-west of Paducah. North-westward within the Ohio flats (or beneath the Port Hudson clays), opposite the town of Metropolis, Illinois, the gravel has a thickness of but

three or five feet for a few miles; but in north-west McCracken and north Ballard we find a large area beneath the superficial clays in which the deposits are ten or more feet thick.

With the exception of comparatively small areas lying south and west of Paducah, in which the gravel has a depth of *five feet* and upward, the remainder or western half of the Purchase region, embracing the greater part of Ballard, west McCracken, Hickman, and west and south Graves, has a very thin deposit of not more than *three feet*, thinning out to southward and south-westward, until in south-west Hickman, and over the entire uplands of Fulton, it is almost entirely missing. A line marking the separation between this and the heavier beds would pass from the Tennessee State line, east of Crossland, north-westward to Mayfield creek; thence, following the east side of that creek until after the latter has accomplished its westerly bend, the line would pass quite abruptly northward to the Ohio, at Metropolis, skipping, however, the very heavy beds of Mayfield creek.

A line marking approximately the limits of the gravel would leave the Tennessee State line about four miles east of the town of Fulton, and pass north-westward to McLeod's Bluff, on Obion creek, seven miles south of Columbus. The immediate bluffs facing the Mississippi bottom, from the town of Hickman southward, contain a thin bed of gravel, and there is another small area of thin beds near Cayce Station, but otherwise in this part of the Purchase the gravel is entirely replaced by sand. There are also other small areas along the Tennessee State line eastward from Fulton, in which the gravel is missing, as between Crossland and Terrapin creek, east of Boydsville, and in the neighborhood of Cuba, Graves county.

It will be seen from the map that these gravel beds, in their several areas of thin and thick deposition, have a general north-west and south-east course, and are thickest on the south-east; and that the heavy beds are almost entirely confined to the eastern half of the Purchase counties, while in the western half they are very thin, and to south-westward disappear almost entirely, the country being



more elevated than on the north. The gravel also is finer on the west, and especially near the border, where it disappears.

Along the bluffs facing the Tennessee river valley, where the Subcarboniferous beds rise high above the valley, the gravel is quite thin and fine, and often is not found at all, the superficial brown loam being the only representative of the Quaternary formation.

Going eastward from the Tennessee river, in Livingston county, along the line of the C., O. & S. W. R. R., nothing but limestone hills are observed for the first mile; but still eastward, and covering hills one hundred feet above the railroad track, are heavy deposits of a white water-worn cherty gravel belonging to the earlier river deposits, as already noticed near Aurora, Marshall county. Still eastward, massive gravel conglomerate rocks, five feet in thickness, and with surfaces thirty by fifteen feet, appear above the white gravel. They resemble the conglomerates that underlie so large an area in south-east Calloway county. A mile eastward are exposed, for the first time, beds of the gravel and sand of the stratified drift in a railroad cut one mile from the Cumberland river bridge. At the base of the cut is a bed of the white river-gravel five feet in thickness; over it a bed of red sand, from five to ten feet thick, and over this, in the upper part of the cut, ten or twelve feet of yellow hornstone and chert gravel. The latter rests upon the eastern slope of the hill, and thins out to a thickness of twelve inches at its foot, the whole being overlaid by brown loam. Keokuk geodes are found in the upper gravel bed at this place; thence eastward, to the Cumberland river, these upper or hornstone gravel beds are frequently seen, and usually have an easterly slope toward the river.

*Sand and Sandstone.*—Along the border of the great gravel region, the beds of gravel thin out, and give place to heavy deposits of red and yellow sands of the stratified drift. The latter are also found occasionally within the territory of the gravel, especially in the western half of the Purchase counties, where the gravel is very thin. Along the bluffs reaching north from Columbus, on the line of the Mobile and Ohio Railroad,

to and a little beyond Laketon, in Ballard county, they are found above the sands and clays of the Lagrange group. The beds are often permeated with iron oxide, which gives to them a reddish color, and frequently cements the mass together into a more or less hard sandstone. In portions of the beds, as near Laketon and Wickliffe, respectively, the sand is hyaline in character, and the grains of some of the dark-red sandstones, when rubbed in the hand or otherwise cleared of the adherent iron oxide or rust, are found to be of the same.

Another feature of these sands is the presence of small particles of white chert, which give to the bed and to the sandstone a speckled appearance. Rocks of this character are found a short distance north of Berkeley, on the M. & O. R. R., also three miles east of Arlington, in Ballard county, and again, a few miles east of the town of Clinton, Hickman county, where the sandstone forms a ledge six or more feet thick. The rocks of these three localities resemble each other very closely, being largely composed of hyaline sand and sprinkled with the particles of white chert. That from the latter place is utilized in Clinton and the surrounding country as foundation stones for small houses, as it disintegrates but very slowly, and is quite firm. Portions of the bed are, however, still quite soft.

The red sand usually underlies the gravel wherever they occur together, and in the heavier beds forms thin layers as part of the stratification characteristic of the drift.

A prominent feature of the thick sand beds is the occurrence of rounded lumps of white or variegated pipe clay, which, at the time of the sand deposition, were evidently loosened from the underlying clay beds of the Lagrange group, and were rounded by the action of disturbed waters and embedded in these sands. Such features are met with occasionally in Ballard and Hickman counties, and in Calloway, a few miles east of Murray, where a broad valley has been cut through the gravel conglomerate into the underlying material, probably previous to the deposition of the stratified drift, to be partially refilled by the sands and the clay lumps which were, doubtless, derived from the clay beds that underlie the conglomerate.



### PORT HUDSON GROUP.

This formation in Kentucky appears to comprise two distinct beds—a lower one made up of dark blue or blackish clays, which underlie the bottom alluvial lands of the large rivers; and an upper bed of greyish or dark micaceous loam of the Ohio and Tennessee river valleys.

*Blue Clays.*—Beneath the alluvial loam of the Mississippi river bottom, and at a depth of several feet, there are beds of dark clays which, in their character, strongly resemble those of the Port Hudson group, as first described by Prof. E. W. Hilgard in his Report on the Geology of Louisiana. They have been identified in the river bottom lands in Arkansas, and, from the strong resemblance between them and the Kentucky clays, I have referred the latter to that formation. They are best exposed in the banks of the river at Columbus, when the water is low, and also at Wickliffe, a few miles south of Cairo.

At the former place the following section was observed:

| | |
|---|---|
| Surface of sandy loam and recently deposited material | 1 foot. |
| Dark to black alluvial loam | 2 feet. |
| Stiff yellow clay, sandy and crumbling, and holding seams of lighter sand | 8 feet. |
| Dark and heavy crumbling clay, stiffer than the above | 3 feet. |
| Somewhat bluish, heavy and crumbling clay, very stiff, and holding white calcareous concretions; reaching to water's edge | 6 feet. |

The clays of the last two beds are highly plastic, somewhat mottled in color, cut smoothly when wet, and crumble readily when dry, strongly resembling the buckshot clays of the river bottom in Mississippi and Louisiana. Small pieces of blackish semi-lignitized wood appear in the clays at Wickliffe, and also near the bluffs, two miles south of Columbus. At the latter place the Tertiary stratum rises from the water's edge, and, as at the bluffs immediately north of Columbus, cuts in two the otherwise almost continuous beds of the Port Hudson and alluvium.

Another feature of the Port Hudson group, both here and in the States south, is the presence of cypress knees and logs within the clays, and covered by the later alluvial deposit. They are seen all along the river bank, from Hick-

man to the Chalk Banks south of Columbus, and more rarely northward. At Wickliffe the river banks show the following section at low water:

| | | |
|---|---|---|
| Alluvial loam with recent stumps | | 6 feet. |
| Port Hudson | Stiff blue plastic clay dipping to the east | 8 inches. |
| | Silty or loamy strata, with ferruginous concretions | 1 foot. |
| | Light blue plastic clay, with rootlets and pieces of lignitized wood; some of the clay quite dark; exposed to water's edge | 2 feet. |

Cypress stumps penetrate this blue clay from below.

The elevation of these beds above sea level is about three hundred feet. Along the Ohio river the beds extend, on the Kentucky shore, to and beyond the Grand Chain, appearing beneath the alluvial loam of the bottom lands, and but little above the low-water mark. Calcareous concretions were not observed in the blue clays, but fragments of lignite were found. Just west of the city of Paducah the clay is again exposed in a deep ravine, but is apparently a thin deposit, rising a little above low-water mark. Coarse yellow sand is interstratified with the lower portion of the bed, the upper being thick, and here marked by the presence of bluish specks of the mineral vivianite, a phosphate of iron.

The region about Paducah is an interesting one, as being the point where the Cretaceous clays outcrop on the banks of the Ohio river, and a number of later formations appear. The Cretaceous beds, comprising thinly laminated black clays, the laminæ separated by a thin sheet of very fine and highly micaceous sand, are exposed on the east side of the foot of Main street (or the boat landing), from about forty-three feet below the surface of the bluff to the water's edge. They have not been observed on the western side of the landing. Passing south-westward a few miles, across the flats to the bluffs, that rise one hundred feet higher, we find the Tertiary black joint clays at their feet, and on a plain higher than the Cretaceous. These in turn are overlaid directly by the Quaternary gravel and brown loam which caps the uplands southward. Within the flats or valleys, and about thirty feet from the surface, the gravel is found in heavy beds, covering the Cretaceous, and reaching westward at about



one hundred feet below the level of the hill gravel, though cotemporaneous with it.

A feature of special interest here is the formation of another trough within this original one, beginning at Paducah and extending westward along the Ohio river to the Mississippi, and marked by the narrow bottom land or surface alluvium. It seems to have been formed by the combined currents of the Ohio and Tennessee rivers, acting suddenly and with sufficient force to bear away the gravel previously deposited along this line, and possibly to cut away the gravel bluffs along the Mississippi to their present outline, scattering their material over the eastern and middle parts of the broad bottoms of the latter river, at various periods of the Port Hudson era, as shown by the interstratification of the gravel, sand, and blue clays in the borings of the Mississippi River Commission. This trough was not entirely filled by after-deposits of clays and alluvium; and we find at Paducah, and elsewhere along the Ohio bottom, a terrace of ten or fifteen feet rising from it to the flats or valley region.

Along the banks of the Tennessee river, except where the uplands approach to the water's edge, the blue clays of the Port Hudson are found outcropping at low water, and presenting the same characteristics as have already been given. At Highland Landing, in the north-east corner of Calloway county, they are dotted with the white and bright blue particles of *vivianite* as at Paducah, though more abundant and larger.

The clays extend up the river to the point where the high Subcarboniferous bluffs reach to the water's edge, and which mark the line between the two States. Beyond this they have not been observed. They are overlaid by yellowish, micaceous, clayey loams, presently to be mentioned.

At Highland the following section appears:

| | |
|---|---|
| Micaceous and yellowish loam | 7 feet. |
| Interlaminated light bluish clay and yellow sand | 15 feet. |
| Blue micaceous clay, in layers one to two feet each, with some yellow sand and ferruginous concretions; the lower dotted with vivianite particles; reaches to water's edge | 10 feet. |

The clay is quite plastic, and, as shown by tests, makes a very pretty bright red ware. It seems to underlie almost the entire valley, and is covered, in part, at the foot of the western bluffs, by gravel washings from the hills.

At Birmingham, the bluish clays appear sixteen feet beneath the loam along the river front, and also in the valley on the west, the central portion being occupied by alternating strata of sand and pipe clays.

*Micaceous Clay Loam Bed.*—Immediately overlying the blue clays just described, and covering both the Tennessee and Ohio river valleys or flats, there is a deposit of brownish-yellow loam, differing from the brown loam of the uplands, in being quite micaceous. It has a thickness of from fifteen to twenty-five feet.

The age of this bed is a matter of conjecture, though, for a number of reasons, I have placed it as Port Hudson, for it overlies the stratified drift; apparently underlies the brown loam, being covered by it to a depth of a few feet, and is not sufficiently silty in character to make it a part of the loess.

An examination of the beds exposed in the ravines around Paducah showed the presence, in places, of many calcareous concretions and of darkened rootlets. The lower portion of the bed has also a tendency toward a dark color. The following section was obtained near town:

| | |
|---|---|
| Soil, light grey loam | 1 foot. |
| Brown clay loam subsoil | 2 feet. |
| Brown micaceous under-clay, becoming stiffer downward, and with much bog ore; at ten feet whitish calcareous concretions | 25 feet. |
| Rather bluish micaceous and massive clays, dark when damp; seams are filled with brownish clays and some concretions; to bottom of the ravine | 4 feet. |

The bottom of the ravine is about level with the upper edge of the blue clays in the bank of the Ohio, already mentioned. The micaceous character of the clays is especially noticeable in the valley of the Tennessee.

The formation reaches up Clark's river valley to the head of the valley flats at Lyell's mill, and up the East Fork of the river, on the south side, to and beyond Benton, Marshall



county. Along Mayfield creek, in Ballard county, it extends beyond Lovelaceville. In all these bottoms it produces a heavy crawfishy land.

### LOESS OR GREY SILT BLUFFS.

This formation overlies the gravel beds of the stratified drift along the immediate bluffs that face the bottom lands of the Mississippi river, and its position in the geologic series is most probably below the Port Hudson group, just described. Its beds are the continuation northward of the similar beds of Mississippi and Louisiana, and, so far as ascertained, differ in no respect from them. The beds, usually twenty to thirty feet thick, are made up of a fine grey calcareous silt, nearly homogeneous throughout, and frequently containing long reddish concretions or small tubes, whose central part is usually darker than the exterior, and sometimes with a central orifice nearly the entire length, as if formed by rootlets.

Another characteristic feature of the silt is the occurrence of a large number of fresh water shells, an enumeration of which may be found below.

The formation is not continuous through Kentucky, though it may originally have been so; there is a sudden slope to eastward from the very edge of the bluffs in that portion south of Hickman, thus limiting it to a very narrow belt. Between this town and the McLeod's Bluff, eight miles south of Columbus, the silt has been entirely removed, together with the high bluffs, while at this bluff, and on to Columbus, it is continuous. Northward from Columbus it occupies a narrow belt to a point three or four miles beyond Wickliffe, when it disappears from the bluffs, which are here very much lower than on the south. The most northerly deposit observed was on the bank of Cane creek. It, however, occurs on the high Illinois bluffs of the Ohio at New Caledonia, almost due north from Wickliffe. I have not observed it eastward from this point along the Ohio river.

The silt in the bluff at Hickman, as shown in the section on page 38, has a thickness of about fifty feet, overlaid by

three or four feet of a yellowish-brown loam. The silt is not uniform in character throughout, but contains ash-colored seams and patches. Between the true silt and the underlying gravel there is a bed more clayey and darker in color, fifteen feet in thickness, the lower four or five of which contains scattered and prettily rounded small white and colored quartz gravel. No shells were found in it, and it bears some resemblance to the lower bed of the upland brown loam that covers the entire region, though the small gravel does not appear in the latter.

Immediately at Hickman the silt bluffs are very narrow, the descent to the lower country being quite sudden; but southward the formation widens out to several miles, though with a gradual slope from the brow of the bluff eastward.

At one point in the formation in the northern part of the bluff there is a great abundance of shells, many of them large. A collection was made and sent to Prof. Wetherby, of Cincinnati, who has identified the following species:

1. Conulus chersina.
2. Hyalina arborea.
3. Helicina orbiculata.
4. Helicina profunda.
5. Limnæa desidiosa.
6. Mesodon profunda.
7. Mesodon albolabris.
8. Macrocycles concava.
9. Patula alternata.
10. Patula perspectiva.
11. Patula solitaria.
12. Stenotrema monadon.
13. Stenotrema hirsuta.
14. Treodopsis appressa.

The following were obtained by Prof. Safford, at Memphis, Tenn. (Geol. of Tenn., page 434):

1. Helix appressa.
2. H. hirsuta.
3. H. monadon.
4. H. solitaria.
5. Planorbis bicarinatus.
6. Cyclas, sp. ?
7. Amnicola lapidaria.
8. Succinea, sp. ?
9. Lymnea, sp. ?

At Columbus the silt bed is thinner than at Hickman, the bluffs showing a thickness of only twenty-five or thirty feet. It is overlaid by four feet of loamy soil and subsoil, and underlaid by about four feet of the stiff, darker loam that appears at Hickman, in a bed fifteen feet thick. Shells are very rare in these beds, and especially those of the larger species, none of the latter being seen. In the railroad cut, east of Columbus, a portion of the silt is well filled with



ESCARPMENT OF BLUFF AT COLUMBUS, HICKMAN CO., KY.



small shells, whose species have not yet been determined. Rounded and reddish concretionary forms are abundant, also seams of ferruginous clay holding shells.

At other localities northward, at Wickliffe and Caledonia, the silt beds are thin, and no shells were observed.

It is a matter worthy of note, that the largest shells were *found only in the most westerly exposures of the silt*, viz.: at Hickman; while in the more easterly bluffs at Columbus, and elsewhere, including that in the railroad cut, just northeast of Hickman, only small species were found; and in the still more easterly bluffs at Wickliffe none were observed.

The following analyses show the chemical composition of this silt:

No. 2142. *Loess*, from the bluff at Hickman, Fulton county; contains remains of land and fresh water shells. It is somewhat plastic; not very coherent when burnt, and acquires a very light brick color; before the blow-pipe it fuses into a light grey slag.

No. 2659. *Loess or Grey Silt*, near top of bluff at Hickman, Fulton county; greyish cinnamon color. The siliceous residue, insoluble in acids, contains 1.410 per cent. of potash, and 1.268 per cent. of soda.

No. 17. *Loess* from the river bluff at Memphis, Tennessee.

ANALYSIS OF LOESS OR GREY SILT.

| Dried at 212° F | Kentucky: | | Tennessee: |
|---|---|---|---|
| | Fulton County. | | Shelby County. |
| | Hickman. | | Memphis. |
| | No. 2142. | No. 2659. | No. 17. |
| Silica | 68.860 | 67.295 | 76.503 |
| Alumina | 12.980 | 4.062 | 3.102 |
| Iron oxide | 2.240 | 2.125 | 4.687 |
| Lime carbonate | 9.587 | 14.900 | 9.528 |
| Magnesia | 1.182 | 7.670 | 3.291 |
| Potash | 1.773 | .521 | .433 |
| Soda | 1.278 | 1.082 | .180 |
| Manganese | Not estimated. | ..... | .094 |
| Phosphoric acid | | .173 | .319 |
| Sulphuric acid | | ..... | .060 |
| Water and loss | 2.100 | 2.172 | 1.730 |
| Total | 100.000 | 100.000 | 99.927 |

The analysis of the Memphis specimen is taken from the Tenth Census Report on Cotton Production in the Southern States, and is here given for comparison with the Kentucky beds. It and No. 2659 are representations of the true grey silt of the upper part of the bed. The Memphis specimen contains nearly ten per cent. more of the fine silt, but much less of lime, potash and soda. The proportion of soda, soluble and insoluble, is enormous in the Kentucky specimen.

The two Kentucky specimens are respectively from the lower and upper portions of the bed, the former being far more clayey, and containing more soluble potash but less lime.

### BROWN LOAM.

The gravel or stratified drift formation was followed upon the uplands, in the interior, away from the loess hills, by that of a clayey loam, having a thickness of from twenty to thirty feet, and which covered the entire Purchase counties, to be subsequently largely removed by erosion along the present creek and river valleys, as well as in minor ravines.

There are two beds of the brown loam, an *upper* and *lower*, perhaps separated from each other, in the bluff sections along the Mississippi river, by the heavy silt or loess formation.

The upper bed is thin, not more than three or four feet, and forms the immediate surface of the uplands between the Mississippi and Tennessee rivers. The lower has a much greater thickness, is lighter in color, and generally permeated with seams of a still lighter grey silt.

At the close of the stratified drift period the gravel was left in uneven beds, either by original deposition or because of the effect of the erosion of the surface by those floods which acted at the same time upon the deposits along the Ohio and Mississippi rivers. In many of the inland gravel hills it has been observed that their outer edges are thinner than in the central portion, the whole having a slope to either side, though the base was horizontal.

Upon this uneven surface the brown loam was deposited, with quite a uniform thickness, the surface of the formation following the contour of that of the underlying beds.



It is very usual to find, in an exposure, a central nucleus of probably a pre-Quaternary bed of clay and sand, covered by the gravel of the stratified drift, either in a horizontal bed, with the edges on either side thinned out, or in a bed dipping to either side conformable to the surface of the underlying stratum. Over the gravel we find the brown loam lying conformably upon it.

The lower portion of the loess in the bluffs of the Mississippi river, which seems to be the equivalent of the interior lower loam, is darker in color than both the overlying grey silt and the upper loam. In the lower portion of its bed there are numerous well rounded and prettily colored quartz gravel, very small, and increasing in quantity downward, as the gravel of the stratified drift is approached. No cherty fragments or fossils of any description, whether of the Carboniferous or of the fresh water species of the overlying silt, have been found in the bed. The gravel has not been observed in this brown loam in the interior of the country.

On leaving the bluffs and proceeding inland, a feature in this lower loam bed presents itself which distinguishes it from the upper, and is interesting in showing a possible relationship with the silt. The upper portion of the bed is usually permeated with streaks of a grey, silty material reaching downward, and plainly seen in freshly exposed vertical surfaces in road cuts. The beds have the appearance of having been cracked open by drying, and the seams filled with the silt, perhaps borne in highly charged waters. Whether or not this was from the silt of the bluffs is a matter of conjecture, but the two have a strong resemblance to each other.

*Upper Brown Loam Beds.*—The loess or grey silt was followed by the deposition upon its surface of a few feet of a light yellow or brown loam, which also extended eastward over the uplands of the entire Purchase counties, resting directly upon the lower loam bed, as has already been mentioned. In the valleys or flats of the rivers it covers, in a thin deposit, the micaceous clays of the Port Hudson formation, except in the Tennessee valley, where it is absent. This loam forms the surface soils and subsoils throughout the up-

land region. The silt percolations observed in the under bed of loam do not appear in this upper bed; and the two beds otherwise seem to graduate into each other, the line separating them being undistinguishable.

### ALLUVIAL, RIVER BOTTOM, OR RECENT FORMATION.

The alluvial formation lying along the immediate watercourses is properly limited to the three large rivers, with minor belts along Clark's river and Mayfield creek. The bottom lands of the other streams are mostly made up of washings from the hill-sides, being changed by ill-drainage into a heavy crawfishy clay.

The alluvial region of the Mississippi is broad from bluff to bluff; but only a comparatively small proportion is included within the State of Kentucky, and all of this is subject to overflow in high water seasons. The river has for many years been encroaching on and wearing away the Kentucky or eastern banks, and inflicting great damage to the towns of Columbus and Hickman. The latter has especially suffered in that portion lying at the foot of the bluffs, and within the past two years the railroad depot, to escape destruction, has been removed to the north-east of town, and back from the river. Many years ago, and within the recollection of many persons now living in Hickman, the river flowed a mile further west, the main current passing to the west of Island No. 6, and a broad cypress swamp existed where the river now runs. Columbus is also suffering, though perhaps to a less degree. Within the last twenty years the river has cut away about 200 feet from the town front, portions of it going faster than others. A small levee has been thrown up along the banks to protect the town from overflow, the water of the river having risen higher during the past few years than it has been known to do heretofore. The river bottom between Cairo and the Tennessee State line is interspersed with sloughs and lakes, the latter frequently forming a chain by connection with each other and with the river by means of these sluggish and narrow streams.

Abrupt and almost perpendicular bluffs face the Mississippi bottom, beginning a few miles north of Wickliffe, and reaching to the Tennessee line, a feature which does not belong to the Ohio bottom or valley land lying within Kentucky.



It would appear that this bottom region of the Mississippi was cut out at a season of very high flood by the waters of the Mississippi (perhaps aided by those of the Ohio), after the deposition of the grey silt or loess formation. To what depth this occurred is not known; but in the bluffs the lower divisions of the Eocene Tertiary are exposed. This erosion of the bluffs at present only takes place at points where the river current sweeps their base, the interior bluffs not being affected by the sluggish waters that reach them in overflows.

Another feature of the bottom region is the presence of ridges of sand in the interior, and along the river bank, representing two eras of deposition. The oldest deposits are situated some distance from the river, but parallel with its present course, and were formed apparently previous to the present alluvial deposit. The ridges of sand are long and narrow, and are still subject to overflow from very high floods. The most prominent of these is Sassafras ridge, lying about seven miles below the town of Hickman.

The other and more recent sand ridges lie along the immediate bank of the river, and are still in process of formation by the yearly addition of sand from the partial checking of the river current in periods of overflow. In the valley of the Ohio similar sand ridges of both eras are seen, especially in the wide bottom lands below the Grand Chain, the most prominent of which lies near Turner's Landing. The newer deposits along the river bank reach still further up the river.

In the suburbs of Paducah there is a low surface ridge or elevation of closely intermixed fine gravel and dark loam, five to eight feet in depth. It lies nearly north and south through the central part of the cemetery, from a point five miles south of Paducah. It has no lines of stratification, and its material was derived doubtless from the gravel and loam beds of the uplands, and washed into this position. The belt is quite broad, and but little elevated above the valley.

# ECONOMIC GEOLOGY.

The economical features of the Purchase counties embrace the soils, the beds of pottery clays, the building materials, polishing powders or sands, lignite or brown coal, iron ore, etc. They will be described under their respective heads; the soils in the chapter given to the agricultural features.

## CLAYS.

Next to the soils and timbers, the material of greatest economic importance occurring naturally in the counties of the Purchase region, is found in the extensive deposits of clay, in beds of varying thicknesses and characters. While they underlie the greater part of the country, it is only in the hill-side ravines, and in the bluffs bordering the streams, that their exposures can be seen.

These clays are derived from the decomposition of the argillaceous shales and rocks of formations older than those with which they are now found, and have been transported to this basin from distant localities, by rivers or other currents, and meeting here the quiet waters of what was then an arm of the sea, were allowed to settle to the bottom, gradually filling up the basin. The shallow nature of the basin is shown in the black clays, which are chiefly colored with organic or vegetable decay, and in the beds of lignite and the decayed leaves in the clays.

The deposition of these dark clays seems to have been followed by a sinking of the region, producing river currents, which swept away the beds in the central part of the region, north to south; again followed by a season, or alternating seasons, of rest and disturbance, during which beds of white clays and of sand were deposited. Such seems to be, in brief, the history of the deposition of these beds during the Cretaceous, Tertiary, and early Quaternary times, after which the heavy deposits of gravel and loam were made, which now cover the entire region.



*Uses of Clay.*—The uses to which clay can be put are dependent upon its character and composition; and its value is dependent upon these uses, and also upon its abundance, as well as the transportation facilities, and the ease with which it can be extracted from its bed.

The following list of articles that are manufactured from clay, together with the methods of manufacture, is taken from the "Report on the Mineral Resources of the United States," by the United States Geological Survey:

### ARTICLES MANUFACTURED FROM CLAY.

I. Building materials:
   1. Common building brick.
   2. Front building brick (pressed brick, molded intaglio, or ornamental brick).
   3. Hollow brick.
   4. Glazed brick.
   5. Roofing tile.
   6. Flue linings.
   7. Door knobs and hardware porcelain.
   8. Terra-cotta lumber.
   9. Hollow tile, fire-proofing or castings.

II. Refractory materials:
   1. Fire brick.
   2. Gas retorts.
   3. Retorts for zinc works and for other metallurgical purposes.
   4. Glass pots.
   5. Stove and zinc linings.
   6. Chemists' and assayers' utensils.

III. Pottery:
   1. Stoneware.
   2. Earthenware (yellow ware, Rockingham ware).
   3. Granite or ironstone ware.
   4. White ware.
   5. Porcelain (as part of the mixture).

IV. Ornamental ware:
   1. Encaustic tile, for walls and floors.
   2. Ornamental pottery.
   3. Ornamental terra-cotta.

V. Miscellaneous:
1. Sewer pipe.
2. Drain pipe or drain tile.
3. Flower pots.
4. Garden border edging.
5. Telegraph insulators.
6. Well tubing.
7. Receivers for acids.
8. Water filters and coolers.
9. Lamp stands.

Clay is also largely used in furnace work for luting, for weighting and sizing paper, and in making alum; while the yellow and red ochreous clays are used as paints.

### METHODS OF MANUFACTURE.

The following are extracts taken from the U. S. report just mentioned, in which the methods are selected from official reports made on the industries in the different States, chiefly Ohio and New Jersey, and exact details are given. The most important of these methods are now presented in this chapter for the benefit of any persons in the Purchase counties who may be interested in such manufactures.

*Common Brick.*—"There is a great variety in the quality of brick produced in different localities, due to differences in the clay used, and to the care taken in manufacture. Clay carrying a large amount of lime is generally avoided, as this would be made caustic in burning, and upon subsequent exposure to the weather would be hydrated, and cause the brick to crumble."

In the Purchase counties, only the clayey brown loam that underlies the soil of the uplands is used for brick, and the ordinary methods of making are employed, such as mixing into a pasty mass in a crude manner, molding in boxes by hand, drying in the yard, and stacking and burning. It is unnecessary to go into detail, as the methods are well known.

*Front Building Brick.*—"The general operations are similar to those followed in making common brick, but a better



quality of clay is required, and all the operations are more carefully performed. Pressed bricks are produced by a combination of the hand and machine processes. The molding is usually done by hand, the green bricks being molded larger than the size required, and then compressed to it in a brick press. The molding sand is an important item in making the bricks, as their color and smoothness depend upon it. The molding, pressing, and drying are entirely done under cover, and the bricks are laid on their faces in drying, instead of being put on edge, as is done with common ones. They are put in the kilns with great care, common brick being used to make the arches, and four or five courses of them being laid over the arches before the pressed brick are piled. The ends and edges of the kiln are also covered with pressed brick, and after it is filled, common brick are put on the top. The firing is conducted slowly and with care, ten or twelve days being the usual length of time required, and when burned, the kiln is slowly cooled. After cooling, the bricks are sorted, and defective ones are rejected."

*Terra-cotta Lumber.*—"A kaolinite, or clay without grit, unmixed with sand or sandy clay, is mixed with sawdust, worked by machinery into slabs, burned, sawed and dressed, and in this condition is ready for market. It is claimed that it is indestructible by fire, water, frost, acids, gases or age. It is a very poor conductor of heat, dampness and sound, and is said to expand and contract but little under changes of temperature. Its weight is put down as one-half that of brick, two-thirds that of marble or granite, and one-seventh that of iron; and it can be worked with edge tools, bored and sawed, and holds nails like timber."

*Fire-brick.*—"While common brick can be made from the poorer grades of clay, containing such impurities as iron, lime, magnesia, soda and potash, fire-brick demand a clay of great purity, and their refractoriness depends in a large measure upon this purity. The reason for this is evident, since if iron, lime, magnesia, soda or potash were present, they would, at the high temperatures to which the finished brick is to be exposed, form fusible compounds with the

silica present, and the brick would be destroyed. Makers mix with such pure clay a certain amount, varying with the formula of the individual makers, of calcined clay and coarse sand, or so-called feldspar. The clays and flint for the mixture being selected, they are thoroughly mixed by grinding them together. This grinding is done in different ways in the districts. A common method is that in which the charge is introduced into a large circular cast-iron pan, which revolves on an upright axis. Two or more large cast-iron wheels, which turn on a horizontal axis, are put in the pan. As it revolves, the wheels turn and crush and mix the clay. Water in proper amounts is introduced during the operation, and the grinding is continued until the feeling of the mass shows the workmen that the proper consistency has been reached. After grinding, the clay is molded, either by hand or machines, like common brick. The hand-made brick are then pressed in a steel brass-lined chamber by lever power. The machine-made ones are not pressed. The pressed brick are now dried, either in covered sheds in the open air, or in chambers heated for the purpose. After they are sufficiently dried they are piled in the kilns, being separated from each other by layers of non-vitrifiable sand. The time required for burning is about six days, and the firing is conducted with the utmost care, as upon it the perfection of the brick largely depends. A low fire is used at first, increasing gradually until the proper temperature is reached. The fires are kept at this for several hours, and are then drawn, and the kiln is allowed to cool for three or four days before opening. The kilns used are of various kinds, some makers preferring up-draft and some down-draft, and their size depends on the extent of business carried on."

*Gas Retorts.*—"The clay used in making these retorts must be able to stand strong heat without tendency to soften, since they have to sustain their own great weight and also that of the charge they contain. Great care is exercised in compounding the mixture from which they are made. The failure of a retort would entail a considerable loss, aside from its own cost. Calcined clay is used in large amounts, but it is more finely crushed than for fire-brick, and requires



a very good and plastic bond clay. The retort is shaped from the tempered clay by filling the space between a large sheet-iron shell and a wooden core. The shell is placed in position and the floor covered with clay four inches deep and tamped. The core is then introduced and adjusted so that it is separated from the walls on all sides by a space of four inches. The clay is then filled in in small amounts, and gently tamped. When the retort is high enough, the core is withdrawn by a crane, and the mouth of the retort is made by hand. The shell, which is made in two sections, is then unbolted, and the finished retort is left standing on end. It is left in this position to dry for several weeks, and is finally removed to the kiln to be burnt. Burning is done in ordinary fire-brick kilns, and bricks are piled about the retorts to keep them in place, and from sagging. Retorts for zinc works and for other similar purposes, are built in like manner."

### POTTERY.

"Before giving the methods used in manufacturing pottery, it is necessary to define the various kinds given in the preceding list, made in this country. The compact and concise definitions used in the Ohio report are quoted: 'Stoneware is the product of an unmixed, natural clay, burned at high enough heat to oblige the impurities to combine with free silica, and thus cause an incipient vitrification or fretting, without loss of shape. It should be impermeable to water without any glazing on it; but it frequently fails in this point. Its color is bluish-grey, and is due to combined iron.'

'Earthenware is a product of very similar clays, burned too lightly to vitrify the body or combine the iron; it is of a yellow or red color, from the free iron, and is porous unless glazed.'

'China (the iron-stone china made in this country) is a mixture of several clays with powdered silica, and enough potash feldspar to make the body vitreous on burning. Porcelain is made in the same way, but in very different proportions of material; white iron-stone china is thick and opaque; porcelain is often as thin as an egg-shell, and nearly

clear enough to be called translucent. China is of a dead or bluish-white color, while porcelain is of a creamy-white tint.'

*Stoneware.*—'The operations are: (1) Wetting the clay; (2) grinding; (3) wedging; (4) turning; (5) drying; (6) slipping; (7) burning; (8) sorting the product. In very many places the clay is put in a bin before using, and allowed to stand over night after drenching with water. This precaution is well taken in small works where horse-power only is used in grinding. In the largest steam works it is unnecessary. The grinders for stoneware clays are of several kinds; the simplest is a pug-mill. The next machine has no specific name, but is the one in use in all the country potteries.'

"It is a square frame, pivoted on an upright beam, which runs through the point of crossing of the diagonals, on the projecting ends of which are fastened cart wheels, which work in a circular trough beneath. The whole frame revolves by the motion of a large frame above, which receives its power from the horse or engine. The motion is slow, but by weighting the corners of the frame the wheels in their revolution manage to cut the clay to pieces quite effectually. Such a machine, which can easily be made by any village mechanic, can grind from one thousand two hundred to one thousand five hundred pounds at a charge, and will occupy about two hours in doing it. This amount of clay will make from one hundred and eighty to one hundred and ninety gallons of ware. The clay, after grinding, is balled into large masses, and wet-blanketed to keep until used. The clay, after being ground, is put through a process called 'wedging.'

"This treatment is supposed to eliminate blebs, or spaces in the clay, and any larger pieces of foreign matter. When wedged, it is rolled up into wads or balls, which have a definite weight for each kind of ware, and is then ready to be turned." Turning will be described later under white ware. The articles made are crocks, fruit jars, jugs. milk pans, churns, etc. As fast as the ware is made it is dried. In small potteries this is done in the sun, but in the larger ones the ware is piled on shelves in a room artificially heated. The dry ware is next "slipped." This term means



the covering of the ware with any wash or solution. The slip used with stoneware is made by stirring a very fine-grained clay into water. The ware, when dipped into this, receives a thin coating of the suspended clay, and this coating, when heated in the kiln, vitrifies and gives a glassy surface. The color of the glaze depends on the composition of the clay used in the slip. That containing alkalies and alkaline earths only, with silica, would give a light-colored glaze, while that containing iron would give a darker color."

A partial analysis of the Albany, New York, slip, as given in the Ohio report, shows the following composition:

| | |
|---|---|
| Sesquioxide of iron | 1.43 |
| Potash | 3.17 |
| Soda | .74 |
| | 5.34 |

There is present also a large amount of carbonates of lime and magnesia, which are undetermined.

"The main trouble to be overcome in the use of slip glazes is a tendency to blister or blubber. The cause of this is not definitely known. Every potter has his theory. The opinion of several of the most intelligent has been, that undue haste in burning is the most frequent cause, and that the wares should be heated to a low red-heat for several hours before any higher heat is attempted, after which raising of the heat can do no harm."

*Earthenware.*—The character of the clays used in making earthenware is nearly the same as that used for stoneware. "In some places the same clay is made into both kinds of ware, the only differences between them being in the processes employed. Generally, however, the clay for earthenware should carry less sand, and any iron present should be disseminated uniformly through it. The clay is allowed to slack in the air, after mixing, for a time sufficient to partially weather it. It is then washed, by which it is freed from sand and impurities, the clay remaining in suspension, and poured off into vats, where it is allowed to settle. By this washing

the clay also becomes uniform in color. The washed clay is allowed to dry in the vats on long exposure, or the water is pressed out of it by subjecting it to great pressure in bags. After the clay is pressed it is rolled into a wad, and still in a moist and plastic condition, is put in a close room, and piled and covered with blankets until it is used. The next step is 'wedging' or 'slipping.' A block of both colors, about 12 by 12 by 6 inches, is cut and sliced up by a wire in six or eight layers each. They are filled alternately into a new block one foot cube. This is then lifted and thrown down with violence to consolidate the layers. It is then cut and welded again by a blow, and so on until the colors are marbled in fine alternating streaks. The clay is then ready for the potter. There are three methods in use for fashioning the numerous articles made from clay, viz: throwing, press-work and casting. The former is used chiefly in making earthenware, the latter two in making white ware and porcelain. 'The first and most ancient is that of throwing, in which the thrower or jigger throws down a lump of clay upon the revolving table of his lathe. Using both hands, he works the lump into the shape of a rude cone, and then flattens the mass within a few inches of the table, the object of his operation being to force out any air bubbles that may remain in the clay. By means of his hands and fingers, and referring constantly to measuring sticks, he fashions the vessel according to a model or after his own fancy.'' This method is in use in all of the potteries throughout the counties of the Purchase.

"Press-work is done in moulds of plaster of Paris, one-half of the pattern being formed on one side of the mould, and the other half on the other side. The two moulding pieces are then accurately fitted together. Handles are moulded separately, and fastened on with slip. Casting is done for articles of very irregular shape. The two halves of the mould are fastened together, and slip is poured in until the cavity is quite full. As the moulds are previously thoroughly dried, the absorbent power of the plaster soon attracts the water, and makes the coating of the clay next to it stiff and doughy. When the liquid is poured out this doughy coating remains. If each half has been cast separately, as is usually the practice, the halves are allowed to dry to the green or most tenacious state, and are then joined with slip. This method is that usually employed in moulding porcelain."



"The ware, now being formed, is next put in seggars for burning. Seggars are vessels of fire-clay, in which all the articles, except the most common earthenware, are burnt. They are made of clay slabs, roughly cut with a spade, and worked with a mallet over an oval form. The bottom is put on separately, and the seggar is burnt before it is used. In earthenware making, the seggars are filled, the pieces being separated from each other by pins or cockspurs, and the covers are luted on. They are then piled in the kilns one above the other. After the kiln is filled, the openings are luted, and the fire is started; at first slowly, and gradually raised; the firing generally occupies forty-eight hours, and about the same time is required in cooling down. When cool, the seggars are removed, and the biscuits taken out. The biscuit is very porous, and when dressed of all prominences is ready for the glaze.

'The theory of the glazing of pottery is very simple, but in its application lies the excellence of one ware over another. There are certain substances that have the power of fusing under heat in the presence of free silica to a clear, transparent silicate, of which glass is a type. To make a potter's product useful, it must have its tendency to absorb liquids removed, which is done by wetting the biscuit ware with a substance which will fuse to a clear glass with the silica of the clay, and give a smooth, imperishable finish to the work.' The alkalies, borax, lead, etc., are usually employed in the glazes; the proportions and the constituents for each glaze being usually kept secret by the potter. The glazes for yellow ware are usually made of litharge, flint, spar and paris white, mixed in a vat with a thin slip of pure clay, to keep the heavier bodies from settling out."

*White Ware and Porcelain.*—"The main distinction between the yellow ware and white ware manufacture, is in the preparation of the clay 'body.' This 'body' or mixture

of clays, flint, and spar, to be used in the moulds, is the great secret of each establishment. Usually not more than two men in the works know it. The clays chosen are selected with reference to plasticity, shrinkage, liability to crack, color, etc.; in a mixture, at least one light clay is employed, and the aim is to keep the mixture of clays as light in tint as may be, and still secure the other qualities necessary. The flint is used in the finest state of division, and is perfectly white, as is also the spar. The body mixture of kaolin alone would, if heated, be liable to crack without apparent cause, and would be infusible at the heat applied. By adding silica, which sometimes forms nearly one-half the mixture, the body is very much whitened, and the clay is much more like a stoneware clay in composition, and is prepared to vitrify on heating; but because of the purity of the reagents, there is nothing present to cause vitrification with the free silica. Should this body be burned, all tendency to shrink or crack would be gone, but the bond would be very slight that would hold the mass together; a blow on a thin edge would give a dull wooden sound, which well illustrates the lack of close union between the particles. By adding spar the mixture is complete; the color is corrected by the flint, as well as the tendency to shrink and crack, and with the presence of the spar, the burning immediately causes a thorough vitrification of the whole mass to a homogeneous solid, with a slightly glassy fracture. A blow now would give a clear, ringing sound. The glazes used in white ware are much more complicated than for yellow ware, and require, perhaps, the most skillful work of all to get just right; there is more value placed on the composition of a good glaze than any secret about a pottery, even including the composition of the body."

"The white ware made in our potteries is graded as: (1) ironstone china; (2) majolica; (3) C. C. ware, a grade of white ware made from poorer clays, and cheaper and inferior. China differs from majolica much as yellow differs from Rockingham ware, in finish and glazing alone. The glazes used in majolica are applied after the first or body glaze, in a soft pasty state and in dabs, which would presage a



very rough appearance when finished; but on heating they melt and flow over the ware, making an effective play of color. The colors used are in the glaze, and differ from all other styles in being neither beneath nor above it."

"In the decoration of glass, pottery, enamels, etc., the coloring agents used are the metallic oxides, these being the only bodies whose coloring effects would last at the temperature used. The forms in which these oxides are used are called enamel paints, and are mixtures of the requisite oxide, with suitable bases and fluxes, so that on heating, the latter unite to form a glass which receives its color from the accompanying oxide. There are several well-marked styles of pottery decoration now used, such as painting, striping, and hand-painting and printing. The decoration is usually placed upon the already glazed ware."

*Ornamental Terra-Cotta.*—"The clay used is a gritty, plastic one, and no special care is taken in preparing it, save that it is thoroughly ground. Terra-cotta proper burns in the kiln to a hardness that give the articles, when struck, the ring of iron. The clays are more or less largely colored with oxide of iron. According as this is present in greater or less color, the ware produced is red, buff or brown in color. The clay is pressed with the hand into the mold, and the objects are afterward finished by hand.

Terra-cotta is used for making chimney tops, outside and inside ornamentation for buildings, lawn vases, statuary, etc."

*Encaustic or Enameled Tile.*—"The clays are washed and beaten up to a slip, the necessary metallic oxides added to give them the desired color, then strained, evaporated to a paste, and stacked in open cribs in a steam-heated room until perfectly dry. It is then reduced to powder, and uniformly moistened, and is then molded. The simplest tiles are made from clay of one color, and the process consists in stamping so much clay powder into a confined space, and consolidating it by enormous pressure. Next come the tile made of two colored clays. The first stamping makes the body, but leaves indentations in its surface, into which the second clay is put, and this is pressed into place. The tile is then scraped to get a cleanly-drawn line of both colors,

and again stamped with a flat die. They are dried in steam-heated closets for as much as six weeks after forming, in order to insure their perfect dryness before burning. The tiles are sold in the biscuit state, or are glazed, plain colored, or majolica."

*Drain Pipe or Tile.*—Almost any clay that will make good brick can be used for drain pipe. The clay is wet down after being dug, and then ground and delivered to the auger machine. "The auger machine consists of a cylindrical shell of iron plate, inside of which works a screw or auger. A hopper at one end catches and collects the clay as it comes from the grinder, and it is dropped upon the revolving screw. It is caught up and carried forward, and is soon forced out at the other end through the orifice in the die. The machine has a set of dies of from two to twelve inches, and can make any size at will. Besides the circular tile, by alterations in the die, fire-proofing, square tile, perforated brick, etc., can be made. There are a great many styles of auger machines in use. The shaped clay issuing from the machine is cut into lengths, and set on end on the drying floors. The tiles are then dried and burnt."

## CHARACTER OF THE PURCHASE CLAYS.

There are in various parts of the region a number of potteries engaged in the manufacture of the very ordinary brown jugs and jars. These potteries are generally crude, and worked at a very small expense. They are distributed as follows: One at Pottertown, six miles east of Murray, Calloway county; one at Bell City, and another three miles south of Lynnville, in the southern part of Graves county; one at Paducah, in McCracken county, the clay being obtained by flats from beds below Metropolis, on the Illinois shore of the Ohio river; two at Columbus, Hickman county, the clay being in part obtained from the bluffs, two miles below Columbus, and in part from near Wickliffe, in Ballard county. The clays from Wickliffe have also been shipped to Union City, Tennessee, for the manufacture of tiles.

In order to more fully test the value of these clays for the finer qualities of ware, arrangements were made with the Rookwood Pottery, of Cincinnati, by which their adaptability for the decorated wares was ascertained. Average specimens from the most important beds were shipped to the pottery, and the results obtained are incorporated with the report on the respective beds, in the following pages.



The clays are divided into three classes—*refractory*, *unrefractory*, and *ochreous*. The former are specially suited to the manufacture of fire-brick, and similar articles, whose chief property is resistance to the effects of a high heat. Those of the second class fuse to a greater or less extent in a high heat, and are more suitable for various forms of pottery, etc.

The following is an extract from a letter regarding these clays written by Mr. Karl Langenbeck, of the factory of Decorative Art in Terra-cotta, etc., in Cincinnati. Speaking in regard to the establishment of a pottery for making regular table-ware, cups, saucers, plates, bowls, pitchers, etc., he says: "I think it would be a very paying thing, because you have raw material equal to the finest in England; the articles have a constant and ready sale, and are subject to heavy freight rates in transportation from New York, Trenton, or East Liverpool, so that they should be produced near a market, and Kentucky is known as a good market. The practical experience I have had with the clay from Russell's, near Murray, and with other clays of the district, have taught me their peculiarities, and I can freely say, that from their great plasticity, they are most easily and cheaply worked, and from their binding qualities, entail less loss in the kiln than any others I have ever met with. The Russell clay, with the addition of some flint, makes a very beautiful ivory-ware, almost exactly resembling that made by the celbrated firm of Copeland & Sons, in England, for table and toilet sets."

### REFRACTORY CLAYS.

The majority of the clays of this part of the State have been found to be highly refractory when tested before the blow-pipe, though many of them contain high percentages of iron and potash, on which their fusibility depends. They

vary in color from nearly white to black, and are more or less sandy in their character. They are found in all of the counties, and in beds varying from two to many feet in thickness. Samples from many of these localities have been analyzed, and the results are given below, preceded by a description of each bed. For convenience the clays are divided into the following groups: *Drab Clays of the Hickman Bluffs*, *Siliceous Clays* of the *Columbus Bluffs*, the *White or light-colored plastic Clays*, and the *Black or dark bluish-black Clays*.

*Clays of the Hickman Bluffs, Fulton County.*—The bluffs rise about one hundred and eighty feet above that portion of the town lying on the river bank, and, as shown in the section on page 38, comprise sixty-five feet of loam and silt, and eleven feet of gravel and sand above the clays. The succeeding beds downward comprise clays, clay-stones, and joint clays, varying from each other somewhat in composition, and in their refractory character. In the following table of analyses, these beds are placed and described in descending order, the first two numbers being of specimens taken from the bed immediately underlying the gravel, but one-fourth of a mile apart.

No. 2137. *Greenish, sometimes bluish sandy refractory joint clay*, taken from beneath the gravel bed, one-fourth of a mile north of Hickman, Fulton county. The clay is quite plastic, burns hard, and of a light greyish-buff tint. Before the blow-pipe it fuses with great difficulty. The bed is several feet thick.

No. 2136. *Greenish, sometimes bluish sandy refractory joint clay*, taken from beneath the gravel bed, in the bluffs in the upper part of Hickman, Fulton county. The dried clay is of a light grey tint, colored in parts buff and ferruginous. It is moderately plastic, and does not calcine very hard, acquiring a handsome light brick color. It is refractory before the blow-pipe. The clay crumbles easily, and has a thickness of about six feet.

No. 2139. *Soft crumbling clay-stone*, refractory, greyish, and somewhat sandy, forming a ledge under the preceding



about two feet thick. It is somewhat ochreous and quite plastic. It burns hard, of a light grey-buff tint, and before the blow-pipe it fuses with difficulty.

No. 2140. *Slate colored or bluish refractory joint clay*, from the Hickman bluff, and underlying the preceding. It is lilac-grey when dried, somewhat ochreous, quite plastic, and burns quite hard to a light brownish tint. It is quite refractory before the blow pipe. The bed is several feet thick.

No. 2138. *Greenish clay-stone and green refractory clay*, from the Hickman bluffs, and underlying the preceding. It is banded with yellow ferruginous lines, crumbles easily, and in places is quite solid. The dried clay is light grey in color. It is quite plastic, calcines to a light brick color, and is quite refractory before the blow-pipe. The bed is about ten feet thick.

No. 2141. *Greenish indurated and refractory joint clay*, from the lower portion of the Hickman bluff, and separated from the preceding No. 2138 by eight feet of massive slate-colored clay-stone, having a jointed structure, and in places holding masses of dark opal. The clay on drying assumes a light olive-grey color. It calcines quite hard to a brownish-buff color, and is quite refractory before the blow-pipe. The bed is at least fifty feet thick, passing below the level of the alluvial plain. This clay has not been found elsewhere within the Purchase counties than along the bluffs southward to the Tennessee line.

No. 2135. *Greenish refractory clays*, from the bluffs at Hickman, ninety-five feet above low water. This is the same bed as that of No. 2141. The dried clay is of a light grey tint, considerably mottled with light brownish ochreous material. It is quite plastic with water, calcines to a reddish buff color, and is refractory before the blow-pipe, but sintered somewhat.

No. 2134. *Indurated clay* from the bluff at Hickman, forty-five feet above low-water. This is also of the greenish clay bed No. 2141, but contains more iron. It is quite plastic with water, calcines to a light buff color, and fuses before the blow-pipe into a grey slag.

CLAYS OF THE BLUFF AT HICKMAN, FULTON COUNTY.

| Air Dried. | Beneath the Gravel. | | Descending order beneath No. 2136. | | | | Above low water. | |
|---|---|---|---|---|---|---|---|---|
| | ¼ mile N. of Hickman. | Refractory Clay, Hickman. | Unrefractory greyish Clay. | Refractory Clays. | | | | Unrefractory clays |
| | | | | Bluish joint clay | Greenish yel. clay. | Greenish joint clay | 95 ft. | 45 ft. |
| | No. 2137. | No. 2136. | No. 2139. | No. 2140. | No. 2138. | No. 2141. | No. 2135. | No. 2134. |
| Silica | 71.340 | 83 380 | 71.080 | 74.100 | 83.500 | 77.960 | 76.860 | 64.800 |
| Alumina | 17.190 | 9.800 | 19 050 | 16 460 | 9.940 | 13.970 | 14.600 | 21.070 |
| Iron peroxide | 2.770 | 2.120 | 2.810 | 2.700 | 2.500 | 2.390 | 3.020 | 5.270 |
| Lime | 1.612 | .963 | .627 | .358 | .358 | .134 | .425 | 1.400 |
| Magnesia | .209 | .187 | .403 | .187 | .173 | .163 | .308 | .050 |
| Potash | .925 | .617 | .578 | .559 | .539 | .797 | .736 | .646 |
| Soda | .232 | .118 | .225 | .135 | .109 | .124 | .257 | .202 |
| Water, etc. | 5.722 | 2.815 | 5.227 | 5.501 | 2.881 | 4.462 | 3.794 | 6.562 |
| Total | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 |

Dr. Peter says of these clays: It is evident that the Tertiary bluffs, from which these clays were collected, offer some valuable materials to the industrial arts. Some of these are quite refractory in the fire, especially Nos. 2136, 2138, 2140, and 2141, and would, probably, make good fire-bricks, etc.; others of them could be employed for terra-cotta work and other forms of pottery, while some of these abundant deposits might, no doubt, be used with advantage, in mixture with the more calcareous soft material found in some of these beds, in the manufacture of hydraulic cement of the character of the celebrated Portland cement.

*Clays of the Columbus Bluffs.*—The bluffs that face the Mississippi river at Columbus, and at the "chalk banks" two miles below, rise more than one hundred feet above the town, the upper portion composed of thirty feet each of grey silt or loess and gravel. Beneath the gravel there is a bed of variegated colored plastic clay, fifteen feet in thickness. Beneath this there are about eighty-five feet of siliceous clays, bluish when freshly exposed, but on drying become greyish and highly indurated. The bed incloses fragments of stems, bark and leaves, and belongs to the lignitic division of the Tertiary formation. The bed in the Columbus bluff is not continuous, but has been cut away in that portion lying nearest the town, and its place filled with thin beds of clay and indurated sands of the Lagrange group.



It also forms the bluff that rises immediately from the water's edge at the "chalk banks." The three analyses that are given below are of this bed, and Dr. Peter reports that they are all very infusible before the blow-pipe, and burn hard to a light cream color. Their refractory character in the fire makes them useful for fire-brick, though the high percentage of potash probably unfits them for use in glass works where an extreme heat is employed. Their fine siliceous character might also make them useful as a scouring material.

These clay-beds are exposed in the bluffs east of the town; the siliceous clays in the deep ravine by the Clinton road, and the upper plastic clays in the face of the bluff, south of the railroad cut, and by the road leading down the edge of the bottom. At the "chalk banks," the siliceous fire-clays have again been cut away on the north side, and in their place we find the interstratified beds of fine plastic clays and white sand.

The same is true of the bluffs north of the Columbus exposures, none of the siliceous beds having been observed until a short distance beyond Laketon, after which they are seen occasionally as far as Wickliffe, and northward to Cane creek. Belonging, as they do, to the lower or lignitic Tertiary formation, we naturally find them, further east, associated with the belt of dark clays in McCracken and Graves counties. Analyses of specimens from several localities are given below.

No. 2715. *Fire-clay*, from the bluff above Columbus, Hickman county; taken sixty-five feet above low-water. It is plastic, and owes this property to the state of very fine division of the large quantity of siliceous sand which it contains; its 10.260 per cent. of alumina being equivalent to only 25.920 per cent. of kaolin, the basis of true clay.

No. 2162. *Clay*, from the bluffs in the upper part of the town of Columbus, Hickman county. This is the same bed as the preceding; is of a light grey color, almost white, and quite sandy. It is plastic, burns hard, and of a light cream color.

No. 2161. *Clay*, from the "chalk banks," two miles below Columbus, Hickman county. It burns hard, is refractory before the blow-pipe, only sintering a little.

WHITE AND SILICEOUS REFRACTORY CLAYS OF HICKMAN COUNTY.

| Air Dried. | Bluffs north of Columbus. | | Chalk Banks 2 miles south of Columbus. |
|---|---|---|---|
| | No. 2715. | No. 2162. | No. 2161. |
| Silica | 85.180 | 84.918 | 76.360 |
| Alumina | 10.260 | 10.560 | 14.951 |
| Iron peroxide | 1.120 | 1.102 | 2.109 |
| Lime | trace. | .572 | .325 |
| Magnesia | .064 | .108 | .173 |
| Potash | .954 | .651 | 1.171 |
| Soda | .146 | not est. | .125 |
| Water, etc. | 2.276 | 2.089 | 4.786 |
| Total | 100.000 | 100.000 | 100.000 |
| Sand | ..... | 68.500 | 69.000 |

The clays from the bluffs north of Columbus are the most refractory, and, in composition, compare well with the German glass-pot clay—containing less iron and a little more potash. The alumina percentage is low, though, perhaps, sufficient. At any rate, the clays of both Columbus and the "chalk banks" are fully worth a trial at an intense heat.

*White or light colored Plastic Clays.*—These are found in greater or less beds in each of the counties, but belong especially to the formation known as the Lagrange group of the Tertiary, and were deposited since the deposition of the black clays. They are usually white or light purple in color, highly plastic when dry, adhering strongly to the tongue, and when cut present a very smooth, unctuous surface. The beds vary in thickness from a few inches to many feet. The chief localities of occurrence are as follows:

No. 2640. *White Pipe-clay*, from Rufus Morris' place, three miles east of New Providence, Calloway county. It is overlaid by about ten feet of loam and gravel. The bed is made up of two inches of clay, then two inches of a white sand,



overlying another bed of about eighteen inches of white clay, which rests upon a thin layer of ferruginous sandstone. The latter separates it from the bed of black pyritous clay, No. 1866, described elsewhere. The thickest part of the bed contains small pockets of a fine white sand, and occasional spots of ochreous clay. This clay, at the Rookwood pottery, made a white biscuit when unglazed, but, on being glazed, became of a brownish-white color, unsuited to the finer classes of ware.

No. 2643. *White Plastic Clay*, from Russell's pottery, six miles north-east of Murray, Calloway county. A section of the bed shows the following: a surface covering of six feet of brown loam, four and a half feet of sandy clay, one foot of white clay, one and a half feet of black clay, and three feet of fine white clay, underlaid by brownish sandy clay and yellow micaceous sand. At the Rookwood pottery, this clay made a beautiful, light cream-colored ware. Dr. Langenbeck says of this clay: "With the addition of some flint, makes a very beautiful ivory-ware, almost exactly resembling that made by the celebrated firm of Copeland & Sons, in England, for table and toilet sets." It requires a high heat for burning, and would be improved by mixing with other clays.

No. 2639. *White Clay*, from one mile east of Wyatt's school-house, in the north-west corner of Calloway county. This clay is very white, has a few ochreous spots, and is exposed at a number of points in the bank of a creek beneath a few feet deposit of gravel and loam, and in beds from three to ten feet thick, its true thickness being unknown. It outcrops also in the bluff at Backusburg. In places it has a bluish and in others a pinkish tint. The upper eighteen inches of the bed is usually of a mottled character, but altogether is highly plastic. The beds here belong to Messrs. Sanders, Keen and Jackson; quantities of the clay have been shipped to the Evansville stoneware potteries, but the yellow ferruginous spots unfit it for such white ware. The Rookwood trials produced a brownish-white color when glazed.

No. 2666. *Clay*, from Howard's pottery at Bell City, Graves county. The clay is of a light brownish-grey color with yellow ferruginous spots, and with some purplish, round and hollow concretions. It is infusible before the blow-pipe. The bed is from six to ten feet thick, and is used here in the manufacture of the ordinary brown jugs, jars, etc. It burns at a moderate temperature, and, with a white slip-clay, would make cream-colored ware.

No. 2663. *Stiff Plastic Clay*, from Pittman's bank, three miles west of Lynnville, Graves county. The clay is very fine, of a brownish-grey color, and infusible before the blow-pipe It is used by Mr. Pittman at his pottery, two miles south of Lynnville, but its very stiff and intractable character compels him to mix with it a silty clay found in the hill-sides near the pottery.

The clay bed is very massive, its fresh, vertical surface showing very pretty lamination markings. The bed is exposed for ten or fifteen feet in thickness, is partly purplish in color, and holds some thin layers of a fine sand. The tests at the Rookwood pottery show a shrinkage of about ten per cent.; the unglazed biscuit is milky-white, but the glazing gives to it a brownish color.

No. 2141. *Clay* from Wm. P. Arnett's land on Panther creek, six miles east of Mayfield, Graves county. The bed is exposed for about eight feet above the water, a bed of lignite appearing below the water at a point near by. The clay is bluish when wet but grey when dry, and is quite sandy. It is quite plastic, and burns to a light salmon color; does not become very hard unless exposed to a very high temperature. It is refractory before the blow-pipe.

No. 2573. *Fire-clay*, from the bank of the branch near the stave factory at Wickliffe, Ballard county. This bed is exposed for a thickness of ten or twelve feet, and underlies a thin bed of lignite. It is again exposed in the bluffs between Wickliffe and Fort Jefferson. It is dark-grey in color, highly siliceous, with more than fifty-three per cent. of fine sand, and fuses with difficulty before the blow-pipe; it calcines white. The Rookwood pottery-tests show that



it burns with moderate heat to a buff or light yellowish-brown color, and would make the Rockingham ware.

No. 2568. *Refractory White Clay*, from one-half mile north-west of Blandville, Ballard county. It is quite plastic, contains no appreciable coarse sand. It is infusible before the blow-pipe, and calcines white.

No. 2104. *Refractory Clay*, from near Moore's mill, one mile south-west of Blandville, Ballard county. It is exposed in the foot of the high bluffs that face the bottom lands of Mayfield creek. A bed of lignite overlies it at another point. When freshly exposed it is bluish in color, but dries to a light grey color, nearly white, but with some yellow ochreous spots. It is quite plastic, calcines to a light salmon color, and is quite refractory before the blow-pipe. It contains nearly forty-eight per cent. of white sand, which was so fine that it was somewhat plastic while wet and adherent when dry. The shrinkage of this clay, as shown by tests at the Rookwood pottery, is about fifteen per cent., and the ware made from it is colored dark buff or yellowish.

No. 2571. *White Plastic Clay*, from the banks of Cane creek, two miles north of Wickliffe, Ballard county. This is silty in character, but quite plastic, as shown in the large percentage of alumina present. The bed has a thickness of several feet. It contains much fine white opaque sand; is infusible before the blow-pipe, and calcines white. It would make a good fire-brick, containing, as it does, comparatively little iron and potash in its composition.

No. 2105. *Clay* from the farm of T. D. Campbell, near Laketon, Ballard county. It has a light purplish-grey color, with a few ochreous specks, and somewhat sandy. It is quite plastic, decrepitates strongly when exposed to heat, unless it is thoroughly dry. Calcines hard, and before the blow-pipe is quite refractory.

No. 4. *Clay* from Mr. Samuel's farm, four miles south of Blandville, Ballard county. Exhibits minute spangles of mica under the lens; heated before the blow-pipe, it becomes first dark colored, then burns white.

No. 2570. *Plastic Clay*, from Geo. Ryan's place, on the north bluff of Little Mayfield creek, four miles north-east of Milburn, Ballard county. It is exposed in a number of places along this bluff, with a thickness of four feet. It is very stiff, and contains some fine sand. It is infusible before the blow-pipe, and calcines to a light-grey color.

No. 2569. *Bluish Plastic Clay*, from a ravine near the road, three miles east of Blandville, Ballard county. On drying, it is of a light buff-grey color; contains no coarse sand. Before the blow-pipe it fuses with difficulty, and calcines to a light grey color. It has an observed thickness of about three feet, and underlies a bed of red sand.

No. 2759. *Micaceous Clay*, from the place of F. N. Burradell, five miles north of Benton, Marshall county. It occurs in layers with white sand, and is interspersed with small pockets of the sand, but otherwise is quite plastic. It outcrops in several places, but its thickness is not known. It is infusible before the blow-pipe, and calcines hard. Washed in water, it left 70.33 per cent. of fine whitish sand, containing small mica scales. The Rookwood test gave a milky-white unglazed biscuit, which became a rather dark cream color on glazing. Its shrinkage is ten per cent.

No. 2763. *Micaceous Clay*, from J. T. Pugh's place, two miles east of Palma, Marshall county. When freshly exposed it has a light bluish cast, but becomes greyish on drying. It is plastic, and fuses with great difficulty before the blow-pipe. It holds small pockets of a white sand, and has a thickness of several feet. The Rookwood test produced a white unglazed biscuit, which on glazing became a dark cream color. Its shrinkage is about fifteen per cent.

No. 2211. *Clay* from Mr. Munier's, five miles south of Paducah, McCracken county. The bed is massive, and its thickness unknown. The clay is bluish when first exposed, but dries to a light grey color, nearly white, and mottled with a very light ochreous material. It is quite plastic; before the blow-pipe it burnt hard, of a light grey color, nearly white, and finally fused with great difficulty. Tests made in the Rookwood pottery gave a white, unglazed



biscuit, and showed a shrinkage of about fifteen per cent. The clay is exposed on the side of a long sloping hill, and has but comparatively little surface covering of earth.

REFRACTORY WHITE OR LIGHT COLORED CLAYS.

| Air Dried. | Calloway County. | | | Graves County. | | | Marshall Co. | | McCr. Co. |
|---|---|---|---|---|---|---|---|---|---|
| | Morris', east of New Providence | Russell's, 6 miles east of Murray | Near Wyatt's school house | Howard's, Bell City | Pittman's, 3 miles west of Lynnville | Panther creek east of Mayfield | Burradell's, 5 miles north of Benton | Pugh's, 2 miles east of Palma | South of Paducah |
| | No. 2640 | No. 2643 | No. 2639 | No. 2666 | No. 2663 | No. 2141 | No. 2759 | No. 2763 | No. 2211 |
| Silica | 61.680 | 57.840 | 46.020 | 56.980 | 62.680 | 75.550 | 84.580 | 62.920 | 64.480 |
| Alumina | 28.500 | 30.340 | 38.980 | 32.160 | 25.880 | 16.751 | 10.650 | 29.880 | 24.691 |
| Iron peroxide | 1.680 | 1.180 | trace. | 2.160 | 2.900 | 1.198 | .330 | trace. | 1.869 |
| Lime | .101 | .011 | .773 | trace. | trace. | trace. | .137 | trace. | .448 |
| Magnesia | .136 | .050 | .136 | .209 | .319 | .144 | .101 | .209 | .137 |
| Potash | 1.158 | .618 | .309 | .838 | 1.147 | 1.094 | .954 | 1.564 | 1.457 |
| Soda | .822 | .519 | .172 | .111 | .928 | .216 | .292 | .172 | .083 |
| Water, etc. | 5.923 | 9.442 | 13.610 | 7.542 | 6.146 | 5.047 | 2.956 | 5.255 | 6.835 |
| Total | 100.000 | 100.000 | 100.000 | 100 000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 |
| Sand | .... | .... | 21.00 | 16.440 | .... | 63.000 | 70.330 | .... | .... |

REFRACTORY WHITE AND LIGHT COLORED CLAYS.

| Air Dried. | Ballard County. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Wickliffe | Blandville | South-west of Blandville | Cane creek, north of Wickliffe | Campbell's, near Laketon | Four miles south of Blandville | Four miles north-east of Milburn. | Three miles east of Blandville |
| | No. 2573 | No. 2568 | No. 2104 | No. 2571 | No. 2105 | No. 4. | No. 2570 | No. 2569 |
| Silica | 73.240 | 74.840 | 74.460 | 63.840 | 67.501 | 71.940 | 76.540 | 71.180 |
| Alumina | 15.760 | 16.580 | 18.070 | 26.040 | 23.051 | 20.700 | 14.820 | 20.800 |
| Iron peroxide | 1.920 | 1.400 | 1.633 | .740 | 2.109 | trace. | .960 | 1.780 |
| Lime | .325 | .269 | .314 | trace. | .257 | .370 | trace. | trace. |
| Magnesia | .519 | .209 | 245 | .137 | .065 | .350 | .331 | .101 |
| Potash | 1.467 | 1.293 | .940 | .714 | .412 | .630 | .926 | .247 |
| Soda | .147 | .283 | .021 | .207 | .020 | ..... | .229 | .291 |
| Water, etc. | 6.622 | 5.126 | 4.317 | 8.322 | 6.585 | 6.200 | 6.194 | 5.601 |
| Total | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.190 | 100.000 | 100.000 |
| Sand | 53 490 | .... | 48.000 | 44.060 | ..... | ..... | ..... | ..... |

Of the above clays, that from near Wyatt's school-house, in the north-western corner of Calloway county, is, by far,

the richest in clay, and at the same time contains the least amount of alkalies and iron, and the highest percentage of lime. The bed itself, however, is more or less permeated with light streaks of yellow ochre, which would give to the whole more than a trace of iron. The next in purity, or in freedom from iron and the alkalies, is that from four miles south of Blandville, in Ballard county (No. 4), which contains but little more than half a per cent. of iron and alkalies. The two clays from Marshall county, and the specimen from Cane creek, immediately north of Wickliffe, in Ballard county, come next, with their one and a half per cent., respectively, while in all the other specimens the combined percentages of iron, potash and soda are above two per cent.

A few of the clays contain a very large amount of sand; but this would be separated from the finer material in the process of manufacture of any ware. The analyses are, therefore, calculated upon only the fine material.

*Black and Bluish-black Clays.*—The clays of this division are confined to the Cretaceous and lower or lignitic Tertiary belts that pass through Calloway, Marshall, McCracken and Ballard counties, and also to the Port Hudson division of the Quaternary, which occurs in the valley and bottom lands of the three bordering rivers. The dark color is chiefly due to decayed vegetable matter, which burns out with sufficient heat. The dark color is also intensified by moisture, becoming a lighter black on drying.

The clays of the Cretaceous and Tertiary divisions are very refractory, and would possibly make good fire-brick; but those of the Port Hudson contain so large an amount of iron and potash that they fuse with readiness before the blow-pipe.

No. 2641. *Black Plastic Clay*, from Rufus Morris' place, three miles east of New Providence, Calloway county. It underlies the white plastic clay No. 1865, and its thickness is unknown. On drying, it becomes a light slate color. It contains, in places, much iron pyrites in small rounded grains. It is imperfectly laminated, fine-grained, and its powder is quite soft.

No. 2642. *Stiff Dark Joint Clay*, or so-called "soapstone,"



from the bluff of the East Fork of Clark's river, at the Paris bridge, south of Murray, Calloway county. It is the characteristic clay of the eastern outcrop of the lignitic Tertiary, reaching from the Tennessee State line northward to Paducah, and thence westward to Caledonia, on the Ohio river. Its thickness is, at some points, as much as ninety feet. It is more or less ochreous in character, its fractures or joints being usually permeated with yellow ochre. It is highly indurated and somewhat micaceous. Tests made at the Rookwood pottery indicate that it can not be used for glazed ware because of the shivering of the glaze. It might be successfully used in the manufacture of water jars, which require no glazing. The unglazed biscuit is pink in color. Mixed with an equal weight of the white plastic clay from Russell's pottery, east of Murray, it receives a good glaze, and makes a light chocolate-colored ware, dotted with black specks from the mica particles.

No. 2644. *Dark Clay*, from the place of F. H. Mahan, Esq., six miles east of Murray, Calloway county. The clay is black when freshly exposed, but on drying becomes a purplish-slate color, and contains fine white sand and minute specks of mica. Its depth is not known, but must be many feet. It is here exposed in the side of a long sloping hill, and there are but a few feet of overlying material. The Rookwood tests produced a yellowish-white ware, a little darker than that from Russell's pottery, which is so highly admired. Dr. Langenbeck, who superintended the tests, thinks, that mixed with a little flint it would not require high heat, and would make very pretty cream-colored ware.

The dark color of these clays seems to be due to the vegetable matter, which burns out, leaving a greyish mass. The alkali percentages are about what are found in the other clays, while that of the iron in the specimen from the Paris bridge, near Murray, is very large, showing itself as a yellow ochre in the cracks and seams in the clay. The amount of lime is very small.

REFRACTORY BLACK CLAYS.

| AIR DRIED. | CALLOWAY COUNTY. | | |
|---|---|---|---|
| | Morris', east of New Providence. | At Paris Bridge, Murray. | Mahan's, north-east of Murray. |
| | Black Plastic Clay. | Stiff joint Clay. | Bluish Clay. |
| | No. 2641. | No. 2642. | No. 2644. |
| Silica | 56.680 | 66.380 | 54.140 |
| Alumina | 29.700 | 16.480 | 32.140 |
| Iron peroxide | 1.480 | 3.500 | 1.040 |
| Lime | trace. | .213 | .011 |
| Magnesia | .281 | .497 | .032 |
| Potash | 1.004 | .928 | .965 |
| Soda | .274 | .228 | .468 |
| Water expelled at 380° F. | 10.581 | 11.774 | 11.204 |
| Total | 100.000 | 100.000 | 100.000 |
| Sand | ..... | 39.780 | 39.000 |

COMPARISON WITH GERMAN CLAYS.

A number of our Kentucky clays compare very favorably in their analytical results with the German glass-pot clays, which are so celebrated for their great refractory character. As will be seen in the table given below, the percentages of iron and potash, the injurious ingredients, are comparatively but little above those of the German clays, and in several instances one or the other is much less; while in the Calloway county clay, No. 2639, there is only a trace of iron, a small amount of potash, and very large percentages of silica and alumina, making this a far purer clay than the German; in fact almost a *kaolinite* or hydrous silicate of alumina, a mineral with the composition of—silica 46.3, alumina 39.8, and water 13.9 per cent.

There is but little doubt that these clays can take the place of the German clays in those establishments where they would be required to withstand the most intense heat. They are at least worthy of the trial. Transportation facilities alone are in favor of the German clays, which are brought over as ballast in vessels, and, therefore, at a very low cost to those who use them.



The German fire-clays are supposed to be the most refractory clays known, and are imported for the construction of crucibles to withstand a very high heat, but particularly for our glass manufacturers, who seem to agree that no other known clay will so completely withstand the great heat of their furnaces, and the fluxing influence of the melted glass, as this. It is consequently almost universally used by them as the material for the construction of the glass-pots or large crucibles in which the glass is made and melted. On a visit to the International Centennial Exhibition at Philadelphia, the attention of Dr. Peter, the chemist of this Survey, was attracted to an exhibit of this clay, made by J. Goebel & Co., importers of German clay and manufacturers of crucibles, etc., Maiden Lane, New York. It showed the clay in its natural and prepared conditions, and accompanying the specimens was a report of the chemical analysis of the material, said to have been made in Germany, a copy of which is given below. Dr. Peter also secured a sample from what appeared to be a washed and prepared specimen on exhibition, which had been moulded into a cubical block, and which he has analyzed.

Another specimen was obtained at the co-operative window-glass works, at the foot of Coal Hill, opposite Pittsburg, from a barrel of the material which was said to be in the condition in which it was imported from Germany. Its analysis was also made by Dr. Peter, and is given below.

H. *German Clay*, obtained at the Centennial Exhibition. It is of a light grey color; adheres strongly to the tongue, and exhibits a large irregularly conchoidal fracture. Before the blow-pipe, it fused only on the extremity of the small pointed fragment into a white slag.

I. *German Glass-pot Clay*, obtained at the co-operative window-glass works in Pittsburg. This had not been reworked or washed. It resembles the preceding, but is a little more friable and slightly lighter colored. Its powder, however, is somewhat darker than the powder of that. Before the blow-pipe, it acted like the preceding.

J. *Copy of the analysis* of this clay made in Germany, as exhibited by J. Goebel & Co.

No. 2639. *Refractory Clay*, from one mile east of Wyatt's school-house, in the north-western part of Calloway county, Kentucky.

No. 2162. *Refractory Clay*, from the bluffs at Columbus, Hickman county.

No. 2571. *Refractory Clay*, from Cane creek, two miles north of Wickliffe, Ballard county.

No. 4. *Refractory Clay*, from four miles south of Blandville, Ballard county.

No. 2643. *Refractory Clay*, from Russell's pottery, six miles east of Murray, Calloway county. This clay is pre-eminent for the beautifully cream-colored ware made from it at the Rookwood pottery, Cincinnati, Ohio.

The above Kentucky clays have been described on a previous page, and their analyses given.

COMPARATIVE ANALYSES OF GERMAN GLASS-POT CLAY AND KENTUCKY CLAYS.

| Dried at 212° F. | German Clays. | | | Kentucky Clays. | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Calloway County. | Hickman County. | Ballard Co. | | Calloway County. |
| | H. | I. | J. | No. 2639 | No. 2162 | No. 2571 | No. 4 | No. 2643 |
| Silica and sand | 70.860 | 73.660 | 70 60 | 46 020 | 84 918 | 63 840 | 71.940 | 57.840 |
| Alumina | 20.900 | 19.460 | 23.60 | 38 980 | 10.560 | 26.040 | 20.700 | 30.340 |
| Iron peroxide | 1.560 | 1.560 | . . . . | trace. | 1.102 | .740 | trace. | 1.180 |
| Iron sulphide | . . | . . . . | 1.10 | . . | . . | . . . . | . . . . | . . |
| Lime | .347 | .168 | .36 | 773 | .572 | trace. | .370 | .011 |
| Magnesia | .220 | .209 | .45 | 136 | .108 | .137 | .350 | .050 |
| Potash | .578 | .520 | not est. | .309 | .651 | .714 | .630 | .618 |
| Soda | .112 | .046 | not est | .172 | not est | .207 | . . . | 519 |
| Water expelled at red heat | 6.800 | 6.200 | *3.89 | 13.610 | 2 089 | 8.322 | 6.200 | 9.442 |
| Total | 101.377 | 101.823 | 100.000 | 100.000 | 100.000 | 100 000 | 100.090 | 100.000 |
| Sand | 4.000 | 3.500 | . . . . | 21.00 | . . . . | 44.00 | . . . . | . . . . |

*Organic matter and loss.

## UNREFRACTORY CLAYS.

Clays of this class, which yield more or less readily to the heat of the blow-pipe, and fuse into slag, are found in a number of the counties, but seem to be chiefly confined to those lying on the eastern side of the Purchase region, viz.: McCracken, Graves, Marshall and Calloway; all of those examined on the west being entirely on nearly infusible. They vary in color from nearly white to dark black, some of them highly gypseous, and two others having a sprinkling of specks of the mineral *vivianite*, a phosphate of iron.



Geologically, they are older than the Quaternary, and, as the class of infusible clays just described, are covered by the gravel, sand and brown loam of that period. They embrace some of the white varieties belonging to the intermediate period between the Tertiary and Quaternary, and the black clays of the next higher or Port Hudson group. As will be seen from the analyses given below, they differ from the refractory class in having a larger proportion of potash and iron, which imparts to them their fusible character.

The following are some of the localities examined, and the composition of the clay from each is given below:

No. 2777. *Stiff Clay*, from a deep ravine on the place of W. J. Jones, four miles south of Paducah, McCracken county. The bed has an exposure of several feet, the central six inches of which is very brittle, with some yellow ochre. It is overlaid by fifteen or twenty feet of gravel and loam. When freshly exposed it has a bluish color, which changes on drying to a greyish tint. It fuses with difficulty before the blow-pipe, and calcines white. The Rookwood tests produced a buff-colored unglazed biscuit, and showed a shrinkage of about fifteen per cent.

No. 2779. *Gypseous Clay*, from W. J. Hough's, four miles south-west of Paducah, McCracken county. It has an exposure of about five feet, and contains small pockets of fine needle crystals of gypsum; it is in places somewhat sandy and with ochreous spots. It is exposed in the bank of a branch, and has but a few feet of surface covering of gravel and loam. It calcines white, and fuses slightly before the blow-pipe. The Rookwood pottery test shows a shrinkage of about twelve and a half per cent., the glazed biscuit having a dark-cream or light-buff-color.

No. 2778. *Purplish Plastic Clay*, from Mitchell's place,

north bluff of Mayfield creek, three miles east of Lovelaceville, McCracken county. The bed is about three feet thick, and variegated in color from white to purple and yellowish. It is sandy in places, and fuses to a grey color before the blow-pipe.

No. 2664. *Stiff Plastic Clay*, from the railroad cut immediately south of Guill Hill and three miles south of Wingo, Graves county. This clay has a bluish cast while fresh in its bed, but dries to a whiter color. It is fused with great difficulty before the blow-pipe.

A section of the cut shows surface loam five feet, gravel one to three feet, thin and uneven purplish clay a few inches, indurated red sand five feet, fine mottled micaceous sand in thin laminæ, somewhat clayey, three feet, and the bed of the above plastic clay, three feet of which is exposed in the foot of the bank. This clay has been tried for the ordinary pottery; but, after burning, the ware cracked, and not knowing how to obviate the difficulty, the work was abandoned by the owner. The tests made at the Rookwood pottery produced a brownish biscuit even when unglazed, whose shrinkage was, however, only seven and one-half per cent.

No. 2665. *Plastic Clay*, from the hill-side immediately north of Boaz Station, Graves county. The bed is composed of three feet of a creamy-white clay, underlaid by two feet of a stiff purple clay, both containing beautiful impressions of fossil leaves. A sand underlies the bed. But little trouble would be experienced in getting out this clay for shipment or for local use, as the surface covering is but a few feet thick until the bluffs are reached some distance eastward.

The white clay, tested at the Rookwood pottery, burned at a low temperature, and made a biscuit rather too dark for cream-colored ware, though, when unglazed, it is milky-white.

No. 2760. *Plastic Clay*, from H. S. Gray's place, in the bed of a branch immediately south of Scale, Marshall county. The clay is bluish when freshly exposed, but dries to a



greyish-white, and contains some spots of yellow ochre, with some fine sand in thin laminæ. It fused before the blow-pipe. The Rookwood test gave a buff-colored glazed biscuit.

No. 2762. *Dark Clay*, with small specks of deep blue vivianite from the Tennessee river landing at Highland, Marshall county. On drying it becomes a light greyish-brown color. The particles of vivianite are frequently white on being freshly exposed, but turn blue after a while. The bank of the river here is made up of a surface deposit of seven feet of micaceous loam, fifteen feet of interlaminated light-bluish clay and yellow sand, ten feet of blue micaceous clay in layers of one and two feet thickness, with some yellow sand and ferruginous concretions. The lower clay bed contains the vivianite. The large amount of iron and potash in this clay causes it to fuse before the blow-pipe. On burning it makes a dark red biscuit, and mixed with fine sand would make nice pressed red brick and terra-cotta.

No. 2781. *Blue Micaceous Clay*, with small particles of vivianite, from a deep ravine, opening into the Ohio, in the western edge of Paducah, McCracken county. This clay, like that of Highland, just described, is interlaminated with a yellow sand, and overlaid by eight or ten feet of loam. Before the blow-pipe it fuses to a grey mass.

No. 2780. *Micaceous Clay*, from Mr. Armstrong's place, one-half mile east of Boring's Ford, on Clark's river, or seven miles south-east of Paducah, McCracken county. The clay is very sandy and micaceous, bluish when wet, but dries to dark grey color. The thickness is unknown. The upper six inches has a yellow color, the whole overlaid by but a few feet of gravel and loam. Before the blow-pipe it fuses to a grey color. At the Rookwood pottery the ochre gave to the biscuit a handsome deep brick-red color. The shrinkage was about twelve per cent.

UNREFRACTORY CLAYS.

| Air Dried. | Light Colored Clay. | | | | | Bluish or Dark Clays. | | | |
|---|---|---|---|---|---|---|---|---|---|
| | McCracken County. | | | Graves County. | | Marshall Co. | | McCracken Co. | |
| | Jones', three miles south of Paducah. | Hough's, 4 miles S. W. of Paducah | Mitchell's, 3 miles E. of Lovelaceville | Guill Hill, south of Wingo | Boaz | Gray's, near Scale. | Highland Landing on Tenn. river | Paducah | Armstrong's, S. E. of Paducah |
| | No. 2777 | No. 2779 | No. 2778 | No. 2664 | No. 2665 | No. 2760 | No. 2762 | No. 2781 | No. 2780 |
| Silica | 59.500 | 67.580 | 66.320 | 75 120 | 61.920 | 52.580 | 60.980 | 73.192 | 69.220 |
| Alumina | 24.960 | 20.040 | 22.930 | 15.960 | 30.060 | 31.070 | 18.480 | 16.540 | 17.540 |
| Iron peroxide | .720 | .540 | 1.190 | 1.420 | .300 | 1.510 | 7.500 | 1.840 | 1.440 |
| Lime | .325 | *a* 1.743 | .437 | trace. | trace. | .137 | .780 | .369 | .437 |
| Magnesia | .396 | .158 | .209 | .317 | .064 | .245 | 1.128 | 461 | .858 |
| Potash | 1.934 | 1.340 | 1.107 | 1.351 | 1.602 | 1.775 | 2.664 | 1.969 | 2.452 |
| Soda | .286 | .075 | .470 | .245 | .239 | .318 | .627 | .541 | .472 |
| Water, etc. | 11.879 | 8.524 | 7.337 | 5 587 | 5.815 | 12.365 | 7.841 | 5.088 | 7.581 |
| Total | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100 000 | 100.000 |
| Sand | .... | .... | .... | .... | .... | .... | .... | 56.60 | 50 580 |

(*a*) Mostly as gypsum.

In all of the above analyses the potash percentages are very high, that of the vivianite clays of Highland Landing and Paducah being exceptionally so. The soda percentages of the last two are also very high, the combined alkali percentage of the Highland clay being thus raised to over three and three-tenths. The clay containing the next highest alkali percentage is that of the Armstrong place, east of Paducah, which, although extremely sandy in character, has nearly three per cent. of potash and soda. In general, all of these unrefractory clays contain a larger amount of alkali than do those of the refractory class, while in the iron percentages the differences are not so great. In the latter the Highland beds again stand out prominently with their seven and a half percentage.

### OCHREOUS CLAYS.

At a number of points in the Purchase counties there are beds of clay so highly colored with yellow ochre as to make them useful as coloring pigments, and they have been used for this purpose to some extent locally. On burning they



become oxidized into a bright red color. They would also make the beautifully red pressed brick so much in demand for house fronts.

In addition to these, there are certain bluish clays which, on burning, make a very pretty red brick. One of these beds outcrops in the banks of the Tennessee river at Highland Landing, Marshall county. Its analysis and description are given on a previous page. An analysis has been made of but one specimen, and that from near Wickliffe, Ballard county.

In Ballard county there are three prominent localities of occurrence, near Wickliffe and Laketon, respectively. At the former place the clay is exposed in a deep ravine that cuts into the hill north of town, on the Harkless place. The bed is apparently several feet in thickness, beneath fifty or more feet of loam and gravel. It is rather difficult of access. The clay is a bright yellow, quite free from sand, and has been used in Wickliffe as a paint for wagons. It fuses before the blow-pipe into a black slag. Tested at the Rookwood pottery, it made a bright red biscuit, which, on glazing, became black. Its shrinkage is about seventeen per cent. Its analysis is given below.

No. 2572. *Yellow Ochre*, from the Harkless place, immediately north of Wickliffe, Ballard county. On calcining it becomes a handsome Venetian red color, and fuses before the blow-pipe into a blackish mass.

COMPOSITION OF THE OCHREOUS CLAYS OF BALLARD COUNTY.

| | |
|---|---|
| Silica | 44.840 |
| Alumina | 22.831 |
| Iron peroxide | 20.350 |
| Lime | .101 |
| Magnesia | .138 |
| Water, etc. | 11.740 |
| Total | 100.000 |

Another exposure of this bed is seen in the deep ravine that cuts northward into the hills from Fort Jefferson, south of Wickliffe. Near Laketon, in this county, there are two

exposures, one on the land of Mr. Hogancamp, two miles north of Laketon, and which also occurs at the foot of a deep ravine, opening westward into the Mississippi bottom, and with a thickness of two feet or more. It has a bright yellow color, and is quite free from sand. On Sandy creek, two miles south of Laketon, the ochre is again exposed in a bed several feet in thickness (said to be ten), near the residence of Mr. T. J. Wilson, and extending down the creek some distance toward the Mississippi bottom, near which it is found embedded in rounded and large lumps in the heavy beds of white sands. It is somewhat interlaminated with whitish clay, and is quite plastic. It contains about twenty-six and a half per cent. of fine white sand, composed of rounded grains of transparent quartz; there is present also a little mica in very fine particles. The ochre may be easily separated from the sand by washing and allowing the latter to settle while the ochre remains suspended and is poured off with the water. The clay calcines to a bright red color, and fuses before the blow-pipe to a black slag.

In McCracken county there is a bed of ochre, about six inches thick, comprising the upper portion of the clay bed on Mr. Armstrong's place, one-half mile east of the Boring Ford on Clark's river, or seven miles from Paducah. It is somewhat sandy in character, but burns to a dark-red brick, and with a shrinkage of about fifteen per cent. It contains much sand, but this can be easily separated from the ochre by washing.

At Wadesboro, in Calloway county, another but thin bed of yellow ochre occurs in the gully immediately east of the store-houses that line the street. The clay is jointed in structure, and forms the upper surface of the black joint-clay, or so-called soapstone, that is characteristic of this eastern lignitic belt. It has a bright yellow color, its iron being derived, doubtless, from the superincumbent ferruginous gravel and sand; the bed is from six to ten inches thick. The clay calcines to a handsome red color, and before the blow-pipe fuses to a black color. Its shrinkage on burning is about fifteen per cent.



### LIGNITE OR BROWN COAL.

Beds of this Tertiary coal are found outcropping at two points within the Purchase counties. From its slightly bituminous character, it has been mistaken by those living near it (and uninformed on the subject) for the outcroppings of true carboniferous stone-coal, supposing that weathering has produced the rotten or shaly character, and that on opening up the beds, and penetrating far into them, the true coal will be found. This false idea has given rise to visions of wealth and to an increase in price of the land, not only in this but in other southern States. The coal cannot be said to have any commercial value, except at Laredo, Texas (where a good quality is mined and sold at six dollars per ton), for although it burns, it gives an insufficient heat for the more ordinary purposes; and the impurities contained in the mass, together with the clayey character and imperfect carbonization, give rise to a very large percentage of ash. At Laredo, the lignite resembles cannel coal, a change from the true lignite, produced, perhaps, during the partial metamorphism of the rocks of the region during the volcanic activity of the neighboring mountains of Mexico, which resulted in the eruptive dykes extending thence to the region of Austin, Texas.

The lignites of the northern part of Texas, as well as of the other States, are coarse-grained, generally show more or less the structure of the original wood, and yield from four to twenty-four per cent. of ash.

In Kentucky the lignites differ from those of other States in being finer, more compact and homogeneous in character, and with comparatively little woody structure. The mass resembles rather a dense peat or accumulation of fine vegetation, which, through age, has become blackened and changed to a lignite. The mass is not laminated in structure (except on the outer edges), is very fine grained, and easily sawed or chopped with a hatchet into solid blocks. This fine grain character especially fits it for purposes for which that of other States is unsuited, viz: in the machinery used in a new process for refining sugar. The attention of the manufacturers in Glasgow, Scotland, was drawn to this lignite, and

at their request samples were sent for trial. They report that the tests were eminently satisfactory, and that they proposed to use large amounts should the cost of transportation warrant it.

The most extensive and important occurrence of the lignite is at Wickliffe, on the line of railroad in the county of Ballard. It is well exposed in the railroad cut, just south of the depot, appearing last year as a long black band in the freshly exposed perpendicular surface of the eastern side, and before covered by earth slides. The bluff is formed of about fifty feet of Quaternary loam, gravel and clays, overlying about forty feet of Tertiary dark sandy clays in which the lignite appears at about five feet below its surface.

The lignite is about four feet thick, and its cross-section shows the following differences in character:

| | |
|---|---|
| Shaly or rotten clayey brown lignite | 18 inches. |
| Blackish lignite, with hard fragments | 12 inches. |
| Light, compact, fine grain and brownish lignite | 12 inches. |
| Black lignite | 12 inches. |

The upper part contains in one place thin crystals of clear Selenite. Iron pyrites is also found occasionally, but the beds appear to be very generally free from this mineral.

Another and thinner seam of lignite is said to exist several feet below this, but was not visible, except perhaps under the railroad track, near what is known as the "Camel's Back," a short section of the track which, because of the sliding out of the bluffs, has been thrown into a hump-shaped condition, and remains so in spite of the efforts of the workmen to correct it. Near this section, and exposed in a culvert beneath the track, is a bed of lignite which once caught fire, and is said to have burned steadily for six or more months. This may, however, be but a fallen portion of the main bed.

The lignite is also found in the beds of the creeks and ravines immediately east of Wickliffe, and in the bank of Cane creek, two miles north. The bed at the latter locality is, however, thin. Still eastward from Wickliffe it is



found occasionally in the bluffs that face the bottoms of Mayfield creek as far east as Blandville, and probably beyond.

The Blandville lignite, in the bed of the branch in the south-west part of town, is very similar in character to that at Wickliffe, except that it is more highly pyritous, that mineral appearing in bright silvery sheets, and partly in lumps, permeating the upper part of the bed.

The only other exposure of lignite found within the Purchase counties occurs on Panther creek, in Graves county, on the land of Mr. Obadiah Whitt. It outcrops at the water's edge, reaching three feet above, and said to be several feet below the water. It very much resembles that of Ballard county, its upper portion being black, and having impressions of vegetable leaves and sticks, the central part being lighter brown and more compact. In the analysis given below, the sample was evidently taken from the upper part.

The coal is again found a short distance further down the creek. It is, however, entirely covered by the creek alluvium.

The composition of the above lignites is shown in the following analyses made for the Survey by Dr. Robert Peter. The samples were dried at the ordinary temperature, except that of No. 2144, which was dried at 212° F.

No. 3. *Lignite*, from the bluffs of Fort Jefferson, immediately south of Wickliffe, Ballard county. A dull brownish-black friable substance, full of irregular cracks or fissures which appear to have been produced by shrinkage or drying; quite absorbent of moisture, adhering slightly to the tongue; fresh fracture producing a dull, pitch-like luster in some of the layers, approaching in some parts the luster of coal. Over the spirit lamp, on platinum foil, it burnt at first with a smoky flame, somewhat like coal, but with the odor of peat; it continues to burn like punk or rotten wood when removed from the flame, until it is reduced to a bulky ash.

No. 214. *Lignite* from the same bluff.

No. 215. *Brown Coal or Lignite*, from one and one-half miles north-west of Blandville, Ballard county.

No. 2144. *Brown Coal or Lignite*, from Mr. Wm. Arnett's land on Panther creek, six miles east of Mayfield, Graves county. The bed shows about three feet above the creek; is said to be several feet below that level.

ANALYSES OF LIGNITE OR BROWN COAL.

| | Ballard County. | | | Graves Co. |
|---|---|---|---|---|
| | Wickliffe. | | Blandville. | Panther Cr. |
| | No. 3. | No. 214. | No. 215. | No. 2144. |
| Moisture | 13.20 | 30.00 | 11.50 | 4.13 |
| Volatile combustible matter | 37.40 | 23.00 | 48.00 | 16.22 |
| Fixed carbon in coke | 38 10 | 40.00 | 31.00 | 10.25 |
| Ashes | 11.30 | 7.00 | 9.50 | 69.40 |
| Total | 100.00 | 100.00 | 100.00 | 100.00 |
| Total volatile matter | 50.60 | 53.00 | 59.50 | 20.35 |
| Coke | 49.40 | 47.00 | 40.50 | 79.65 |
| Total | 100.00 | 100.00 | 100.00 | 100.00 |
| Specific gravity | 1 219 | 1.201 | 1.173 | . . . . . |

The ashes of No. 3 was buff-colored, and was found to contain a trace of phosphoric acid, and notable quantities of oxide of iron, alumina and lime. When dried at 212° F. its composition was—

| | |
|---|---|
| Volatile combustible matter | 43.088 |
| Fixed carbon | 43.894 |
| Ashes | 13.018 |

No. 2144 was dried at 212° F. The ash was found to contain a considerable proportion of alumina, some little lime and magnesia, as well as a trace of phosphoric acid. As this material contains a little more than thirty-six per cent. of combustible matters, it could scarcely be made available as a fuel. Possibly it may find use as a cheap pigment.

## IRON ORES.

The iron ores found in the region are entirely Quaternary in origin, and occur associated with the gravel deposits in, however, but few localities. These localities are also nearly



in a line north-west and south-east, and in almost every instance adjoining the outcrops of hard Onandaga quartzite. The ore is a limonite, occurring in irregular plates, from one-half to two inches in thickness, and in all variety of forms. It sometimes incloses clay, and often has cemented to its surface the Quaternary gravel. The beds may be classed in two divisions, or as belonging to the upper and lower gravels, respectively, and varying in their outward appearance. In addition to these, there are ores of a more recent origin, and also some magnetite, all of which will be mentioned under their respective heads.

*Iron of the Ore Region Gravel.*—The beds thus named by Prof. Safford, in his Tennessee Report, are found, in this section of the State, only in the south-eastern part of Calloway county, near the Tennessee river, and south of Blood river, in what is locally known as "The Coalings," overlying directly the limestones and cherts of the Subcarboniferous. These are the most important beds within the Purchase counties, viewed economically, and in years past they have been extensively worked. The ore is embedded within the gravel deposit in pieces, large and small, partly specular on some of its surfaces, and with interstices holding some gravel and clay. To secure the ore, great excavations have been made in the thick gravel beds; but in spite of this expense it is said to have been gotten out in "paying quantities." There are two of these beds within a few miles of each other. At one, near Shannon creek, a furnace was in operation for a number of years, the entire surrounding country ("Coalings") being denuded of its timber to supply charcoal for the reduction of the ore. Either the exhaustion of the fuel, or the expense of obtaining the ore from the gravel beds, caused a suspension of the works. From the other bed, or Marbery's bank, the ore was shipped to the furnaces on the east side of the Tennessee river. At this locality the ore is concretionary in part, and in plates cemented to dark flinty fragments, the whole forming locally a solid ledge a foot in thickness, the ore being from one to eight inches thick, and under about fifteen feet of cherty and clayey debris. Fine and clear crystals of dark quartz, both terminals perfect, occur in the cherty beds in abundance.

*Iron of the Later Gravel.*—These beds have already been alluded to as occurring in a belt lying north-west and south-east, though the ore has been observed in but a few localities. The gravel with which it is associated is of the stratified drift or upper Quaternary bed, though from its position at the base of those beds, and the strong resemblance to the ore just described, it may have been formed prior to the stratified drift period. Its close association also with the massive quartzose sandstone at each of its exposures would indicate this.

There are two of these iron beds in McCracken county, west and south-west of Paducah. On the place of W. J. Flournoy, four miles west of town, the ore forms a ledge from four to six inches thick beneath the gravel, and about fifty feet below the surface of the adjoining upland. Immense boulders of Onandaga quartzite sandstone lie to the west of and adjoining it, and perhaps pass under it, though in a well a hundred yards to the east neither the iron or the sandstone was found. The ore is not in any great quantity. South-east from this point, or five miles south-west of Paducah, at Mrs. Alexander's place, rounded lumps of the same limonite ore occur at the foot of the elevation on which the house stands. Some of the ore is in curved layers. As at Mr. Flournoy's, there does not seem to be any great quantity of it. The following analysis gives its composition, dried at 212° F.:

No. 144. LIMONITE, FROM MRS. ALEXANDER'S, FIVE MILES FROM PADUCAH, ON BLANDVILLE ROAD, McCRACKEN COUNTY.

| | |
|---|---|
| Oxide of iron | 83 80 |
| Alumina | .60 |
| Oxide of manganese | .50 |
| Potash | .13 |
| Soda | trace. |
| Magnesia | trace. |
| Phosphoric acid | .07 |
| Combined water | 8.30 |
| Silica and insoluble silicates | 6 60 |
| Total | 100.00 |
| Iron in the above | 58.68 |



This analysis gives probably a fair average of all the iron ores within the Purchase counties, both in the lower and upper gravel beds.

Another occurrence of the ore is at Mr. McClure's, two miles south of Hard Money, in Graves county, and in a line south-east from those localities already mentioned. Fragments of the quartzite sandstone were picked up in the neighborhood, though no large boulders were found. The ore occurs in curved plates, forming boulder-like masses, and with sharp angles, and sometimes holding ochreous clay. It, as well as the ore of the other localities, has the appearance of having been formed by evaporation and crystallization from a solution of the iron oxide that had permeated through the open seams and cracks in the clayey gravel beds to the more impervious clay beds. The mass of the ore is crystalline in character, the outer face roughened by contact with the fine gravel and sand, the inner surface smooth and bright or specular, the cross-section through the ore being capable of receiving a bright polish.

At Mr. McClure's there is quite an amount of the ore fragments in spots, but no regular bed has been found, and it is not at all likely that it occurs in paying quantities.

Iron ore, very similar in character to the above, also occurs on the place of Mr. Cox, a few miles west of Birmingham, Marshall county. The masses are found at the base of the Quaternary gravel, and immediately overlying the Subcarboniferous beds.

*Clay Iron-stone.*—Specimens of beautifully banded clay iron-stone occur in a deep gully in the field of Mr. Jones, three miles south of Paducah.

*Magnetite.*—This has been found at only one point within this region, and then not in any quantity, a few pieces only having been picked up at the foot of the bluff, on the bank of the Ohio, near the Grand Chain. At this point the cherty layers and limestones of the Subcarboniferous rise above the river surface, and appear in the bluff below the Quaternary gravel. The ore is very compact, and highly magnetic. There is nothing to indicate the near presence of any body of it, and these pieces have doubtless been brought here

from other localities, possibly from the magnetite region of Connellsville, West Virginia.

*Iron Pyrites.*—This is a very commonly occurring mineral in the black clays of the Tertiary lignitic belt, which extends from the southern part of Calloway county northwestward toward Paducah and to Caledonia, and also along the bluffs of the Mississippi river. The mineral appears either in thin sheets or in small lumps, the surface sometimes blackened by oxidation and by the admixture of black clay, but usually bright and shining with a silvery, or sometimes with a golden luster, which, from its deceptive character, has won for it the name of "Fool's Gold." The finder of this mineral has often had visions of gold mines floating before his imagination, and frequently spends much money in making excavations in the ground, or in having specimens analyzed by some so-called chemist, who generally announces the presence of gold, silver, bismuth, or some other metal. The test which would prove the character of pyrites (a compound of iron and sulphur) is very simple, and can be made by any person. The usual trial by persons in the country is to mix with it some fluxing material, such as blue vitriol or sugar of lead, and then melt it down in an iron spoon or ladle in a blacksmith's forge. The flux, and frequently the pyrites itself, forms metallic looking lumps, which deceives the workman. The following is the true test which should be applied: Powder the mineral finely, and place three or four thimbles full of it on a clean shovel, and heat the latter to redness in an open fire, without bellows or fan. The mineral will turn black, and then burn with a blue sulphur flame, the odor of whose fumes will be recognized. When the flame has expired, stir the powder with a stick, and heat to redness on the shovel. On cooling, the powder will be at first black, and then turn red, being then simply a red ochre, containing no metal but iron. Iron pyrites, when powdered and moistened, and left exposed to the air for a time, gradually changes into copperas. The only use to which the mineral can be put is in the manufacture of sulphur and sulphuric acid, and even for that purpose it would not be profitably mined, except where it can be obtained in almost inexhaustible quantities.



### VIVIANITE.

In the black Port Hudson clays in the ravine that empties into the river just west of Paducah, and in the same black clays that are exposed in the Tennessee river bank at Highland Landing, in north-east Calloway county, there are small specks, in part a bright blue and in part a white color, that, upon analysis, proved to be the mineral *vivianite*, a phosphate of iron. These soft clayey particles are most abundant at the latter locality, but in neither are they in sufficient amount to be used as a pigment, or to so enrich the inclosing clay as to make it valuable as a fertilizer.*

### GALENA.

Pieces of this ore of lead have been picked up in various localities throughout the Purchase counties, and have led to the supposition that they are but the outcrops of veins of the mineral, the continuation of those occurring at Rosiclair and near the mouth of the Cumberland river above Smithland. So far as my observation extends, there are here no indications of the presence of such lead deposits, even within the belt of Subcarboniferous rocks lying along the west side of the Tennessee river. The strike of some of the faults that hold the lead and zinc ores at Rosiclair, it is true, is in a S. S. W. course, but it is more than probable that they are ore-bearing for only a short distance; and had they ever reached as far as this basin region, they, together with the accompanying limestones and sandstones, have been partially removed by denudation, and their surface subsequently covered by several hundred feet of clays, sands, and gravel. It is, at least, very certain that no lead, silver, or zinc veins occur between the Mississippi river and the belt of Subcarboniferous rocks, and that the tales regarding silver mines on Clark's river are all myths, so far as any natural deposit is concerned.

As to the origin of the fragments that have been found,

* The same mineral was found in the dark clay underlying Washington, D. C.

also in the clay under the bluffs along the Elkhorn creek and tributaries, in Pike county, Ky., and there is scarcely a doubt that they have been brought or dropped in the various localities by human agencies, probably by the Indians, who obtained the ore in other States, and probably deposited masses of it in the banks of the streams or other points, where they could have easy access to it. That they did use the ore for some purpose is shown in the fact that quite a large mass of it was found in an Indian mound on the bluffs of the Mississippi river, north of Laketon, in Ballard county, and other pieces in mounds elsewhere.

The report of a silver mine having once been found on Clark's river has its origin, so far as can be ascertained, with a gang of counterfeiters, who, for a long time, carried on their operations somewhere on the borders of that stream, and who naturally were anxious to establish the belief that they were doing legitimate work in the development of the mine. Near the point at which it is supposed that they worked, there is an abrupt bluff forming the river bank, and in the exposed black Tertiary clay there occurs quite a quantity of large nodules of iron pyrites, which have been erroneously thought by some persons to "lead to silver ore;" the clay also is in places highly micaceous, giving to the mass a sparkling appearance.

### GYPSUM.

This mineral, important for agricultural purposes, occurs but sparingly within the Purchase counties, and then only in association with the white plastic clays of the Quaternary and Lagrange groups, and occasionally with the lignite beds. It is found in small masses or pockets, of not more than one half inch diameter, and in the form of radiated crystals, and sometimes in thin sheets of Selenite. It has been observed in the clay bed on the place of Mr. Hough, four miles south-west of Paducah, in the clay outcropping in the branch south of Benton, and in the lignite of the Fort Jefferson bluff, near Wickliffe. At no point does it occur in sufficient quantity for commercial or agricultural purposes.

### GREENSAND.

No beds of this valuable potash fertilizing material have been found within this part of the State. They were, however, observed at the foot of the Ohio bluffs, at Caledonia, on the Illinois shore, being well exposed for four feet at low water, and easily accessible at the water's edge. The thickness is unknown. The mass is very friable, dark green in color, and composed of a little black clay and hyaline sand, with a large proportion of the green grains of *glauconite*, a potash mineral. The bed lies at the base of the lignitic Tertiary black sandy and joint clays, which here have a thickness of forty-five feet. The following analysis, made by Dr. Robert Peter for the Survey, shows its composition:



GLAUCONITIC CLAY, TAKEN FROM THE FOOT OF THE OHIO BLUFF, AT CALEDONIA, ILLINOIS.

| | |
|---|---|
| Silica or sand | 59.940 |
| Alumina | 13 370 |
| Iron peroxide | 10.210 |
| Lime | .549 |
| Magnesia | 2.010 |
| Potash | 3.243 |
| Soda | .078 |
| Water, etc. | 10.600 |
| Total | 100 000 |

*Sand.*—Deep beds of sand, varying from pure white to red and yellow, occur in several of the geological formations represented in the Purchase counties. These formations are the Cretaceous, the Lagrange division of the Tertiary, and the stratified drift of the Quaternary. The massive Onandaga quartzite rocks that outcrop at certain points south and south-west of Paducah, and in east Calloway county, would, if crushed, make a very clear and pellucid sand, suitable for glass manufacture. The grains are sharp, and quite free from iron stains.

The sand-beds of the Cretaceous, occurring east of Murray, in Calloway county, and near Benton, in Marshall county, are very deep, and highly charged with fine particles of mica, which give to it a sparkling appearance. The grains are sharp and the sand can be used as a coarse polishing material.

In Calloway county the beds are well exposed at the

cross-roads, north-east of New Concord, and southward in the hills facing the valley of Beechy creek. The sands are variegated in color, but mostly white, and are slightly calcareous. The analyses by Dr. Peter given below show them to be quite free from impurities.

The sand-bed, occurring on the north side of Clark's river and two miles from Benton, Marshall county, is well known as the "Sand Hill." It underlies a black clay, and is stratified, its layers having a south-easterly dip. The upper part of the bed has a yellowish color from the iron, in solution, brought by percolation from the overlying beds, but, in the main, is white and micaceous, and holds thin layers of a plastic clay. Its exposure is from six to ten feet, being hidden below by debris from the bluff above. A few concretionary forms of sand, cemented with iron, occur occasionally in the sand. The analysis of this sand is also given below.

No. 2636. *Fine Micaceous Sand*, slightly calcareous; Cretaceous formation. Taken from a heavy bed, two miles north-east of New Concord, Calloway county.

No. 2637. *Sand*, apparently similar to the preceding, but slightly colored light-brownish with iron oxide. Taken from the same locality as the above.

No. 2758. *White Sand*, Cretaceous formation, taken from the Sand Hill on the north side of Clark's river, two miles north of Benton, Marshall county. A fine hyaline quartz sand, with a yellowish tint. Contains small mica specks.

ANALYSES OF SANDS.

| | Calloway County. | | Marshall Co. |
|---|---|---|---|
| | Near New Concord. | | Near Benton. |
| | No. 2636. | No. 2637. | No. 2758. |
| Organic and volatile matters | 1.815 | 0.690 | 0.395 |
| Alumina, iron oxide, etc. | .605 | .505 | .323 |
| Lime carbonate | .090 | .095 | trace. |
| Magnesia | .232 | trace. | .017 |
| Phosphoric acid | .044 | trace. | .093 |
| Potash | not est. | .289 | .189 |
| Water expelled at 380° F. | .000 | .000 | .054 |
| Sand and insoluble silicates | 97.395 | 98.145 | 98.989 |
| Totals | 100.181 | 99.724 | 100.057 |
| Hygroscopic moisture | 0.075 | 0.025 | 0.050 |
| Potash in the insoluble residue | 0.074 | not est. | .001 |



The Tertiary sands, belonging to the Lagrange group of interstratified sands and pipe-clays, are usually quite white, and, in large part, of the clear hyaline variety. The beds between the clay strata vary in thickness, and could, with some difficulty, be kept free from clay admixtures. The beds are most largely exposed at points along the bluffs facing the Mississippi river bottom, from the mouth of Mayfield creek southward to Columbus. A prominent exposure is at the water-tank, one mile south of Laketon, the bed here rising about fifty feet above the railroad track. The sand is, however, intermixed with two per cent. or more of fine clayey particles, which injure it for the manufacture of fine glass ware. The grains are rounded, and largely of hyaline quartz, mixed with some very fine sand.

In the bluffs north of the town of Columbus there is a very thick bed of fine white sand, colored, in part, from iron percolations from the gravel above, and composed of over ninety-nine per cent. of pure hyaline quartz grains.

All of the above Cretaceous and Tertiary sands would be useful in the manufacture of any but the finer kinds of glass ware, in mixing with the stiff plastic clays for the manufacture of pottery, etc, and in mixing with mortar and cement.

The sand of the stratified drift is very generally colored yellow and red from iron oxide, which injures it for any but ordinary uses. The beds are found interstratified with the gravel, and also alone in the south-western part of the Purchase counties.

POLISHING POWDER.

There are several localities within the Purchase region in which occur beds of a fine siliceous earth, or sharp, silty sand, which could be utilized as a polishing powder for silver or other metals. The most prominent of these places is at Pryorsburg, Graves county. The beds are here exposed in a bluff a short distance east of town, on the east of the first branch. There are two grades of the powder in this bluff, one made up of extremely fine and sharp grains, one thousandth of an inch in diameter, whose grittiness between the finger is just perceptible, while the

other grade is a little coarser, the diameter of the grains being about twice as large as the former. A little clay accompanies the powder. The thickness of the entire bed is unknown, as there is a large amount of debris at the foot of the bluff.

The bluff shows about fifteen feet of loam and gravel, and ten feet of purplish plastic clays, above these beds of fine sand, which are exposed ten or fifteen feet thick, and slope to the north-east. The beds are much indurated, but the powder readily yields to attrition. Put up in packages, it should find a ready sale as polishing powder.

Another bed of fine silty or arenaceous clay, also suitable as a polishing material, occurs in the railroad cut three miles north of Boaz Station, Graves county. It is very similar to the beds of decomposed Subcarboniferous chert of the eastern part of Marshall and Calloway counties, a few pieces of the rounded chert being embedded in it. It is light brownish-grey in color, indurated, or of the hardness of chalk, and contains about two and a half per cent. of very fine white sand. From the analysis which is given below, it will be seen that it contains a very large amount of potash, as indeed do most of the clays of the region. It is refractory before the blow-pipe, and fuses with great difficulty. Many of the clays of the Purchase counties are more or less arenaceous, and might serve the purpose of a polishing or finishing material.

The beds of decomposed chert of the Subcarboniferous belt, along the west side of the Tennessee river, are made up of a white, non-plastic, siliceous earth, indurated, but friable and easily crumbling, and which is infusible before the blow-pipe.

In Marshall county this earth is exposed in the bed of the branch on the place of Mrs. Lou. Stone, four miles west of Birmingham, and at several points nearer town; fragments of undecomposed and angular chert are inclosed in the beds.

In Calloway county the white earth is more prominently and extensively developed in the hills bordering Blood river on the east, in the neighborhood of Brandon's Mill. The



beds are here exposed for ten or more feet in thickness above the bottom of the ravines or branches, and are made up of alternating layers of chert and siliceous earth. The same beds are also found eastward in the hills facing the Tennessee river, in the region of Buffalo Landing.

All of these siliceous earths are very similar in their composition, being chiefly silica, with some alumina and potash, as will be seen from the analyses given below.

No. 2662. *Arenaceous Clay*, from the railroad cut three miles north of Boaz, Graves county.

No. 2764. *Siliceous Earth*, or decomposed white chert, from Mrs. Lou. Stone's place, four miles west of Birmingham, Marshall county.

No. 2638. *Siliceous Earth*, from Brandon's Mill, on Blood river, Calloway county.

No. 2761. *Ash-colored Earth*, from a cistern on the old Winter's place, eight miles south-east of Olive Post-office, Marshall county.

COMPOSITION OF SILICEOUS EARTHS.

| Air Dried. | Graves County. | Marshall County. | Calloway County. | Marshall County. |
|---|---|---|---|---|
| | 3 m. N. of Boaz. | 4 m. W. of Birmingham. | Brandon's Mill. | Winter's Place. |
| | No. 2662. | No. 2764. | No. 2638. | No. 2761. |
| Silica | 76.780 | 93.700 | 87.300 | 91.580 |
| Alumina | 14.740 | 3.580 | 10.480 | 5.980 |
| Iron peroxide | 1.640 | . . . . . | trace. | .220 |
| Lime | trace. | trace. | .045 | .045 |
| Magnesia | .389 | .127 | .281 | .055 |
| Potash | 1.440 | .618 | .888 | .094 |
| Soda | .117 | .117 | .209 | .032 |
| Water | 4.894 | 1.858 | .797 | 1.994 |
| Total | 100.000 | 100.000 | 100.000 | 100.000 |
| Sand | 2.400 | . . . . . | . . . . . | . . . . . |

The earths from Marshall and Calloway counties, being very fine and highly siliceous, with very little of such fluxing materials as iron oxide, lime, soda and magnesia

(though the potash percentage is high), could be well used to mix with plastic clays to reduce their shrinkage, and also as scouring and polishing bricks. They might also be used in glass-making.

### WATER SUPPLY.

The large streams of the country have a continuous flow throughout the year, except near their sources; but the water is mostly sluggish and muddy, holding in suspension the clay derived from the bordering hill-sides. The smaller streams or creeks become dry during the summer months, the water standing in pools along their beds. There is, however, always a sufficient supply for stock running at large.

For domestic purposes the people are dependent chiefly on wells and cisterns, though small springs are found frequently issuing from the hill-sides and banks of streams.

The wells vary in depth and in character of water, according to the nature of the country and the geological formation. The water stratum is almost always the sand or gravel overlying immediately a thick bed of impervious clays.

In the hills bordering the Tennessee valley, and within the Subcarboniferous belt, water is hard to obtain in wells, except by penetrating the cherty or flinty layers which underlie the Quaternary gravel, sand, and clay. The thickness of these layers is not known. In a well three miles west of Birmingham, Marshall county, no water was obtained after penetrating thirty feet of loam, gravel and pipe-clay, and then twelve feet of the chert. Near Aurora, in the south-eastern part of the same county, more than one hundred feet of cherty material were penetrated without finding water; while west of this, on one of the branches tributary to Jonathan creek, water was obtained after passing through forty feet of the chert. Southward, in Calloway county, the limestone beds approach nearer the surface, the chert is thinner, and water is sometimes obtained at from twenty to thirty feet.

The Cretaceous formation, forming a belt west of the above, is represented by beds of sands, and black, thinly



laminated clays. The wells are, therefore, usually very deep—one hundred or more feet—though sometimes water is obtained above the black clays which overlie the sands.

In Calloway county, east of New Concord, a well on the place of Mr. Christian was dug sixty-five feet in the white micaceous sand, and delightfully cool and clear water was reached. Curbing was required, and to prevent the sand from coming in at the bottom, grass, rocks, and gravel were thrown in. A few miles south-west, on Mr. Alexander's place, water was obtained below fifty-four feet of the sand. At Hico, in the northern part of the county, and east of Briensburg, Marshall county, wells are dug one hundred feet. In the latter county, the black clay often forms a sufficiently thick and impervious stratum to support a water vein; and near Fair Dealing, Palma, and Calvert City, wells are sunk frequently to a depth of only fifty or seventy-five feet.

At Paducah, the well of the ice factory, after penetrating through loam and gravel for about forty feet, reached water in sand at one hundred and ten feet from the surface. The water is strongly chalybeate, as shown in the following analysis, made by Dr. Barnum, of Louisville.

*Chalybeate Water*, from the well of the ice factory in Paducah, McCracken county. It has been largely used as a tonic by the citizens, and the cup in use has been thickly incrusted with the iron.

| | |
|---|---|
| Silicates | 1.707 grains. |
| Carbonate of iron | 3.500 grains. |
| Oxide of iron and alumina | 2.310 grains. |
| Sulphate of magnesia | 0.663 grains. |
| Chloride of sodium | 2.540 grains. |
| Chloride of aluminum | |
| Bromine and iodine | |

"The whole combined so as to possess strong tonic and alterative properties, without the disagreeable styptic taste common to most chalybeate waters."

The well of the vinegar works, in Paducah, passed through the following strata:

| | | |
|---|---|---|
| Loam and gravel | | 40 feet |
| Cretaceous. | Black and blue clay | 8 feet. |
| | Colored sand | 6 feet. |
| | Blue clay | 8 feet. |
| | Sand | 50 feet. |
| | | 112 feet. |

The wells along the lignitic Tertiary belt, lying west of the Cretaceous, are usually not more than thirty or forty feet deep, water being found at the base of the gravel. The impervious clay, which immediately underlies the gravel, is black and more or less pyritous and fetid, giving a disagreeable taste and unhealthy properties to the water. The clay bed is very thick, one hundred or more feet, and very few wells, if any, have passed through it. In a well on the hills south of Paducah, one hundred and forty feet of clay was penetrated and no water found. Cisterns are, therefore, largely in use in this region, which extends from the Tennessee State line northward via Murray, between Clark's river and Mayfield creek towards Paducah, and thence westward toward Caledonia.

In the region underlaid by Lagrange sands and clays, in the south and west parts of Graves county, at Mayfield, Lynnville, Cuba and Stubblefield, and also in Hickman and south Ballard counties, it is difficult to find a good vein of water on the uplands at a less depth than from seventy-five to one hundred feet, and even more. Cisterns are, therefore, largely used. In Fulton county wells are from fifty to seventy-five feet deep.

In the Tennessee valley, at Birmingham, Marshall county, water is obtained at fifteen to twenty feet, while on the north, near Calvert City, it is found at from twenty-five to thirty feet.

In the Ohio valley or flats, wells are, at Paducah, near the river, more than one hundred feet deep, as shown above; but in the southern and south-western parts of the town, and westward to the Mississippi river, they are from fifty to sixty feet.



In the Mississippi river bottom, south-west of Hickman, near the Sassafras ridge, water is found at fifteen or twenty feet in a blackish sand beneath sands and blue clays.

There are a number of springs in the Purchase counties whose waters are more or less chalybeate in character. A few belong to the class of sulphur springs, the water being charged with sulphuretted hydrogen gas. The latter are usually confined to the belt of bluish-black clays of the eastern and northern counties, and the sulphur is due to the iron pyrites occurring in those clays.

The chalybeate springs are most numerous, and largely derive their iron also from the pyritous clays, and from the highly ochreous gravel and clay beds. There are none, however, that have gained particular notoriety, and the waters of but few have been analyzed. The following analyses, excepting that of the Paducah well, have been obtained from the reports of Dr. Robert Peter, Chemist of the Survey:

No. 1438. *Chalybeate Water*, from Nick Combs' spring, four miles south-west of Hickman, Fulton county. This contains free carbonic acid, and 0.302 per cent. of saline matters in 1000 parts of water. These consist of iron, manganese, lime and magnesia carbonates, with some lime and magnesia sulphates. It is probably a valuable chalybeate water.

No. 2107(*A.*) *Water* from Bluff Spring, Ballard county, on the road from Columbus to Cairo, in the "milk sick" region, and supposed by some to cause this sickness. This water has deposited a considerable brownish sediment, which did not all dissolve in hydrochloric acid. Analysis showed the presence of some free carbonic acid, much of bi-carbonates of lime and magnesia, some little bi-carbonate of iron and of chlorine and sulphuric acid. The water had a slightly alkaline reaction, and the spectroscope showed the presence of a trace of lithium. There is no reason to suppose that the water has any thing to do with the causation of milk sickness.

No. 2107(*B.*) *Water* from the Mahon Spring, Ballard county. Said to be unhealthy, and by some thought to cause "milk sickness." On examination, it gave similar

reactions with the water from the Bluff Spring, but did not seem to contain as much iron; and there was no brown sediment in the bottle. A weighed portion of the water, evaporated to dryness, left only 0.36 per cent. of whitish saline residue in 1000 of the water. The soluble part of this had an alkaline reaction, and the spectroscope showed the presence in it of soda and lithia. It seems to be a perfectly wholesome water, although, like the above, somewhat "hard," from the presence of lime and magnesia bicarbonates.

No. 2554. *Mineral Water* from the old Kilgore spring, two miles south of Blandville, Ballard county. It is in the bank of a creek and ten feet below the surface of Mayfield bottom, and flows perhaps two barrels per minute. It is a slightly chalybeate and alkaline saline water. It is clear when fresh, and has a temperature of 58° F. Contains only 0.064 grammes of solid contents in a thousand. There were carbonates, chlorides and sulphates of iron, soda, lime and magnesia, with a trace of lithia, and some silica. It is a good weak chalybeate water.

*Mineral Water* from the McGee Spring, Hurricane creek, south-east of Blandville, Ballard county. The water is clear, but deposits a sediment in cups and pitchers in use. The temperature is 60° F. The spring is also in the bank of the creek, but is protected from overflow. Its flow is not great.

Evaporated to dryness, the water left 1.644 grains of solid matter in a thousand. This residue was composed of the following:

| | |
|---|---|
| Carbonate of iron | 0.376 grains. |
| Carbonate of lime | .166 grains. |
| Carbonate of magnesia | .029 grains. |
| Chloride of magnesium | .152 grains. |
| Chloride of sodium | .082 grains. |
| Carbonate of soda | .487 grains. |
| Sulphate of potash | .112 grains. |
| Silica | .240 grains. |
| Total in 1000 | 1.644 grains. |

This is a good alkaline, saline, chalybeate water, containing only a trace of organic matters, and not too much saline materials.



## AGRICULTURAL FEATURES.

That portion of the State lying west of the Tennessee river, and known as the Purchase Region, differs from that on the east, not only in its geological and topographical, but also in its agricultural features. The general surface of the uplands is lower, varying from four hundred to six hundred feet above the level of the sea; and while there are no high hills or mountains, it is rendered very uneven by the numerous large streams and their many tributaries, each having in turn their deep ravines bordered by gullies and washes, the soil being very light and easily transported by the drainage waters. After each heavy rainfall the streams are heavily charged with the brownish yellow loam from the hill-sides and open fields. Between the streams there are often large areas of uplands presenting a very level surface; their southern and western edges bordering the larger streams, generally descend abruptly and almost perpendicularly; those on the opposite side sloping gradually to the level of the bottom lands. This feature is prominently seen along the bluffs of the Mississippi river, along the bluffs on the northern or Illinois side of the Ohio, and those on the northern and eastern side of Mayfield creek, from its mouth almost to the town of Mayfield. Again, these bordering bluffs are usually higher than the general surface of the interior of the country, the drainage waters flowing almost from their very edge towards the interior and away from the streams into their smaller tributaries.

The lands of the region also differ from those of the eastern part of the State, in being almost entirely free from those rocks and rock fragments that characterize the country east of the Tennessee river. There is, again, an absence of those limestones that give to the Blue-grass region their extreme fertility, and of those sharp and angular cherty fragments that are associated with so much of the land among the hills and mountains of the State. Instead of the latter, there are beds of rounded gravel which lie below the surface of the soil at such a depth as not to interfere with its tilling qualities.

Another difference between the lands of the uplands of

the two sections lies, not only in the greater depth of those of the Purchase region, but in their having been formed of material transported from distant regions through the agency of water, those of the rest of the State being formed generally *in situ* from the disintegration of the local rock formations.

The lands of the Purchase region have a depth of from ten to twenty or even thirty feet, before the beds of gravel or impermeable clays are reached; they are made up of the two beds of light brownish loam which cover almost the entire uplands of the region, and extend southward through Tennessee into Mississippi. The country, too, is entirely covered with a timber growth, except where removed for purposes of soil tillage. A large portion was, however, once an open prairie, with no vegetation other than grass and weeds, but which has now grown up in a low growth of red and black jack oaks, and is known as "the barrens."

The lands are divided naturally into the following classes, and under which heads they will be further described:

| | |
|---|---|
| *Lowlands* -- | River alluvial lands.<br>River valleys or flats. |
| *Uplands* ---- | Cane hills or bluff lands.<br>Flatwoods.<br>Red oak Barrens.<br>Oak and hickory lands. |

Among the wild forage plants that are quite common to the entire country, is a clover known as Japan clover. (*Lespedeza striata*). It suddenly appeared a few years ago, almost simultaneously, in various sections of the country, and is regarded with high favor, especially as grazing for sheep. It is found along road-sides, and grows well on old fields, crowding out the sedge grass and weeds. It gives no trouble in fields under cultivation.

The cultivation of cotton was, during the war, carried on only on a small scale in localities as far north as Paducah; but the short seasons cut the crops short with a yield of only 300 to 500 pounds of seed-cotton per acre, one-half of the bolls not coming to maturity.

The planting season began about the first of May, blooms



appeared in July, and picking began about the first of October.

### RIVER BOTTOM OR ALLUVIAL LANDS.

The alluvial or first bottom lands of the three great rivers that border the Purchase region on its three sides cover an aggregate area of about one hundred and sixty-five square miles, being almost entirely confined to the Mississippi river. The greatest width of the alluvial region is at the Tennessee State line, where, from the town of Hickman westward to New Madrid, on the Missouri shore, the distance is about twenty miles; the bottom is, however, divided by a southward or horseshoe bend of the Mississippi river, which entirely isolates a large part of the lands from the rest of the State of Kentucky.

Northward to Wickliffe, a portion of the bottom is in places several miles wide, but at several points is entirely absent, the current of the river sweeping the foot of the projecting highlands. In the region of the junction of the Ohio and Mississippi rivers, the bottom lands are more than five miles in width on the Kentucky shore; but as we follow the Ohio up its course we find the lands becoming more and more narrow until, at the Grand Chain, where the river bends nearly at right-angles from its north-west to its south-west course, the width is not more than a mile, and beyond this point eastward to Paducah it is almost nothing. Along the Tennessee river there is scarcely any alluvial land, and the same is true of other large streams of the region, the bottom lands of the latter being more clayey and of a stiff crawfish character.

The Mississippi bottom is a broad and very level tract of land, interspersed with sloughs and lakes, and entirely subject to the yearly overflows of the river. The houses, in which the planters dwell, are usually raised above high-water mark by means of posts on which they rest as foundations. Along the immediate bank of the river the lands are usually higher than in the interior, being really a belt of sand deposited by the river current during high water. Its intermixture with the finer river sediments gives to this sand a degree of fertility suitable for the maintenance of good crops

of corn, and it is upon this belt that the river farms are mostly found. Cottonwood is its most prominent timber growth.

The interior of the bottom region is low and swampy, its soils made up of the rich alluvium yearly brought down by the river current and deposited during overflows from the more sluggish waters. The surface of this interior region is but slightly elevated above the ordinary river water level, and but a small proportion of it is considered suitable for tillage, because of its swampy character. The little drainage it has is largely into the prongs of Reelfoot Lake, which reach northward from the Tennessee portion of the bottom, the lake itself being tributary to the Obion river many miles south.

The soils are deep and rich loams, black from the large amount of decayed vegetation. There is an entire absence, so far as examined, of those buckshot clays that form so prominent a feature of the Mississippi bottom lands in Mississippi and Louisiana, though beneath the alluvium are found the blue clays of the Port Hudson geological formation, and to which the buckshot clays are believed to belong. These interior or back-lands are valuable chiefly for their magnificent timber growth of black walnut and red gum; there is also a large growth of hickory, ash, sweet gum, pecan, water and overcup oaks and catalpa. Much lumber is annually taken from these river bottoms.

In the immediate vicinity of the high bluffs that border the bottoms on the east there are frequent areas of this alluvial loam that are sufficiently elevated for successful cultivation, as for instance on the south of the town of Hickman, where they are under tillage and produce fine crops of corn. The soil has a depth of several feet, and is loose and warm in character. Analyses showing its chemical composition are given below, of samples taken from two localities.

The lands northward from Hickman, in the counties of Hickman and Ballard, have the same character as those on the south, except that there is an absence of the sand front-land, because of the yearly cutting away of the eastern bank



of the river. A portion of it just south of the "chalk banks," two miles south of Columbus, is under cultivation.

The alluvial lands of the Ohio river bottom are similar to those of the Mississippi river in their general features, having, like the latter, a front-land of white sandy ridges, and an interior or back-land of richer and dark alluvial lands, lower in elevation, and interspersed with lakes and sloughs.

While the lands of these two river bottoms are similar in their physical features, they differ in chemical composition, as will be seen in the analyses given below.

In North Ballard and McCracken counties the bottoms are very narrow, the valley or flats approaching, in some places, very near to the river. At Paducah there are no bottom lands nearer than about a mile below the town, the flats forming a bluff some fifty feet above low-water mark, and affording a splendid boat landing. On the Illinois shore, opposite Paducah, the bottoms are very broad, narrowing toward Metropolis, a few miles below.

Along the Tennessee river there are no first bottoms worthy of mention, the river having cut its way northward through the Paleozoic limestones and sandstones to within a few miles of its junction with the Ohio, and forming a deep channel from which the waters scarcely ever escape to overflow the valley that borders the stream. The alluvial lands, therefore, are found only in very irregular and limited areas along the banks.

In the low flats that lie along near the foot of the upland bluffs, we sometimes find larger areas of overflowed or alluvial lands, differing greatly from those of the valley, and quite rich in character. In the south-eastern part of Calloway county, near the Tennessee State line, such tracts occur and are generally under cultivation. The soil has a timber growth of hickory, white, water and red oaks, poplar, gum, linn, box elder, some ash and sycamore; black locust springs up on lands that have once been in cultivation. On the second bottoms, which have an elevation a little above that of the first, the growth is white and red oaks, poplar, black locust and hickory. These first bottom lands produce an average of ten barrels of corn per acre. Their

chemical composition is given below. Near Birmingham there is an additional growth of pin oak and a few walnuts.

No. 2123. *Virgin Soil* from the Mississippi bottom, three miles south-west from Hickman, Fulton county. Principal growth, white oak, hickory, gum and beech. The dried soil is in pretty firm clods, of a light yellowish-umber color. All of its siliceous residue, remaining after digestion in acids, passed through the fine* sieve, except a small proportion of small particles of partly decomposed concretions, and only one or two small quartz grains.

No. 2124. *Soil* from the surface of a field twelve years in corn without manure. Mississippi bottom land, about two miles south of Hickman, Fulton county. Yield this season (1878) over fifty bushels of corn per acre. Dried soil in friable clods, of an umber color.

No. 2557. *Virgin Soil* of the Ohio river bottom, taken eight inches deep, from Clear Lake ridge, four miles west of Barlow, Ballard county. When dry, it is of a dark greyish-brown color. The clods are small and friable, and the soil contains a small quantity of fine white quartz sand.

No. 2622. *Virgin Soil* of first bottom of the Tennessee river on W. E. Brown's place, south of Shannon creek, Calloway county; is of a greyish-brown color, and contains only a small quantity of fine sand.

*The fine sieve has about 4,000 meshes to the inch square.



RIVER FIRST BOTTOM LANDS.

| Composition, Dried at 212° F. | Mississippi River. | | Ohio River. | Tenn. R. |
|---|---|---|---|---|
| | Fulton County. | | Ballard Co. | Callo'y Co. |
| | 3 miles S. W. of Hickman. | 2 miles S. of Hickman. | 4 miles W. of Barlow. | Brown's place, Buf. Landing. |
| | Soil. | Cult'd soil. | Soil. | Soil. |
| | No. 2123. | No. 2124. | No. 2557. | No. 2622. |
| Organic and volatile matter | 9.305 | 4.725 | 5.772 | 6.080 |
| Alumina and manganese oxide | 10.437 | 5.127 | 6.876 | 8.171 |
| Iron peroxide | ..... | ..... | 4.124 | 4.791 |
| Lime carbonate | 1.385 | 1.045 | .210 | .280 |
| Magnesia | .461 | .234 | .273 | .461 |
| Phosphoric acid | .198 | .198 | .226 | 218 |
| Potash | .142 | .321 | .723 | .461 |
| Soda | ..... | .419 | .145 | ..... |
| Water expelled at 380° | 3.110 | 1.150 | 1.263 | 2.135 |
| Sand and insoluble silicates | 74.840 | 87.145 | 80.999 | 77.719 |
| Total | 99.878 | 100.364 | 100.611 | 100.316 |
| Hygroscopic moisture | 4.100 | 2.350 | 2.290 | 2.650 |
| Potash in insoluble silicates | 1.889 | 1.814 | 1.069 | 1.487 |
| Soda in insoluble silicates | .607 | .858 | .277 | .253 |

The above analyses show marked differences in the composition of the bottom soils of the three rivers, the virgin soil of the Mississippi being richest in decayed vegetation, alumina, lime and magnesia, all of whose percentages are large. Its phosphoric acid is lower than that of the other two rivers, though still in fair amounts, and its potash percentage is low for a soil so rich in lime and decayed vegetation. It is especially surprising that so large an amount (1.889) should remain in an insoluble condition in the presence of so large a per cent. of the latter two ingredients, whose office is to render it available for the use of plants.

A notable feature in the analysis of the Ohio bottom soil is the very high percentage of potash; that of the phosphoric acid and vegetable matter is very fair. The soil is not as clayey as that of the Mississippi bottom, and the power for retaining hygroscopic moisture is consequently not as great.

The soil of the Tennessee bottom is well supplied with both potash and phosphoric acid in an available condition, while in the insoluble portion there is a large percentage of the former. It is less sandy than the Ohio bottom soil, and there are larger percentages of decayed vegetation and hygroscopic moisture.

*Sand Ridges.*—The sandy ridges in the Ohio bottom lie parallel with the present course of the river, and at a distance of about a mile, and have a width of about half a mile, bordered on either side by small lakes and sloughs. Their lengths are respectively only from one to two miles, and their soil is chiefly a reddish sand with some decayed vegetation. Some of them have a breadth giving sufficient area for cultivation, yielding, it is claimed, fifteen bushels of wheat or forty bushels of corn per acre. The soil is not durable.

The sand ridge of the Mississippi bottom below Hickman, lying north-east and south-west, known as the Sassafras Ridge, is overflowed at extreme high-water of the river. It has a growth of gum, cottonwood, oak, ash and sassafras. The latter was formerly the chief growth, but has been cut out for rails. The surface of the ridge is uneven, wide and long, and its soil is sandy, but mostly under cultivation, yielding, it is claimed, twelve to fourteen barrels of corn per acre.

*Bottom Lands of Other Streams.*—The lowlands that comprise the bottoms of other streams in the Purchase counties are not alluvial in character, but are formed by the washing down of the neighboring brown loam hills, by small streams, the currents of which, being checked upon the bottom plain, permitted the deposition of the sediment in part. The flat nature of the bottoms prevents any natural drainage, and hence this sediment has become compacted and leached, producing a whitish, cold and stiff soil, highly crawfishy in character, and covered by a thin deposit of decayed vegetation. The bottoms are annually overflowed, but very little sediment is deposited from the current. It is only near the bluffs that any deposition takes place, and that is from the adjoining hills. A tall and heavy timber growth usually shades these bottom lands, and yearly adds to the amount



of vegetable decay. Comparatively little of these lands are under cultivation.

Of the many streams, Mayfield creek has the broadest bottom land, and more of it is under cultivation than on any other, but even then the amount is very small. The timber growth is white oak, hickory, sweet gum, a little poplar, walnut, redbud, papaw and catalpa. The soil is generally a bluish clay, on which clover and herds grass flourish. Other crops do not grow well except near the foot of the bluff; corn is here the chief crop.

The bottom lands of the two forks of Clark's river are next in width, in some places being as much as two miles. Their timber growth is finer than on any other of these minor streams, consisting of white and Spanish oaks, poplar, hickory, sweet and black gums, some walnut, dogwood and sassafras, with an undergrowth of papaw.

The bottoms of Obion and Bayou de Chien are comparatively narrow, and of no special importance except for their timber, which consists of water and white oaks, hickory, cypress, black and sweet gums, maple, sassafras (two and one-half feet in diameter), and some birch.

The following soils from several of these streams have been analyzed:

No. 2100. *Virgin Bottom Soil*, near Shelton and Moore's mill, on Mayfield creek, Ballard county; said to produce good hay, but to be otherwise unproductive. Original growth, black, white and red oak, sweet gum, elm, persimmon and hickory.

No. 2101. *Top Bottom Soil*, from an old field long in cultivation; on Mayfield creek, Ballard county.

No. 2102. *Bottom Subsoil* of the next preceding; on Mayfield creek.

No. 2556. *Bottom Soil;* crawfishy; on West Fork of Mayfield creek, Ballard county, taken to the depth of ten inches, near the bridge on the road from Blandville to Milburn.

No. 2757. *Bottom Soil*, of West Fork of Clark's river, near Brewer's old mill, Marshall county. Rich yellow loam soil. Sample taken to the depth of ten inches. Growth exclusively beech.

No. 2749. *Virgin Bottom Soil;* from East Fork of Clark's river near Benton, Marshall county. Soil crawfishy. Sample taken ten inches deep. Growth mostly white oak.

No. 2621. *Virgin Bottom Soil*, of Clark's river. Taken ten inches deep. Murray, Calloway county.

No. 2558. *Virgin Bottom Soil;* of Obion creek, south of Arlington, Ballard county. Taken to the depth of ten inches.

No. 128. *White Bottom Soil* of Bayou de Chien, at Moscow, Hickman county, Kentucky (Quaternary formation).

BOTTOM LANDS OF OTHER STREAMS.

| Composition, Dried at 212° F. | Mayfield Creek. | | | | Clark's River. | | | Obion. | Bayou deChien |
|---|---|---|---|---|---|---|---|---|---|
| | Ballard County. | | | | Marshall Co. | | Cal. Co. | Ballard County. | Hickman Co. |
| | Near Blandville. | | | | Brewer's Mill | Benton. | Murray. | Nr. Arlingt'n. | Moscow. |
| | Soil. | Cul. soil | Subsoil. | Soil. | Soil. | Soil. | Soil. | Soil. | Soil. |
| | No. 2100 | No. 2101 | No. 2102 | No. 2556 | No. 2757 | No. 2749 | No. 2621 | No. 2558 | No. 128. |
| Organic and volatile matters | 3.210 | 2.565 | 2.125 | 3.306 | 3.394 | 3.757 | 3 475 | 4.635 | 2.000 |
| Alumina and manganese oxide | 6.150 | 3.864 | 5.088 | 2.945 | 3.248 | 3.706 | 3.612 | 4.217 | 6.170 |
| Iron peroxide | | | | 1 860 | 1.764 | 1.360 | 2.116 | 1.915 | |
| Lime | .155 | .385 | .245 | .196 | .146 | .026 | .021 | 1.463 | 1.150 |
| Magnesia | .268 | .163 | .184 | .181 | .180 | .143 | .180 | .267 | .160 |
| Phosphoric acid | .115 | .061 | .077 | .008 | .084 | .109 | .062 | .133 | .129 |
| Potash | .203 | .319 | .276 | .477 | .172 | .083 | .310 | .504 | .170 |
| Soda | .364 | .362 | .129 | .389 | . . . . | .210 | . . . . | not est. | .020 |
| Water expelled at 380°F. | 1.065 | .635 | .675 | .556 | 1.028 | .583 | 1.100 | .941 | . . . . |
| Sand and insoluble silicates | 88.890 | 92.010 | 91.570 | 90.616 | 89.757 | 90.070 | 88.432 | 86.856 | 90 570 |
| Total | 100.420 | 100.364 | 100.369 | 100.534 | 99.773 | 100.047 | 99.308 | 100.931 | 100.369 |
| Hygroscopic moisture | 1.865 | 1.075 | 1.125 | 1.100 | 1.300 | 1.520 | 1.450 | 1.625 | . . . . |
| Potash in the insoluble silicates | 1.659 | 1.358 | 1.401 | 1.497 | 1.604 | 1.438 | 1.146 | 1.435 | . . . . |
| Soda in the insoluble silicates | 1.150 | .616 | .911 | .834 | .698 | .402 | .535 | 1.243 | . . . . |

The Mayfield creek lands are fairly supplied with potash and lime, but the phosphoric acid is deficient in all except in No. 2100, where the proportion is fair. The cultivated soil shows a falling off in phosphoric acid, but an increase of potash at the expense of that held as insoluble silicate, and due, perhaps, to the loosening and aeration as well as the drainage afforded by tillage.



VALLEY LANDS.

The valleys that border the Tennessee, Ohio and Clark's rivers, are from fifteen to thirty feet higher than the bottoms proper, and can hardly be classed as subject to overflow. Neither are they properly a *second bottom* of those streams.

*The Tennessee River Valley.*—The width of this valley, beginning at the Tennessee State line, where the limestone escarpments almost reach the river, varies from one to one and a half miles northward until Gilbertsville is reached, whence to westward it widens to three miles at Calvert City, and again narrows to the upland bluffs, which rise from the water's edge at Lawton's Bluff. Thence to the mouth of Clark's river, where it merges into the broad flats of that river, the valley is very narrow.

The eastern border of the valley from the State line to and beyond Gilbertsville is against high limestone bluffs; the western, which is at a greater distance from the river, is also bounded by bluffs, at whose base limestones are exposed in several places, and on whose sides chert debris is generally found. The last exposure of limestone is near Gilbertsville, where the river cut its way through this narrow belt of rock and entered the basin of the old gulf embayment which is now filled with sands and clays. The line of bluffs, however, fall in elevation from one hundred and sixty feet at the Tennessee line to about seventy-five, near Gilbertsville, and beyond to Lawton's Bluff.

The surface of the valley presents an uneven plain, the central part being higher than that lying along the river on the east and that adjoining the bluffs on the west, and comprising, too, the greater portion of the area. The lower lands are subject to overflow from high-water from the river, and have usually a stiff crawfishy soil, dark from decayed vegetation, and are not very much under cultivation.

The valley upland soil is a yellowish loam very similar to that of the high interior uplands of the Purchase counties, but differing from the latter in being micaceous. It has a depth of from ten to twelve feet, overlying directly the blue micaceous clays that outcrop along the river bank at numerous places.

The soil is said to produce eight barrels of corn, one thousand pounds of tobacco, or fifteen to twenty bushels of wheat per acre.

The lands are in many places very flat and inclined to be cold, heavy and crawfishy, from insufficient natural drainage. These flats usually have a growth of hickory, red and post oaks, and sassafras, showing a fertile soil. Wherever there is sufficient drainage the land is light and loamy, friable and easily tilled. North of Calvert City the growth is chiefly white and black oaks, hickory, poplar and dogwood, the soil being a dark loam, producing about seventy bushels of corn, fifteen bushels of wheat, or one thousand pounds of tobacco per acre.

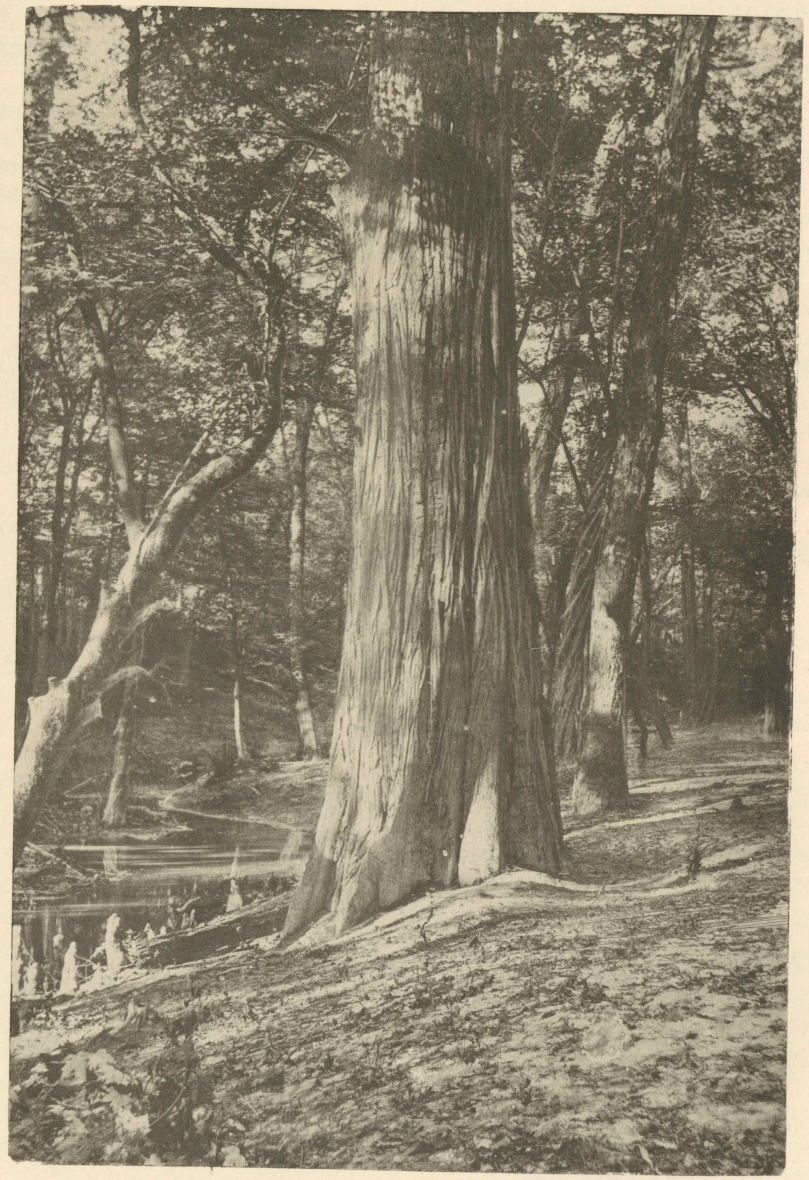
There are a number of small streams which either lie entirely within this valley or have their source within the bordering uplands, and for the greater part of their lengths run through the flats that lie at the foot of the highlands, then suddenly turning to the river. They have usually but little bottom land, though in places they are bordered by flat swamps.

The Shannon creek bottom, in the south-east part of Calloway county, and entirely within this river valley, has a surface loam soil, black from decayed vegetation. It spreads out over a broad flat in places, presenting a swamp covered with white and red oaks, and poplar, some hickory and walnut, and a dense undergrowth of gum and hazel. The soil is thin, averaging about six inches in depth, and suddenly changes to a compact crawfishy white clay subsoil. The analyses of both soil and subsoil are given below. Cypress creek has scarcely any bottom lands.

The analyses given below show the chemical composition of these valley lands.

No. 2752. *Virgin, Crawfishy, or Glady Soil*, of Tennessee valley, one mile north of Calvert City, Marshall county. Sample taken to the depth of twelve inches. Growth, red and post oaks, hickory and dogwood. The soil is mottled yellow and white in color, and silty in character. The subsoil seems to be of the same character.

No. 2753. *Virgin Loam Soil*, of the central portion of Tennessee river valley, one mile north of Birmingham, Marshall county. Sample taken to the depth of twelve inches. Growth, oak and sassafras



SWAMP CYPRESS, CALLOWAY CO., KY.

No. 2751. *Virgin Soil.* Dark sandy loam, from low ridge of Tennessee river valley, two miles below the mouth of Jonathan creek, Marshall county. Sample taken to the depth of twelve inches. Growth, white and Spanish oaks and dogwood.

No. 2747. *Virgin Soil* of the crawfish flats of the Tennessee river valley, Marshall county; two miles below the mouth of Jonathan creek. Sample taken to the depth of eight inches. Growth, hickory and red and post oaks, and sassafras.

No. 2748. *Subsoil* of the next preceding soil; color somewhat lighter than that. Clods are firmer. Contained about 3.9 per cent. of bog iron.

No. 2627. *Virgin Soil* of the valley of the Tennessee river; W. E. Brown's place, south of Shannon creek, Calloway county. When dry it is of a dark greyish-brown color; clods are friable. Contains small bog iron ore.

No. 2628. *Subsoil* of the next preceding; when dry it is of a light reddish, greyish-brown color. Clods are friable.

No. 2634. *Virgin Bottom Soil*, of Shannon creek; is umber color; clods are friable.

No. 2635. *Subsoil* of the next preceding; taken at the depth of six to twelve inches. A stiff yellowish clay.

TENNESSEE RIVER VALLEY LANDS.

| Composition, Dried at 212° F. | Marshall County. | | | | | Calloway County. | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Calvert City. | Birmingham. | Two Miles North of Jonathan Creek. | | | Brown's Place N. Buffalo Ld. | | Shannon Creek. | |
| | Glady Soil. | Loam Soil. | Loam Soil. | Glady Soil. | Glady Subsoil. | Loam Soil. | Loam Subsoil. | Loam Soil. | Glady Subsoil. |
| | No. 2752 | No. 2753 | No. 2751 | No. 2747 | No. 2748 | No. 2627 | No. 2628 | No. 2634 | No. 2635 |
| Organic and volatile matter | 3.506 | 4.411 | 3.467 | 3.443 | 2.373 | 5.482 | 2.627 | 5.848 | 3.500 |
| Alumina and manganese oxide | 3.030 | 4.448 | 4.875 | 3.303 | 5.021 | 3.595 | 5.333 | 4.982 | 4.332 |
| Iron peroxide | 2.037 | 3.395 | 2.332 | 1.955 | 2.630 | 3.060 | 4.365 | 2.455 | 5.575 |
| Lime carbonate | trace. | trace | .046 | .025 | trace. | .147 | .222 | .163 | .132 |
| Magnesia | .281 | .344 | .194 | .162 | .139 | .245 | .180 | .378 | .364 |
| Phosphoric acid | .110 | .094 | .113 | .136 | .110 | .124 | .124 | .249 | .159 |
| Potash | .305 | .160 | .192 | .047 | .515 | .246 | .517 | .259 | .604 |
| oda | .046 | .... | .... | .... | ... | ... | .... | .... | .... |
| Water expelled at 380° F. | .509 | .557 | 531 | .607 | .227 | 1.401 | .859 | 1.323 | .814 |
| Sand and insoluble silicates | 89.643 | 86.678 | 88.460 | 90.217 | 88.877 | 84.792 | 86.200 | 84.356 | 84.426 |
| Total | 99.467 | 100.087 | 100.210 | 99.895 | 99.892 | 99.092 | 100.427 | 100.013 | 99.906 |
| Hygroscopic moisture | 1.900 | 1.400 | 1.225 | 1.300 | 1.100 | 1.500 | 1.050 | 1.850 | 1.700 |
| Potash in insoluble silicates | 1.506 | 1.614 | 1.600 | 1.544 | .515 | 1.469 | 1.360 | 1.268 | 1.380 |
| Soda in insoluble silicates | .312 | .598 | .398 | 1.418 | .153 | .267 | .694 | .309 | .588 |
| Fine quartz sand | .... | .... | .... | .... | .... | .... | .... | 2.050 | 2.200 |

From the above it will be seen that none of these lands are very clayey; but, on the contrary, are largely made up of a fine silty material insoluble in acids.

The lime percentage is almost nothing in the lower portion of the valley; is very small in the central part, and much greater, though still small, in the upper portion near the Tennessee State line, where limestone becomes a more prominent rock in the hills. The magnesia percentage is more constant throughout the valley.

The phosphoric acid percentage is very variable, being small in all of the soils, and fair in the land of Shannon creek.

The amount of potash is deficient in the glady soil near Jonathan creek, though large in its subsoil; is fair in the lands of the lower portion of the valley, and soils of the upper portion, while the subsoils of the latter are very rich in it. The insoluble silicates contain extremely large percentages of potash, except in the glady subsoil near Jonathan creek.

In decayed vegetation the lands of the upper part of the valley are again richer than in the central or lower portion, being marked by a denser and greater variety of undergrowth.

*Valley of the Ohio.*—This valley, exclusive of the bottom lands, lies entirely within Kentucky, and covers an area of about seventy-five square miles, from Paducah, where it joins that of the Tennessee and Clark's rivers, westward to the Mississippi bottom.

At first the valley has a width but little more than two miles; but when near the Ballard county line it suddenly widens, the southern limit changing from its north-west to a south-west and west course, giving to it a width of about six miles.

The surface of this valley is uneven, and lies about thirty feet above the bottom lands and one hundred below that of the bordering uplands.

This highland border is usually quite abrupt in the region of Paducah; but westward the change from the valley to the hills is somewhat more gradual.



The bottoms bordering the streams that cut across the valley are but little below the general level, and are very narrow.

The character of the valley lands is very similar to that of the Tennessee. Its soils are brownish loams, more or less micaceous, light and mellow where properly drained, but whitish and crawfishy, cold and compact, where drainage is wanting. On the latter lands, which embrace the *flats* of the valley, water usually stands for some time after rains, slowly permeating the soil and producing a leaching effect. The growth of these flats is generally post oak, with some hickory.

Very little of the valley land is under cultivation, because of its cold, stiff and untillable character.

Analyses of samples of the soil from several localities are given below.

*Valley of Clark's River.*—The valley of this stream begins properly just below Kaler post-office, in Graves county, on the West Fork, where, from a mere point, it widens slowly to the McCracken county line at Hard Money, where it suddenly turns westward for a mile or so, and thence, to near Paducah, has a very uneven upland border, which rises one hundred feet above it. Its extreme width, from Florence to the junction of the East and West Fork, is about five miles. On the East Fork it begins above the town, and thence, to the main body, has an average width of less than a mile. The river has scarcely any bottom land within the valley.

The surface of the valley is very level and with no drainage, and its soils, in consequence, have a whitish, leached character, cold, stiff and crawfishy, affording very little land naturally fit for cultivation. Along the borders of streams or gullies, however, the water, percolating through the soil, has an opportunity to escape into these channels, and we find very narrow belts that are thus rendered tillable, being light, open and brownish-yellow; but such are not in abundance.

The valley land is chiefly valuable for its fine timber, embracing large oaks and hickory. There is comparatively little undergrowth, and this gives to the region an open appearance. An analysis of a representative soil is given below.

No. 2561. *Virgin Soil* of the flatwood loam, Bandana, Ballard county; it is of a yellowish-brown color. Clods are friable. Contains some shot iron ore and a few small quartz pebbles. Taken to a depth of ten inches. Timber growth is post oak and hickory.

No. 2562. *Subsoil* of the next preceding; it is of a dirty light-yellowish color, and contains only a little shot iron ore; the clods are firm. Taken from ten to sixteen inches.

No. 2767. *Soil* of the oak and hickory flat lands of Albert Bradshaw, south-west of Paducah, McCracken county. When dry it is of a brownish-grey color. Clods are firm. The soil contains a small quantity of fine hyaline quartz sand. Taken to a depth of ten inches. Timber growth, post oak and hickory.

No. 2768. *Subsoil* of the next preceding; it is of a lighter and more yellowish color than the preceding. Clods are firm. Contains 2.75 per cent. of fine hyaline quartz sand. Taken from ten to fifteen inches.

No. 2773. *Virgin Soil* of post oak flatwoods, one mile west of Paducah, on Hinkleville road, McCracken county. The soil is brownish-grey; the clods are friable. Contains 2.3 per cent. shot iron ore, and a little hyaline quartz sand. Taken to a depth of ten inches. Timber, chiefly post oak.

No. 2774. *Subsoil* of the next preceding; when dry is of a light yellowish-grey color. Clods are quite friable. Contains some shot iron ore and a small quantity of fine quartz sand. Taken from ten to fifteen inches.

No. 2775. *Virgin Soil* of the post oak flatwoods, near the county line north of Woodville, McCracken county; when dry is of a light-grey or ashy color, and friable. Contains some shot iron ore. Taken to a depth of ten inches. Timber growth, almost exclusively post oak.

No. 2776. *Subsoil* of the next preceding; it is of a very light-grey color. Small clods are somewhat firm. Contains some shot iron ore and hyaline quartz sand. Taken from ten to fifteen inches deep.

No. 2750. *Virgin Soil* of post oak flats of East Fork of Clark's river, north of Stringtown, Marshall county. It is crawfishy in character. Contains some shot iron ore and fine white sand. Taken to a depth of ten inches. Subsoil apparently similar in character to the soil. Timber growth, post oak, chiefly.

RIVER VALLEY OR FLAT LANDS.

| Composition, Dried at 212° F. | Ohio River Valley. | | | | | | | | Clark River. |
|---|---|---|---|---|---|---|---|---|---|
| | Ballard County. | McCracken County. | | | | | | | Marshall County. |
| | Bandana. | Near Paducah. | | | | | North of Woodville. | | Near Stringtown. |
| | | Oak and Hickory Flats. | | Post Oak Flats. | | | | | Post Oak Flats. |
| | Soil. | Subsoil. | Soil. | Subsoil. | Soil. | Subsoil. | Soil. | Subsoil. | Soil. |
| | No. 2561 | No. 2562 | No. 2767 | No. 2768 | No. 2773 | No. 2774 | No. 2775 | No. 2776 | No. 2750. |
| Organic and volatile matters | 3.642 | 2.114 | 4.385 | 3 781 | 2.807 | 2.309 | 2 083 | 1.637 | 3.845 |
| Alumina and manganese oxide | 4.639 | 4.523 | 7.307 | 6.578 | 5.336 | 4.982 | 2.818 | 3.295 | 4.623 |
| Iron peroxide | 2.363 | 3.077 | 3.094 | 3 416 | 3 086 | 3.441 | 1.533 | 1.950 | 3.039 |
| Lime carbonate | .071 | .046 | .215 | .164 | .127 | .097 | .171 | .161 | .076 |
| Magnesia | .198 | .344 | .046 | .047 | .394 | .327 | .161 | .235 | .181 |
| Phosphoric acid | .103 | .115 | .110 | .085 | .095 | .079 | .062 | .030 | .127 |
| Potash | .295 | .422 | .271 | .227 | .167 | .302 | .179 | .125 | .477 |
| Soda | .248 | .136 | .119 | .032 | .087 | . . . . | .145 | . . . . | 084 |
| Water expelled at 380° F. | .842 | .648 | .909 | .488 | .946 | .761 | .538 | .463 | .224 |
| Sand and insoluble silicates | 87.952 | 88.866 | 83.233 | 84.790 | 87 213 | 87.476 | 92.726 | 92.642 | 87.057 |
| Total | 100.353 | 100.291 | 99.689 | 99.608 | 100.258 | 99.774 | 100.416 | 100.538 | 99.733 |
| Hygroscopic moisture | 1.430 | 1 375 | 2.750 | 2 825 | 1.500 | 1.700 | 0.875 | 1.050 | 1.800 |
| Potash in insoluble silicates | 1.439 | 1.591 | 1.215 | 1.348 | 1.428 | 1.435 | 1.446 | 1.566 | 1.284 |
| Soda in insoluble silicates | 1.208 | 1.551 | .480 | .500 | .704 | .718 | 1.062 | 1 219 | .526 |

A notable feature in all of the above analyses is the low percentage of both lime, phosphoric acid, and of decayed vegetable matter.

The potash is in fair amounts in all except the lands of the post oak flats around Paducah; while, on the contrary, the percentage is very good in the soil of the flats near Stringtown on the East Fork of Clark's river, and in the subsoil of the Ohio valley, near Bandana.

A marked difference is observed in the lands of the oak and hickory flats, and those of the post oak flats, near Paducah, the former having nearly double the amount of lime, a little more phosphoric acid, and much more potash; this, too, although the amount of potash in the insoluble condition is greatest in the poorer soil. The reason for this lies, probably, in the action of the larger amount of decayed vegetation in the oak and hickory land.

The soil of Clark's river valley, near Stringtown, is the richest of all the above soils in its potash and phosphoric acid. Lime is, however, deficient, and its surface is too flat for good drainage.

## UPLANDS.

The physical features of the uplands of the Purchase have already been given on a previous page. They comprise an uneven surface, grooved by many streams and their small tributaries, which have cut deep into the soft brown loam of the surface, the gravel underlying, and the under-clays and sands. The uplands bordering these streams are in turn often deeply gullied and washed for some distance back from the bottoms, the soil being easily carried away by rains.

The uplands comprise several divisions; the *Cane Hills* or bluff lands that cap the high bluffs bordering the Mississippi river bottom; the *timbered* (oak and hickory) *region*, or that portion bearing a large and varied growth of oaks, hickory, poplar, etc., and so designated popularly to distinguish them from the *Barrens*, another division which was originally an open prairie; and the *Flatwoods*, which occupy only a small area in Calloway county.

At present the entire region is timbered, except where cut away for tillage purposes.

The divisions are considered separately.



### CANE HILL OR BLUFF REGION.

The lands belonging to this division are confined exclusively to the high bluffs that border the bottom lands of the Mississippi river, forming a narrow belt, which is continued southward through the States of Tennessee and Mississippi into Louisiana, and is characterized throughout by the same soils and timber growth, together with an undergrowth of cane, whence the name of Cane Hills. The surface is underlaid by a grey calcareous silt, having a depth of from ten to as much as thirty feet, and which forms another distinguishing feature of the belt.

In Kentucky the region reaches from the Tennessee State line northward to Shawnee creek beyond Wickliffe, Ballard county. Northward it was probably at some time continuous into the State of Illinois, as it appears on the Ohio bluffs at Caledonia; but all traces of the formation between these points have been swept away by the floods that excavated the broad valley flats along the south side of the Ohio river and, at a later period, the broad bottoms of the Mississippi, from Wickliffe to Caledonia.

The fact that the present belt is highest along its river border, and that this border is highest in its most westerly portion, viz., at the Tennessee line, gradually falling in elevation northward as the border recedes eastward, indicates that at some time the bluffs were very much wider, having been worn away by the combined currents of the three great rivers; those portions offering greatest resistance in their compact Tertiary clay deposits still standing out to the water's edge, and gradually yielding to the undermining action of the river current.

The region in Kentucky covers about forty-five square miles, and is widest along the Tennessee State line, reaching eastward to about Snapneck creek, a distance of about four miles. The slope inland is here very gradual, but northward, as the belt rapidly narrows, the ridge feature is more and more prominent, until at the town of Hickman, where the ridge comes to a point, its eastern descent is very abrupt. After passing the wide bottoms of Bayou de Chien and Obion creek, the Cane Hills begin again at Mc-

Leod's Bluff, with an elevation of but fifty feet; but, along the north-westerly trend, the bluffs rise, and at "Chalk Banks" and at Columbus they have an elevation of about one hundred and eighty feet above the bottom lands. Here they have a rather gradual slope to the Obion creek. Going still northward from Columbus, the bluffs recede from the river to the eastward, and consequently become lower, terminating at Shawnee creek in low elevations and but a small width.

The soil of the Cane Hills region is a light loam, dark from decayed vegetation, and considered to be the richest upland within the Purchase Region. The timber growth indicates this in its splendid walnuts, poplars, maples, white and Spanish oaks, and in the cane undergrowth.

The surface of the region is, however, so broken and cut up by the deep ravines and washes that have been produced by the drainage waters flowing from the edge of the bluffs toward the interior, that it is only occasionally that areas of level land can be found sufficient for fields of any size, except in the broader region near the Tennessee line.

The following analyses of samples of these lands, from several localities, have been made by Dr. Peter for the Survey.

No. 2128. *Virgin Soil.* Farm of Capt. Henry Tyler, three miles south-east from Hickman, Fulton county. Growth, mostly poplar, maple, white and Spanish oaks, and some walnut. Contained but a small proportion of partly-rounded ferruginous particles.

No. 2129. *Subsoil* of the next preceding, etc., taken twenty-four inches below the surface.

No. 2130. *Soil* from an old field near the location of the next preceding soil, on Capt. Henry Tyler's farm, near Hickman, Fulton county. Taken ten inches deep. The yield is sixty-five bushels of corn per acre.

No. 2131. *Subsoil* of the next preceding; taken carefully from fifteen to twenty-four inches below the surface. The bulk of the sample is from twenty-four inches below the surface.



No. 2132. *Virgin Upland Soil* on Capt. Henry Tyler's farm, near Hickman, Fulton county. Timber, proportion in order named: black walnut, white oak, sugar maple, and red oak.

No. 2133. *Subsoil* of the next preceding soil, from Capt. Tyler's farm; taken twelve to twenty-four inches below the surface.

No. 2164. *Soil.* Two years in cultivation in corn. Thought to be the prevailing upland soil in Hickman county.

No. 2566. *Virgin, Dark, Bluff Loam Soil.* Near the mouth of Mayfield creek, Ballard county. Taken eight inches deep. Growth, poplar, white oak and hickory.

No. 2567. *Subsoil* of the next preceding; bluff loam; taken from eight to twelve inches below the surface.

GREY SILT OR BLUFF LANDS.

| | Fulton County. | | | | | | Hickman Co. | Ballard County. | |
|---|---|---|---|---|---|---|---|---|---|
| | Near Hickman. | | | | | | Columbus. | South of Mayfield Creek. | |
| Composition Dried at 212° F. | Cultivated. | | | | Virgin. | | Cultivated Soil. | Soil. | Subsoil. |
| | Soil. | Subsoil. | Soil. | Subsoil. | Soil. | Subsoil. | | | |
| | No. 2128 | No. 2129 | No 2130 | No. 2131 | No 2132 | No. 2133 | No. 2164 | No. 2566 | No. 2567 |
| Organic and volatile matter | 3.090 | 2.285 | 8 375 | 4.140 | 2 860 | 2.165 | 4 140 | 3.733 | 1.281 |
| Alumina and manganese oxide | 3 825 | 7.700 | 6.860 | 10.560 | 3.560 | 6.550 | 3.694 | 2.130 | 3.268 |
| Iron peroxide | | | | | | | | 1.519 | 2.224 |
| Lime | .395 | .145 | 1.395 | .795 | .345 | .110 | .495 | .349 | .146 |
| Magnesia | .214 | 268 | .598 | .169 | .142 | .232 | .232 | .175 | .234 |
| Phosphoric acid | .125 | .115 | .125 | .115 | .125 | .140 | .156 | .095 | .078 |
| Potash | .066 | .186 | .332 | .208 | .074 | .275 | .182 | .265 | .109 |
| Soda | not est. | .142 | .073 | 317 | .182 | .050 | .564 | .057 | .023 |
| Water expelled at 380° F. | 1.050 | .840 | 2.650 | 1.501 | .975 | .650 | 1.010 | 1.064 | .958 |
| Sand and insoluble silicates | 91.125 | 87.795 | 79.340 | 82 395 | 91.740 | 89 670 | 90.095 | 90.303 | 91.069 |
| Total | 99.890 | 99.476 | 99.748 | 100.200 | 100.003 | 99.842 | 100.568 | 99.690 | 99 390 |
| Hygroscopic moisture | 1.335 | 2.610 | 3.585 | 3.975 | 1.000 | 1.725 | 1.735 | 1.300 | .900 |
| Potash in the insoluble silicates | 1.784 | 1.675 | 1.865 | 1.873 | 1.969 | 1.935 | 1.899 | 1.859 | 2.031 |
| Soda in the insoluble silicates | 1.208 | .893 | 1.030 | .841 | .892 | .991 | .573 | 1.025 | .927 |

The above soils, being derived from calcaceous silt, show naturally a fair percentage of lime—that of the soil No. 2130, and its subsoil, being very large.

As a whole, the percentage of phosphoric acid in the different soils is fair for a soil with so little clay—that of the soil of the Columbus bluffs being the greatest.

The potash percentage varies greatly—is low in several instances, and fair in the richer soils.

## THE FLATWOODS.

In the counties of Marshall and Calloway there are large areas of uplands that are very level, and are known as "the Flatwoods." That in Marshall county lies south-west of Benton, and covers an area of nearly ten square miles upon the divide between the drainage waters of the East and West Forks of Clark's river. The surface is a little undulating, and in the low places the soil is inclined to be crawfishy, with a post oak growth. On the higher places it is the brownish-yellow loam of the rest of the county, with a timber growth of black oak and hickory, and some white oak, dogwood and sassafras. The soil is said to yield about twenty-five bushels of corn, or ten of wheat per acre; it is, however, best for tobacco, of which it yields from eight hundred to one thousand pounds per acre.

The Flatwoods of Calloway county lie south of Murray, reaching from the south side of the river to the Tennessee State line, covering an area about six miles long and two to three in breadth, or about sixteen square miles of surface. It is the northern termination of that long and narrow belt reaching from the central part of Alabama north-westward and northward through north-east Mississippi and West Tennessee, and possessing features very similar throughout.*

In Kentucky, the Flatwoods presents a very level surface, with large bodies of stiff, whitish, crawfishy land, timbered with a growth of red and post oaks; the better lands, with their loamy soils, having an additional intermixture of hickory. The crawfish lands are impervious to a depth of several feet, and in wet seasons water stands in ponds upon these flats for a long time. These soils yield very poorly,

*See Tenth Census Reports on Cotton Production for these States, volumes V and VI.



the average being, it is said, but five bushels of corn, ten of wheat, or seven hundred pounds of tobacco per acre.

The following analyses of these Flatwoods lands have been made by Dr. Peter for the Survey, the soils having been collected during the progress of the Survey.

No. 2632. *Virgin Soil* of the post oak Flatwoods, two miles east of the Murray and Paris road, near the State line, Calloway county. Taken six inches deep. When dry it is of a dirty grey-buff color; clods are friable. It contains some bog iron ore and fine white quartz sand. Timber growth is post and red oaks.

No. 2633. *Subsoil* of the next preceding. It is of a light yellowish-grey color. Taken from six to ten inches in depth. The clods are somewhat firmer than those of the preceding, and the soil contains some shot iron ore and fine white quartz sand.

No. 2625. *Virgin Soil* of upland, one mile north of New Providence, Calloway county. Taken six inches deep. When dry it is of a light grey-brown color; clods are friable, and the soil contains some shot iron ore. Timber growth is post and red oaks and hickory.

No. 2626. *Subsoil* of the next preceding. It is of a lighter color, and more reddish than the preceding, and the clods are firmer.

No. 2754. *Flatwood Virgin Soil*, four miles south of Benton, on Harvey road, Marshall county. Taken eight inches. When dry it is of a light grey-brown color, and contains a small quantity of shot iron ore. Timber growth comprises red and white oaks, hickory and sassafras.

No. 2755. *Subsoil* of the next preceding. Taken from eight to fourteen inches deep. It is of a light grey-brown color. The clods are moderately firm.

UPLAND FLATWOODS SOILS.

| Dried at 212° F. | Calloway County. | | | | Marshall Co. | |
|---|---|---|---|---|---|---|
| | Two miles east of the Murray and Paris road. | | One mile north of New Providence. | | Four miles south of Benton. | |
| | Crawfish Soil. | Crawfish Subsoil. | Soil. | Subsoil. | Soil. | Subsoil. |
| | No. 2632 | No. 2633 | No. 2625 | No. 2626 | No. 2754 | No. 2755 |
| Organic and volatile matter. | 2.650 | 2.188 | 2.862 | 2.569 | 2.949 | 2.330 |
| Alumina and mangan'se oxide | 1.989 | 2.899 | 3.321 | 4.920 | 3.671 | 4.037 |
| Iron peroxide . . . . . | 2.564 | 2.836 | 2.968 | 4.145 | 2.077 | 2.667 |
| Lime carbonate . . . . . | .652 | .096 | trace. | .046 | .046 | .046 |
| Magnesia . . . . . | .089 | .153 | .234 | .215 | .226 | .327 |
| Phosphoric acid . . . . . | .076 | .094 | .062 | .062 | .046 | .014 |
| Potash . . . . . | .068 | .127 | .369 | .151 | .117 | .079 |
| Soda . . . . . | . . . . | . . . . | . . . . | .097 | . . . | .048 |
| Water expelled at 380° . . . | .657 | .522 | .824 | .755 | .974 | .794 |
| Sand and insoluble silicates . | 91.345 | 90.900 | 89.353 | 86.342 | 89.452 | 89.453 |
| Total . . . . . | 100.090 | 99.815 | 99.993 | 99.302 | 99.558 | 99.795 |
| Hygroscopic moisture. . . . | 1.150 | 1.300 | 0.950 | 1.125 | 1.300 | 1.300 |
| Potash in insoluble silicates . | 1.090 | 1.093 | 1.245 | 1.264 | 1.434 | 1.462 |
| Soda in insoluble silicates. . | .455 | .439 | .374 | .339 | .542 | .430 |
| Fine quartz sand . . . . . | 5.800 | 5.050 | . . . . | . . . . | . . . . | . . . . |

It will be seen at a glance that these soils and subsoils are deficient in phosphoric acid, and also in potash, in an available form, with the exception of the soil from near New Providence, which has a fair amount of the latter.

The soil and subsoil, Nos. 2632 and 2633, from the typical flatwoods, near the Tennessee line, are crawfishy in character, and contain much less clay than the others whose analyses are given; there are larger percentages of phosphoric acid and lime than in the others.

The analyses of the lands from the other two localities in Calloway and Marshall counties show them to be more clayey and somewhat richer than the first, a result to be expected, because of their better drainage and more loamy condition.

In all of the specimens the analyses show that while the alkalies are present in very large amounts, they are very largely held in an insoluble condition as silicate. The remedy is obviously the application of lime to release the potash and render it available for the plant roots, the mechanical condition also being improved by thorough drainage. The phosphoric acid must be supplied by some fertilizer.



## UPLAND "BARRENS."

There is within the Purchase counties a broad region of country which was formerly an open treeless prairie, but which, within the past thirty years, has been covered with a low growth of red and black jack oaks, and is still known as the "*Barrens.*" In the country west of Mayfield to Obion creek it is said that twenty-five years ago the prairie grass was as high as the head of a man on horseback.

The region occupies the central part of the Purchase country, and comprises two regions—the first beginning at the Tennessee State line in the southern part of Graves county, reaches northeastward and northward into south Marshall and northern Graves. It is outlined on the agricultural map accompanying this report. Beginning a little west of Boydsville, the eastern limit, with very irregular outlines, passes east of Harris Grove, a little west of Murray, north to and a little beyond Wadesboro, thence west nearly to the West Fork of Clark's river, and from west side of that river northwestward to Ragsdale, Mayfield creek bluffs. It embraces the country west of the latter creek from two or three miles west of Lewisburg, southward via Kansas, Pottsville, Fancy Farm, Dublin and Wingo, to the Tennessee line. The region passes but a very short distance into Tennessee, apparently limited by the water divide that separates the streams of that State from those of this part of Kentucky.

The second and large region lies still north-west from this region, but separated from it by the uplands that border the north side of Mayfield creek. This tract has its western limit in a line with that of the southern barrens, and reaches from Hazlewood south-east to and beyond Slater post-office, and thence it bends north-east to near Maxon's Mill post-office, and is limited on the northern border by the Ohio river valley.

The entire area covered by the Barrens is about five hundred square miles. Within this area most of the streams are bordered by the so-called timbered uplands in narrow belts.

The growth that first sprang up on the prairies was black jack oak, which, as the soil was improved by decayed vegetation, was replaced by red oak, which at present is only about twenty or twenty-five feet high, the tops presenting quite an even appearance. A larger post oak tree is occasionally found standing among the other oaks.

In its general character, excepting the growth, the Barrens region is very similar to the Oak and Hickory uplands, and it often happens that the timber itself changes but gradually from one to the other.

In their chemical composition, also, the lands of the two divisions are very similar, as may be seen from the analyses of their respective soils.

The soil is a brown loam, several feet in depth, the subsoil being lighter in color, and permeated by seams of a whiter and more silty character.

In the flat portions of the region the soil has a stiff and white crawfishy nature, often containing much red and yellow ferruginous concretionary gravel or bog iron ore. It is said that only upon these bog ore tracts will water remain for any length of time in ponds prepared for watering purposes; the other lands being so loose that water will percolate downward and drain off.

The tilling qualities of the Barrens land is the same as of other uplands. The crops are corn, wheat and tobacco, the land being especially adapted to the latter.

A tobacco merchant in Milburn asserts that he can at sight determine the kind of land a crop of tobacco has been raised upon, when offered to him for purchase; that from the Barrens having small stems, small fibre, dark color and good body; that of the oak and hickory uplands being the reverse in condition.

The yield in tobacco is from eight hundred to one thousand pounds per acre. For corn and wheat the yield is no better than on other lands.

Analyses have been made of the following soils, as shown in the table below.

No. 2096. *Barrens Soil.* Farm of W. H. Reeves, about



six miles north of Blandville. Four years in cultivation in tobacco, three years in corn, and four in wheat. The dried soil is in friable lumps, of a dirty yellowish-brown color. It contains a few soft ferruginous concretions and small quartz pebbles.

No. 2097. *Subsoil* of the field above described. Sample taken twelve to eighteen inches below the surface. The dried subsoil is in friable clods; its color is somewhat lighter than that of the preceding. It contains only a few small, rounded ferruginous concretions.

No. 2559. *Virgin Upland Brown Loam Soil* from Barrens, one mile south-east of Hazelwood, Ballard county. Contains some bog iron ore. Taken eight inches deep. Timber growth comprises red and black jack oaks.

No. 2560. *Subsoil* of the next preceding. Contains some bog iron ore. Taken eight to fourteen inches deep.

No. 2771. *Virgin Soil of Red Oak Barrens*, four miles east of Woodville, McCracken county. Soil is of a grey-brown color. Clods are friable. Taken eight inches deep. The silicious residue contains a small quantity of fine hyaline quartz sand. Timber growth is small red and post oaks; occasionally a large oak tree.

No. 2772. *Subsoil* of next preceding. It is of a brownish-buff color, lighter colored than the preceding. Taken from eight to twelve inches deep. Clods are friable. Contains 3.60 per cent. of bog iron ore.

No. 2660. *Virgin Soil of Black Jack Oak Barrens*, three miles north-west of Mayfield, Graves county. Taken six inches deep. Soil, when dry, is of a brownish-grey color. Clods are friable.

No. 2661. *Subsoil* of the next preceding. Taken from six to twelve inches. When dry is of a greyish-buff color. Clods are comparatively firm.

No. 2623. *Virgin Soil* of the Big Barrens. Ten miles northwest of Murray, Calloway county. Taken six inches deep. The dried soil is of a greyish-brown color. Clods are friable. It contains some bog iron ore and fine white sand. Timber growth, red, black jack and post oak, and some hickory, all small.

No. 2624. *Subsoil* of next preceding. Taken from six to twelve inches. It is of a lighter and more reddish grey-brown color than the preceding. Clods are more firm.

COMPOSITION OF BARRENS SOILS.

| Composition, Dried at 212° F. | Ballard County. | | | | McCracken Co. | | Graves County. | | Calloway Co. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Six miles north of Blandville. | | Hazelwood. | | Four miles east of Woodville. | | Three miles N. W. of Mayfield. | | Four miles west of Murray. | |
| | Cultivated Soil. | Cultiv'd Subsoil. | Soil. | Subsoil. | Soil. | Subsoil. | Soil. | Subsoil. | Soil. | Subsoil. |
| | No. 2096 | No. 2097 | No. 2559 | No. 2560 | No. 2771 | No. 2772 | No. 2660 | No. 2661 | No. 2623 | No. 2624 |
| Organic and volatile matter | 4.056 | 2 790 | 3.096 | 2.079 | 3 863 | 2.335 | 2.639 | 2.187 | 3.540 | 2.632 |
| Alumina and manganese oxide | 5.904 | 7.597 | 3.065 | 4.613 | 4.089 | 4.941 | 2.636 | 3.511 | 3.190 | 5.239 |
| Iron peroxide | | | 1.907 | 2.478 | 2.763 | 2.883 | 1 756 | 2.484 | 2.862 | 4.234 |
| Lime carbonate | 1.095 | .295 | .096 | .071 | .134 | .097 | .096 | .147 | .096 | .096 |
| Magnesia | .394 | .308 | .134 | .202 | .220 | .290 | .159 | .235 | .125 | .107 |
| Phosphoric acid | .246 | .093 | .062 | .052 | .121 | .095 | .084 | .049 | .093 | .084 |
| Potash | .289 | .449 | .420 | .836 | .190 | .216 | .149 | .110 | .084 | .389 |
| Soda | .242 | .148 | not est. | not est. | .302 | .168 | | 039 | .119 | |
| Water expelled at 380° F. | .935 | .760 | .571 | .425 | .662 | .885 | .696 | 1.156 | 1.060 | .860 |
| Sand and insoluble silicates | 87.120 | 87.395 | 90.696 | 90.219 | 88.033 | 88.309 | 91.295 | 89.813 | 88.883 | 86.106 |
| Total | 100.291 | 99.835 | 100.047 | 100.975 | 100.377 | 100.219 | 99 510 | 99.731 | 100.052 | 99.747 |
| Hygroscopic moisture | 2.000 | 2.300 | 1.175 | 1.180 | 1.655 | 1.500 | 0.915 | 0.575 | 1.150 | 1.250 |
| Potash in insoluble silicates | 1.619 | 1.482 | 1.476 | 1.229 | 1.513 | 1.252 | 1.732 | 1.827 | 1.592 | 1.378 |
| Soda in insoluble silicates | .680 | 674 | not est. | 1.032 | .578 | .167 | 1.401 | .870 | .331 | .792 |



In the above analyses the cultivated soil is clearly the richest in lime and phosphoric acid, the presence of so much lime pointing to the conclusion that manures of some kind have been used, or that the spot from which the sample was taken was enriched in some way far above the natural condition of the lands represented by the other analyses, and which show a great deficiency in lime and phosphoric acid.

The potash percentage in the Hazelwood soils and subsoils is very large, especially in the latter; the amount is fair in lands near Woodville, and in the Calloway county subsoil, but very low in other lands, excluding the cultivated soil already mentioned. There is, however, a very large amount of potash in the insoluble silicates, which liming and the application of decayed vegetation would render available. The phosphoric acid must be added in the form of fertilizers, before the land can attain any degree of durable richness.

### OAK AND HICKORY UPLANDS.

This division covers a little less than two-thirds of the entire uplands, reaching from the foot of the Cane Hills on the west, to the brow of the highlands that face the Tennessee valley on the east, excluding the region of Barrens that occupy a large central portion of the country.

The surface is rolling and somewhat broken, in consequence of the denudation by streams, and is well timbered with red, black, Spanish and post oaks and hickory, and an undergrowth of dogwood and sassafras.

The soil is a brown loam, some four feet in depth, overlying a lighter colored loam, which is often permeated with seams of a lighter or greyish-ashy silt. These seams apparently represent cracks produced in the original deposit by drying, and which were filled by silt at the time of the deposition of the silt of the Cane Hills; they contain scarcely any clay. This under-clay varies in depth from a few feet to as much as twenty, and overlies the gravel beds of the Quaternary age.

The loam contains but about ten per cent. of clay, the rest being mostly silica in a fine state of division, holding also mineral silicates.

When drained, the soil is light and loose, and of a bright brownish-color; but where, on the contrary, drainage is deficient, the iron in the loam is accumulated in the pools of water into the form of small blackish concretions or bog ore, and the soil becomes whitish and highly compact, differing but little, however, in its chemical composition from the better and well-drained land.

These lands are highly productive for a few years, yielding good crops of corn and tobacco. The latter crop does best on the Barrens, where it is also said to be much finer in character.

Analyses of the following samples show the average composition of these uplands:

No. 1437. *Subsoil* of an old tobacco field. The soil proper has been washed away. Field about one hundred and fifty feet above the Mississippi river, four miles east of Hickman, Fulton county.

No. 2125. *Virgin Soil*, from the land of Dr. G. W. Pascal, half a mile north of Fulton, Fulton county.

No. 2126. *Surface Soil*, from an old field forty years in cultivation. Farm of Dr. Pascal, half a mile from Fulton, Fulton county. Sample taken three to twelve inches below the surface.

No. 2127. *Subsoil* of the next preceding. Taken from thirteen to twenty inches below the surface. Contained small ferruginous concretions.

No. 2563. *Virgin Dark Loam Soil;* from Barlow, Ballard county. Taken to the depth of eight inches. Timber, white oak, poplar, gum and sassafras. Contained a little bog iron ore.

No. 2564. *Subsoil* of the next preceding; taken from eight to ten inches below the surface.

No. 2. *Soil* from the north-western part of Ballard county, near Col. Gholson's.

No. 219. *Subsoil* from the north-western part of Ballard county, from near Col. Gholson's. Contained rounded fragments of bog iron ore.

No. 2098. *Subsoil* of the uplands around Blandville, Ballard county. Taken from eighteen to twenty-four inches



BARTRAM OAK, CALLOWAY CO., KY.
(*Quercus heterophylla.*)

below the surface. Characteristic of most of the upland subsoils in the "Jackson Purchase."

No. 2099. *Under-clay* of the uplands around Blandville. Taken several feet below the surface. It crops out just below the gravel-bed, and is several feet thick. It is observed nearly all over the "Jackson Purchase" where there is much soil. Shows some thin, dark-colored infiltrations of iron and manganese oxides.

No. 1. *Soil* from heavy timbered land, southern part of Ballard county, between the waters of Bowles and west branch of Mayfield creeks.

No. 218. *Subsoil* of heavily timbered land, southern part of Ballard county. Contained some particles of iron ore.

No. 2061. *Surface Soil* from the farm of L. M. Flournoy, three miles from Paducah, McCracken county. Taken to the depth of eight inches. Forest growth, mostly oaks of various species, with some hickories, etc. The corn crop averages twenty-five to forty bushels per acre. It is good tobacco soil, and considered an average soil of the county.

No. 2062. *Subsoil* of the next preceding, etc.

No. 2063. *Under-clay* of the two preceding soils, etc. (Sand beneath this.)

No. 2769. *Virgin Brown Loam Soil;* New Hope Church; south-west corner of McCracken county. Sample taken to the depth of six inches. Timber, white and red oaks, hickory, dogwood and sassafras.

No. 2770. *Subsoil* of the next preceding. Taken at the depth of from six to twelve inches. Contained a little bog iron ore.

No. 2629. *Virgin Upland Soil*, five miles east of Murray, Calloway county. Taken to the depth of ten inches. The soil is dark for one inch, and then a light brown loam, to the subsoil. Growth, red oak chiefly, some post oak and hickory. Contained a small quantity of bog iron ore.

No. 2630. *Virgin Upland Sandy Loam Soil* of the "Coalings" of the south-east corner of Calloway county. Taken to the depth of six inches. Original growth, red, black, Spanish and post oaks, and hickory. Contained a little small bog iron ore.

No. 2631. *Subsoil* of the next preceding. Taken to the depth of between six and twelve inches. Small quantity of small bog iron ore contained in it.

| Composition, Dried at 212° F. | Fulton County. | | | | McCracken County. | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 4 miles E. of Hickman | Near Fulton. | | | Flournoy's, 3 miles west of Paducah. | | | New Hope C'h., S. W. part of county. | |
| | Subsoil. | Soil. | Cultivated Soil. | Subsoil. | Soil. | Subsoil. | Underclay. | Soil. | Subsoil. |
| | No. 1437 | No. 2125 | No. 2126 | No. 2127 | No. 2061 | No. 2062 | No. 2063 | No. 2769 | No. 2770 |
| Organic and volatile matter | 2.250 | 3.075 | 2.300 | 2.535 | 2.050 | 2.650 | 2.675 | 3.549 | 2.365 |
| Alumina and manganese oxide | 6.005 | 5.335 | 4.974 | 8.690 | 5.497 | 12.300 | 10.834 | 3.160 | 3.339 |
| Iron peroxide | | | | | | | | 1.681 | 1.880 |
| Lime carbonate | .230 | .360 | .190 | .195 | .115 | .190 | .190 | .197 | .121 |
| Magnesia | .414 | .175 | .162 | .331 | .268 | .521 | .649 | .327 | .289 |
| Phosphoric acid | .172 | .055 | .156 | .125 | .093 | .115 | .061 | .096 | .078 |
| Potash | .159 | .179 | .290 | .141 | .167 | .284 | .643 | .329 | .282 |
| Soda | .072 | not est. | .124 | .098 | .171 | . . . . | .087 | .583 | not est. |
| Water expelled at 380° F. | .650 | 1.025 | .775 | .900 | 1.000 | 1.000 | 1.000 | .547 | .379 |
| Sand and insoluble silicates | 90.490 | 89.945 | 91.745 | 86.895 | 90.940 | 82.490 | 83.865 | 90.050 | 91.147 |
| Total | 100.442 | 100.149 | 100.716 | 99.910 | 100.301 | 99.550 | 100.004 | 100.519 | 99.880 |
| Hygroscopic moisture | 2.250 | 1.685 | 1.400 | 2.585 | 1.425 | 4.000 | 3.425 | 1.265 | 1.100 |
| Potash in insoluble silicates | 1.479 | 1.767 | 1.664 | 1.892 | 1.700 | 1.605 | 1.427 | 1.621 | 1.467 |
| Soda in insoluble silicates | 1.306 | .828 | .749 | .715 | .598 | .911 | .668 | 1.050 | .753 |





| Composition, Dried at 212° F. | Ballard County. | | | | | | | | Calloway County. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barlow. | | North-west part of the county. | | Blandville. | | Southern part of the county. | | 5 miles E. of Murray | "Coalings" in S. E. part of county. | |
| | Soil. | Subsoil. | Soil. | Subsoil. | Subsoil. | Underclay. | Soil. | Subsoil. | Soil. | Soil. | Subsoil. |
| | No. 2563 | No. 2564 | No. 2. | No. 219. | No. 2098 | No. 2099 | No. 1. | No. 218. | No. 2629 | No. 2630 | No. 2631 |
| Organic and volatile matter | 3.510 | 2.364 | 4.120 | 2.920 | 2.185 | 1.565 | 0.500 | 2.110 | 3.000 | 2.497 | 2.999 |
| Alumina and manganese oxide | 3.906 | 4.602 | 4.850 | 2.610 | 8.557 | 7.835 | .058 | 2.670 | 4.395 | 1.924 | 4.725 |
| Iron peroxide | 2.112 | 2.870 | | 3.390 | | | | 2.240 | 3.711 | 2.020 | 4.250 |
| Lime carbonate | .146 | .086 | .134 | trace. | .195 | .645 | .098 | .150 | .146 | .131 | .041 |
| Magnesia | .289 | .222 | .280 | .470 | .544 | .601 | .112 | .860 | .217 | .118 | .273 |
| Phosphoric acid | .100 | .126 | trace. | .180 | .093 | .140 | trace. | .410 | .094 | .094 | .094 |
| Potash | .419 | .674 | .139 | .190 | .131 | .175 | .036 | .120 | .238 | .035 | .256 |
| Soda | .260 | not est. | .063 | trace. | .653 | .309 | .067 | .020 | .029 | not est. | not est. |
| Water expelled at 380° F. | 1.038 | .698 | . . . | . . . . | .450 | .435 | . . . . | . . . . | .834 | .453 | .609 |
| Sand and insoluble silicates | 88.394 | 88.766 | 89.650 | 90.210 | 87.110 | 87.495 | . . . . | 91.720 | 88.122 | 92.631 | 86.522 |
| Total | 100.174 | 100.408 | 99.236 | 99.976 | 99.918 | 99.200 | . . . . | 100.300 | 100.786 | 99.903 | 99.769 |
| Hygroscopic moisture | 1.300 | 1.235 | . . . . | . . . . | 2.735 | 2.300 | . . . . | . . . . | 1.100 | 0.875 | 1.650 |
| Potash in insoluble silicates | 1.415 | 1.389 | . . . . | . . . . | 1.085 | 2.138 | . . . . | . . . . | 1.307 | 1.605 | 1.866 |
| Soda in insoluble silicates | .257 | not est. | . . . . | . . . . | .536 | 1.208 | . . . . | . . . . | .411 | .424 | .274 |

The average of composition of the soils in the above show about .090 per cent. of phosphoric acid and .192 per cent. of potash, a very low percentage of each for these soils. In the insoluble silicates there is, however, an average of about one and a half percentage of potash, from which source a sufficiency of that substance might be rendered available by proper methods.

The subsoils, on the contrary, are fairly supplied with both phosphoric acid and potash, the averages being respectively .155 and .248 per cent.

In all of the soils and subsoils the amount of lime is small, almost a deficiency; while, on the other hand, that of magnesia is high in several of them.



## ANTIQUITIES.

Earthworks and ancient mounds, which are found so abundantly on the Missouri and Illinois shores of the Mississippi and Ohio rivers, occur also on the Kentucky shore, and chiefly upon the sharp spurs that reach out from the high bluffs bordering the Mississippi river bottom. These spurs run to a point, and thus afforded a large degree of protection by their extremely abrupt sides, or at least could be easily defended; while at the junction with the main land or bluffs a line of earthworks or embankments, from one side to the other, very generally were thrown up as a point of defense against a foe approaching from that direction. It is within such inclosures that the mounds are now found.

Along the Ohio river and streams of the interior, very few have been observed. The following detailed description, by counties, covers the more important of these remains. The mounds have very generally been visited by relic hunters, who do no more than dig a hole or two into the surface of each, after first probing with a sharp iron instrument. Many relics have been gathered and carried away; but a systematic and careful examination would, doubtless, greatly reward the searcher, for not only relics, but for information regarding the life history of this ancient people.

*Fulton County.*—There is abundant evidence that the bluffs at Hickman were once the scene of Indian life and settlement, for we find many remnants of earthworks thrown up by them. In the southern part of the bluff portion of the town, and not far from the Methodist Church, are numerous small excavations, bordered by circular ridges about fifteen feet in diameter, and two or three feet deep in the center, evidently the site of wigwams. They lie in two rows, and I am told once extended nearly two hundred yards, but have been effaced by the erection of buildings and by other recent improvements on the ridge. The rows are about fifty feet apart, and the circles about twenty feet from each other. Back of the main rows are a few scattering circles. Pieces of baked clay, pottery, etc., have been picked up on the place.

On the bluffs, south, about three-quarters of a mile, have been found skeleton remains, human teeth, bones, etc., and these are still being exposed by the sliding in of the bluffs.

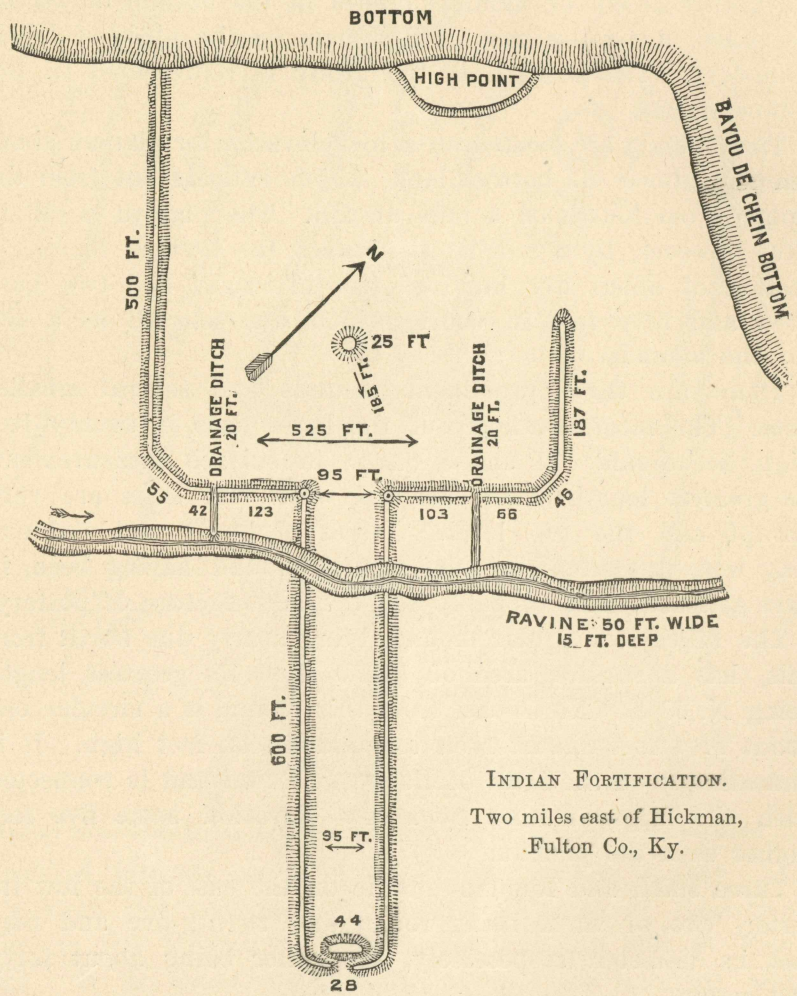
The most interesting locality, however, is that of an ancient fortification or earthworks, situated about a mile north-east of Hickman, a short distance from the railroad on the north side, and on the bluffs of the Mississippi and Bayou de Chien bottoms. These bluffs are here about seventy-five feet high, and quite abrupt, and gradually slope eastward for a short distance to a flat area, which is intersected by a branch or deep ravine running northward to the Bayou de Chien. A sketch of the earthworks is given below. It represents a large inclosure of about two acres, extending southeastward nearly to the branch, when it is abruptly narrowed for six hundred feet further. The low elevation that borders it on the south for about five hundred feet is now partly plowed down in the cultivated field that lies along the bluff, and is somewhat broken in the flat until it turns northeastward, where it is very prominent. While it would in itself be scarcely recognized as a line of earthworks by any person passing over it, yet when the other and prominent lines are followed and outlined, its own connection is clearly seen. Its course is N. 50 W. or parallel with the other sides, and has a width of ten to fifteen feet, much worn away by drainage of the slope. When near the branch it turns due east for about fifty-five feet, and then N. 40 E. for about one hundred and eighty-five feet, to a mound somewhat higher.

On the north side of the inclosure another line of earthworks appears parallel with the one on the south, but beginning about half way between the bluff and branch. It is very regular and unbroken for about one hundred and ninety feet, when it turns S. 60 E. for nearly fifty feet, and thence S. 40 W. for about one hundred and ninety feet to another mound within about ninety-five feet of the former one. This ridge is also prominent and broad; the mounds are about twenty-five feet in diameter, and from them two parallel lines of earthworks turn S. 40 E. for six hundred feet. They are high and wide, and lying, as they do, in a flat cultivated field, are very prominent. Their width is about twenty feet. On the south-east they turn towards each other and terminate, leaving an opening of about twenty-five feet. This was protected on the interior by a large mound 45x35 feet and higher than the earthworks, leaving but a very narrow opening.



The branch that crosses these narrow inclosures is fifty feet wide and about fifteen feet deep, its banks very steep and abrupt. Within the large inclosure there is a small mound about twenty feet in diameter, directly in front of the opening to the narrow fort, and at a distance of about one hundred and seventy-five feet.

For drainage purposes, apparently, a deep and narrow ditch was dug from either corner of the large inclosure to the branch.




INDIAN FORTIFICATION.
Two miles east of Hickman, Fulton Co., Ky.

This fortification was admirably planned for defense. The large inclosure was presumably occupied by the tribe as a

habitation, for fragments of pottery are very abundant, especially near the top of the bluff. It was protected by the steep bluffs and by the earthworks against small forces; but in an emergency, or against overwhelming numbers, the tribe could retreat into the narrow inclosure, and with a deep ditch at one end and a protected gateway at the other, could better defend themselves. An earthen headless image, found in this place, was presented to the museum by C. W. Bryant, of Hickman.

Another group of mounds occurs in the bottom of Bayou de Chien, five miles east of Hickman, on the place of Lewis Lumsford. The position of the group is represented in the following cut.

The mounds are located on a low elevation or plateau about ten feet above the bottom land, which extends out from the uplands one-fourth of a mile distant. The plateau is cut in two, however, by a narrow portion of the bottom, leaving a section of about five hundred feet in length and two hundred and fifty feet in width, which was selected as a site for the mounds.

There are three prominent mounds and several smaller ones. The most southerly of the large ones is twenty feet high, rectangular in shape, 85x50 in surface measurement, its greatest length being east and west. Its sides are very abrupt and the top level. Pieces of burnt and unburnt clay were dug from the surface, the mound having been, in part at least, used probably for the manufacture of pottery.

The other rectangular mound, lying nearly due north from this, has a surface area of 55x50 feet, its greatest length being N. 60 E. North-east from this mound is a circular one about fifty feet diameter on top and fifteen feet high. It is immediately on the bank of Bayou de Chien, and is connected with the larger mound by a low elevation some five feet higher than the plateau.

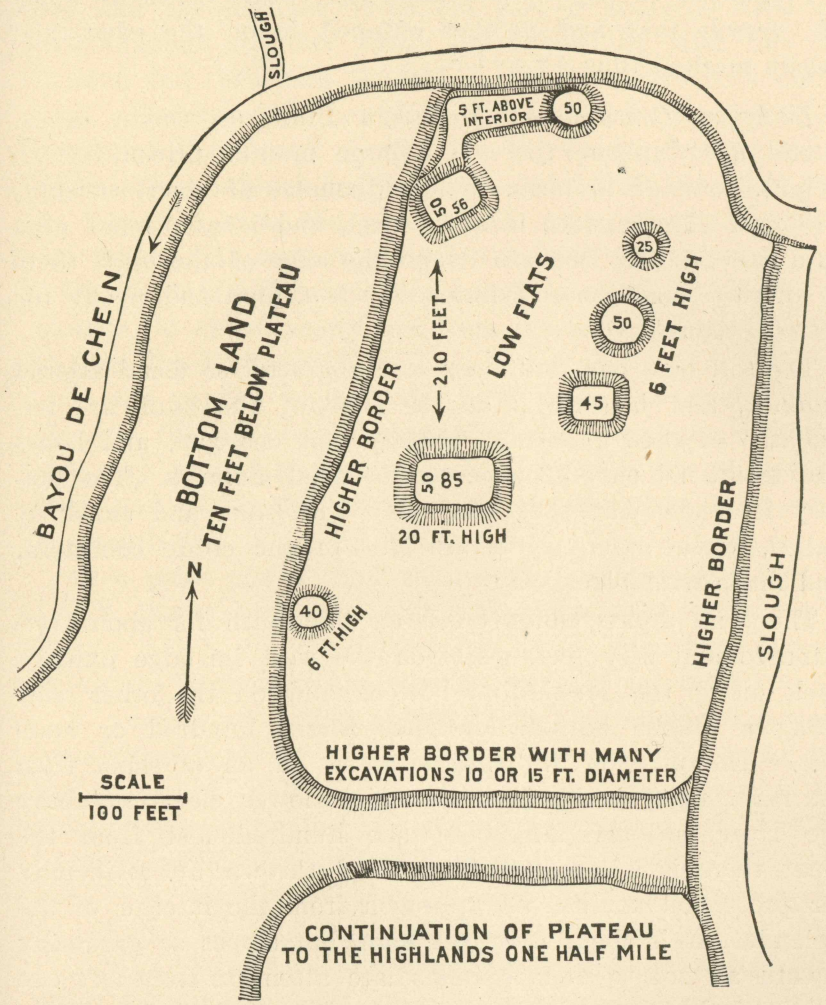
Three small and low mounds lie on the east of the low interior, two of them being round and twenty-five and fifty feet in diameter, respectively, the other being about forty feet square.

On the southwestern edge of the plateau another large



and rounded mound ten feet high and forty feet in diameter occurs.

On the southern edge are large numbers of excavations rounded, ten or fifteen feet in diameter.




Indian Mounds on Bayou de Chien, five miles east of Hickman, Fulton county.

Isolated mounds occur in other parts of the county. A very large one occupies the north-east point of Sassafras ridge, in the Mississippi river bottom, at the foot of Fish Lake. It is about twenty feet high, one hundred and twenty in length, N. 20 E., and 65 feet in breadth. One side has largely been dug down by parties in search for relics.

A small mound lies near it on the east, and another about one hundred and fifty feet distant on the south-west, both about twenty feet in diameter, and low.

Fragments of pottery are abundant, some of them being of vessels that had notches chipped in on the edge, and others marked thus ▵▿▵▿▵▿

*Hickman County.*—At McLeod's Bluff, on Obion creek, south of Columbus, there is a large mound, fifteen feet in height, rounded in form, with a diameter of about seventy-five feet. The surface is quite level, and is at present used as a grave-yard. Between it and the edge of the bluff there is another small mound but a few feet high and about ten feet in diameter.

The soil here has that deep rich character so usual around mounds, and beneath it at the edge of the bluff are frequently exposed pieces of pottery and charcoal, and bones and teeth, not only of men, but of small animals. The pottery is made partly of blue clay and sand, and smoothly baked, while other pieces are still in the crude condition, and made with black clay.

The bluff fronts Obion creek on the south for about two hundred and fifty feet, while on the west its edge extends back along the Mississippi bottom, and on the other side along a branch bottom for some fifteen hundred or more feet. The mounds are thus situated on an off-shoot from the main upland, though at a much lower elevation above the river bottom. At about six hundred feet from the front there is a low elevation, as if thrown up artificially for protection against an approach from the interior of the uplands. It is about four feet high, but slopes so gradually inward as not to attract immediate attention from any one passing. Its outer slope is abrupt. The line, as in similar groups of mounds on the river bluffs in Ballard county, forms an obtuse angle with apex outward, one side running thence southward on one side for about one hundred and twenty-five feet, and on the other for about 55 feet N. 50 E.

On the bluff back or east from the Chalk Banks there are



several mounds, some distance from each other, and near the brow of the bluff.

Mr. W. J. Kerr, who has lived here sixty years, informs me that the outlines of an old fort or inclosure were once very distinct on this bluff; but since the land has been cleared and cultivated the old earthworks have been obliterated. It reached eastward from near the brow of the bluff for one hundred and seventy-five or two hundred yards, the eight acres inclosed being surrounded by an elevation three or four feet high, the eastern side being at right-angles to the others. At each corner a low mound was raised.

On the south side another or inside line of earthworks was thrown up about ninety feet from the first, and parallel with it from the bluff eastward.

In the portion nearest the bluff numerous small excavations in the surface are observable, and fragments of pottery are very plentiful. The mounds are mostly round, not very high, and twenty-five or thirty feet in diameter. The one on the south-west is oblong, 30x50 feet.

At a point of the bluff southward, just beyond where the Chalk Banks terminate, and where the road turns to Mr. Kerr's house, very many human bones have been exposed below the surface by the wearing away of the bluff.

A number of relics, chiefly flint and stone implements, have been found in this locality. The most interesting is in the possession of Mr. Kerr. It is made from quartz, in part amethystine, and seems intended to represent a hen in sitting posture, a hole being drilled through the head in place of eyes. In size, it is hardly an inch long and half an inch in height.

On the bluffs between Obion creek and Bayou de Chien there are several small mounds, isolated and of no special importance. Lying near the foot of these bluffs, and connecting the two streams, there is a slough, known as "the Lake," and thought by some to have been dug artificially to connect the mounds on McLeod's bluff with those near the mouth of Mud creek on the Bayou de Chien, in Fulton county.

As seen near the road leading from Clinton to Hickman,

"the Lake" presents an irregular and crooked outline, with banks about seventy-five feet apart and fifteen feet deep. Several smaller sloughs connect with it. Its banks, both here and on Bayou de Chien, are sharply defined, as are also those of the large streams. It joins the Bayou de Chien but a short distance below the group of mounds, but on the Obion its junction is more than half a mile below McLeod's bluff. There is not evidence sufficient to show that it is any thing more than a natural slough.

*Ballard County.*—In this county, which is bordered by a larger river front than any other county of the Purchase region, there are probably also a greater number of Indian mounds and earthworks, and they are for the most part located upon the sharp spurs that reach out from the bluff facing the Mississippi river bottom.

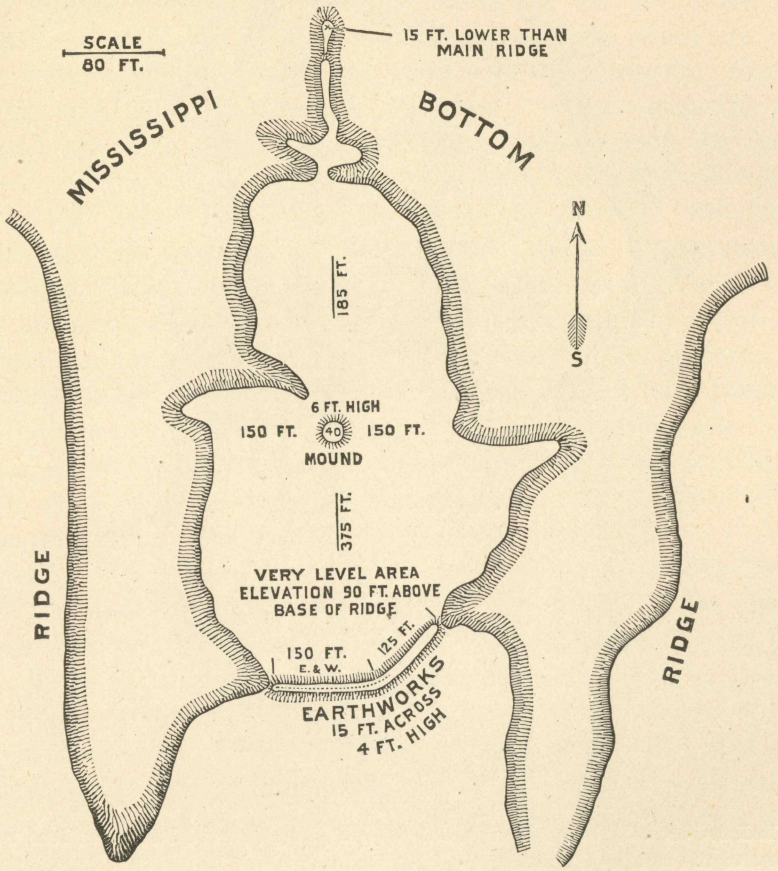
Going north from the Hickman county line, the first locality of importance and prominence is upon one of these spurs, forming the south bluff of Sandy creek, and two miles south of Laketon, and whose summit is about ninety feet above the river bottom plain.

On entering this spur from inland we first pass through an old field, now in cultivation, for about one hundred and fifty yards to a point where the spur is cut into from either side, leaving a width of only about two hundred and fifty feet. Here we find the fence perched upon a low line of earthworks which are worn down to but about five feet in elevation, and with a width of about fifteen feet, connecting the two points of indenture. Beginning on the west, the earthworks have a direct east course for one hundred and fifty feet, when they turn north-east to other edge of the bluff, a distance of about one hundred and twenty-five feet, with three different courses, that of the first forty feet is N. 60 E., the next fifty feet is N. 45 E., and the next thirty-five feet is N. 30 E. There are no excavations along this line to indicate from whence the dirt was obtained for this work.

Within this inclosure the summit of this spur widens to about three hundred feet, and is again abruptly narrowed to three hundred and seventy-five feet by deep indentations



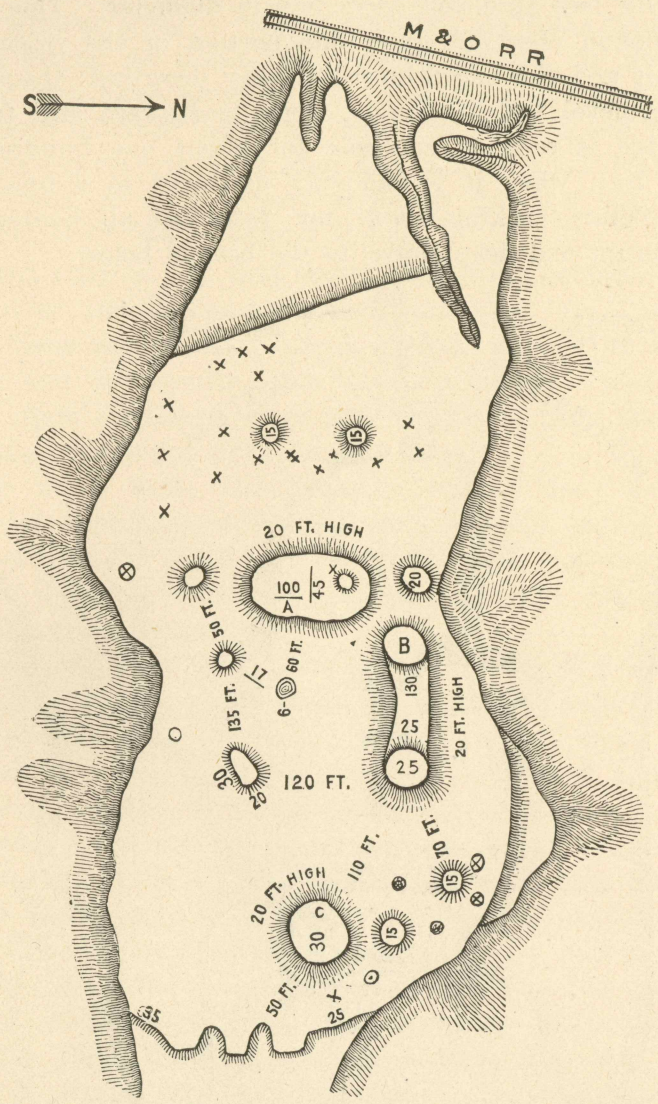
on either side, at which point is a rounded mound now about six feet high and forty feet in diameter. This is the only mound observed upon this portion of the ridge. Between it and the embankment already described, the surface is quite level and timbered. Going northward still further, the ridge is seen to continue for about one hundred and eighty feet, when it is suddenly narrowed to a number of sharp points, sinking about ten feet, but all bordered by very abrupt and deep slopes to the bottom below.




Ancient Fortification upon a spur of the south bluff of Sandy creek, two miles south of Laketon, Ballard county, one-fourth of a mile from M. & O. R. R.

Another and more interesting group of mounds are located upon another of these bluff spurs about half way between Laketon and Mayfield creek, or where the Punckney Bend

road enters the Mississippi bottom from the east, and on the land of Dr. Wm. Graves.




Indian Fortification and Mounds on a spur of bluffs near the Punckney Bend road, south of the mouth of Mayfield creek, Ballard county.

The space in the center is low and flat, with a very rich soil.

The numbers represent diameters of, and distances between, mounds.

The spur is somewhat lower than the main bluff ridge, and projects nearly westward from it for a distance of a couple of hundred yards, bordered on either side by deep canon-



like ravines, to the bottoms of which the descent is very abrupt. At the point of the spur there is a very narrow offshoot, which, with a curving course, slopes to the lowlands beneath, and seems to have been once used as an easy means of reaching the river from the bluff; for there is a deeply worn path along its summit. The spur has a width varying from fifty to five hundred feet.

On going out on the spur from the bluff ridge there is a gentle slope to a point where lateral denudation has left a very narrow summit, and here are found the first evidences of artificial earthworks. As shown on the diagram, these are in the form of an embankment, presenting an irregular front to the east, about five feet in elevation. The irregularity is caused by three bastion-like extensions, each about ten feet wide, and reaching out, respectively, nine, eighteen and nine feet, their fronts and sides, and also the front of the embankment between them, being quite steep. The central projection has, during the past few years, been leveled or cut down, to admit of the passage of teams into the interior. From the brow of this line of earthworks the surface is quite level for about forty feet to the first mound, and thence to the interior of the mound-area there is a gentle slope.

As shown in the diagram, there are three large mounds, with eight or more smaller ones. The first of the former (C), situated about fifty feet from the earthworks, already described, is round, and has a diameter of about thirty feet and an elevation of about twenty feet. A tall beech tree, three feet in diameter, stands upon it. An excavation in its top, by relic hunters, some years ago, exposed pieces of bone, earthenware, and some *galena*. Between it and the brow of the ridge on the north are two small mounds several feet in height, and with diameters of about fifteen feet. Around them are small excavations as if for the material for the mounds.

In a N. 60 W. course from the first mound, and at a distance of about one hundred and ten feet, there is another peculiarly constructed mound (B) about twenty feet high, twenty-five feet wide, and about one hundred and thirty feet long. It is near the western margin of the ridge; it has

a nearly east and west course, its northern side being in nearly a straight line, its southern side having a concave outline, its ends rounded, perhaps by erosion; upon each end is perched a mound about twenty-five feet in diameter, and a few feet high. The surface of this large mound is otherwise quite level; a few pieces of pottery were picked up on it.

Lying at nearly a right-angle to the west end of this is the third large mound (A), with the same elevation, a length north and south of one hundred feet, and a top width of forty-five feet. The surface is quite level, with the exception of a small mound on the north end, which seems to have been the scene of pottery manufacture, as fragments of burnt and unburnt moulded pieces were found mixed in its earth with pieces of charcoal. The form of this large mound was apparently originally a rectangle, with its corners beveled, the inner sides still retaining that form, while the outer or westerly sides are rounded.

The space between the ends of these two large mounds is protected on the outside by a smaller mound, some twenty feet in diameter and ten in height, rounded in form.

The group thus described forms the ends and northern side of a space doubtless occupied by the tribe, while on the south side is a row of smaller mounds, the largest of which is about thirty by twenty feet on its surface, and having an elevation of about six feet.

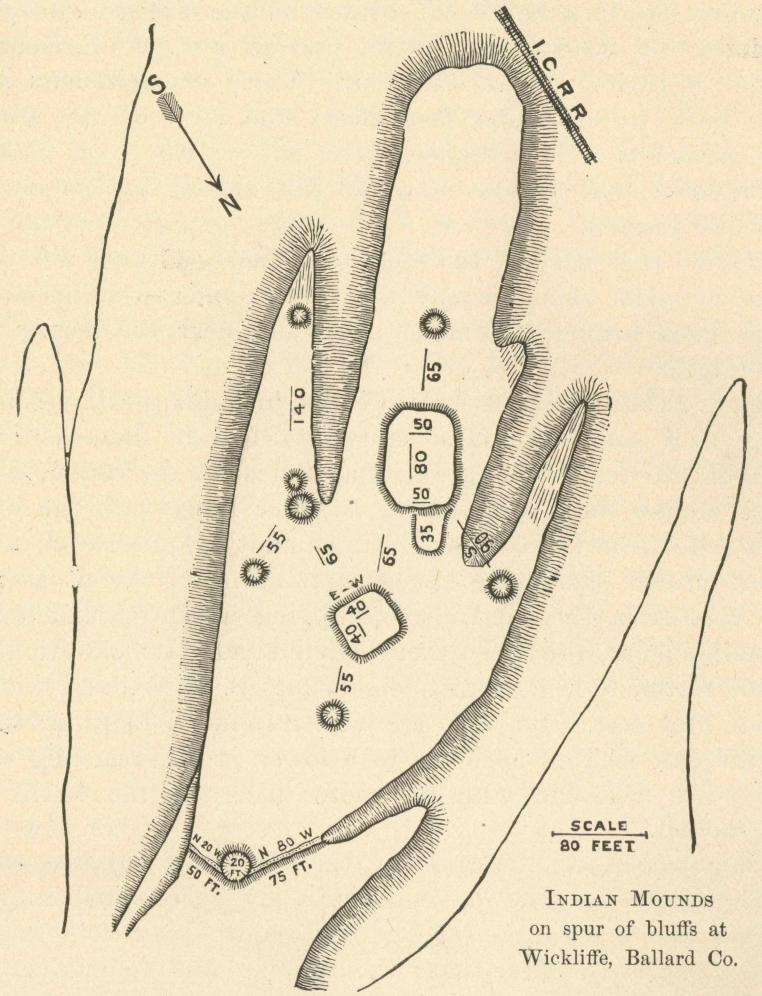
The area thus inclosed is low and flat, about one hundred and twenty-five feet wide by two hundred and thirty feet long, and with a very rich black loam soil, much richer than that of the rest of the ridge—a feature characteristic of the soil bordering the mounds of other localities. Near the western end there is a deep excavation, now filled-in to within a few feet of the surface.

To the west of this, and outside of the inclosure, are two other but smaller mounds, but ten feet in diameter and a few feet high.

Proceeding northward along the bluffs, we find another group of mounds on the high bluffs, immediately north of



Wickliffe, and here also occupying a spur running out in a south-west course from the bluff, but at a lower level.




INDIAN MOUNDS
on spur of bluffs at
Wickliffe, Ballard Co.

The surface is, for the most part, quite even, sloping gently from the main bluff to about sixty feet above the railroad, and is bordered by very abrupt slopes to the deep ravines and bottom lands of the river. At one point near the bluff, on the north side, a ravine cuts deeply into the spur, leaving to the latter a width of a little more than one hundred feet, and across this, as on the spur south of Mayfield creek, there is a low line of earthworks, as if for protection against an approach from the bluff.

A low mound occupies an almost central place on this narrow point, and from it the embankment reaches for seventy-five feet in a N. 80 W. course on the one side, to the point of the penetrating ravine, and in a S. 20 E. course to the opposite side of the spur. These embankments are now but two or three feet above the level of the spur. The mound is a little higher. The entire line is so nearly worn down that at first it would not attract the notice of any one passing.

Within that part of the spur thus inclosed there are two large mounds which occupy the center, and seven or more large ones arranged around these, and near the border of the ridge.

Going inward from the earthworks just described, we first come to a small mound some twenty feet in diameter and four or five feet high. Next, and almost in the center, is a large mound forty feet square, its sides lying with the cardinal points of the compass. Its summit is quite level, and about fifteen feet above the general surface. About sixty-five feet from this, and also occupying a central and more westerly point, lies the other high mound. Its elevation is about fifteen feet, its length eighty feet S. 25 W., and width about fifty feet. Its ends are rather rounded in form, that of the east sinking abruptly to a lower prong, reaching out thirty-five feet, and with not more than half the width of the mound.

The outlines of the spur of the bluff, the relative sizes and positions of the mounds, etc., are represented in the accompanying diagram. Numerous small excavations occur in the surface of the spur. Upon one of the mounds stand two trees—a poplar, four feet in diameter, and a beech, nearly three feet.

In a search made by digging a small hole into the central part of the largest mound, by relic-hunters, some mussel shells and pieces of charcoal were obtained.

On the extreme summit of the bluffs there are two small mounds, some ten feet or more in diameter, and three or four feet high.

Leaving the bluffs of the Mississippi and following the



Ohio, we find in the bottom, a mile from the banks of the latter, in the northern part of the county, near Terrell's Landing, opposite Mound City, Illinois, a couple of large mounds. They are situated on the south bank of a slough, and are more or less rounded, except on the sides nearly facing each other. One of them has a surface area of forty-five by forty-five feet, and is about twelve feet high. A negro cabin is perched upon it, and cultivated fields extend to eastward and southward from its foot. There are several red oak trees, each about two feet in diameter, growing on its summit.

The other mound lies about seventy-five feet distant in a south-west course, the two connected by an elevation about six feet above the bottom land, and about forty-five feet in width.

The second mound is also nearly rounded in form, and its level surface is about eighteen feet above the base, or twenty-five feet above the bed of the slough, and twenty-five feet wide. It also has a large tree growing on the summit. Fragments of pottery and pieces of flint are abundant on both mounds. It is said that relic-hunters, by digging, a few years ago, found a piece of *galena* and a few earthern vessels in the highest of the mounds.

During high-water overflows from the river, these elevated points are used as places of refuge for stock; the sides and summits are much worn away.

*Foot-prints in Sandstone.*—A locality of very special interest occurs a couple of miles north-east of Wickliffe, in the bed of a small branch emptying into Cane creek from the north, and on the place of Mrs. R. Burns. In the bed of this branch is a broad sandstone, reddish in color, its surface somewhat uneven from the action of water running over it, and covering an extent of about twenty feet in length. In its width it is exposed for only about six feet, being covered in the valley to the west by the washings from the hill-side.

The hills rise about forty feet above this rock, and are formed of Quaternary silt, loam and gravel—the rock disappearing beneath them. Upon the surface of the sandstone

are easily traced human foot-prints and large bird tracks, in some cases deeply indented one-half inch, with the conformation of the bottom of the foot and toes; in others but shallow imprints, one-eighth of an inch deep, in which the toes do not appear, and in which there is lacking the barefoot feature, indicating rather a moccasined foot. The tracks are in every direction and position, the stream flowing across them in a northward course.

A peculiarity of the imprints is in the fact that all but three are of the left foot.

In some cases the toes are deeply indented, while the rest of the sole of the foot is shallow; sometimes the space between the toes is filled.

A sketch showing the position and size of each foot was made by means of tracing linen and pencil; and is given below in a form reduced by photography. The outer lines mark the extreme limits, while the interior lines indicate the deepest portion of the track.

The rock is several feet thick, reaches across the branch and into the opposite bank on the east. Upon the latter portion a large bird track was seen, and also what seems to be a part of a human foot-print.

The following are the measurements and peculiarities of each track, as numbered in the accompanying photographic print:

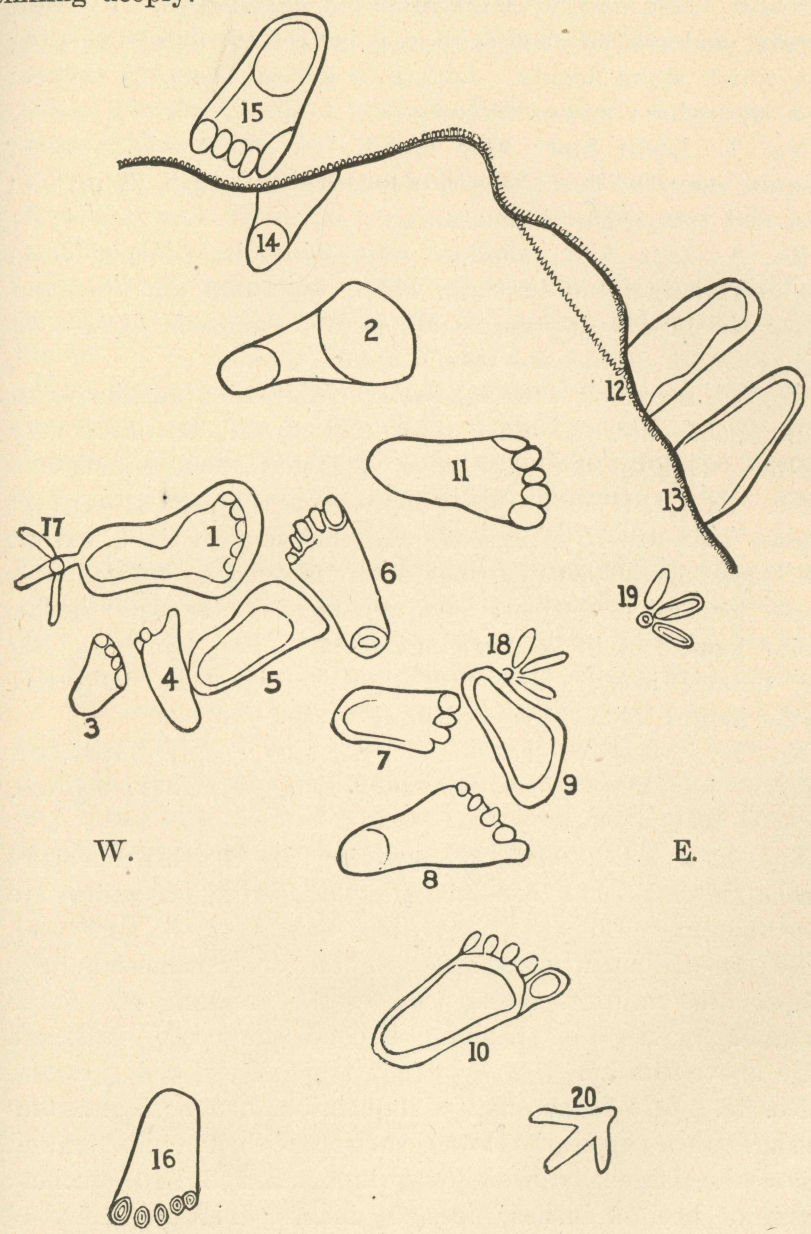
No. 1. Right foot. Central impression deep, with sloping sides, and showing a clear outline of the instep. The toe impressions are very faint, and only in the lowest depression, and sink a little below its surface. Extreme length, $11\frac{3}{4}$ inches; spread of toes, $5\frac{3}{4}$ inches. The foot was apparently moccasined, the toes having nearly worn through. The outer line shows the edge of the moccasin.

No. 2. Left foot, the probable mate of No. 1. The toes not so apparent, but still discernible. Instep shallow; heel and ball of foot deeper, as indicated in the sketch. Also covered by a moccasin. Extreme length, $11\frac{1}{2}$ inches; heel, $2\frac{1}{2}$ inches; and spread of toes, 6 inches.

No. 3. Right foot of a child. Deep impression of foot and toes; that of the two smallest toes combined. Length, $4\frac{1}{2}$ inches; heel, 2 inches; toes, 3 inches.



No. 4. Left foot highly deformed. Impression distinct; big toe projected; second and third absent in imprint. Length, 7 inches; heel, 2 inches; toes, $3\frac{1}{2}$ inches, the balls sinking deeply.




Foot-prints in Sandstone near Wickliffe, Kentucky.

No. 5. Left foot, probably with moccasin; deep impression, with no toes; sloping inward on all sides to the inner depression. Length, 9 inches; heel, 3 inches; toes, 4¼ inches.

No. 6. Left foot, with irregular toe impressions. The heel deeply, and rest of foot shallowly impressed, except the big toe, which sinks deeply. Length, 9 inches; heel, 2½ inches; toes, 4½ inches; spaces between the toes but slightly raised.

No. 7. Right foot; very broad, but shallow impression, deepest near the heel; toes run together. Length, 7½ inches; heel and toes, each, 3½ inches.

No. 8. Left foot; shallow impression, but deeper heel; the toes distinct, but imprints widely separated, and the sand filling the intervening spaces apparently removed Length, 11 inches; heel, 2½ inches; toes, 6 inches.

No. 9. Left foot, with moccasin. Impression shallow, with slope from outer to inner line; foot broad, but heel very narrow. Length, 8½ inches; heel, 2¼ inches; toes, 5 inches.

No. 10. Left foot, deep impression, sloping upward at edges; toes widely separated, and not very distinct, except the largest; sand between toes not removed; no instep. Extreme length, 12 inches; heel, 3¼ inches; toes, 6½ inches. Inside length, 8½ inches; heel, 2¼ inches; toes, 4 inches. Big toe, outside length, 2¼ inches; width, 1¾ inches. Big toe, inside length, 1⅜ inches; width, 1¼ inches.

No. 11. Shallow impression, but toes deeply impressed. Length, 10¼ inches; heel, 3 inches; toes, 5½ inches; big toe, 2 by 1½ inches.

Nos. 12 and 13. Shallow impression; heels a little deeper; toes apparently hid beneath the thin ledge on which are the other foot-prints.

No. 14. Right foot; shallow impression, but heel a little deeper; toe imprints either lost by the breaking off of the rock, or by the foot reaching beyond the edge. It lies a little above No. 15.

No. 15. Left foot; shallow impression, but heel and toes deeper. It is upon the lower surface with 12 and 13, and below the large body of foot-prints. Length, 10½ inches; width of heel, 3 inches; toes, 5¼ inches; big toe, 2 by 1½ inches.



No. 16. Left foot; shallow impression of the foot, but the toes deeply depressed. Length of foot, 9 inches; spread of toes, 6 inches; width of heel, 3 inches.

No. 17. Bird track; deep impression; the back toe overlapping the foot imprint No. 1. Spread of toes, 5½ inches; length of toes, 3 inches.

No. 18. Bird track. Spread of toes, 4¼ inches; length of toes, 4½ inches.

No. 19. Bird track; deep impression; back toe absent. Spread of toes, 4½ inches; center toe, 3½ inches, and side toes, 3 inches long.

No. 20. Bird track; only three toes appear. Spread, 5½ inches; length of middle toe, 5½ inches; side toes, 5 and 4 inches.

The foot-prints seem to be naturally formed by the direct imprint of the feet in the slightly yielding Quaternary sand, before the latter was hardened into a rock by the permeation of iron oxide, the cementing material. These sandstones are, in other localities, even in this day, in process of formation, wherever the sands and gravel of the Quaternary gravel-beds are exposed to the action of the weather. A very great antiquity, therefore, can not be claimed for these tracks—at least, not more remote than the mound-builders, or Indians, whose mounds and earthworks are found upon the Mississippi river bluffs, a mile or more to westward.

In all the above foot prints there is an entire absence of any thing like the mark of an implement that could be used in chiseling them into shape.

*McCracken County.*—The only mound visited in this county was that on the place of Mr. McCutcheon, one mile west of Paducah. It is about fifteen feet high, oblong in form, measuring about one hundred feet north and south, and seventy-five feet east and west. An old and rotten stump on the summit has a diameter of two and one-half feet. The central part of the mound is a little concave. A dwelling-house is situated on it, the cellar of which was dug through three feet of rich loam soil, two feet of white or yellow sand, two feet of ashes and charcoal and clay.

The mound is surrounded by about six acres of a very

rich, dark loam, three feet in depth, in which were pieces of mussel shells. This character of soil is often a notable feature of other mound surroundings. The soil is all under cultivation, and said to yield seventy-five barrels of potatoes per acre. Around the mound were originally twelve or fifteen smaller ones, respectively six or seven feet high and twenty-five feet in diameter; but many of them have been plowed down, and can scarcely be distinguished. Arrow-heads and fragments of pottery are abundant, and Mr. McCutcheon informs me that a nest of five or six nearly perfect vessels was plowed up in the field, together with a large piece of stone-coal. Among other things, the handle of some vessel, made of a bluish clay, about two inches long, and shaped like a wrist and hand, with half closed fingers, was found.

*Marshall County.*—In the neighborhood of Sharp, in the north-western part of the county, there are a couple of small mounds in an old field, but now nearly obliterated by long-continued cultivation of the latter. The field has very many fragments of mussel shells, and the soil immediately about the mounds is very rich.

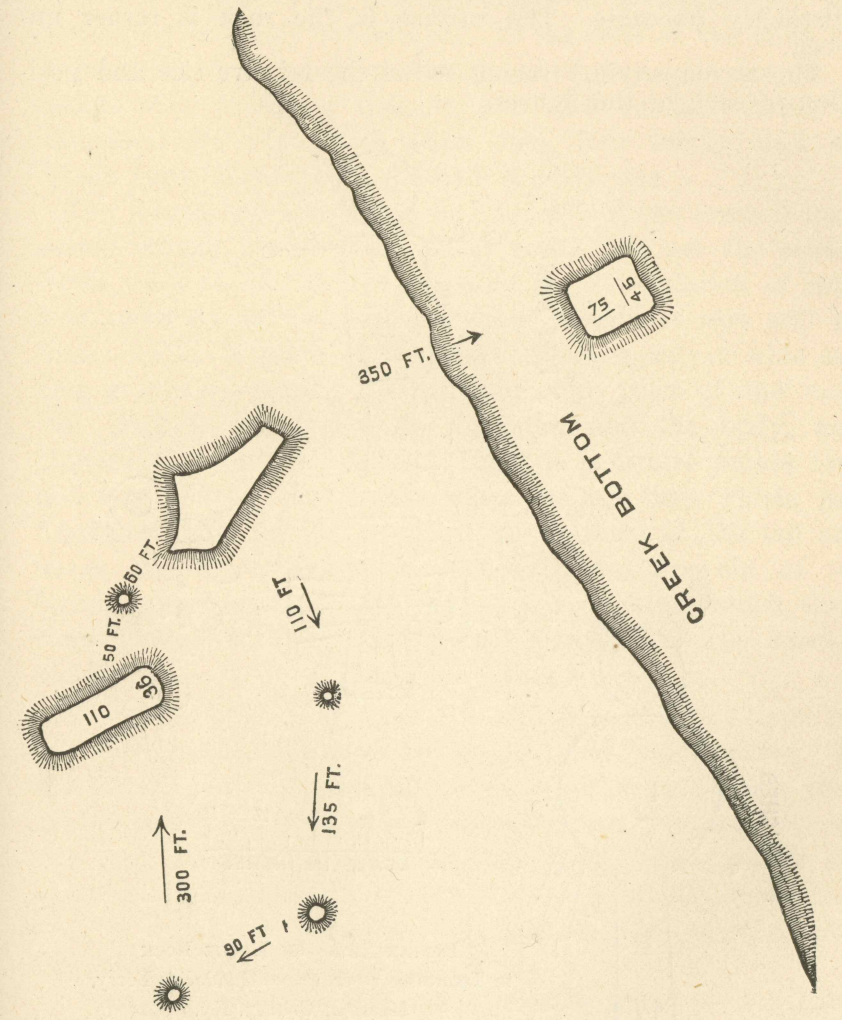
South-east from this, on the "Bottom road," between Benton and Paducah, and near the crossing of Chestnut creek, and situated upon the uplands overlooking the bottoms of Clark's river, is a mound measuring thirty-five feet north and south, and twenty-seven feet east and west. It is rounded in form, its surface slightly depressed in the center, and has an elevation of about six feet. Flint chips and fragments of pottery are abundant.

A more important locality is on the place of Mr. W. F. Hinson, on Jonathan creek, eastern part of the county. There are here three large mounds, grouped with four or more small ones. Their relative position is given on the following diagram.

The mounds are situated in a broad flat reaching southward from the largest ones. The most southerly of the large mounds has a trend of N. 80 E., and is oblong in shape, with a length of about one hundred and ten and a width of thirty-six feet. A little north-east from it is an elevation



of peculiar shape, but, so far as could be ascertained, is artificial. Its height is fifteen feet, and its length about one hundred and fifty feet. Its sides have the appearance of having been worn away, leaving a sharp angle to westward, and somewhat concave sides, while the north and south ends are narrow. North-east from this, about three hundred and fifty feet, and in the bottom land of Jonathan creek, there is a very large and high mound, rectangular in shape, and lying seventy-five feet in a N. 70 E., and sixty-five feet S. 20 E. Its height is about twenty feet.

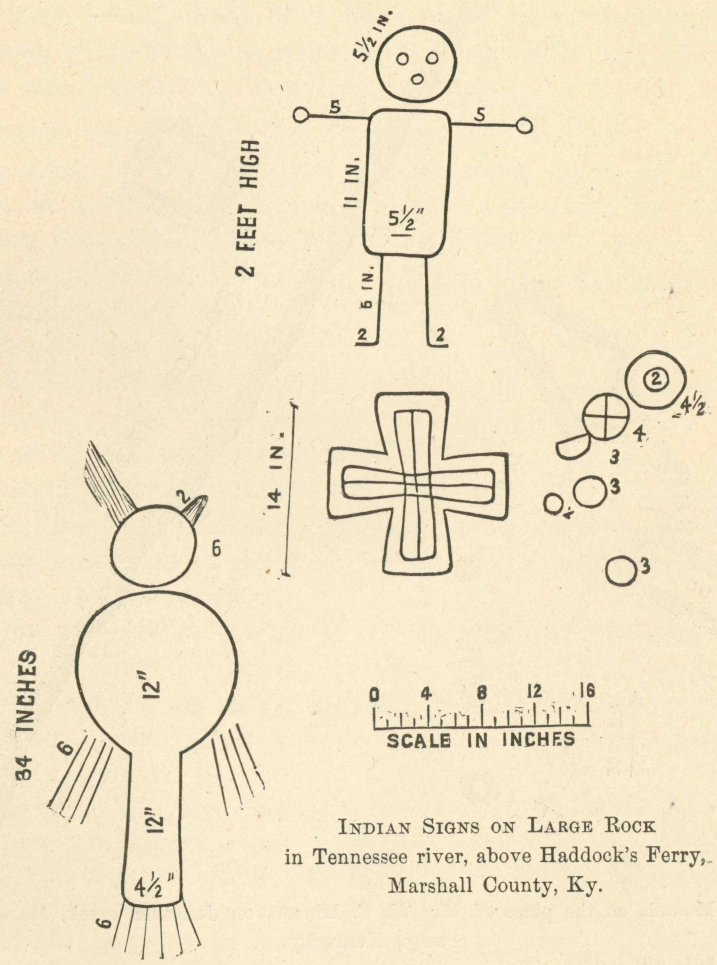



Indian Mounds on the place of Mr. W. F. Hinson, on Jonathan creek, Marshall county, Kentucky.

Fragments of pottery are abundant in the vicinity of the mounds; but, so far as known, nothing of special interest has been found.

At Haddock's ferry, on the Tennessee river, north of Calvert City, there are masses of chert rock and fragments which also form shoals in the bed of the river on the north side. Upon one of these rocks, a few hundred yards above the ferry, there are markings which show age, and were, perhaps (or according to the "oldest inhabitant"), made by the Indians. Their form and position are given below. Some of the characters are much worn away, but the outlines are distinctly traceable. The surface of the rock is rather uneven.

The accompanying tracing shows the relative size and position of each of the figures.




INDIAN SIGNS ON LARGE ROCK
in Tennessee river, above Haddock's Ferry, Marshall County, Ky.



The uppermost figure is that of a boy, and is two feet long. The head round, five and one-half inches in diameter, with eyes and mouth represented by small holes The body rectangular, eleven inches long and five and one-half inches wide; the arms, as straight lines, five inches long; the hands as round holes; the legs, straight lines, six inches long, and each turned outward two inches at the end, for the feet.

The most remarkable character, however, is the representation of a Maltese Cross, fourteen inches in measurement. The lower part is nearly obliterated. To the west of the cross are a number of rounded characters as shown, the largest of which, with a central ring, is four and one-half inches in diameter; the next, with cross lines, four inches, and the others three inches each, besides a small one.

The fourth and last figure on the east of the cross is more nearly erased, by the wear of the rock, than are the others. From what is left, it was probably a representation of some bird—possibly an owl, one of whose prominent ears still remain—while, in place of the other, there is only a wide and long groove connecting the different worn parts of the rock. The head is six inches in diameter, and the body, now obliterated, is twelve inches. The tail is twelve inches long and four and one-half inches wide, and the lines which, perhaps, are intended to represent the feathers of the tail and wings are, respectively, six inches. There are six of the former, and four for each wing. The rock upon which these characters are made is exposed only during low-water seasons of the river.

*Graves and Calloway Counties.*—In these counties there are but few mounds, and these are isolated and uninteresting. In the latter county, on the high upland bordering Clark's river at Backusburg, was a group of small ones, but now so cut into and disfigured by relic-hunters that their outlines are scarcely discernible. A number of excavations occur here also, in which are fragments of unburnt and moulded pottery clay.

In Graves county, a few small mounds occur on the place of Mr. J. R. Ray, on Panther creek, a few stone relics having been found.

# APPENDIX I.

Species of Fossil Plants collected near Somerville, Tenn., by Dr. J. M. Safford. Described and figured by L. Lesquereux, in Silliman's Journal (May, 1859). The descriptions and figures are taken from the "Geology of Tennessee," by Prof. Safford, a work now out of print and very difficult to obtain:

FIG. 1. *Quercus crassinervis* (Ung.) The specimen is broken, and shows only the middle part of a large, sharply dentate leaf, apparently oval-lanceolate in outline. The broad nerves, and the running of the secondary nerves to the point of the teeth, as the form of the acute teeth, would refer this species to *Quercus crassinervis* (Ung.), a species found in the Upper Miocene of Europe.

FIG. 2. *Quercus Saffordi* (Lsqx.) Fig. 2 a, b, c. Leaves nearly linear, rarely an inch broad, four to six inches long, gradually tapering to a point. Margins regularly and distinctly mucronate-serrate, entire near the base and decurrent in a broad petiole or enlarged nerve. Medial nerve, broad and flat; secondary nerve, oblique, straight, running to the point of the teeth, and alternating with shorter and slender ones. There is not any published fossil species that might be compared with this. It is distantly related to living species of southern Texas and Mexico, but among the leaves kindly furnished to me for comparison by Dr. Asa Gray, there were none of these new species to which it could be referred.

FIG. 3. *Quercus myrtifolia* (Willd.) Inhabits now the islands south of Georgia and along the coasts of Florida. Comparison of living specimens with this fossil shows a perfect identity of form and venation.

FIG. 4. *Andromeda vaccinifoliæ affinis* (Lsqx.), a, b. Thick, oval-lanceolate, pointed or obtuse leaves, with perfectly the same size, outline and nervation as the *A. vaccinifolia* (Heer), a plant of the Upper Miocene of Europe. Its nearest relative in America is, I think, *Andromeda acuminata* (Michx.)

FIG. 5. *Andromeda dubia* (Lesqx.) A thick, smooth, round elliptical, obtusely pointed leaf, with entire wavy, somewhat reflexed margins and obsolete nervation. It is related to *Andromeda ferruginea* (Michx.), of the pine barrens of the South.

FIG. 6. *Prunus Caroliniana* (Michx.) (Wild orange tree.) The species is now confined to the islands, and near the coasts of Carolina, Georgia, etc., and in the Bahama Islands, where it is at its true latitude. Michaux remarks that this species is not found on the mainland, at a distance of two to ten miles from the shores, where the temperature is five to six degrees colder in the winter, and proportionally milder in the summer.

FIG. 7. *Elœagnus inœqualis* (Lsqx.) Leaf long elliptical, obtuse with entire wavy margin, rounded near the base on one side, and about one inch longer, and decurrent on the other side of the short petiole. Secondary nerves well marked, thick near the base, emerging in acute angle, with a camptodrome much divided nervation. I do not know of any living species to which this could be compared.



Among the fossil plants published till now, its nearest relative is *Elœagnus acuminatus* (Web.), of the Miocene of Europe.

FIG. 8. *Sapotacites Americanus* (Lsqx.) Though the specimen shows only the upper part of the leaf, the form and the nervation agree well with that of the species of this genus found in the Miocene of Europe. I have not seen any other specimen but the one figured here.

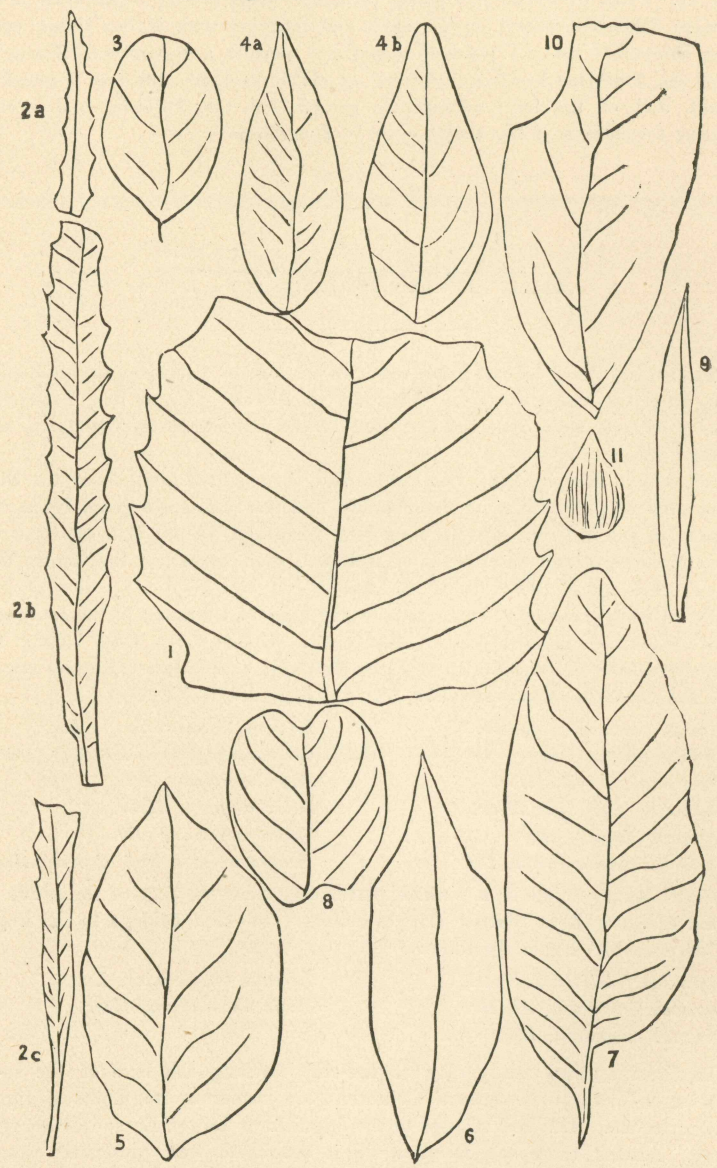



FIG. 9. *Salix? densinervis* (Lsqx.) Leaves narrow, one and a half to two inches long, lanceolate or tapering at both ends, entire. Medial nerve scarcely

inflated at the base. Secondary nerves very close, anastomosing as in the leaflets of a fern or of a Trifolium. This nervation is quite peculiar for a Salix, and probably, when better specimens are found, the plant will be referred to another genus.

FIG. 10. *Quercus Lyellii.*

FIG. 11. Fruit of *Fagus ferruginea* (Michx.) (Red beech.) This fruit is somewhat more distinctly ribbed on the sides and margins than in our living species; but the characters are not marked enough to permit a separation. Though the range of the American beech is indicated as rather northern, the tree is found most abundant, and of the most remarkable growth, on the Tertiary, and even the Cretaceous formations of the south, even in Louisiana.

## APPENDIX II.

Specimens of fossil leaves from the two geological horizons, Lignitic and Lagrange, occurring respectively at Wickliffe, in Ballard county, and Boaz Station, in Graves county, were collected and sent to the United States Geological Survey for identification of species.

This has been done by Prof. Leo Lesquereux, through the kindness of the Director and the chief of the division of Paleobotany, and the results are given below. Only the names of the different species have been furnished us, but it is expected that a report embracing a full description of each will soon appear in the Tenth Volume of the Proceedings of the National Museum.

1. Fossil leaves from clay-stone beds in the bluff of a branch in the south-eastern part of Wickliffe, Ballard county, Kentucky. Geologically, they belong to the Lignitic or Lower Eocene division of the Tertiary, a thin bed of lignite appearing in the same bluff a little westward:

*Myrica elaenoides (sp. nov.)*
*Myrica copeana, Lx.*
*Ficus multinervis, Heer.*
*Sapindus falcifolius, Heer.*
*Sapindus dubius, Heer.*
*Sapindus angustifolius, Lx.*
*Laurus Californica (?) Lx.*
*Quercus Saffordii, Lx.*
*Juglans rugosa, Lx.*
*Salix angusta, Heer.*
*Salix media, Al. Br.*
*Fragment of a leaf of Ailanthus.*

2. Fossil leaves found in a pinkish plastic clay near the foot of the bluffs facing Mayfield creek, at Boaz Station, Graves county. The bed belongs to the Lagrange group of probably Upper Tertiary:

*Sapindus falcifolius, Heer.*
*Quercus nervifolia, Al. Br.*
*Quercus cuspidata, Ung.*
*Laurus Californica, Lx.*
*Ficus multinervis, Heer.*

3. In the indurated sandy clay or fire-clay forming the base of the so-called "chalk banks," two miles south of Columbus, are numerous fragments of lignitized sticks, leaves, etc. The bed belongs to the Lignitic or Lower Eocene division of the Tertiary. Among these was found a single specimen, well preserved, that Prof. Lesquereux terms "Fruit of Fagus," and for which Prof. Ward proposes the name *Fagus Loughridgei*

THE COUNTIES OF

# JACKSON'S PURCHASE.

## GEOLOGICAL AND AGRICULTURAL FEATURES.

pp. 199, 200.

# DESCRIPTIONS OF COUNTIES.

## FULTON COUNTY.

Fulton, the extreme south-western county of the State, was organized from Hickman in 1845, and has an area of about 178.6 square miles, of which about seventy are embraced in the Mississippi bottom region.

The drainage waters of the entire middle and eastern portions of the county are carried northward into the Bayou de Chien and thence westward into the Mississippi river, there being but a very small area along the Tennessee line, which is drained southward into that State. Again, on the west, the drainage is eastward, or away from the bluffs that border the bottoms of the Mississippi river, the waters reaching that river only through the stream that flows southward into Tennessee. The divide, therefore, that forms the southern rim of the Purchase drainage basin, from the Tennessee river westward, leaves the State line at the point where the N. C. & L. R. R. crosses it from Union City, and turns northwestward to the town of Hickman.

The main channel of the Mississippi river once passed west of Island No. 6, through what is now but a slough. East of the island a small current flowed, and between it and the bluffs there was, in 1842, a bottom one-quarter of a mile wide. Within this latter a broad cypress brake or slough extended southward, apparently connecting with what is now known as the Morrow slough, that, beginning at the river a mile from Hickman, connects with Reelfoot Lake.

There is also every reason to believe that the Obion and Bayou de Chien were once united before reaching the river, but had become separated by the wearing away of the river banks. We are informed by some of the citizens living in the vicinity, that about thirty years ago the mouths of the two streams were within four hundred yards of each other,

though now separated by one and a half miles. Since then the current of the river, thrown against the eastern bank, has carried it away, not only removing all traces of the lowland in front of Hickman, but threatens to sweep the river portion of the town itself away. The railroad tracks along the front have been repeatedly relaid, nearer each time to the foot of the bluff, and have been finally removed and the depot located out of town.

The Morrow slough, mentioned above, has a broad and deep channel, with abrupt banks, and lies along the eastern side of Reelfoot Lake several miles before entering it. The channel even then preserves its identity, and, according to Mr. Carpenter, who lives at the lake, has a depth of twelve feet and width of one hundred feet; it crosses the lake in a west course, then follows the west side for about ten miles, crosses again to the east, and thence to the Obion river, fifteen miles distant.

The strong resemblance between the channel of the slough and those of the Obion and Bayou de Chien, their continuity in general course, as well as with that of the Hickman slough, now swept away, makes very plausible the theory that these two streams once unitedly found their way through this slough channel southward to the Obion river, in Tennessee, before entering the Mississippi.

The Mississippi bottom presents a comparatively level surface, interspersed with a number of large lakes and ponds, which are connected by sloughs with either Reelfoot Lake on the south or the Mississippi river. The bottom lies about forty feet above low-water, and is, therefore, subject to annual overflows. It is very heavily timbered with walnut, hickory, ash, sweet and red gums, water and overcup oaks, pecan, sycámore, cottonwood, willow, catalpa and papaw. On the bottom and low ridges sweet gum, spicewood, honey locust, swamp dogwood and sugar maple, persimmon, redbud, mulberry, some black and red haws, cane and elder brush, form the chief growth.

A few low sandy ridges lie parallel with the river and not far from it, the most prominent among which is the Sassafras ridge, with a length of about three miles and a width of



from one-fourth to one-half mile. Its elevation above the surrounding bottom is only about ten feet, and it is subject to high-water overflows. The growth is cottonwood, oak, ash and sassafras. It is said that walnut was once the chief growth, but was cut off and used for fence rails.

That portion of the bottom lying in New Madrid bend is entirely isolated from the rest of the State, and can not be reached by land except by passing through a portion of Tennessee or Missouri. It is but a few feet above overflow, and is largely in cultivation.

The uplands of the county comprise a bluff ridge along the border of the Mississippi river bottom, and lower lands in the interior. South from the Bayou de Chien to the Tennessee State line the uplands rise from the bottom region very abruptly and steeply to an elevation of over one hundred and sixty feet, presenting fronts to westward. At Hickman their extreme elevation is one hundred and eighty feet above the business part of town, or two hundred and twenty-five feet above low-water, and about four hundred and eighty feet above the sea. The summit of this bluff ridge is narrow, falling suddenly on the east for fifty or sixty feet, with still another fall eastward to the general level of the uplands, or fifty to seventy-five feet above the river bottoms.

Southward, the bluff ridge widens, but its immediate western front forms a sharp water-divide, the gullies which mark the head-waters of easterly flowing streams usually approaching to within fifteen or twenty feet of the edge of the brow of the bluff, cutting the surface of the plateau sharply into deep ravines, and giving to the country a very broken and hilly character. This is especially so in the southern portion near the State line, where the general elevation falls gradually eastward from one hundred and sixty feet above the bottom to about sixty feet at Reelfoot creek, a decline of about one hundred feet in a distance of five and a half miles.

This ridge is a continuation of the line of bluff or cane hills that border the Mississippi river bottom in Louisiana through Mississippi and Tennessee. It has a timber growth of beech, poplar, hickory, elm, oaks, black locust, walnut,

ironwood, hornbeam, dogwood and sassafras. Cane undergrowth was once luxuriant.

On the north of Bayou de Chien, in this county, this high ridge is not found; the bottom lands reach four miles further eastward than at Hickman, and the bluffs that border them are much lower, and present features similar to the ordinary uplands lying due southward.

The rest of the county lying east of the bluff ridge is comparatively level or but slightly rolling, cut into by the several streams, and presenting broad and arable lands, originally timbered with white and red oaks, hickory and sweet gum. The general surface has an elevation of from fifty to seventy-five feet above the Mississippi bottom, rising thirty-five or forty feet higher to the ridge, along which the M. & O. R. R. is laid, and again falls eastward.

## GEOLOGICAL FEATURES.

The uplands of the county are composed of Quaternary loams and sands to a depth of from twenty-five to forty feet, and the underlying older formations are exposed only in the vertical banks of the various streams (where not covered by eroded material), and especially in the high bluffs that border or face the Mississippi river bottom. The formations thus exposed in the county comprise

| | |
|---|---|
| *Quaternary*---- | Alluvial or recent. |
| | Brown loam. |
| | Loess and bluff. |
| | Port Hudson. |
| | Stratified drift. |
| *Tertiary*------- | Lagrange. |
| | Lower Eocene. |

The series are well seen at Hickman, where they are exposed in the almost vertical bluffs and in the banks of the river at low-water seasons.

The following section is given in the order, position and thickness of the different strata:



### SECTION OF BLUFF AT HICKMAN.

| | Feet. | |
|---|---|---|
| Quaternary. | 4 | Yellow or brownish yellow loam. |
| | 50 | Light grey silt or loess with calcareous concretions and very numerous land shells. |
| | 15 | Dark brown loam with some scattered gravel in the lower two feet. |
| | 1 | Dense deposit of hornstone and chert gravel and loam. |
| | 10 | Heavy bed of gravel, with red sand and clay somewhat stratified. |
| Tertiary. | 6 | Greenish or sometimes bluish sandy joint clay, crumbling easily. |
| | 2 | Ledge of sand and claystone, crumbly, greyish and soft. |
| | 3 | Thinly laminated slate-colored or bluish joint clay. |
| | 10 | Greenish clay-stone and green clay, soft, banded with yellow ferruginous lines, crumbles easily, and in places is quite solid. |
| | 8 | Slate colored clay-stone. massive, jointed structure, in places containing a dark opal in small lumps. |
| | 50 | Greenish joint clay, the exposure hidden by the alluvial loam of the bottoms. |

## TERTIARY FORMATION.

The lower eighty feet of strata and material that are here referred to, the Tertiary formation, have not been recognized elsewhere in any other county. They form a group peculiar to themselves, and in nowise resembling any other of the Tertiary series, either in this or other States, so far as I can ascertain; and I have, for that reason, provisionally given to them the name *Hickman Group*, from the locality where best exposed.

The position of the group, with relation to the lignitic, which is represented in the other counties of the Purchase, has not been positively ascertained; but from its easterly dip, and its more westerly position than the Columbus beds,

and the resemblance of the uppermost six feet to the sandy clays of the latter, there seems to be little doubt that it underlies the lignitic black and grey clays, probably forming a part of that group.

The lowest member of the series, as exposed in the Hickman bluff, is a light greenish or drab colored and stiff joint-clay, crumbling and hardening on exposure; it is compact and hard, and has an exposed thickness of fifty feet. In a well in the southern part of town the clay was exposed to a depth of five feet, and under it ten feet of blue, plastic, micaceous and lignitic clay over ten feet of white sand. This well was within the curve formed by the south-easterly trend of the bluff, and the strata are probably a part of the Tertiary series. This is rendered more probable from the fact that in another well, outside of this bluff curve, or within the river bottom, blue alluvial sediment was penetrated to twenty-two and a half feet, where cypress knees, leaves, logs, etc., were found.

Immediately overlying the clay, at the north end of the main bluff, is a ledge of slate-colored clay-stone, very brittle, breaking with sharp and jointy fracture, crumbling on exposure to air, and containing small lumps of a dark but very brittle opal, inclosed in a semi-opal matrix or mass. The opal was found only in this portion of the bluff. The ledge of clay-stone is about eight feet thick, but not homogeneous in structure. It is overlaid by ten feet of a softer clay-stone, crumbling readily, and for the most part thinly laminated, the laminæ separated by seams of yellow ochreous clay. Above the clay stone is a stratum of blackish-blue clay one foot in thickness, and in turn overlaid by two feet of sandy clay-stone, the series capped by another layer six feet thick of blue or green colored clay, quite brittle, and resembling somewhat the grey "soapstone" clay of the lignitic series found in other counties.

The clay-stone ledge is again exposed in a deep ravine or creek near the spring on the place of Mr. T. R. McMahon, in the eastern part of town. It is here two feet thick, and is both overlaid and underlaid by the greenish clays. Still eastward, in the bed of a creek one mile or more from town,



the clay is exposed to the depth of a couple of feet. Beyond this, at Mud creek, only the bluish clays of the upper strata could be found.

This series of clays and clay-stones are exposed southward into Tennessee, the last bluff examined being near Reelfoot Lake, east of Mr. Carpenter's. Here the ledge of clay-stone is a foot thick, lies fifty feet above the bottom land, underlaid by six feet of a softer clayey grey sandstone permeated with streaks of yellow, and in turn underlaid by the grey clays. Blue clays here also overlie the clay-stone ledge, and eastward are found exposed in a deep ravine. They have a disagreeable fetid odor, and are not micaceous. The eastern limit of the formation seems to be just beyond Blue Mud creek, where the top stratum of blue clay is found in wells below the superficial loam and gravel, and also in some of the creeks. On the south-west of Cayce station it is reached at from twenty to forty feet, and has been penetrated for ten feet without reaching its limit.

*Lignitic Group.*—In the Hickman bluff, and overlying the ledge of clay-stone referred to the provisional *Hickman group*, there is a stratum of a light bluish sandy clay which is probably the representative of the lignitic beds so prominent in all of the other counties of the Purchase region.

Its resemblance to the indurated sandy clay beds of the Columbus bluffs on the north, and its continuation southward into Tennessee, where Prof. Safford reports the existence of bluff lignite, make it more than probable that its reference to the lignitic group is correct. As already stated, the clays are well exposed in the high bluffs at the Tennessee State line near Mr. Carpenter's, and also eastward in the deep ravines, and, as at Hickman, overlie directly the clay-stone ledge.

The bed has a thickness of six feet, and is overlaid by the gravel deposits of the Quaternary.

*Lagrange Group.*—This formation appears immediately overlying the Hickman and lignitic clays, or at least begins just as the latter cease. It seems to be the uppermost of the series, being overlaid by Quaternary gravel and sand. It does not appear in the Hickman bluff.

The group embraces white and yellow sands, with occasional layers of white or bluish-white plastic pipe-clay a few inches in thickness. No exposure could be found; but in wells that have been dug to any great depth these strata were passed through. White sand is especially prominent.

At Cayce station a well was dug through twenty feet of loam, four feet of pipe-clay, and thirty-six feet of red and white sand, with some clay—in all sixty feet—and no water found. A couple of miles westward the strata are different, and the blue fetid clay is reached at twenty feet. At Wesley, five miles north of Fulton, twenty feet of loam, twenty-five feet of red sand, and fifty feet of white sand and layers of clay, were penetrated. At Fulton, in a valley, four feet of loam, ten feet of pipe-clay, twenty-five feet of white sand, one and a half feet of pipe-clay, and three feet of white sand were passed through in digging a well. Two miles north-east of Fulton white sand was found at a depth of one hundred and sixty feet.

## QUATERNARY FORMATION.

*Stratified Drift.*—The Tertiary strata are overlaid directly in the Hickman bluff by eleven feet of rather coarse and rounded hornstone and chert gravel, mixed with red and yellow sand and some clay. The usual water-worn Subcarboniferous crinoids, etc., are found, but not abundantly. The deposit is somewhat stratified, and has a general inclination east or north-eastward. The upper part of the bed is especially dense or compacted, containing more stiff red clay than the lower bed. At one point the following stratification was apparent:

| | |
|---|---|
| Dense gravel and loam bed | 12 inches. |
| Dense gravel and red clay, highly cemented | 8 inches. |
| Dense gravel and red sand, loose in character | 8 feet. |

Lumps of blue plastic clay are dispersed throughout the bed, and frequently inclose a few gravel.

In the brown loam or silt that overlies the gravel, a few scattering pieces of quartz gravel, from red to black in color, occur for a foot or two, and occasionally some hornstone is found.



Southward, toward Reelfoot Lake, the gravel-beds are seen, but with a thickness of only a foot or two, while eastward from the immediate bluff, and for many miles, it is, so far as known, entirely absent, a red sand taking its place. In most wells water is obtained in the blue clay at thirty or forty feet from the surface.

What seems to be an isolated bed of gravel was found in a well one mile south of Cayce station, and was four feet in thickness. A gravel conglomerate and some loose gravel occurs a mile south of Wesley; but the bed is thin and the gravel fine. A little gravel is also occasionally found in wells near Fulton and at Jourdan station.

*Port Hudson.* — This formation, which, geologically, is placed above the stratified sands and gravel, is found exposed along the banks of the Mississippi below the alluvial deposit. Its material consist of blue and stiff clays, inclosing some pieces of lignite. The beds are also marked by old cypress stumps, which are found still in an upright position, buried below the alluvial proper.

In the broad bottom region these materials are reached at ten to fifteen feet, as shown in digging wells. In the low portion of Hickman, cypress knees, weeds, and a cypress log, were struck in a well at twenty-two and a half feet. In a well near Sassafras ridge, in the western part of the bottom, after passing through four feet of alluvial loam and ten feet of white and yellow sand, two feet of blue clay was penetrated, and water was found in a blackish sand. Some lignite and fossil leaves were observed in the clay.

*Loess or Bluff Formation.*—This formation is confined to the bluffs that border the Mississippi bottom, lying in this county between the Bayou de Chien and the State line, and, in elevation, is above the general level of the rest of the county. Its material consists of a light-colored soft and fine silt, yellowish when moist, and grey and compact or indurated when dry. It contains numbers of land shells. (See page 78.)

The bed of silt is about fifty feet thick, changing below to a more clayey loam, in which the shells were not found, and

which, with a thickness of about fifteen feet, directly overlies the gravel, and incloses a few scattering small colored quartz pebbles in the lower two feet.

The silt beds of the bluff contain also numerous calcareous concretions and yellow tube-like forms, showing, when broken, concentric layers and a small central hole, as if made by some rootlet. Near the upper part of the bed such rootlets were seen as long strings inserted in the interior of these forms. On the summit of the bluff the silt is covered with four or five feet of yellow loam.

*Brown Loam.*—This material forms the surface of the uplands of the county, and has a general depth of from fifteen to twenty feet. The upper two feet is usually a light yellowish loam where drained, while the lower portion is more compact, lighter colored, and permeated by seams of a whitish silty material.

## AGRICULTURAL FEATURES.

Fulton county does not possess those varied features that characterize some of the other counties of the Purchase, for in its uplands there is lacking the flatwoods and the barrens; and in its lowlands we do not find a belt of valley land along its river, as in McCracken, Ballard, Marshall and Calloway counties.

*Uplands.*—The uplands of the county embrace the high Cane Hills ridge, or bluff lands, along the Mississippi bottom, and the lower and more level country reaching east across the county.

The *Cane Hills* form a narrow belt on the north, near Hickman, and a wider but very broken section on the south, thus affording a comparatively small area suitable for tillage. The soil is, however, very rich and fertile, formed from the calcareous silt or loess of the bluff, and, where bodies large enough for farms are found, will repay the husbandman for his labor.

An analysis of the silt on page 79 shows it to be extremely rich in potash and soda and magnesia, and with a large percentage of lime, a richness also indicated by the large timber growth of poplar, oak, walnut, etc., whose roots draw the



necessary food from this silt. Cane undergrowth is a characteristic feature of the surface growth throughout the length of the bluff.

The remaining uplands of the county, known as the *oak and hickory brown loam lands*, have a brownish loam soil, loose in texture where well drained, or where lying along the edges of ill-drained flats, and has a depth of two to four feet to the more compact under-clay. The immediate surface soil is usually dark from decayed vegetation. On flat areas, where there is no natural drainage, the soil becomes heavy, crawfishy and leached, the iron and a portion of the other ingredients withdrawn in the form of small rounded bog ore gravel. These spots are marked by a whitish soil.

The timber growth of these uplands comprises white and red oaks, and hickory, with dogwood and sassafras, and persimmon; poplar is confined to the country west of Mud creek.

A comparison of the analyses of virgin soils from near Hickman and Fulton, given in the general report (page 159), show the strongest differences in their potash and phosphoric acid; those from the former place being deficient in the amount of potash available for plants, while having a fair amount of phosphoric acid; and the soil from Fulton having a fair percentage of potash and rather a deficiency in phosphoric acid. The insoluble portions of the soil, however, hold a large amount of the former constituent (more than one and a half per cent.), which should be made available by the addition of more lime to all these soils.

The subsoils are naturally poorer in vegetable or organic matter, but are more clayey in character, and contain less lime and larger percentages of potash and phosphoric acid than their soils. The differences are so great in the latter two elements of plant food that they point clearly to deep subsoil plowing as one means of keeping up the fertility.

The uplands wash into ravines and gullies very badly on hill-sides, unless well cared for. Little or no hill-side ditching or horizontal plowing was observed, the crops being usually "laid by" with the rows forming excellent water drains down the hill-sides, with a consequent loss of soil.

The central and eastern portions of the county, from the bluffs of the river bottom eastward beyond the M. & O. R. R., are very generally opened up and in cultivation, the roads passing almost continuously through lanes.

The crops of the uplands are chiefly corn and wheat, the average yield being, in good seasons, eight to ten barrels of the former, or ten to fifteen bushels of wheat per acre. Some tobacco is cultivated, but the plant grows too large and coarse. In the neighborhood of Wesley it is said to yield one thousand pounds per acre. A little cotton has also been produced in the southern part of the county, but the seasons are too short for the complete opening of the bolls. The plant grows luxuriantly. East of Cayce, land-plaster or gypsum is said to be used extensively on the lands.

*Bottom Lands.*—The *bottom lands* of the Mississippi river cover an area of about seventy square miles, by far the greater part of which are subject to overflow, and not under cultivation. Along the river bank, with a width of about a mile, there is a belt of sandy lands somewhat higher, which, together with some low ridges in the swamp, are sufficiently elevated to escape disastrous floods, except in unusual high-water seasons. Such lands embrace almost the only tilled area, the rest being valuable chiefly for their fine timber growth, though having a very rich and light alluvial loam soil, several feet in depth, which would produce immense crops. Corn is the chief and almost only crop cultivated in the bottom, the sandy lands, including Sassafras ridge, yielding from sixty to seventy bushels of corn per acre.

New Madrid Bend is several feet higher than the main bottom region, and for the most part is above ordinary high-water. Large farms lie along the river, producing both corn and wheat.

Analyses made of samples of these soils from near Hickman are given in the general report. (See page 145.)

The most notable feature brought out by the analyses is the large amounts of organic matter and lime carbonate, which are valuable additions where so little potash occurs in an available form and so much held in an insoluble condition. The phosphoric acid percentage is good, with, however, comparatively little to fall back on in the insoluble residues when the soil becomes at all exhausted.



In the cultivated soil, the land is seen to not only hold its own, but to improve by the plowing, the phosphoric acid remaining the same, and the available potash increasing at the expense of the insoluble portion. The alumina and iron oxide (probably the latter, chiefly) seem to have gone into an insoluble form. The withdrawal of the corn crop seems not to have affected the land.

The lands of the bottom above Hickman are similar in character to those on the south. Along the river bank cypress stumps stand in the underlying blue clays, and are embedded and covered by the alluvial loam.

The bottom reaches eastward for several miles, and has a heavy timber growth similar to that already given.

Those portions of the bottom land of the Obion creek and Bayou de Chien, lying within this county, are formed by overflows from the Mississippi river, chiefly, and are similar to the lands already described.

On Little Bayou de Chien, and smaller streams, the lands are formed by washings from the brown loam uplands, and are yellowish and stiffer than the river lands, and crawfishy to a large degree. The surface soil is dark or black to a depth of an inch. Their valleys are usually from one-fourth to one-half mile in width, and not very much in cultivation. The growth comprises white and other oaks, hickory, gum, and some pecan.

## ECONOMIC FEATURES.

There are no minerals occurring in this county that deserve attention. Some iron, in the form of oxide, occurs in the gravel beds of the bluffs, staining them yellow or red, and forming a cementing material for the gravel conglomerates; occasionally a thin sheet of limonite is found, but in no great quantity. To this iron oxide is due the chalybeate character of so many of the springs that come from beneath the gravel.

In some of the clays (especially the blue) are frequently found bright particles of iron pyrites, having yellow or silvery colors, and often mistaken for gold or silver. They give rise, by decomposition, to the fetid or disagreeable odor so generally observed in the blue clays, and to the sulphur springs which sometimes are found issuing from these clays, and which are recognized by the accompanying odor.

A chalybeate water from Nick Combs' spring, four miles south-west of Hickman, was, on analysis, found to contain free carbonic acid and 0.302 grains of saline matters in one thousand of water. This consists of iron, manganese, lime and magnesia carbonates, with some lime and magnesia sulphates.

*Potter's Clay, Etc.*—The bluffs at Hickman, and southward to the Tennessee State line, contain an inexhaustible amount of pure clay, free from coarse sand and pyrites, and which doubtless could be utilized in the manufacture of tiling, terra-cotta and pottery. The clay is said to have been successfully tried for fire-brick; but the amount of potash it contains would seem to unfit it for the severest tests. The greenish color is probably due to diffused glauconitic clay.

Analyses have been made of the following specimens of clay from this county, with results as given in the general report:

No. 2141. Clay; bed about twenty feet thick or more above the railroad track; upper part of the town of Hickman; of a pretty uniform olive-grey color; calcines quite hard, and is quite refractory before the blow-pipe.

No. 2136. Clay from the bluff at Hickman; upper part of town; first clay below gravel bed; about four feet thick. It is of a light-greyish tint, and ferruginous in parts by infiltration; moderately plastic; it did not calcine very hard, acquiring a handsome light brick color, and is refractory before the blow-pipe.

No. 2138. Clay from the Hickman bluff; upper part of town; it lies about ten feet below the gravel bed, and is about four feet thick; it is light-grey in color, infiltrated somewhat with ochreous material in striæ, and is quite plastic; calcined to a light brick color, and is quite refractory before the blow-pipe.



No. 2140. Clay from Hickman bluffs; upper part of town; the bed is about five feet thick, below No. 2139; light lilac-grey color, and stained with an ochre on the exterior; it is quite plastic, burns quite hard and to a light-brownish buff tint, and is quite refractory before the blow-pipe.

No. 2134. Indurated clay from Hickman bluff; forty-five feet above low-water; grey color, with some light ferruginous stains in fissures; quite plastic with water when powdered. It calcines to a light-buff color, and fuses before the blow-pipe into a grey slag.

No. 2135. Clay from Hickman bluff; ninety-five feet above low-water; it is quite plastic with water, calcines to a reddish buff color, and is refractory before the blow-pipe, but sintered somewhat.

No. 2137. Clay from Hickman bluff; same bed as No. 2136, but one-fourth mile further up the bluff; three to four feet thick; it is quite plastic, burns hard and to a light greyish buff tint, and fuses with great difficulty before the blow-pipe.

No. 2139. Clay above No. 2138; it is about four feet thick, quite plastic, and burns hard; of a light grey-buff tint; fuses with difficulty before the blow-pipe.

Dr. Peter remarks: "The refractory clays would probably make good fire-brick, etc.; others of the above could be employed for terra-cotta work and other forms of pottery, while some of these abundant deposits might, no doubt, be used with advantage in mixture with the more calcareous soft material, found in some of these beds, in the manufacture of hydraulic cement of the character of the celebrated Portland cement."

The following samples of the clay-stones, or indurated siliceous clay and concretions, that occur in the bluffs bordering the Mississippi bottom, have been analyzed and given in the general report:

No. 1439. Indurated siliceous clay (clay-stone), from the bluffs, one hundred feet above low-water mark, at Hickman; is somewhat plastic when powdered and rubbed up with water.

No. 1440. Siliceous concretion, or soft sandstone, from the bluff at Hickman, fifty feet above low water; slightly plastic when powdered and rubbed up with water; adheres to the tongue.

No. 1441. Siliceous concretion from Chickasaw Bluff, eight miles south of Hickman; a light-grey or dove-colored soft and porous siliceous rock, adhering to the tongue; scarcely at all plastic when powdered and rubbed up with water.

No. 1442. Soft sandstone, Chickasaw Bluff, near the base, eight miles south of Hickman; a dull light yellowish-grey porous soft sandstone; adheres strongly to the tongue; composed of minute rounded quartzose grains with whitish cement.

"These siliceous deposits do not contain enough mineral fertilizing ingredients to make them available for application to the soil, nor enough alumina to constitute a good plastic clay. Yet they may be made useful in tempering clay which contains too much alumina, or for the formation of common glass and for scouring purposes. Some of them are plastic enough to enable them to be moulded, and the siliceous material is fine enough in some to permit them to be used as 'bath brick' for household scouring."

The white and bluish pipe-clays that occur in strata in the sands of the Lagrange group, in the eastern part of the county, are covered too deeply by the sands and loams of the Quaternary to be utilized profitably, though they undoubtedly would make splendid ware. So far as known, no outcrop occurs in any of the creeks or gullies within the county. There is, in the bluff of a creek immediately north of the town of Fulton, a small exposure of a light bluish plastic clay, but is intermixed with yellowish sand.

The gravel of the bluff at Hickman has been largely utilized in grading the streets of the town. It is of the cementing variety, being mixed with iron oxide, clay and sand, which rapidly harden on being packed and exposed to the air.

The grey silt, comprising a fifty-foot bed in the top of the bluff at Hickman and southward, is a fine polishing powder, and has also been used by dentists as a moulding clay for casts.



## HICKMAN COUNTY.

The county of Hickman now contains an area of about 229.5 square miles, nearly all of which is uplands, there being but about twenty miles of bottom lands within the Mississippi river bottom, including Wolf Island, and about thirty square miles of bottom along the larger streams. It originally embraced all of Jackson's Purchase, and was organized in 1821 from Caldwell and Livingston.

The general surface of the county is rolling, and was originally well timbered, and is drained by Obion creek and Bayou de Chien, the former flowing at first north-westward and then turning nearly abruptly south-westward, the Bayou de Chien on the south having a nearly continuous westward course, both streams entering the Mississippi on the southwest and not far apart. The Obion has very much the largest drainage basin within the county, the water-divide being very near the Bayou de Chien, and limiting its northern tributaries to very small streams.

The general level of the uplands east of Clinton is about four hundred and fifty feet above the sea, falling westward to three hundred and fifty feet at the Clinton depot, and three hundred feet at Obion creek, but rising again to four hundred and thirty feet on the bluffs at Columbus. Here there is an abrupt descent to the town, located in a broad flat (originally the Mississippi bottom) two hundred and eight feet above the sea or thirty-five feet above low-water.

The river bottom is here limited to a narrow belt, of not more than three miles in length, by the bluffs at Columbus and the "chalk banks" on the south, both of which come immediately to the water's edge. South of the latter bluff the bottom widens rapidly, the river having a more southwesterly course, and the bluff itself turning south-eastward to the Obion creek, by which it is cut in two at McLeod's bluff. The bottom here has a width of about three miles.

The bluff ridge, forming a sharp water-divide between the Mississippi bottom on the west and the small tributaries of the Obion on the east, maintains its high elevation until the bluff turns south-eastward, when its summit falls rapidly to about three hundred and fifty-five feet at McLeod's bluff.

Between the Obion and Bayou de Chien the uplands terminate in a low bluff not more than sixty feet above the bottom land, a short distance from the county line. Backwater from extreme floods in the Mississippi reach to a point south of Clinton on the Bayou de Chien, and about west of Spring Hill on the Obion.

The current of the Mississippi, thrown against the eastern banks, has been rapidly undermining the bluffs on the north of Columbus, and portions are annually falling in. It is said that in the spring of 1847 seven acres were carried away. The town itself is also suffering greatly by the washing away of the river front. At the "chalk banks" the indurated material affords greater resistance to the current, and the bluff remains unaffected.

## GEOLOGICAL FEATURES.

The entire uplands of the county have a superficial deposit of from fifteen to thirty feet of brown loams, which very generally hide the Tertiary strata. These latter are, however, well exposed in the high bluffs at Columbus and "chalk banks," and much light is thrown on their occurrence elsewhere by the deep wells that have been dug.

The Columbus bluffs do not present a uniform outcropping of each stratum, and different characters and material sometimes appear at the same levels, making it often difficult to arrive at a definite conclusion as to the relations and position of each.

SECTION OF BLUFF AT COLUMBUS.

| | Feet. | |
|---|---|---|
| Quaternary. | 3 | Soil and subsoil. |
| | 30 | Grey calcareous silt or loess. |
| | 30 | Coarse gravel with yellow sand and clay, in part cemented together. |
| Tertiary. | 15 | Grey, chocolate and variegated colored stiff clays. |
| | 85 | Siliceous earths or clays; white or grey when dry, but bluish when wet or damp; becomes highly indurated on exposure; incloses lignitic stems, leaves, and pieces of bark. |
| | 10 | Light grey whitish clay; disappears below water. |



The lower 110 feet of the above belong to the Tertiary, while the upper 65 feet are of the Quaternary. More recent deposits occur in the bottom lands at the foot of the bluffs.

## TERTIARY FORMATION.

*Lignitic or Lower Eocene.*—The lignitic strata have a very limited exposure within this county, being confined to the two bluffs at Columbus and the "chalk banks." It is elsewhere replaced or overlaid by the later, or Lagrange group.

The siliceous earth or clay forming the bluff to an elevation of ninety-five feet above low-water is, in places, more clayey than in others. Where freshly uncovered, the material is soft and dark in color, sometimes bluish, and more or less plastic. On drying it becomes grey, and hardens into a solid mass, which, however, is inclined to crumble when wet. Large blocks of this indurated earth lie at the foot of the bluff.

Blackened and lignitic stems and leaves are found throughout the bed, and are best shown in the dried and hardened portions, the leaves being frequently well preserved. A piece of bark six inches in width was observed. In the bluffs east of Columbus an exposure of this siliceous clay-bed is again seen.

At the "chalk banks," two miles south of Columbus, where the bluffs come to the water's edge, this siliceous earth has, by its long exposure, been made to present a white appearance, and hence the name given to it by river men. This name is, however, a misnomer, and is apt to mislead, for there is here an entire absence of anything resembling chalk. The bluff is highly indurated, and presents a bold face to the river, with a dip of about fifteen degrees to the east. The interior of the hardened masses is dark or somewhat bluish, and incloses lignitic sticks and leaves. A small nut, resembling that of a beech (*Fagus*), was found in one place.

*Lagrange Group.*—The plastic, white and variegated clays, interstratified with sand, have been referred to this group, which is, so far as can be determined, an intermediate bed between the Eocene Tertiary and the Quaternary stratified drift.

In the Columbus bluffs it is seen in the clays that immediately underlie the gravel beds, and in the deep beds of white sand, with their associated layers of clay, that appear on the south of the Columbus bluff and on the north of the "chalk bank."

In the Columbus bluff the sand bank rises from the water's edge (immediately south of the Tertiary siliceous earth bluff), to an elevation of ninety-five feet above low-water, and shows plainly the strata of white or bluish-white pipe-clay. The sand is fine, and varies in color from white to yellow. Portions show beautifully the cross-lamination peculiar to the stratified drift. A section taken from one point is given in the general report. (Page 54.)

The sand and clay strata are here overlaid directly by a thick bed of loess, but where they appear elsewhere the gravel bed is in place between them and the grey silt or loess. The dip of this group is to the east. The bluff, in its eastern trend from this point, until it again curves southward, shows well the strata. The deep bed of white sand dips below a series of purplish clays and sands, the former imparting its color to the outcropping sand and giving to the bluff the appearance of a large bed of purple clays.

The clays are in layers of from a few inches to a foot, or even two feet, in thickness, each separated by several feet of variously colored sand, the series being overlaid by the heavy deposit of gravel and loam.

At the "chalk banks" the same series appears, but with some blue plastic clay at the base of the bluff or level of the swamp land.

It would seem that the Lagrange series of sands and clays had been deposited here after the erosion of the Tertiary strata had taken place. The trough or valley being filled, the deposition of the material was extended over the adjacent Eocene clays, as shown by the beds immediately below the gravel.

Eastward, in the interior of the county, this clay and sand series is again reached below the superficial gravel and loams, as appears in the deepest wells, neither the blue lignitic clays or the siliceous earth of the Columbus bluffs being anywhere



observed. Unfortunately no well has penetrated deep enough to determine the true thickness of the strata or the character of the underlying material. In Clinton, after passing through ten to fifteen feet each of loam and gravel, sixty feet of red and white sand and clay strata were penetrated, water being obtained in the white sand at one hundred and twelve feet. An impervious clay doubtless underlies it.

At Oakton, nearer the bluffs, wells are usually dug but fifteen or twenty feet, the water being from seepage, through white and yellow sands. Blue clay is reached below the sand at fifty feet, and in one well was penetrated thirty feet, no water being found. In these wells no white clays were found. Near Wesley, in the south-western part of the county, a well passed through twenty feet of surface loam, twenty-five feet of red sand, and fifty feet of white sand and thin white pipe-clay strata of the Lagrange group.

On the Obion, at McLeod's bluff, and in the bluffs between the Obion and Bayou de Chien, the lowest stratum exposed is the bed of the red sand below five feet of gravel and about thirty feet of surface silt.

### QUATERNARY.

*Stratified Drift.*—This division or upper stratified drift has its greatest thickness of thirty feet on the bluffs at Columbus and the "chalk banks."

Its material is coarse hornstone and chert gravel, with a little small, white and colored quartz, all being more or less water-worn, but the latter especially so. Subcarboniferous crinoid stems and other fossils, also water-worn, are abundant. Among them at Columbus were found several pieces of Lithostrotian Canadense. One piece of cherty rock observed was half a cubic foot in size, and weighed twelve or fifteen pounds. The gravel is very highly stained to a bright red with iron oxide, and this color has given rise to the name "Iron Banks," by which these bluffs have been distinguished. They are, however, no more ferruginous than the great body of gravel deposits over the Purchase region.

The beds are more or less stratified with thin but not continuous layers of red sands. There is a perceptible in-

clination of the layers to the east, but not of the bed itself. In the Columbus bluff they present, with the overlying grey silt and loam, a vertical face of at least sixty feet down to the clay stratum below. Much is cemented into a hard conglomerate by the clay and ferric oxide. In the upper portion of the gravel bed, in the north end of the bluff, the stratification is well seen, and embraces, below the superficial silt and loam, the following:

| | |
|---|---|
| Red loamy clay and gravel, in thin irregular layers | 6 feet. |
| Yellow sand, with lumps of blue or purple plastic clay, thinning to south-west | 1 to 3 feet. |
| Red and yellow sand | 3 feet. |
| Heavy gravel bed | 20 to 30 feet. |

At the "chalk banks" the bed is very similar to the main bluff at Columbus; but at McLeod's bluff, on the Obion, there are but five feet of gravel outcropping from beneath the grey silt and loam. It seems to be largely replaced by red sand. It is, too, at a much lower level than the beds above described.

Going eastward to Clinton, we find the gravel with a thickness of about ten feet; but in the southern part of the county the bed thins out, and is seldom found either in ravines or in wells. Wherever it appears north of Clinton, as at Spring Hill and Cypress post-office, it is small and in thin beds, showing a near approach to the limits of the deposit. East of Clinton it is found in wells at a depth of about fifteen feet on the uplands, and has a thickness of about four feet. The bluffs of the Obion show from two to four feet of gravel above a thick bed of yellow sand.

There is much *ferruginous sandstone* in the county, varying in color from yellow to dark red—chiefly the latter. The most noted locality is that of the quarry about five miles east of Clinton, on the north brakes of Bayou de Chien. The sandstone is made up of coarse grains of a clear hyaline sand cemented together with ferric oxide, forming ledges as much as six feet in thickness, much of it hard and durable, other portions soft and easily crushed. The rock is specked throughout by small grains of white cherty material.



The rock is used in Clinton as supports for frame buildings, being easily quarried and dressed.

*Bluff Loam and Silt.*—This upper division of the Quaternery is well observed in the Columbus bluffs, where, with a thickness of thirty feet or more, it overlies the gravel bed, forming at one place part of a vertical exposure.

The grey silt or loess has a thickness of about twenty-five feet, changing below to a more clayey and brownish loam, five feet in thickness, the lower two feet of which contains usually a few scattered rounded quartz gravel. It has the calcareous and concretionary nature that characterizes it elsewhere, but at this point does not contain the great numbers of fresh water and land shells that are found at Hickman, Fulton county.

In a deep cut on the M. & O. R. R., east of Columbus, the grey silt is prominently exposed, and in it have been found abundantly, and sometimes well preserved, shells belonging to the species *Helix*, *Helicina*, *Mesodon*, *Succinia*, *Patula*, *Cyclas*, *Planorbis*, *Limnea*, *etc.* (See page 78.) These shells are especially abundant in a bluish silt at the south end of the cut, which also contains very numerous reddish and cylindrical concretionary forms with small central holes, as if once occupied by rootlets; also seams of ferruginous clay holding many of the shells. The small forms are best preserved, the large ones being very generally broken or crushed. They are found also in the railroad cut between Columbus and South Columbus junction.

The formation lies chiefly along the bluffs that border the Mississippi river bottom from Columbus southward to the Obion at McLeod's bluff, where a thickness of about thirty feet is observed above about eight feet of light loam and clay. Still southward, between the Obion and Bayou de Chien, the silt was not found, the bluffs being formed or capped by the brown loam.

Eastward from the line of bluffs the silt was found to extend nearly to the Obion creek on the Columbus and Clinton road.

As seen by the analysis of a sample from the M. & O. R. R.

cut near Columbus, the silt is rich in carbonate of lime and magnesia. The potash and phosphoric acid were not determined, but analyses of the same formation in Fulton county and in Tennessee show the presence of 1.7 per cent. of potash (Page 79.)

The hills in which this silt occurs are marked by a heavy growth of white oak, hickory, poplar, black walnut, black and red oaks, black and sweet gums, persimmon, and a little maple, dogwood, elm, etc.

A cane undergrowth once prevailed on the bluffs, but is kept down by the grazing of stock. These hills are a continuation of what are known as the *cane hills* of Louisiana, Mississippi and Tennessee.

*Brown Loam.*—On the east of the Obion, and covering the rest of the county, the stratum of more clayey loam is the prevailing deposit immediately over the gravel beds. It is here a stiff and tenacious material, permeated with seams of what appears to be a whitish silt, and having a thickness of about twenty feet. The upper two feet is of a more reddish loam, loose and homogeneous, especially where good drainage is had.

This loam was deposited upon the beds of gravel in layers of apparently even thicknesses, regardless of the irregular surface of the latter. This is often well shown in cuts where the gravel is covered evenly on top and on the sides of the hill. Subsequent denudation has added to the unevenness of the surface of the deposit.

*Port Hudson Group.*—This formation, more recent than the stratified drift, occurs in this county only below the alluvial deposits of the Mississippi, its outcrop being observed along the river banks. It is also reached in wells in the bottom lands and at a depth of from fifteen to twenty feet below the surface.

It is well exposed in the river banks at Columbus, where a section presents the following strata:

| | | |
|---|---|---|
| *Very recent* | Sandy loam | 4 inches. |
| | Black clay, gravel, glass, etc | 8 inches. |



| | | |
|---|---|---|
| *Alluvial* | Dark sandy alluvial loam | 15 inches. |
| | Black sandy alluvial loam | 8 inches. |
| | Stiff yellow clay, sandy and crumbling, and having seams of lighter sand | 8 feet. |
| *Port Hudson* | Heavy crumbling black clay, stiffer than the above | 3 feet. |
| | The same as the last, but a deeper blue, and holding white calcareous concretions, to water's edge | 6 feet. |

The clay of the last stratum is very plastic, smooth and mottled in color. Cypress stumps standing erect are a prominent feature of this clay bed below Columbus, and are covered by the alluvial deposits. One of the stumps is said to have been fifteen feet in circumference. The tops of the stumps appear on nearly a horizontal line.

The beds extend southward into Fulton county. Just south of "chalk banks" the blue clay contains many fragments of lignite, or similar woody pieces. Much yellow and white concretions also occur, and cypress stumps are a prominent feature.

## ECONOMIC FEATURES.

*Potter's Clay, Etc.*—The clays that form so prominent a feature in the Columbus and other bluffs bordering the Mississippi river, have been subjected to analyses and tests as given in the general report. (Page 102.) They embrace the following:

No. 129. White earth; base of "chalk banks," two miles below Columbus; color, light grey; it has rather a harsh feel, and adheres to the tongue; dried at 212° F., it lost five per cent. of moisture.

No. 2161. Clay from "chalk bank," two miles below Columbus; light buff and lead grey color; has a few ferruginous impressions of vegetable leaves; seems to be quite sandy, yet is quite plastic and burns hard, and of a very light cream color. It is refractory before the blow-pipe, only sintering a little. On washing the air-dried clay with

water, it left about 69 per cent. of a very fine sand, of a drab color, containing a few very small spangles of mica.

No. 2162. Clay from the bluffs at Columbus; almost white; quite sandy and quite plastic; burns hard, to a light cream color, and is quite refractory before the blow-pipe. The air-dried clay washed in water left 68.5 per cent. of fine sand of a light grey color, nearly white, which is composed of very small rounded grains of quartz, with a few small specks of mica.

No. 127. White earth; from the white deposit of the bluffs at Columbus. A nearly white, fine, granular, soft mass, easily crushed with the fingers to a fine granular powder.

No. —. White earth overlying the siliceous earth or No. 127, of the bluff at Columbus.

Dr. Peter makes the following comment on some of the analytical results: No doubt No. 2162, if it will burn hard enough, would make quite refractory fire-brick; and it, as well as that from the "chalk banks," might be made available for terra-cotta and other forms of pottery ware. No. 2162 is less refractory, because, doubtless, of its larger proportions of iron peroxide and potash.

A comparison between these and the celebrated glass-pot clay of Germany shows that the main difference is in a larger proportion of potash in the Hickman county clays. Whether this would be fatal to the application of these refractory clays in the glass-works, is a question worthy of a practical trial on a small scale.

Nos. 127 and 129 contain much less potash than those remarked by Dr. Peter, and unless the large amounts of lime and magnesia would prove injurious, would seem to be even more suitable for the purposes named.

The clays above analyzed belong to the Tertiary beds proper. Those of the Lagrange group, appearing as white plastic strata in the heavy beds of white sand, have not been analyzed. They would doubtless make good iron-stone ware. For the ordinary pottery they are too intractable, and would require the admixture of a more siliceous clay in order to be readily worked up into a homogeneous mass.



Such plastic clays occur in the bluff east of Columbus, where they can be easily and cheaply obtained.

Two potteries have been in operation in Columbus for some time. They use a blue clay from the base of the sand and clay bluff just north of the "chalk banks." It is, however, obtained with difficulty, and only during low-water seasons in the river. It is easily worked or kneaded, and makes good pottery. Clays are also brought from Wickliffe, in Ballard county.

*Sand.*—The white sand of the Lagrange group, which at Columbus and the "chalk banks" forms high bluffs, is nearly white, and contains some fine particles of clay. It has in places a purple color. The grains of sand are of hyaline quartz and rounded. When washed in water, 99.4 per cent. of nearly pure white sand remains.

"The sand is doubtless pure enough for the manufacture of any but the very finest of glass."

It is often shipped per railroad to Union City and other points.

*Gravel.*—The gravel of the bluffs around Columbus is of the cementing character, which makes it useful for grading streets and roads, and is being used for that purpose in Columbus. The beds are very thick and the gravel easily accessible. Instead of ferruginous clays, a red sand accompanies the gravel in some places and impairs its usefulness.

East of Columbus the gravel is not exposed in sufficient thickness and quantity to make profitable its removal to desired points.

### AGRICULTURAL FEATURES.

The uplands of the county, comprising by far the greater part of its area, and, therefore, almost exclusively the agricultural portion, lie from fifty to one hundred feet above the bottom lands of the streams, the bluffs at Columbus having an elevation of one hundred and twenty feet above the Mississippi bottom.

Large areas of this upland are level or slightly rolling, presenting fine farming tracts which have already been largely inclosed and under cultivation.

*Cane Hills or Bluff Land.*—From the edges of the bluffs that face the Mississippi bottom southward from Columbus to Obion creek, the surface of the country slopes eastward, and is very broken and washed into deep ravines and gullies by the streams that flow *from* the bluff eastward to the creek. This drainage feature of the river bluffs is characteristic throughout their extent. Upon the high bluffs themselves are some large farms, but the rest is almost too uneven for successful cultivation, except in small areas.

This region is underlaid by the fine calcareous grey silts of the bluff formation, and has a fine timber growth of walnut, poplar, maple, hickory, white oak, sweet gum, papaw, grapevines and cane.

The soils are devoted almost exclusively to crops of corn and wheat.

*Brown Loam Uplands.*—The Obion creek, in its varied course across the eastern, northern and western parts of the county, is bordered on each side by a strip of country several miles in width, which is much broken by the many tributaries of that stream. Through the central part of the county, from two or three miles west of Clinton eastward nearly to the county line, and at the heads of the Obion tributaries, there is a plateau some three or four miles wide and about ten long, having a rolling surface, and very generally under fence or cultivation. Its elevation above the Mississippi bottom is about one hundred feet. Ravines and gullies occasionally cut deeply into its surface, giving good drainage facilities to its flat lands.

On the south it is bordered by the westerly flowing Bayou de Chien, whose tributaries give rise to another broken belt of country along the southern border of the county.

A large proportion of these broken sections along both this stream and Obion creek afford large areas of fine farming lands, having easy drainage facilities.

The brown loam lands cover the greater part of the county and overlie the lighter clayey deposits, which reach to a depth of fifteen to twenty feet.

The soil, when well drained, is light, porous and very fertile, the surface darkened by decayed vegetation to the depth of but an inch or two. The subsoil differs only in being a brighter yellow, and perhaps a little more clayey. The growth comprises white and red oaks, hickory, persimmon and sassafras. On level tracks of land, where no drainage facilities are had, the soil becomes glady or whitish, the result of leaching by standing water, and there is an abundance of a small soft gravel or bog iron ore (with a light-colored surface, and brown or even black interior) in the subsoil. Such spots are found in all flat lands of large area, and need only drainage and deep tillage, with application of manures (to restore lost plant food), to make them as good as the rest. The bog iron ore or gravel is the result of the leaching, the iron, etc., being obtained at the expense of the soil. The lands wash badly into gullies, and efforts are seldom made to counteract this by proper cultivation of the soil.



But one analysis has been made of the upland soils, and this is given in the general report. (Page 159.)

In this there is a fair percentage of phosphoric acid (0.156), vegetable matter (4.140), and lime (0.495), but a surprisingly small amount of potash (0.182), in presence of so much lime, especially as the insoluble portion of the soil retains so large a percentage. The soda is excessive (0.564.)

The soil altogether has more the character of those derived from the calcareous silt of the bluff than those of the brown loam that cover the country east of Obion creek. The latter usually have very little lime and phosphoric acid.

The crops of the county uplands are chiefly corn and wheat the yield being about forty bushels of the former and fifteen of wheat per acre.

Very little tobacco is produced, except in the central and eastern parts of the county, its yield being about eight hundred pounds per acre. Clover grows luxuriantly, yielding it is claimed, two tons per acre and two crops per year. Some cotton has been raised, but not profitably.

*Bottom Lands.*—The *bottom lands of the Mississippi* are subject to overflow, and are in cultivation only south of the "chalk banks." The soil is a rich alluvial loam, easily tilled, and having a heavy timber growth of walnut, pecan,

oaks, sycamore, cottonwood, cypress, hackberry, etc. The bottom is interspersed with numerous sloughs and ponds.

The *bottom lands of Obion and Bayou de Chien* are from a half mile to one and a half miles in width, and are timbered with beech, white and red oaks, walnut, cypress, elm, poplar, and sweet gum. There is also some sweet brier and cane undergrowth.

The soil is mostly a whitish heavy clay, crawfishy in nature, and difficult to till. It is best suited for grasses, which yield fine crops. Some of the lands, however, are under cultivation in corn.

An analysis has been made of a white or light-grey soil of Bayou de Chien bottom at Moscow. (Page 148.) It contains about 79 per cent. of rounded grains of clear quartz and some irregular bog iron ore concretions. In this soil there is a fair percentage of lime (1.15) and phosphoric acid (0.13), but the potash (0.17) is low for so clayey a soil. The organic matter (2.00) is also very small. However, with good drainage and tillage, the soil should produce well for a few years.

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## BALLARD COUNTY.

Ballard county was organized in 1842 from the counties of Hickman and McCracken. It has an area of 426.2 square miles, about sixty miles of which are comprised in the Mississippi and Ohio bottom lands.

The bottoms along the Ohio river vary in width from about a mile at Ogden's landing to two or more miles south-westward at Terrell's landing; the bluffs thence have nearly a due south course to Wickliffe, and the river, in its south-west course, is bordered by a bottom of nearly five miles in width on the Kentucky side. The bottom lands of the Mississippi, from Wickliffe south to Columbus, vary in width from one-fourth of a mile to about three miles, due to the winding course of the river and the regular southward trend of the bluffs.



The bottom lands of Mayfield creek are about a mile in width, those of smaller streams being from one-fourth and less to one-half mile.

The bottom lands of the two rivers are interspersed with ponds and lakes, long and narrow, which are usually connected by sloughs in courses parallel with the rivers, the entire system indicating the course of former currents which, sweeping over these bottom lands, cut away the uplands to their present very regular westward limits, which are marked by high and abrupt bluffs. Low sand ridges, also parallel with the streams, lie within the bottoms, and are formed by deposits on either side of currents of water during the river floods. These ridges afford almost the only farming lands of the bottoms, being elevated above all but extreme high-water, which yearly covers the lower lands.

The uplands of the county present a variety of features of much interest, topographically as well as agriculturally. With an extreme length north and south of thirty miles, the county is divided unevenly by Mayfield creek flowing almost due west from the McCracken county line to the Mississippi river. This stream is almost entirely supplied by the waters of that section of the county known as South Ballard, Little Mayfield creek being the main tributary. A small part of South Ballard is drained by Obion creek, which bends around into this county for a short distance.

On the north side of the Mayfield creek its basin is very narrow, and after passing beyond the immediate bluffs, we find the northern part of the county drained, in part, by Shawnee creek flowing westward, by Humphrey's creek flowing north-westward, and by Clanton creek, with at first a northward and then a westward course, into the Ohio.

South of the mouth of Mayfield creek the bluffs that face the Mississippi river bottoms form another divide, abrupt on the west, but sloping more gradually eastward and from almost its edge, throwing the streams in that direction into the tributaries of Mayfield creek. This is the most northern occurrence of a feature that marks the eastern bluffs of the Mississippi river through Kentucky, Tennessee and Mississippi and into Louisiana, the large rivers alone having suc-

ceeded in piercing this bluff barrier. On the north of Mayfield creek the high bluffs continue for a few miles toward the north, but are not as abrupt as on the south, and their continuity is broken by numerous small streams.

The bottoms at Ogden's landing, on the extreme north, have an approximate elevation of 315 feet above the sea. They are bordered on the south by a very level plateau or flatwoods elevated from thirty to thirty-five feet above them, which reaches south for six miles, its limit extending eastward along Humphrey's creek to Oscar post-office, and northeast two miles north of Woodville. From these flats the country again rises rather suddenly, in places, to an elevation of from fifty to seventy-five feet up to the true uplands of the county. Hinkleville and Barlow have respectively appproximate elevations of four hundred and fifteen and four hundred and twenty feet above the sea, while south, on the divide between the waters of Mayfield and Humphrey's creeks, there is an altitude of about four hundred and twenty-five feet.

Still southward, we come suddenly to the brakes and abrupt bluffs of Mayfield creek, rising one hundred and twenty feet at Wickliffe, one hundred and twenty feet at Blandville, to about one hundred feet at Lovelaceville, above the bottoms. After passing the wide bottoms of the creek we do not find any bluffs, but the country gradually rises southward to Milburn, which seems to have an altitude of four hundred and eighty-five feet above the sea, or fifty feet above the bluffs at Columbus, and is the highest point in the county.

## GEOLOGICAL FEATURES.

*Tertiary.*—The Ohio river on the north sweeps along the base of the uplands on the Illinois shore, and exposes the Quaternary material, and, in places, the Tertiary black or dark-grey clays, there being on the Kentucky side only a broad and low bottom land.

At the Grand Chain are also exposed the flinty limestones of the *Lower Subcarboniferous*, which outcrop only at low-water on the north side of the river, and do not appear at all in the country south, this being the limit of the shelf of



Subcarboniferous rocks that underlies the Illinois Tertiary and Quaternary beds. At Caledonia to westward the lower portion of the bluffs are composed of the heavy joint Tertiary clays, which are black when wet but grey when dry, and crumble into small shaly fragments. They are underlaid by a bed of greensand from two to four feet thick.

In Ballard county, the lowest strata observed was that of the black or grey lignitic clay and lignite beds overlying dark sandy clays. The beds are best seen in the cut of the Illinois Central Railroad, just south of Wickliffe, an exposure being made by the removal of a long portion of the high bluff on the east of the railroad.

BLUFF ONE MILE SOUTH OF WICKLIFFE.

| | | Feet. | |
|---|---|---|---|
| Quaternary. | | 12 | Light grey silt or loess. |
| | | 3 | Brown loam (silty) with small quartz pebbles. |
| | | 15 | Rounded and angular chert and hornstone gravel. |
| | | 10 | Coarse red sand. |
| Tertiary. | Lagrange. | 6 | Interlaminated red and white clays and sands, two inches each. |
| | Lignitic. | 5 | Dark massive lignitic clay. |
| | | 5 | Lignitic peat. |
| | | 25 | Massive dark clays plastic and sometimes with leaf impressions to railroad track. |

The limit of exposure of the formation is from Wickliffe east to Blandville, southeast to Milburn and back to Laketon, seven miles south of Wickliffe, thus forming a triangle,

with its base resting on the river and its apex at Milburn. Outside of this area I have been unable to find any outcrops, or to learn of the clays having been struck in the deepest wells. It has apparently been swept away by currents, and its place occupied by the later Lagrange sands and clays. They are overlaid by Quaternary material and by a thin representation of the Lagrange group.

The lignitic clays vary from a dark to whitish color, and contain more or less lignite, besides the bed of lignite itself, and in places an abundance of leaf impressions.

The lignite bed possesses varied characters, and is doubtless a lignitic peat bed. The upper twelve inches is light grey or brown, and shaly, containing probably very little combustible matter. The next twelve inches is a black mass, composed of small woody fragments, leaves, etc., all lignitic and easily broken up. It contains much *selenite* in crystals, as does the upper bed. This in turn overlies what seems to be originally a bed of peat, without fragments of sticks, but a fine, indurated or compressed mass, brownish in color, very light when dry, and cracking if exposed to the sun or heat in drying. It is about a foot thick. It contains from twenty-three to thirty-seven per cent. of combustible matter as shown by the analysis on page 122. Under it is another bed of black lignite in stick fragments, leaves, etc., similar to the upper bed. The entire bed was well exposed for several hundred yards by the removal of a portion of the bluff by the railroad steam shovel, forming a long black line in the lighter colored material.

In the base of the bluff and below the railroad track there is another bed of the lignite thought to be six feet thick. It was exposed in a culvert under the track, and at one time caught fire, burning or smouldering, it is said, for six months. It is now covered, and no opportunity was afforded for examination.

Going eastward from the cut, we find the lignite outcropping in the beds of the streams and deep ravines for a mile, though usually immediately covered by debris of gravel. The accompanying plastic clays also appear.

The beds of lignite, etc., at Wickliffe, are about three-



fourths of a mile east of the Columbus bluffs in a due north and south course, and the slight easterly dip of the latter, if not interrupted, would bring them much below the Wickliffe lignite beds.

In the bank of the branch that runs by the spoke-factory, in the south part of town, the clays are overlaid at ten feet by a thin bed of black lignite about a foot thick. On going up the creek one-fourth of a mile, a clay-stone is exposed in a bed six to eight feet above the water's edge, and probably passing below it. The clay-stone is of a dark, creamy white color, breaking into many fragments, thinly laminated, and holding very many fossil leaf impressions, some of the species of which are given in Appendix If of the general report.

Its position is below the lignitic beds, and probably syncronous with the leaf-bearing silicious earths of the Columbus bluffs.

In the region of Blandville, seven miles east of Wickliffe, the upper bed of lignite is exposed in the bed of a branch or deep ravine in the south-western part of town, and is very similar to the exposure near Wickliffe, except that there is here an absence of the light shaly material that forms the upper layer of the Wickliffe bed. There is also an absence of selenite. In one place the Blandville bed is very highly charged with iron pyrites in black pieces, in sizes from a pea to sheets of several inches surface, and when broken presents a bright silvery appearance. This pyritous feature is, however, local, for at another exposure near the lignite was very free from it.

As at Wickliffe, the upper and lower portions of the lignite are black and in layers, holding stick fragments, leaves, etc., but in the center the mass is more of a lignitic peat, of a brownish color, and compact.

Another bed of lignite occurs one and a half miles southwest of Blandville, and doubtless the bed underlies the entire ridge or upland between Blandville and Wickliffe.

Going south from Wickliffe, on the M. & O. R. R., the road lies through Mayfield creek bottom, and nothing is seen until after passing the steam shovel excavations on the south

of the creek. From there to Laketon the black leaf-bearing clays are frequently exposed in the bluffs on the east of the road, and in the few small cuts that are passed through at the foot of the bluffs. A bed of lignite similar to the one at Wickliffe is seen a short distance south of the creek, and about twenty feet above the track, and underlaid by the plastic clay. The bluffs here are about one hundred feet high, composed mostly of Quaternary material. South of the lignite, the cuts show ten feet of the leaf-bearing clays underlaid by interlaminated sands and lignitic clays. Adams' cut especially presents a good exposure, the coarse yellow sands and sand-rock forming the upper part of the bank, while beneath is a dark, black plastic clay inclosing a great abundance of leaves and some lignite. Eight feet of the clay is exposed, though it extends probably very much deeper. It is lighter colored on drying and becomes shaly. Its exposure is about one hundred feet in length.

In the cut immediately north of Laketon the dark leaf-bearing clay contains much white sand in thin laminæ, and is exposed fifteen feet in thickness. Heavy beds of yellow and white sands and ferruginous sandstone overlie it. This is the southern limit of the exposure of black clays, and southward to Columbus we find only the group of heavy sand beds with layers of pipe-clay that belongs to the Lagrange series.

*Lagrange Group.*—That the surface of the lignite formation was, after its deposition, very much corroded, is shown in the exposures along the M. & O. R. R. south from Wickliffe, and especially south of Mayfield creek. Near Laketon the Lagrange sands and clays begin to appear.

In the northern part of the county no outcrops or exposures of the lignite clays could be found. The grey "soapstones" or shaly joint clays of the lower portion of the group that form the high bluffs at Caledonia, and are exposed so frequently over that portion of Illinois lying south of Cache river, seem to be entirely absent, unless they underlie the flatwoods along the Ohio bottom land. This I believe to be true; for wells in that region derive their waters from Quaternary sands, which would indicate the presence of a



heavy impervious clay-bed beneath, on which the water flows.

The lignite beds reach north from Wickliffe for a mile or more, and are found outcropping in the bank of a branch between beds of a highly plastic clay. The bed of lignite is only about a foot in thickness.

About half way between Laketon and Berkeley there is an exposure of white and purplish clays in alternating strata with a fine and white sand, the latter varying in thickness from a few inches to a foot, while the clay is usually but a few inches. The lowest bed of the latter is prettily mottled, white and purple in color, and is a foot thick. It is jointed in structure; on drying, crumbles to a shale, and between the teeth is not harsh. A yellow sand underlies it and passes out of sight below the railroad track.

Eastward from Berkeley to Arlington, and beyond toward Milburn, the country is not broken enough, and the ravines not sufficiently deep to reveal the underlying formations. In the deepest wells water is found in white sand far below the level of the black clay, which is exposed two and a half miles west of Milburn, and it is safe to presume that here it has been removed, and its place now occupied by the materials of the Lagrange group.

In the region of Barlow and Hinkleville, north of Wickliffe and to the flatwoods, the country is high and rolling, and no exposures of clays were found.

In wells, water is usually found at from sixty to one hundred feet, and in a white sand below the gravel. White pipe-clay is occasionally found. Beds of white clay and sand occur in the banks along Cane creek four miles north of Wickliffe.

In the neighborhood of Lovelaceville the same clays and white sands are found, the former white and purple in color, breaking with a conchoidal fracture, and similar in character to the leaf-bearing clays of the Lagrange group. They appear also westward toward Blandville and south to Milburn; a well at the latter place reaching water in a fine white sand at forty feet. A thick bed of white pipe-clay occurs in a ravine back of the church in Milburn.

QUATERNARY.

*Gravel and Sand.*—The heaviest deposits of gravel occur along the north bluff of Mayfield creek, presenting a bold and abrupt face to the south, and running east and west through the county. The bed is twenty feet thick at Lovelaceville, twenty-five feet at Blandville, and fifteen feet at Wickliffe. The gravel is composed of coarse chert and hornstone fragments with rounded edges, well water-worn quartz pebbles of various colors, and mixed with yellow and red sands and clays; portions of the mass are sometimes cemented together into a conglomerate varying in firmness.

Northward the bed thins out to four feet at Hinkleville, but again thickens to ten feet at Barlow and fifteen feet at Woodville and in the flatwoods region, all, however, covered by a thick deposit of loam.

South from Mayfield creek the gravel bed, smaller in size, while continuous below the loam, varies from one to four feet along the line of the Illinois Central Railroad, and from five to eight feet in the eastern part of the county southward to Milburn. Near Arlington there is scarcely any gravel. Along the line of the M. & O. R. R., south of Mayfield creek, in the western part of the county, the gravel has an apparent thickness of ten to fifteen feet, and overlies beds of red and white sands, the latter largely of a clear hyaline character. The colored sands, when well washed, are mostly of the same, the color being derived chiefly from superficial iron stains.

Thick beds of these sands form the bluffs at the railroad water tank south of Laketon, and thence to Columbus at intervals. Near Wickliffe they overlie the lignite and clay beds, and contain isolated lumps of white plastic clay.

The sand is frequently found cemented into sandstone, often firm enough to bear considerable weight. Beds of these are found along the M. & O. R. R. to Berkeley, and over the southern part of the county. Near Berkeley the rock is composed of hyaline grains cemented with red and dark ferric oxide, and contains fine particles of white chert, as in the quarry east of Clinton, Hickman county. Three miles east of Arlington they form ledges of very hard rock several feet in thickness.



The usual fossils are found in the gravel, including crinoids, favosites, occasionally small Lithostrotian Canadense corals, and oolitic fragments. In the gravel at Milburn, a piece of chert with an impression of a trilobite was picked up.

At the time just previous to the gravel deposition the surface of the country was very uneven, as shown by the relative positions of the beds. A deep trough occupied the portion now marked by the flatwoods or river valleys along the Ohio in the northern part of the county, its greatest depth being just south of where the Ohio now flows, and about the level of the top of the exposure of Subcarboniferous limestone at Grand Chain. The trough narrowed south-westward, or was merged into that of the Mississippi river.

The base of the gravel now marks the former bottom of the trough westward to Grand Chain, beyond which it ceases. Its depth here is fifteen feet, and is overlaid by from forty to sixty feet of superficial brown loam.

On the Illinois shore the gravel occupies a position about twenty feet above the limestone. At the head of the Chain this twenty feet is occupied by sharp, cherty, flint layers in place, as part of the Subcarboniferous, the gravel resting directly on them. The base of the gravel on the Kentucky shore is, therefore, about twenty feet below what was apparently, at the close of the Tertiary, a Subcarboniferous barrier, the top of the gravel being about on a level with that of the barrier.

On the edge of the trough, or on the uplands, we find the base of the gravel at elevations of about four hundred feet above the sea at Barlow, Woodville and Blandville, three hundred and twenty-five at Wickliffe, the latter being forty feet and the former one hundred and fifteen feet above that at the Grand Chain. At Lovelaceville the gravel base is at three hundred and eighty-five feet, and at Milburn four hundred and sixty feet above the sea.

*Loess or Grey Silt.*—Immediately over the gravel is a deposit of brown loam containing a few quartz pebbles, and over this a grey silt or loess, all of the same bluff formation.

The upper part or grey silt occurs only along the Missis-

sippi bluffs, and with a thickness of from fifteen to twenty feet. In width it occupies the upland between Columbus and Arlington on the south, but narrows northward to Wickliffe, the most northerly outcrop observed in the county being on Cane creek, three miles north of Wickliffe. On the Illinois shore it forms the summit of the bluffs at Caledonia.

The silt is a yellowish-grey, very fine, and contains calcareous concretions. At Caledonia small yellow ferruginous tubular concretions were seen.

At no place in the county were any fresh water or land shells observed in the silt. The silt is calcareous, as shown by the analysis given on page 79.

A yellowish brown loam forms the superficial deposit all over the county uplands, and gives rise to the soils and subsoils. The upper two feet is more of a yellow loam, the underlying material being heavier and permeated with a light colored and light silty seams, apparently the infiltration through sun-cracks.

The loam varies in thickness from forty and sixty feet in the flatwoods, twenty feet along the Mayfield creek bluffs and at Woodville, to sixteen feet at Woodville, and ten to fifteen feet at Bandana and Barlow. The material remains the same throughout, except where glady lands have produced bog iron ore and white silty soils.

## ECONOMIC FEATURES.

The materials occurring in this county suitable for manufacturing purposes comprise brown coal or lignite, clays for stoneware and fire-brick, sand and clays for building purposes, ochre for paints, besides mineral waters, soils, timber, etc.

*Brown Coal or Lignite.*—This variety of coal, but of a much more recent period than the true stone-coal, occurs in layers in the Tertiary clays, and are exposed in the bluffs between Wickliffe and Fort Jefferson, and also near Blandville. The main bed has a thickness of several feet, and is very fine and peaty in character, except in the upper portions, which contain some pieces of black lignitized wood.



The color of the peaty portion is a dark brown. The mass is more or less pyritous in character; that at Wickliffe but slightly, and that at Blandville very much so. The character of the coal and the conditions that surround the beds have been fully described in the general report.

The uses to which this coal can be put are very limited, because of the large amount of impurities it contains, and the semi-carbonized character of its organic matter. It burns but does not produce much heat, leaving nearly ten per cent. of ash. Recent and satisfactory tests by a Scotland firm, lead us to hope that a profitable demand for it will soon spring up, in a new process ,for refining sugar.

*Yellow Ochre.*—Beds of this material occur in the bluff of creeks near Laketon, and in a deep ravine that cuts into the high ridge immediately north of Wickliffe. At the former place it is continuous for some distance, exposed along the edge of the branch bottom that leads from Mr. Wilson's house westward into Sandy creek, south of Laketon; while in the banks or bluffs of the latter, only large masses of it were found embedded in the heavy deposits of hyaline and opaque sands. Again, north of Laketon, it is exposed on the place of Mr. Hogencamp, in a deep ravine or branch running westward to the Mississippi bottom, at Adams' cut of the M. & O. R. R. The bed here seems to be two or more feet thick, and the clay is bright yellow in color. Near Wickliffe it appears at several points, but chiefly on the land of the Harkless Bros., in a very deep ravine north of the town. The bed is, apparently, several feet in thickness, but its extent has not been ascertained. It is of a very bright yellow color, fine texture, and has been used in painting wagons.

All of these ochres are deeply covered by bluffs of sand, gravel, and loam, and their extraction and bringing to market would be attended with considerable expense. As tested at the Rookwood pottery, in Cincinnati, they make a beautiful red brick; but if glazed, the surface is deep black in color.

*Clays.*—In the central and southern portions of the county there are many exposures of white and variegated colored

clays, some of which are quite refractory. North of Cane Creek and Hinkleville, there have been no exposures observed; a large portion of the region being occupied by the river valley flats.

The clays that may be considered as the most valuable, because of their convenience to transportation facilities, lie on the western side of the county, exposed in the bluffs that border the Mississippi bottom, and in the banks and bottoms of the several streams tributary to that river.

They vary from the dark-grey and black clays of the Lignitic formation, to the whitish and more plastic varieties of the more recent or Lagrange group.

The black or dark clays are exposed at the base of the bluffs along the Mississippi bottom, from Laketon to Wickliffe, along Mayfield creek to and beyond Blandville, along Cane creek, north of, as well as in the creek bottom flats to the east of Wickliffe, and in an isolated bed, two miles west of Milburn. They are for the most part covered deeply by the Quaternary gravel and silt, though in many places but little surface material covers them. This is especially so in the neighborhood of Wickliffe, where, in the bed of the creek bottom that reaches east of town, the clay is found immediately below the surface, and is, even now, being dug up and shipped by railroad to points south.

These dark lignitic clays have an exposed thickness of several feet, and are siliceous and refractory in character, resembling thus those of the Columbus bluffs. Their description and analyses are given in the general report (page 107), and show that they are largely adapted to the manufacture of fire-proof material, such as fire-brick, tile, etc.

The second class, or whiter and more plastic clays, are not extensively found in this county, their beds occurring almost entirely in thin beds, separated by whitish sands. These are seen in the high bluffs from Laketon southward, and at a few points in the eastern part of the county, in all cases below the gravel. Such beds are found a mile north of Blandville, a few miles south of Blandville, where there was once a pottery in operation, and in the town of Milburn. The clays are of various colors, usually from white to purple,



and in beds from a few inches to a couple of feet thick. They are of no special value, though they would make the ordinary brown jug and lighter-colored ware. (See analyses, page 107.

*Gravel.*—This material, which occurs in such abundance and in thick beds along the bluffs of the Mississippi and Mayfield bottoms, and in thinner deposits in other parts of the county, is well suited for use on road-beds and streets. Near Wickliffe there is a large bed of it, which has been thus utilized on the streets of that town, at a cost of about ten cents a yard.

## AGRICULTURAL FEATURES.

In its agricultural features, Ballard county presents a variety not found in any one of the other counties, embracing, as it does, representative bodies of land of the Mississippi alluvial bottom and grey silt bluffs on the west of the Ohio valley on the north, and of the upland barrens and timbered lands of the central portion of the Purchase counties.

The western part of the county being more hilly and broken than the eastern and middle, we find the greater portion of the tilled lands on the east and middle and south, the extreme northern region being too level and ill-drained, and the soils, therefore, unsuited for cultivation.

The lands of the county embrace the usual varieties, viz.:

| | |
|---|---|
| *Lowland.* | River alluvial or bottoms. |
| | Creek clayey bottoms. |
| | River valley or flats. |
| *Upland.* | Grey silt or Cane Hills. |
| | Brown loam timbered lands. |
| | Brown loam "Barrens." |

The *river alluvial* or *bottom lands* embrace a large area along the Mississippi river, from the Hickman county line, near Columbus, northward to Cairo, and thence along the Ohio river to the Grand Chain, beyond which there is but a narrow strip to and beyond the McCracken county line. These lands are subject to yearly overflows, the waters covering the entire bottoms, except, perhaps, the surface of the

low and narrow sand ridges which lie parallel to the river, and at no great distance from it. These ridges comprise almost the only portion of the bottoms that are under cultivation, though even they are liable to inundation from high floods. They are said to yield as much as sixty bushels of corn per acre.

Along the immediate bank of the rivers there is a white sand frontland, a little higher than the interior of the bottoms, and characterized by a growth of tall cottonwood trees.

The interior of the bottom or back-land has a rich alluvial loam soil, deep and fertile, and covered with a heavy timber growth, comprising hickory, sweet gum, some black and overcup oaks, pecan, walnut, locust, red and slippery elm, prickly ash, hackberry and papaw. The undergrowth is very dense; cypress swamps are of frequent occurrence.

The bottoms of Mayfield creek have a width of about a mile, and are heavily timbered with white oak, hickory, sweet gum, some poplar and walnut, redbud, papaw and catalpa.

From Blandville toward the Mississippi river there is much poplar growth. The lands are subject to overflow, and backwater from floods in the Mississippi river reach four miles above Blandville, covering the creek bottoms, however, but a short distance from the river bottoms. The soil is a whitish clay, very compact and cold, and is entirely unsuited to cultivation, except near the upland bluffs, where it is covered by washings of brown loam.

The soil is said to be best suited for pasturage in herds-grass. Cane was once a prominent growth in the bottom, but has been kept down by the grazing of cattle.

The newly-made land at the foot of the bluffs is generally under cultivation, yielding thirty bushels of corn, and sometimes as much as sixty bushels. The land is said to yield three tons of clover per acre. The crops are a little later than on the uplands.

The bottoms of Clanton creek are about three-fourths of a mile wide, and have a growth of post and white oaks and a few red oaks. Humphrey's creek has but little bottom land.

The west fork of Mayfield creek has a wide bottom, well



timbered with elm, maple, black oak, poplar, gum and sycamore. The soil is of the same character as that of Mayfield creek—a heavy, whitish clay, having but little decayed vegetable matter. It is not in cultivation because of its lack of drainage, though in places, where this defect is corrected, the land is said to yield as much as fifty or sixty bushels of corn per acre.

The *Ohio river valley region* or flatwoods, of the northern part of the county, covers an area of about forty square miles, and forms, as it were, a bench between the bottom lands and the uplands, having an elevation of about twenty-five or thirty feet above the former, and twenty-five or thirty below the latter. It forms the western limit of the valley that lies eastward along the southern border of the Ohio, and along Clark's and Tennessee rivers, and which preserves very nearly the same features throughout.

The valley here is very broad, reaching from five miles north of Hinkleville, northward, to the Grand Chain or Ogden's Landing, a distance of six miles, though narrowing quite abruptly up the river to but a mile or two.

The surface of the valley is quite level for the most part, somewhat rolling in places, and timbered with a growth of post oak chiefly, some hickory, etc. The region is in many places quite open and free from any dense undergrowth. This level character is productive of whitish, compact, impervious soils, on which water often accumulates in shallow swamps and flats. The soils are, therefore, cold in character, lack sufficient drainage, and, as shown by chemical analyses (page 154), deficient in the chief elements of plant food. Bog iron ore or black gravel occurs abundantly in places.

That these lands have been rendered thus cold and unproductive by ill-drainage and the leaching effects of stagnant water, is shown by the fact that, along the immediate banks of gullies and streams, and at points a little above the flats, where natural drainage exists, the soils are light and loamy and of a brownish-yellow color, very similar to the higher uplands, and have a growth of oaks, hickory, gum, sassafras and dogwood. The valley soils are very generally of this cold, impervious nature, and we therefore find but a small area under tillage.

The *Bluff* or *Cane Hill* land is found only along the border of the Mississippi bottom, from whose edge it extends inland but a short distance. These lands are the highest in the county, and so gradually do they merge into the brown loam uplands that the separating line is undistinguishable.

From the Hickman county line the bluffs are prominent as far north as Cane creek, north of Wickliffe; but beyond this they are not noticeable, either in soil, timber or elevation, until the Ohio river is passed, when, at Caledonia, they are again prominent.

This bluff region is very considerably eroded by deep ravines leading from the almost vertical face of the bluff inland, and carrying drainage waters to interior streams. The land of the region is, therefore, not largely under tillage, though having a rich dark loam soil marked by a heavy timber growth of poplar, oak and hickory. A dense cane undergrowth once prevailed over the lands, but has been eaten down yearly by stock.

The *Upland Barrens* embrace a large area in the northern part of the county, or east and north of a line passing near Northington's store or Hazlewood post-office through a point a little south of Hinkleville, and south-eastward into McCracken county. The region is limited on the north by the river valley or flats.

The surface is rolling and more or less broken, and in all respects very similar to other uplands, except in its timber growth, the region having been at one time an open prairie —the continuation northward of a belt that reached to near the Tennessee State line south of Graves county. It has since grown up in a low growth of black-jack and red oaks, all preserving a nearly uniform height.

The undergrowth is hazel and sumac; the soil is a light-brown loam about three or four feet in depth, over a more clayey bed of loam, permeated with seams of a whiter, silty material. The land is best suited to the cultivation of tobacco. Some portions of the surface of the Barrens are very level, with but little natural drainage, and are, therefore, inclined to be glady and unproductive. The usual black bog ore gravel occurs in such spots.



The *timbered uplands*, so designated popularly to distinguish them from the Barrens, and because they have a greater variety of timber, and of larger growth, cover more than two hundred square miles, an area of the county greater than that occupied by any other division. This embraces all of the uplands south of Mayfield creek except the bluff or Cane Hills land, while on the north side it takes in all but the Barrens and a small area of bluff lands, and lies between the two latter.

The surface is more rolling and broken on the north than on the south side of the creek, and is probably less under tillage. The soil is a brownish-yellow loam, darkened by decayed vegetation for a couple or more of inches, the subsoil being lighter brown, resting at three feet upon a bed of more clayey loam, which is permeated with thin seams of a greyish silt, as in other counties.

The timber of the lands of the southern part of the county is black and white oak, hickory and dogwood. That of the breaks on the north side of Mayfield creek is poplar, black oak, hickory, black gum, dogwood, redbud, sassafras and persimmon. To the west of the county poplar is more abundant than elsewhere.

The soil is said to yield forty to fifty bushels of corn, ten to fifteen of wheat, or eight hundred pounds of tobacco per acre. The land washes readily into gullies and ravines, against which injury, even in cultivated fields, none of the ordinary precautions are taken, such as hillside ditching or horizontilizing.

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## McCRACKEN COUNTY.

McCracken county was cut off from Hickman and organized in 1824. It has an area of about 2,373 square miles, and is bordered on the north by the Tennessee and Ohio rivers.

Clark's river flows in the eastern part of the county northward into the Tennessee river, and these three streams are bordered by a broad and nearly level flatwoods region, whose

elevation is about fifty-five feet above low-water mark in the Ohio, at Paducah, or three hundred and forty-four feet above the sea. These flats are from two to three miles in width, and from them the country suddenly rises on the south to a height of from seventy-five to one hundred feet and then again gradually to the dividing ridge along the north side of Mayfield creek, whose elevation is about one hundred and ten feet above Paducah, or four hundred and fifty feet above the sea.

Mayfield creek enters the county from Graves county on the south, and immediately turns westward into Ballard county; otherwise the drainage of the county is all northward into the Tennessee and Ohio rivers by numerous small and independent streams.

The surface of the uplands is rolling, but with large areas of level land between the streams and at their head-waters.

On the breaks of the creeks the lands are often washed into deep ravines and gullies.

## GEOLOGICAL FEATURES.

There are in this county several localities where very large and massive quartzose sandstones are exposed, and which seem to belong to the Onandaga quartzite series of the Illinois Report. The grains are sharp and clear or whitish, sometimes strongly cemented into a hard quartzite, and then less so into a very friable mass. In one specimen the cementing material was silica, which coated the sand grains. Iron stains occur frequently.

The largest of these outcrops is at Mr. John Byer's, four miles south of Paducah, to the west of the Paducah and Mayfield road. The rocks cover, to the height of seventy-five feet, the north-east, east and south sides of a hill that faces one of the branches of the head-waters of Island creek, and also occur in the bed of the branch by the side of Tertiary, micaceous sand-rocks. The quartzites are in large fragments, some of them having a surface of six to eight feet square, and an exposed thickness of two to four feet above the ground. Their surfaces are mostly dark and smooth, showing the wearing effects of water.



A gravel bed ten or fifteen feet thick overlies them on the hill. A well dug seventy-five yards north of the rocks passed through soil and loam six feet, gravel eight feet, and blue or black joint-clay ("soapstone"), thirty-five feet, without reaching water. The clay was not passed through and no rocks were found.

A mile west of this, and on the same branch, the rocks in large masses are again exposed in the bank at the foot of the hills, over a distance of fifty yards. A black clay (Tertiary) outcrops in the bed of the branch a little eastward, overlaid by gravel in process of cementation into a hard conglomerate. An indurated red sand also occurs in the bed of the branch near by.

Still westward, near the Pepper's mill and Clinton road, another quartzite exposure occurs, the rocks being large and water-worn on the surface, and lying below the gravel bed, and over a distance of fifty feet. One of these rocks has a surface area of twenty by ten feet.

There is another exposure on the place of W. J. Flournoy, a little west of north of the Byer's place, and four miles west of Paducah, near the crossing of Perkins creek. The rocks here are numerous, scattered over one-half mile or more, and are seen on the side of hills and in a ravine or branch. One of these rises ten feet out of the ground, and has a surface area of twelve by twenty feet. The rock is sharp grained and massive, and the surface much water-worn; a piece had been blasted from it. In adjoining wells, black joint-clay or "soapstone" is found below the gravel at twenty feet from the surface, and has been penetrated seventy-five feet without being passed through.

Again, near the crossing of the west fork of Massac creek, on the place of Mr. Bryant, the quartzite or sandstone is exposed, not massive as elsewhere, but in layers two feet thick, and for one hundred and fifty yards along the branch. The same sandstone ledges are seen a short distance south of Massac post-office, in the road, on the side of the hill and in ravines. They are from two to four feet thick and sharp-grained. Masses of them, water-worn, occur in the gravel beds on the north of town.

Besides these, there are other localities where large pieces are isolated, water-worn, and appear to be erratic, probably carried by the Quaternary floods which brought the gravel to its present bed.

Such pieces are found in the flats south and west of Paducah, buried in the surface of the loams which overlie the gravel, and not very far from the base of the hills. Another group occurs at Palestine Church in the edge of the flats south of Metropolis. All of these pieces have a surface area of several square feet each, and a thickness of from one to three feet.

*Cretaceous.*—This formation is but feebly represented in this county, and its exposure is limited to a belt of country bordering the Tennessee river from the Marshall county line to Paducah, passing thence into Illinois. It is deeply covered by the superficial loams and gravel, and its exposures are not very frequent. Its material embraces very highly micaceous, laminated black clays; their thin laminæ separated by a mixture of very fine sand and scales of mica, the whole being underlaid by a bed of fine white micaceous and calcareous sand, the grains of which are very sharp. No fossils have been found, and these beds have been referred to this formation chiefly from their position below the black and grey Tertiary joint-clays, from their similarity to the Tombigbee and Ripley beds of Mississippi, and because of their continuity with the latter through Tennessee.

The beds are best seen in the river bank at Paducah, where they were recently exposed in digging the tunnel for the water-works. The strata here consist only of the finely laminated and pyritous shaly black clays and fine sands, the underlying sands not having been reached. The well dug for the old vinegar works in Paducah shows the following strata:

| | |
|---|---|
| Loam or heavy yellowish clays | 30 feet. |
| Gravel bed | 10 feet. |
| Blackish-blue clay | 8 feet. |
| Colored sand | 6 feet. |
| Blackish-blue clay | 8 feet. |
| White fine sand to water | 50 feet. |
| | 112 feet. |



The blue clays in the above are the thinly laminated micaceous clays already alluded to. The white sand is doubtless synchronous with the white micaceous sand beds of Calloway county and with those of Tennessee, which are there known as Coffee Sands.

*Tertiary.*—The lowest division of Eocene Tertiary, comprising black or grey joint-clay or "soapstone," and designated "Porter's creek group" in Tennessee, passes through the county from the south-eastern corner north-westward into north Ballard, and across the Ohio river into Illinois. The clay is black when wet or when freshly exposed; it is jointed in structure, and cuts in a peculiarly harsh and brittle manner. On drying it becomes grey in color and crumbles into a shale. It is pyritous. In the upper portion there is usually a ledge of soft micaceous sand-rock which hardens on exposure, and in some places contains casts of Eocene fossils. The bed has a thickness of at least one hundred feet, the lower portions being only reached in wells. It is everywhere covered by the superficial Quaternary gravel and loam.

In the extreme southern part of the county it forms steep banks on the east side of Clark's river and of its two forks. The bluffs are well exposed on the East Fork, at Captain Edwards' place, on the West Fork at Lyell's, and down these streams to the Fish Trap Ford, in the big bend of the main river. At the latter place a narrow belt of flatwoods extends back from the river for a short distance. Its river bluff shows eight or ten feet of Quaternary loam and three feet of Tertiary bluish sandy clay overlying a ledge of the grey micaceous sandstone eighteen to twenty-four inches thick, and, from this to the water's edge, eight feet of black joint-clay. Below this it extends sixteen feet, as shown by borings made in the vicinity, and is then underlaid by the thinly laminated, highly micaceous, black clay and fine sand belonging to the Cretaceous.

The Tertiary clays are very highly pyritous, the bright, silvery looking mineral occurring in nodules of various sizes, from half an inch to several inches in diameter. They have frequently been mistaken, according to color, for silver or

gold, and in part have given rise to the legends of "silver mines on Clark's river."

The grey micaceous sandstone not only forms a regular ledge over the "soapstone," but penetrates it downward in seams of several inches thickness, which sometimes cross each other. The sandstone becomes indurated and crumbles on drying.

Still further down the river, at the mouth of Spring creek, about four miles from the Tennessee river, the following section is exposed in the bluff:

| | |
|---|---|
| Flatwoods soil and coarse yellow sandy micaceous loam | 15 feet. |
| Coarsely laminated dark clay and yellowish sand | 20 feet. |
| Deep blue plastic micaceous clays, to water's edge | 20 feet. |

The micaceous sandstone ledge does not appear in this place, and the strata seem to dip slightly to the north-west. At Hard Money the black clay is found in wells.

Going north-westward, we find another exposure of these clays in the road on the north side of the hill, south of Eden's hill, or three miles south of Paducah, and again one mile still further south on the south side of the hill. The clays are at the base of these hills, and accompanied by the micaceous sandstones. This sandstone, at the latter place, is fossiliferous, containing casts of numerous Eocene varieties. (See page 45.)

The following section shows the position and character of the strata:

| | |
|---|---|
| Soil and brown loam, probably | 20 feet. |
| Red sand and gravel | 10 to 15 feet. |
| Bluish pipe-clays | 2 feet. |
| Grey sandy clay ledge without fossils | 4 feet. |
| Grey sandy clay ledge with fossils | 2 feet. |
| Dark joint-clay (soapstone) to foot of hill, weathering to a light grey shale | 6 feet. |

The fossil portion of the ledge is about two feet thick; it again occurs in the bed of the branch that flows at the foot of the quartzose sand-rock hill, a mile south, but here the ledges are almost vertical, and seem to be fifty feet thick with a due north and south trend. The rock is grey when dry and greenish when wet, due probably to grains of green-sand or glauconite.



On Massac creek, at Maxon's mill, the clay was reached at about eighteen feet from the surface, in digging a well, and the stratum was found to be ninety-eight feet thick, overlying a coarse, white sand, from whose bed water rose to a height of sixty feet, and was so strongly impregnated with fetid sulphur gas (sulphuretted hydrogen) as to be unfit for use. The well was dug in the flats of Massac creek, above which the uplands rise fifty feet. The joint-clay is found along the banks of the creek, and has the same shaly properties possessed by the beds on Clark's river.

Still westward, on the hills, three miles east of Woodville, a well on Mr. Bradshaw's place passed through twenty feet of loam, six feet of gravel, and some light-colored yellow sand, beneath which the joint-clay was struck and penetrated to a depth of one hundred and thirty feet from the surface of the ground.

The flatwoods north of Woodville are, doubtless, underlaid by this joint-clay or so-called "soapstone," for it is found outcropping in the Ohio river bluffs at Caledonia, due westward from Woodville. In the southern part of the county the clays do not appear.

In a well on Mrs. W. J. Flournoy's place, four miles west of Paducah, the black clay was reached at twenty feet and penetrated for seventy-five feet. Lignite is said to have been found in it.

*Lagrange Group.*—The south-western half of the county, or that part south of a line from Woodville to Florence, is embraced in that part of the Purchase Region in which the black clays seem to have been in part removed, and replaced by beds of fine sands, mostly white, and interstratified with thin layers of pipe-clay.

In wells at Pepper's mill, five miles south-west of Paducah, the following section was observed: brown loam ten feet, gravel eighteen feet, yellow or white sands eighty to one hundred feet, in which water was found flowing over a black clay which is said to have been penetrated nearly one hundred feet, but not passed through. At Massac post-office, still south-west, wells were dug through thirty feet of loam, two feet of sandstone rock, forty feet of gravel, thirty-six

feet of white sand, and four feet of quicksand to water—in all one hundred and twelve feet. Such is said to be the nature of wells between Massac and Lovelaceville and eastward toward Florence.

The bluffs on Mayfield creek are about one hundred feet high, and are composed of thirty feet of brown loam and soil, twenty-five feet of gravel, thirty feet of red sand, three feet of white pipe-clay, and ten feet of white and yellow sands.

This white pipe-clay usually marks the upper limit of the Lagrange beds, though sometimes we find a thin Quaternary stratum of clay beneath the gravel.

*Quaternary Gravel Beds.*—Deposits of gravel are found all over the county, and occupy various altitudes.

At the close of the Tertiary period, or before the deposition of the gravels, there existed a deep basin along the west side of Clark's river, and thence along the south side of the Tennessee and Ohio rivers into Ballard county, an area now marked by the valley "flatwoods." The bed of the basin was about ten feet above present low-water of the rivers, and nearly sixty feet below the top of the Tertiary strata of the adjoining upland.

From Paducah westward in this basin we find gravel beds ten to fifteen feet thick, resting immediately upon the black clays, but in the Clark's river section they do not appear. Opposite Metropolis, the bluffs, thirty feet above the river bottom lands, approach to one-fourth mile of the river; their height is, however, about that of the flats of Paducah. The gravel here is only about twenty feet below the surface, or ten feet higher than at Paducah.

On the uplands, south of the flatwoods, the beds of gravel are from ten to fifteen feet thick, increasing in thickness south to Mayfield creek, along whose bluffs twenty-five to thirty feet are seen. In the western part of the county, south of Woodville, the gravel bed is but from five to eight feet thick.

The gravel is composed of fragments of Subcarboniferous chert and hornstone with crinoidal stems, favosites and other fossil forms. They are more or less rounded, but numerous



fragments show very little effects of attrition and cannot have come from a very great distance. Some well rounded Carboniferous quartz pebbles are found in the beds, but are small. The gravel shows some signs of stratification, though not as much as in the bluffs of the Mississippi river.

Red ferruginous clays and sand are associated with the gravel, and act energetically in cementing the mass into a hard conglomerate. It is this that renders these beds so useful for street grading and covering.

Small fragments of a conglomerate are sometimes found in the beds, as if broken from large masses formed prior to the deposition over the Tertiary and Cretaceous beds.

The gravel is not uniform in extent or thickness, having either been deposited thus irregularly or subjected to erosion before the deposition of the superficial loams.

*Brown Loam.*—These loams cover the gravel everywhere, except in the river valleys. The upper two feet of the deposit is of a brownish-yellow color, and, where drained, is light, and affords a thrifty soil. Beneath this is a heavier and more intractable loam, lighter in color and permeated with lighter colored silty seams.

Throughout the county the thickness is from fifteen to twenty feet, apparently regardless of the irregular contour of the gravel beds, the surface of the loam deposit often being seen to conform in slope to that of the gravel.

The light character of the loam renders it easily carried by rains down hill-sides, and, as a consequence, its surface is frequently cut up into deep ravines and gullies.

*Port Hudson.*—The lower bed of this formation covers the gravel deposit in the valley of the Ohio and of Clark's rivers, and is represented by a yellowish micaceous loam from ten to twenty feet thick. White calcareous concretions, very similar to those found in the blue clays of the river bank at Columbus, Ky., occur in the loam of the ravines around Paducah. This bed is generally covered by a thin surface deposit of loam, which, because of ill-drainage, is compact and crawfishy in character.

Along the river bank, beneath the alluvial deposit, and beginning just west of Paducah, are exposed the *blue clays*

that characterize the formation along the Mississippi river. The clay is interstratified with thin beds of red, yellow and white sands, and contains particles of blue vivianite, a phosphate of iron.

*Later Gravel.*—After the deposition of the Port Hudson clays, the flatwoods seem to have been swept by some deep current, probably the Tennessee and Clark's rivers, which bore down from the adjoining hill-sides loam and fine gravel, the latter being re-deposited in a low and wide ridge, which extends from a point five miles south of Paducah, on the line of railroad, in a nearly north and south course, through the city cemetery on the west of town. The gravel is more rounded than that of the other beds, and is uniformly mixed with a fine loam. The bed is five to eight feet thick. A similar deposit of gravel occurs on the east in the bottom of Little Cypress creek, in Marshall county.

Loose gravel is also found scattered over the flatwoods as far west as Metropolis.

## ECONOMIC FEATURES.

The materials within the county that are valuable from an economic point of view, comprise, chiefly, clays, iron ore and gravel. There are a few others that will be mentioned below.

CLAYS.—In color the clays of the county vary from black to white, each distributed according to geological formations.

The *black clays* are found in the Cretaceous and lower Tertiary Eocene belts in the eastern and middle parts of the county. Those of the former outcrop in the banks of Clark's river above the railroad bridge, and are highly micaceous in character, and are in thin laminæ which are separated by a fine white micaceous sand. They are of no value.

The Tertiary black clays overlying these occur also in the Clark's river bluffs, with an exposure of about fifteen feet; also, at the foot of the hills that rise above the flats or valleys south of Paducah. These hills are capped with Quaternary gravel, sand and loam, a Tertiary micaceous sand-rock stratum appearing below. The black clay exposure is here only about twelve feet thick, but in wells and excavations



in the vicinity, as well as north-westward (or west of Paducah), the thickness is found to be as much as ninety feet. The clay is massive and jointy in structure, breaking with rounded fracture; it is black when wet or damp, but dries to a light slaty color, and is speckled with minute particles of mica. An analysis of a specimen of the clay taken from the same belt near Murray, Calloway county (page 110), shows the presence of nearly one per cent. of potash, three and a half of iron, and sixteen and a half of alumina, half a per cent. of magnesia, and two-tenths of one per cent. of lime. Tests made at the Rookwood Pottery, in Cincinnati, indicate that it can not be used for glazed ware, because of the shivering of the glaze. The unglazed biscuit is pinkish in color, while the fine particles of mica burn to black specks throughout the mass. For dark ware that requires no glazing, it could be used very sucessfully.

At Mr. John Munier's, five miles south of Paducah, there is, in the side of the hill beneath the road, a thick bed of a highly plastic *bluish clay*, mottled with very light ochreous material. It is quite refractory, fusing before the blow-pipe with great difficulty. It makes a cream-colored ware. The analysis (page 107) shows the presence of one and a half per cent. of potash and soda, half per cent. of lime, and nearly two of iron oxide.

The same clay occurs beneath the railroad bed at Florence Station, southward from Munier's.

On the east of Clark's river, at the spring on the place of Mr. Armstrong, there occurs another bed of bluish micaceous clay, which, on exposure, dries to a dark grey. The thickness is unknown. It is quite sandy, somewhat ochreous in character, and fuses to a grey mass before the blow-pipe.

The yellow ochre in the clay, however, makes it of value, as it burns to a handsome deep brick-red color, and could be utilized in the manufacture of brick. The shrinkage is about twelve per cent. It can be easily obtained, as it is overlaid by but a few feet of gravel. The analysis of a sample taken below the ochreous portion is given on page 116.

There is, in a ravine on the river bank, just below Paducah, a thin bed of dark or black clays holding blue particles of

the mineral *Vivianite*. The bed is the same that outcrops at Highland Landing, on the Tennessee river, in south-east Marshall county. On analysis it has been found to contain nearly two per cent. of iron oxide. The amount of potash and soda is more than two and a half per cent. The clay is interlaminated with beds of yellow sand, and is of no value. It fuses readily to a grey mass before the blow-pipe.

The *whitish clays* belong almost entirely to formations later than the Lignitic Tertiary, and in this county are exclusively found in the central and western portion. The Lagrange formation embraces most of the beds.

At Mr. W. J. Hough's place, four miles south-west of Paducah, there is an exposure of five feet of a whitish clay, holding small masses of gypsum in needle crystals. It has but few feet of overlying gravel and loam, and is, in places, rather sandy. The analysis of a sample (page 116) shows the presence of about one and a half per cent. of potash and soda. Glazed ware from it has a dark cream-color.

Still further south-westward a very pretty, white, plastic clay has been found on the places of Dr. Roof and Mrs. Annie Grief, about ten miles from Paducah. The clay holds some pockets of white sand, and is somewhat stained with yellow ochre. Its thickness has not been ascertained, and no tests or analyses have been made of it. It would, doubtless, make a fair cream-colored ware. There are but a few feet of overlying material at the locality where observed on Mrs. Grief's place, and there would be but little expense attending its working.

The north bluffs of Mayfield creek are high and precipitous, and at their base there is a frequent exposure of a whitish and purplish clay, that seems to be continuous under that portion of the county. An outcrop occurs near the road opposite Lewisburg, having a thickness of three feet, but overlaid by seventy-five feet of red and yellow sand, gravel and loam.

Again, near the county line to westward, on the place of Mr. Mitchell, there is another outcrop of purplish and white clay; it is sandy in places, and before the blow-pipe fuses to a grey mass. Its analysis is given on page 116.



Iron Ores.—There are two localities in this county which are marked by the presence of limonite, though in small quantities.

One of these is at Mrs. Alexander's place, five miles south-west of Paducah. The ore occurs in rounded masses more or less concretionary in form, some of them a foot or more in diameter. Unfortunately, they are not in sufficient quantity for use. The analysis on page 124 gives 83.8 per cent. of iron oxide, equivalent to 58.7 per cent. of metallic iron.

The other locality of occurrence is on the place of W. J. Flournoy, four miles west of Paducah. Here the ore forms a ledge of from four to six inches in thickness beneath the Quaternary gravel. The bed is, however, only local, though fragments of the ore have been found within a short distance from it. In its semi-concretionary and banded character it resembles that mentioned above, and it probably has the same composition.

A clay iron-stone occurs in small quantities on the place of Mr. Jones, three miles south of Paducah. Its edges present very pretty banded lines of yellow, red and darker colors.

Gypsum.—This mineral has already been mentioned as occurring in the clay at Mr. Hough's, four miles west of Paducah. There is, however, no great quantity of it.

Vivianite.—In the blue clay alluded to as occurring in a ravine leading into the Ohio river in the western limits of Paducah, there is readily seen very many particles of the blue mineral which, on analysis, proved to be *Vivianite*, a phosphate of iron. In such small amount it has no value, and its occurrence is only a matter of interest.

Gravel.—The thick beds of gravel that outcrop in the ravines around Paducah and in the hill-sides in other parts of the county, are very generally made up not only of gravel but of ferruginous clay and sand, which give to them the property of cementing to hard masses on exposure to the air. This property is utilized in Paducah, the streets being covered to a depth of several inches with the freshly obtained material, which, in a short time hardens and furnishes a firm road-bed, capable of bearing up heavily loaded drays. The

constant grinding of the latter, however, after a time, reduces the softer gravel to a powder, which in wet seasons covers the streets with a soft mud an inch, more or less, in depth, and in dry weather the fine dust is readily raised by wind. The cost of graveling the streets is about one dollar per yard.

## AGRICULTURAL FEATURES.

The various agricultural regions of the Purchase country have their representatives in McCracken county, with the exception of the high bluff or grey silt lands bordering the Mississippi bottom lands, and the flatwoods of Calloway county. The following divisions are described below:

| | |
|---|---|
| *Uplands.* . . | { Oak and hickory "Timbered" lands.<br>{ Red oak and black-jack "Barrens." |
| *Lowlands.* . | { River valley lands or flats.<br>{ River alluvial and creek bottoms. |

UPLANDS.—The area embraced in the upland portion of the county is about one hundred and forty square miles, or about sixty per cent of the entire county. The remaining forty per cent. comprises the valley and bottom lands of the Tennessee, Clark's and Ohio rivers. The valleys of creeks are not taken from the estimate of the uplands, as they are narrow, and would not affect the result very greatly. The valley or flats of Clark's river divides the uplands in two, leaving about thirteen square miles only on the east.

The upland surface is more or less rolling and uneven, especially in the eastern and south-eastern portions, where the many small streams have cut very deeply into the loose material, often to depths of as much as one hundred feet below the general level.

In the western and south-western portions there are, however, large tracts of land which have but an undulating surface, rendered more uneven and broken along their drainage streams and creeks by gullies and ravines, the result of washing rains.

These uplands abruptly terminate on the south at the brow of the almost vertical bluffs that border the bottom lands of Mayfield creek. On the north they decline more gradually



to the Ohio valley, though in the region of Paducah, and thence southward, the hills facing the valley of Clark's river are quite high and abrupt.

The uplands are naturally divided into two regions—the *Oak and Hickory Lands*, or, as popularly termed, "The Timbered Region," and the *Black-jack and Red Oak Barrens*, generally known as simply "The Barrens."

*Oak and Hickory Lands.*—This division comprises two-thirds of the uplands of the county, and has a timber growth of post, red and Spanish oaks, hickory, etc.

The soil is a brownish-yellow loam, varying but little in character to a depth of two or three feet, except that the surface itself is darkened by a little decayed vegetation. It is underlaid by another bed of loam, somewhat lighter in color and permeated with seams of apparently infiltrated silt, a feature characteristic of this bed throughout the Purchase region. This latter is of greater depth than the upper bed, the entire loam being usually from fifteen to twenty feet deep.

Where well-drained, the soil is loose and easily tilled, producing good crops. There are, however, large areas of flat uplands, from which the waters are not readily drained, and the soil, by a leaching process, has become white, compact and crawfishy, filled with small, dark rounded ferruginous concretions or bog ore. The soils of these uplands contain small percentages of phosphoric acid, potash and lime, as shown by the analyses given in the general report (page 170).

On the breaks or borders of Mayfield creek bottom the growth consists of black oak, hickory, poplar, black gum, dogwood, sassafras, persimmon and redbud. The soil here contains more potash than that of the interior, and in fair percentages, .329 per cent. The phosphoric acid is low, not a tenth of a per cent. The presence of a larger amount of humus or decayed vegetation on the bluffs may account for the difference in potash, as the amount held in an insoluble condition is less here than in the interior. Lime is deficient everywhere.

*Barrens.*—In the western part of the county, reaching from the west fork of Massac creek to the Ballard county line, and

south from the river valley or flats to the road from Paducah to Blandville, there is a large area, covering a little more than fifty square miles, on which the upland timber is chiefly a low red or black-jack oak, the region having once been a prairie. Only along the creek bottoms is there a better upland growth. The region is a continuation northward of the large area of Barrens in Graves county, and separated from it by the bottom lands of Mayfield creek, and the high uplands that border that stream on the north side. This region has a soil very similar to that of the oak and hickory uplands, but it is thought to be better adapted to the cultivation of tobacco.

As in the oak and hickory region, there are also in the Barrens tracts of badly drained lands on which water stands, and which are whitish, stiff and crawfishy, with an accumulation of small bog-ore gravel

An analysis (page 166) of a sample of this soil and its subsoil, taken from a point about four miles east of Woodville, shows but a small clay percentage, a small amount each of lime and available potash, a fair percentage of phosphoric acid, and a large amount of soda. There is but little lime in either soil or subsoil, while the potash in both, held in an insoluble condition, is very large (1.5 per cent.)

The subsoil, taken at a depth of eight inches, contains more available potash.

Both soil and subsoil are quite sandy (or silty), containing more than eighty-eight per cent. of insoluble matter, and capable of holding but one and a half per cent. of moisture. Compared with other lands of the same region at Hazelwood, in Ballard county, we find in this lower percentages of potash, but more phosphoric acid and lime, while in comparison with the soils of the large region in Graves county, this has larger percentages of potash, phosphoric acid and lime.

LOWLANDS.—The area embraced in the river valley and bottom lands is a little less than one hundred square miles, or about forty per cent. of the total area of the county. This lowland division comprises the *bottom lands* of the creeks and rivers, and the somewhat higher *valley lands* of



the rivers. The creek bottoms, excepting that of Mayfield creek, are, however, very narrow and of no special importance, as they are scarcely under tillage.

*River Valley Lands.*—This region borders the Ohio river for its entire length in the county, the Tennessee river from its mouth (at Paducah) to and a little beyond the mouth of Clark's river, and along Clark's river southward to and beyond the county line. The widths vary from about three miles at the Graves county line, to five and a half miles across the center of the valley of Clark's river, and from two and a half to three miles across the Ohio river valley. At the Ballard county line on the north-west the valley suddenly widens to five or six miles.

On the east of Clark's river the limiting upland bluffs pass from a point about a fourth of a mile east of the railroad bridge, southward to the junction of the two forks. A narrow belt thence extends along the south side of the East Fork into Marshall county; while on the east side of the West Fork the uplands come to the bank of the stream.

The western limit of the valley of Clark's river is marked by rather abrupt bluffs, in irregular outline, for most of the distance, beginning at the Graves county line at Hard Money, passing northward via Florence and Bond's stations to a point one mile south-west of Paducah; thence the southern limit of the Ohio valley, marked by lower hills, passes slightly north of west via Maxon's mill to the Ballard county line, about three miles north of Woodville.

The area thus embraced is little more than eighty square miles. The surface is very level along Clark's river to Paducah and westward to Massac creek, resembling a plain, from which circumstance that city is sometimes called "The Plains City." The surface is very generally ill-drained, and the soil in consequence stiff, cold and crawfishy, and considered of little value for tillage. The growth is mostly post oak, with tracts of hickory timber.

As shown by the analyses given in the general report (page 155), these lands have low percentages of available phosphoric acid (from .030 to .110) and lime, and generally of potash also (.167 to .302); there is, however, more than one per cent.

of potash held in an insoluble condition. The post oak and hickory lands are richer in available constituents than the post oak lands, as observed in the analyses of the contiguous tracts near Paducah.

Going down the valley from this plain, we find beyond Massac creek, at Palestine Church, a tract of country reaching from the uplands nearly to the river at Metropolis, that is generally under cultivation, with better natural drainage than that section just described. Its surface is, however, quite level, and as we go still westward it becomes more and more flat and ill-drained, and near the county line the soil assumes an ash-colored and light character, and at the same time is poorer in potash, phosphoric acid, lime and decayed vegetation, and has a growth chiefly of post oak, except near the creeks and bottoms, where the soil is better and the undergrowth and timber is heavier.

The flat lands of the two rivers thus described are scarcely in cultivation, except in few small patches near Paducah.

The soil needs under-drainage, and deep and thorough cultivation above every thing else. Then the application of phosphate manures, lime and decayed vegetable matter would, probably, render available a sufficient amount of the potash that now exists in an insoluble condition.

*Bottom Lands.*—There are no *alluvial* soils within this county except in a very narrow belt along the Ohio, beginning a short distance below Paducah. Wherever it is in strips of sufficient breadth for cultivation to any extent, it is found to be rich and mellow, producing good crops. Its growth is pecan, ash, hickory, elm, gums, cottonwood and sycamore.

The undergrowth comprises dogwood, hackberry, some papaw, redbud, black haw and large grapevines; some cane is found. Along the Tennessee and Clark's rivers there is, within this county, very little bottom land, the valley flats extending generally to the banks of those streams. The bottoms of Mayfield creek are broad and flat and subject to overflow. They have a soil that is cold and heavy in character, and whitish, except on the immediate surface, which is dark from a little decayed vegetation. The growth



is white oak, hickory, sweet gum, a little poplar and walnut, and an undergrowth of papaw, redbud and catalpa. The land is not suited for cultivation, except in grasses, because of its heavy undrained character. Herds-grass is said to do especially well.

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## MARSHALL COUNTY.

Marshall county was organized in 1842 from Calloway county. It has an area of about 324.5 square miles, nearly all of which is uplands, excepting the valley of the Tennessee on the east and north, and the bottom lands of Clark's river, embracing in all about sixty square miles.

The valley of the Tennessee has an average width of two miles on the north between Calvert City and the river, but up the river above Gilbertsville to the Calloway county line, its width is about a mile, greater or less in places. Its surface is uneven, a low and broad elevation of from eight to ten feet high traversing the length of the valley parallel with the river. On either side of this ridge the lands are low and glady. There is but a very narrow strip of bottom land bordering the river. The elevations of Gilbertsville, Birmingham and Aurora are respectively about 339, 347 and 350 feet above the sea.

The numerous streams that enter the valley usually run parallel with the river for some distance, finally cutting across to the latter.

From the valley the uplands rise rather abruptly to from forty to sixty feet on the north near Calvert City, and eighty feet near Birmingham and Aurora, to the dividing ridge between the waters of the Tennessee and east fork of Clark's rivers. This water-divide is highest on the south, viz.: four hundred and seventy-two feet above the sea, and declines northward to four hundred and fifty-seven at Briensburg, four hundred and thirty-two at Scale, four hundred and thirty at Palma, and four hundred and seventeen at Sharp.

The water-shed of the Tennessee is from five to nine miles

in width, and very numerous streams drain the surface of the country, which in the eastern part of the county is very broken and hilly. The divide is very broad on the north, and narrow on the south, presenting altogether a very large area of level and fine farming land.

The drainage basin of Clark's river is but a few miles in width, and the bottom land near Briensburg is one hundred feet lower than that village. During the Paducah overflow, back-water from the Tennessee came within a couple of miles of the Benton bridge.

The hills on either side of the bottom are quite abrupt, but are probably more so on the north side. The bottom lands are about a mile wide on the north side, but very narrow on the south below Benton, rising six to ten feet to the surface of the belt of level valley lands that on the north-west connect with the broad flats of the Tennessee and Ohio rivers. These *valley* lands are about a mile in width, very level, and timbered with post oak. South of Benton they merge gradually into the bottoms.

From the flats the country again rises to the divide between the waters of the east and west forks of Clark's river, at an elevation of about four hundred and eighty feet above the sea, or one hundred and twenty-five feet above the river.

The surface of this divide is broad and quite level, giving rise to a section of country locally known as the *flatwoods*.

This, as well as the ridge on the north of Clark's river, has a north-west and south-east trend.

The west fork of Clark's river drains but a small section of the county in the south-west corner, its bottom lands being about eighty-five feet below the high uplands.

## GEOLOGIC FEATURES.

Marshall county is in the north-eastern portion of the old gulf embayment, its eastern border resting on the Subcarboniferous formation. We therefore find in the county a variety of geologic formations, embracing the Subcarboniferous, Cretaceous, Tertiary and Quaternary. The coal measures are entirely absent, the transition from Subcarboniferous to Cretaceous being abrupt.



From the Calloway county line on the south the formations have at first a northerly and then a north-westerly trend, following in their line of outcrop a line parallel with the old shore-line.

SUBCARBONIFEROUS.—On the eastern side of the Tennessee river, in the adjoining counties of Lyon and Trigg, the Siliceous division of this formation rises in high and precipitous bluffs nearly from the water's edge; while in Livingston, on the north, the representative limestone and flinty material are more or less hidden by Quaternary and Subcarboniferous debris for some distance back from the river.

On crossing the Tennessee river into Marshall county, we do not immediately find high Subcarboniferous outcrops, but, after passing the river valley, there is a low shelf or terrace of that formation reaching inland from the river for a few miles, and covered by Quaternary gravel and superficial loam. The limestones have for the most part disappeared, leaving their associated flint layers in place, exposed only in the beds of the streams. On the west the formation suddenly disappears, and, instead, we find the sands and clays of the Cretaceous.

The only points in the county where the Siliceous group appears on high ridges, are on Possum Trot ridge between the forks of Bear creek, and on the sides of the ridges on the west and south of Jonathan creek, near Aurora, in the south-eastern corner of the county.

Upon this Subcarboniferous terrace I have been unable to find any Cretaceous or Tertiary strata, and the conclusion is plain that it was but a long and narrow belt reaching northward from the Tennessee line through Calloway county, to a point about a mile south of Gilbertsville, or to the edge of the valley, where the river cut its way to westward through the limestones.

In the Tennessee river, one mile below Haddock's ferry, on the Calvert and Smithland road, there is a long ledge of flint strata extending out from the Livingston county shore in a S. 30 W. course. It rises to about twenty feet above low-water, reaches about two hundred yards from the shore, and has a width of fifty or sixty feet. Its south-west end is only

about six feet above low-water, and suddenly terminates. The strata or layers dip eastward very steeply, and at one point are much contorted. It forms what is locally known as the *Big Chain.*

A short distance above the ferry there is another line of outcrop of cellular chert in large masses, but without stratification. It is known as the Little Chain, and has a strike across the river of S. 60° W., reaching for two hundred or three hundred yards from the north shore.

The south bank of the river at the ferry shows an outcrop of the cherty masses, and forms an excellent landing. It is covered by twenty feet of micaceous brown loam.

At Barber's landing, just above the mouth of Cypress creek, there is, on the north shore of the river, a high bluff of quartzose sandstone. The bluff is about forty feet high, overlaid by Quaternary gravel. Its lower layers are thin and much cracked. The rock incloses pyritous spots, and the faces of the layers are much roughened by exposure. In places, the edge of the rock is stained in banded yellow lines, sometimes evenly, sometimes wavy.

Limestone appears one mile south-east of Calvert City in the bed of Cypress creek, and also outcrops on the side of Limestone Hill, one mile south of Gilbertsville. These points mark the northern end of the long Subcarboniferous belt referred to above. Quaternary loam and gravel cover the hills southward to Bear creek, and it is only on the eastern side facing the Tennessee valley that we find the associated sharp flints. No limestone appears here.

The Bear creek hills are high and rough, the main prong of the creek flowing along their eastern base, and in the valley. The ridge between this and Little Bear is known as "Possum Trot ridge." Its summit is seventy-five feet above the valley, and its sides, almost to the top, are covered with sharp flint fragments of the Siliceous group. The ridge rises southward to the Paducah road, and the Quaternary loam and some gravel covers these Paleozoic rocks.

On the west of the Little Bear the same flint hills are encountered, but disappear to the westward. In the bed of this stream the flint strata appear in regular beds.



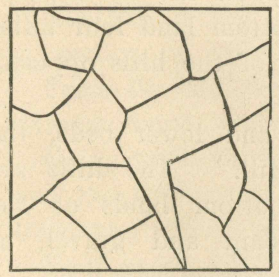
One mile south-west of the junction of the two forks of Bear creek there are, on the hills, many lime-sinks, having diameters of from fifteen to twenty-five feet and depths of from ten to fifteen feet, being largely filled by washings from the hill-sides The ponds that occur north of these are also mostly large sinks that have become filled with water.

South from the lime-sinks, near Mr. Riley's place, on the west side of Little Bear creek, there is, at about forty feet up on the hill-side, an exposure of hard siliceous rocks, the lower ledge a conglomerate two feet thick, and the upper a bluish quartzite, three feet exposed. They have not been recognized elsewhere in the county.

Going west from Birmingham we find an outcrop of blue limestone forming a ledge in the ridge of the hills that face the Tennessee valley.

The exposure continues for one-fourth of a mile southward from the Benton road, and then disappears, the associated flint alone being found on hill-sides to the Calloway county line.

Still further west from Birmingham, the flint fragments are found in the beds of creeks and branches for four or five miles. On the place of Mrs. Lou. Stone, on the head-waters of Buckhorn creek, the flint has decomposed into a whitish siliceous earth, holding some of the flint or hornstone fragments.



It is brittle or crumbling, and is, in part, stained yellow. It is several feet in thickness. Some of the clay still retains the original form of the flint fragments, as is seen in the annexed horizontal section. The central portion of each block is usually stained yellow.

Southward from Birmingham to Aurora the country is hilly and broken, especially beyond Jonathan creek, between which and the Calloway county line flint fragments are a prominent feature. The hills rise about one hundred feet above the river valley, the flint appearing on their sides to elevations of seventy-five feet above the valley. North-westward, toward Fair

Dealing, the siliceous Subcarboniferous group is thus exposed to one mile west of Jonathan creek, while on the Olive and Aurora road its most westerly outcrop is seen on Clear creek, east of Jonathan creek.

CRETACEOUS.—The series of micaceous sands and clays, that have been referred to this formation, form a belt across the county from south-east to north-west, and with a width of from three to six miles.

The upper portion of the formation embraces from ten to twenty-five feet of thinly laminated dark micaceous clays, their laminæ separated by thin sheets of highly micaceous and fine white sand. The lower comprises white and yellow sands, laminated and micaceous, with very thin layers of a bluish or light colored, sometimes white, pipe-clay. The layers of clay vary from a fraction of an inch to two or three inches in thickness, and are separated by, sometimes, several feet of sand.

The beds of the formation are covered everywhere by from twenty-five to forty feet of Quaternary gravel and clay, and it is only in bluffs or in banks of creeks and ravines that exposures can be found. Wells, also, frequently penetrate into the strata.

The east fork of Clark's river very nearly marks the western limit of Cretaceous exposures, the upper clays being seen at Dishman's mill, just south of Sharp on the north-west; again in a well at eight feet in the bottom land four miles south-east of this, and also on the side of the hills opposite Benton.

The latter place shows both upper and lower beds, the locality being known as the "Sand Hill." The hills are from fifty to sixty feet above the bottom lands of the river, and are chiefly composed of loam and gravel, as shown in the following section:

| | |
|---|---|
| 1. Brown loam | 20 feet. |
| 2. Gravel beds in part cemented into a conglomerate | 10 feet. |
| 3. Light blue plastic micaceous clay | 2 to 4 feet. |
| 4. Blue micaceous clay in thin laminæ separated by fine micaceous sand and in horizontal layers | 5 feet. |
| 5. Thin layer of red hematite or iron-stone, irregularly deposited, and in places concretionary or rounded | 2 inches. |



| | |
|---|---|
| 6. Reddish and yellowish micaceous sands, changing to fine white sand at one or two feet—in thin layers, and separated by sheets of stiff, plastic greyish or whitish clays—exposed | 26 feet. |
| 7. Sand and clay debris to foot, but probably covering *sand* strata | 15 feet. |

The sand bed is in strata with a S. 70 E. dip, as nearly as could be ascertained, and incloses a few concretionary yellow sand nodules which are filled with loose sand.

The upper blue clay bed is again exposed about one-fourth mile eastward up the branch on the road leading to Briensburg. Still further east the Cretaceous beds rest against the Subcarboniferous rocks.

In the northern part of the county, near Little Cypress post-office, on the banks of the creek of the same name, one-fourth mile north of the railroad tank, the Cretaceous clays are exposed in the low bluff, showing the following section:

| | |
|---|---|
| 1. Yellow or brown loam | 4 feet. |
| 2. Coarse hornstone gravel | 3 feet. |
| 3. Ferruginous sandstone, uneven | 2 to 4 inches. |
| 4. Micaceous shale or shaly sandstone in thin layers, separated by light slate-colored sand or clay stratum one inch thick. Breaks sharply into fragments | 4 feet |
| 5. Bluish black clay in very thin laminæ, micaceous and pyritous, and separated by very thin sheets of fine white micaceous sand to water's edge | 6 feet. |

The sandstone No. 4 splits evenly and thinly, and in places is somewhat quartzose. At another point near this it contains a few rounded and small lumps of black clay. A section of this bluff is represented on page 35.

From the McCracken county line the Cretaceous formation extends north-westward, by way of Paducah, into Illinois.

Going southward from Calvert City, the country is high, and the Cretaceous or other strata are so deeply buried by loam and gravel as to be seldom exposed even in wells.

Four and a half miles south, a well dug sixty feet, reached water in white sand. One and a half miles east of Palma, a well passed through six feet of loam, twenty feet of gravel, thirty-five feet of white and red sand, and five feet of sand-rock.

South-east of Benton the Cretaceous belt is narrow, and the clay is buried at sixty to eighty feet below the sur-

face. Three miles south of Olive, the blue micaceous sandy fetid clay was reached at about thirty feet.

On the west side of the river, in the side of the hills, on the road from Olive to Wadesboro, and one mile from the latter village, the Cretaceous clay, light blue and thinly interlaminated with fine micaceous sand, occurs in a ravine by the road-side. This is the most westerly outcrop in the southern part of the county, Tertiary clays being found at Wadesboro.

At Benton, the Cretaceous clays were reached in a well dug at the mill, at a depth of thirty feet, and were not passed through at fifty feet.

TERTIARY.—The Lignitic or Lower Eocene division of the Tertiary formation is alone represented in the county, and underlies all that portion south-west from the east fork of Clark's river, on the line of the Cretaceous.

The *Porter's Creek* (one of the Tennessee subdivisions) beds of blackish clays or "soapstones," alone make up the series, being exposed along some of the streams, occasionally in a ravine that cuts through the superficial gravel and loams, and is also frequently reached in deep wells. The clay is blackish when wet or freshly exposed, and is very brittle under the knife. It is jointed in structure, breaking with a conchoidal fracture, and when exposed to the air, crumbles into a grey shale, very tenacious to the tongue.

West from Benton we find the clay outcropping in the bluffs of the middle fork of Clark's river, and again two miles south-east of Stringtown, where a deep pit was once dug into it by parties in search of coal.

The clay is again found three miles south-west of Benton, in wells at a depth of thirty-five feet, and nearer town is seen outcropping in the side of a hill by the road-side.

South from Benton, the "soapstone" or jointed clay is exposed in a branch at Pace's old school-house, two miles north of Wadesboro. The joints are coated with yellowish clay, as at Murray, in Calloway county, and elsewhere.

In Wadesboro, just across the line in Calloway county, the clay is again exposed in a ravine immediately in the rear of the stores. It is deeply ochreous and jointed, and forms a good rough paint.



Again, in a well two and three-fourth miles south-west of Nick post-office, the black clay was reached at a slight depth. It again appears along the west fork of Clark's river.

The formation in this county is a part of the belt that passes through Calloway county from Tennessee, and northwestward through this county into McCracken county and into Illinois.

QUATERNARY.—The entire surface of the county is covered by the gravel and loam that belong to this age.

Prior to the gravel deposition, the surface of both the Cretaceous and Tertiary strata had been much denuded, and we find the Quaternary beds at all elevations.

The gravels are the lowest of the series, and, as in other counties, are made up of more or less rounded fragments of chert and hornstone from the Subcarboniferous rocks, and of all sizes, from an English pea and smaller, to pieces holding fifty or one hundred cubic inches. The usual fossil crinoids, favosites, oolite pieces, etc., occur very generally. The thickness of the beds varies greatly.

In the Tennessee valley no gravel is found. On the Subcarboniferous hills on the west, immediately facing the valley, there is very little; while still westward the bed quickly increases in depth as it recedes from the valley.

The beds are thinnest in the north and north-east portion of the county, and vary from five to ten feet. Elsewhere they are from fifteen to twenty feet thick, increasing to twenty-five and thirty as we approach the Calloway county line.

A red sand usually underlies the gravel on the northern and eastern part of the county, and is more or less intermixed with it throughout the entire area.

White pipe-clays are also of no unusual occurrence immediately below the gravel or sand, but are frequently in thin sheets with a fine whitish sand, and inclose pockets of the latter.

The gravel is often cemented into a hard conglomerate by the ferruginous clays and ferric oxide, some of the masses being so firm that a fracture would pass evenly through both the gravel and the cementing material. Such rocks are found

especially in the southern and eastern parts of the county, while on the south-west they are in thinner ledges. They are not as prominent a feature of the county as southward in eastern Calloway, and their beds are not as continuous. They often have a thickness of several feet, and are dark red in color, sometimes blackened by exposure or by fire. Small fragments of conglomerate are frequently found elsewhere among the loose gravel as if transported with it.

The rock is sometimes quarried and used for mill-stones, and seem to answer for the purpose very well, but are gotten out and dressed with difficulty. A noted locality is known as Millstone Hill, on the north side of Jonathan creek, and about one and a half miles east of the Fair Dealing and Aurora road. The rock is a conglomerate of white and dark quartz or flint pebbles, and occurs in ledges two or three feet thick. It is overlaid by twenty feet of red and hard gravel conglomerate and sand-rock and loose gravel, with some pieces of rounded quartzite, six inches in diameter.

A ledge of ferruginous conglomerate is frequently exposed along the east bluff of the east fork of Clark's river, nearly capping the hills. It is prominent near Benton, and southeastward near the crossing of the Olive and Wadesboro road. At the latter place it caps a narrow or backbone ridge, seventy feet above the river, and is about four feet thick. It also occurs near New Liberty Church on the west side of the river.

The red sand underlying the gravel is often cemented into a hard sand-rock—sometimes massive and sometimes in thin layers. The rock is more generally an indurated sand, which hardens on exposure. It is not usually very firm, and is almost useless as a building material, though sometimes used as underpinning for foundations of small and light buildings.

In the Tennessee valley, the only gravel observed was at Cypress P. O., and thence westward to the county line at Lawton's bluff. It is at a higher elevation than that at Paducah and further down the river, and seems to be the eastern limit of the valley gravel.



The *clays* that form the lowest of the Quaternary series are of a stiff plastic character, white or bluish-white in color, and of various thicknesses.

The most northerly outcrop observed occurs on the place of J. T. Pugh, two miles east of Palma, and at Stice's old mill place, still eastward, near the line of the Subcarboniferous outcrops. At both places some white sand is associated with the clay both in layers and in pockets. Southward the same beds are found at Mr. Frank Burradel's, three miles north-west of Briensburg, and at Scale, where a small pottery was once begun but failed because of want of experienced workmen. Heavy beds are reported as occurring in wells around Harvey, west of Benton.

The *brown loam* that covers the county, and overlies the gravel everywhere, is in two beds, and has a thickness in this county of from ten to twenty feet.

The upper two feet is of a yellowish-brown color, light when drained, and furnishing the best upland soils. Below this it is of a stiffer character, lighter colored, and, as in other counties, is permeated with thin seams of whitish silt.

In the Tennessee valley, the deposit overlying the blue clays is micaceous in character, though otherwise strongly resembling the upland loams.

On hill-sides, the loams are easily washed away by the rains, and huge ravines are of common occurrence.

Slides also take place on the sides of steep bluffs, a notable instance of which is to be seen two miles south of Benton, on the east side of Watch creek, and which has resulted in the formation of the "sink" so well known in the county.

The hills here are about ninety feet above the creek, and their sides are quite steep. A number of small terraces occur above each other along the foot of the hill, which have clearly been formed by the sliding down of the loams and gravel.

The "sink" occurs on the side of the hill about thirty feet above the creek, and is rather rounded on all sides of the interior basin except the west or outside, which is parallel with this part of the hill. The side next the hill is very steep, a continuation downwards of the bluff. The sink has

a diameter of about one hundred and fifty feet; the outward sides capped with conglomerate gravel, which prevent them from being washed away. The sink holds water, and has many logs, etc., in it.

*Recent Gravel Bed.*—In the bottom of Cypress creek, the Paducah and Calvert City road lies for a distance of one-fourth mile along a low elevation of small, loose, but firmly compacted gravel without a loam covering. It resembles the low gravel ridges that cover the loam of the valley at Paducah—a more recent deposit than the loam. It is about ten feet high and fifty yards wide and its trend is N. 60 E.

The *Port Hudson Group* is represented in the valley of the Tennessee by the blue clays and micaceous loams that make up the beds exposed from low-water mark in the banks to the surface of the valley. The clays are in layers of from a few inches to a foot and more in thickness, and interbedded with white, yellow, and red sands. The exposures occur at several points from the Calloway county line on the south, along the river to McCracken county.

The superficial loam accompanies the clay throughout the entire valley. At Birmingham it is fifteen to twenty feet thick. The river here seems at one time to have flowed on either side of the valley, for Mr. Charles Lilley informs me that in wells along the river front, and on the west side of the valley, blue clays are reached at fifteen to eighteen feet, while in the central part, comprising a width of about six hundred yards, the clay is not reached at all, but alternating strata of sand and pipe-clay are passed through for sixty feet, water being found between the clay strata.

At Highland, near the Calloway county line, the following section was observed:

| | |
|---|---|
| Brown loam, slightly micaceous | 7 feet. |
| Interstratified light bluish clay and yellow sand | 15 feet. |
| Blue micaceous clay in layers one to two feet thick, with some yellow sand and ferruginous concretions | 10 feet. |

The lower bed or layer is speckled with white and deep blue particles of the mineral earth, *vivianite*—a phosphate of iron.

On the north, at Haddock's ferry, where the valley cuts westward through the Subcarboniferous, the clays do not



outcrop on the river bank, the chert and flint rock ledges appearing instead. Toward Calvert City, however, the blue and black fetid micaceous clays are reached in wells at ten or fifteen feet.

Again, down the river at Barber's Landing, the clays are reached at eighteen feet, the following section of a well being given:

| | |
|---|---|
| Loam | 18 feet. |
| Blue clay | 6 inches. |
| Yellow clay | 11 feet. |
| Yellow sand | 6 inches. |
| Yellow clay | to water. |

## ECONOMIC FEATURES.

The natural resources of the county comprise, chiefly, the lands, timber and pipe-clays, besides small quantities of various other material. All of these have been described in the general report, and it is not necessary, in this place, to give more than a notice of the localities where each occurs, and the general character of the most important.

CLAYS.—The varieties of clay occurring at different points within the county comprise the greyish-black joint clay of the Tertiary formation, and the more recent plastic, lighter colored and more or less refractory pipe-clays, together with a thinly laminated, dark and micaceous, Cretaceous clay, which is exposed in the base of the sand-hill north of Benton, in thin layers, separated by micaceous sand. The latter is again exposed below the foot of the uplands bordering Clark's river bottom near Sharp P. O.

The black joint clay of the Tertiary occurs to the west of Benton, forming a part of that belt which reaches from Murray, Calloway county, on the south, into McCracken county on the north-west. Exposures may be seen a few miles west of Benton at the foot of the uplands of the middle fork of Clark's river, at Brewers' old mill on the south-west, and near the road three miles south-east of Stringtown, on the north-west. Wherever found, the clay presents the same jointed, massive character, the joints mostly conchoidal in form. The clay is slightly micaceous, black when wet and dark-grey when dry.

The dark color seems to be due to the organic matter which burns out, leaving a grey mass. Chemical analysis shows the presence of nearly forty per cent. of sand, one per cent. of potash, and a little lime, besides magnesia, iron and soda, and a large amount of alumina. The clay is refractory in nature, but will not take a glaze. It might be used in the manufacture of water jars.

The plastic clays, variegated in color from white to purple, are found chiefly to the east of the belt of the black joint variety just mentioned, and always just below the gravel beds.

At Cypress creek railroad tank, in the northern part of the county, there is exposed, in the bed of a railroad cut, made for the purpose of getting gravel for the road-bed, a stiff lead-colored plastic clay, finely siliceous and micaceous in character, very similar to that found at the Armstrong place, a few miles south, on the east side of Clark's river, in McCracken county. The latter contains nearly two and a half per cent. of potash, and is quite unrefractory, a property that probably also belongs to this Cypress Creek bed. The thickness of the bed has not been ascertained, and no tests have been made.

Another lead-colored, micaceous clay occurs in the hill-side at the spring near the house of Mr. J. T. Pugh, a few miles east of Palma. It has a thickness of several feet, is plastic, and fuses with great difficulty before the blow-pipe. At the Rookwood Pottery it formed a white unglazed biscuit, which on glazing became a dark cream color. Its shrinkage on burning was about fifteen per cent. This clay contains only a trace of lime, but a little more than one and a half per cent. of potash.

Going southward from this, we find another exposure of the light colored and plastic clay at Mr. F. Burradell's, several miles north-east of Scale P. O. It occurs in some deep washes in the hill-side within an old field east of the residence, and is in beds of from a few inches to about two feet in thickness, separated by yellowish sand, and holding pockets of the same. The lower beds exposed are in thin layers. A specimen from the thickest bed, and as free from sand pockets



as possible, was, on analysis, found to contain seventy per cent. of fine sand. After freeing it from the latter, it contained a very little lime and nearly one per cent. of potash. The clay is highly refractory, shrinks about ten per cent. on burning, yielding a milky-white biscuit, which, on glazing, becomes darker.

An unrefractory clay occurs in the bed of a branch on the place of Mr. S. Gray, just south of Scale post-office, and also about a mile west of the latter, where a pottery was once established for a short time. The clay is quite plastic, and with variegated white, bluish and red colors, and occurs in layers from a few inches to as much as two or more feet in thickness, and interbedded with yellow and red sands. A rather broad valley reaches to either side of the branch, and there is, in consequence, but little surface covering above the clay. A chemical analysis of a sample of the clay shows the presence of one and a half per cent. of iron, a very little lime, and over two per cent. of alkalies. It is unrefractory, fusing before the blow-pipe, and in the pottery test gave a buff-colored glazed biscuit.

These clays are exposed in other parts of the county, as at Stice's old mill, north of Briensburg, at Mr. Holland's place, a few miles west of Birmingham, and in the hill-sides east of Clark's river on the road to Fair Dealing, but are not of sufficient purity or in quantities sufficient for working purposes. A gypseous variety outcrops in a ravine on the road-side just south of Benton, the gypsum occurring in needle-shaped crystals.

The blue clays, already alluded to as occurring in the valley of the Tennessee river, are well exposed at Highland Landing in the south-east corner of the county. A section at the river bank shows a surface-covering of seven feet of a light brownish micaceous loam, fifteen feet of light bluish clay interlaminated with yellow sands, and ten feet of blue micaceous clay in layers of from one to two feet in thickness, separated by irregular beds of yellow sand with ferruginous concretions. The lower bed of clay is speckled with white and blue particles of the mineral *vivianite*. This bed is at water's edge. The analysis of a sample of this

clay (see general report) shows the presence of more than seven per cent. of iron, nearly one of lime, and more than three per cent. of alkalies. It fuses before the blow-pipe, and on burning makes a dark red biscuit.

*Siliceous Earth or Polishing Powder.*—There is in the county a fine floury powder, rather clayey between the fingers, though containing but little real clay, derived from the decay of the chert or flint masses occurring sometimes in the limestone of the Tennessee river section, or in thick masses almost free from limestone. Chemical analysis shows it to be composed of nearly ninety per cent. of silica, from three to ten per cent. of alumina, a bare trace of lime, and from three-tenths to one per cent. of alkalies.

No use has been found for this earth except as a fine polishing material for cutlery. It occurs at several points in the eastern part of the county, especially within a few miles of Birmingham along the base of the hills, and in the region of Aurora. Pieces of the undecomposed chert frequently remain in the clay.

*Iron Ore.*—Very little iron ore occurs within the county, though some hematite was found on the place of Mr. Cox, four miles west of Birmingham; it outcrops on the side of a hill in his field, in the form of rounded irregular concretionary masses, more or less specular on the inner surface, and in size from small pieces to lumps weighing fifteen or twenty pounds. There is, however, no indication of the presence of a sufficient quantity for working.

## AGRICULTURAL FEATURES.

Each variety of land, both bottom and upland, that occurs in the Purchase Region, is represented in this county, with the exception of the Mississippi river alluvial and the Bluff or Cane Hills. They embrace the following:

| | |
|---|---|
| *Uplands* . | Oak and hickory timbered lands.<br>Black-jack and low red oak barrens.<br>Flatwoods. |
| *Lowlands.* | River valleys.<br>River and creek bottoms. |



The surface of the country, while rolling and in places hilly, is very generally level enough for tillage, and is all timbered to a greater or less extent. A large proportion of the surface has been cleared for cultivation—some of it now lying out because of exhaustion.

The crops of the county embrace corn and tobacco chiefly, with some small grains. Shipping facilities are afforded only by the Tennessee river boats on the east and the C., O. & S. W. R. R. on the north, while for the greater part of the county hauling by wagon to Paducah is resorted to. The lands differ in no regard from those of similar regions in other counties.

The lands are more generally under cultivation in the central and western parts of the county, especially to the west and north of Benton. The upland crops comprise corn, tobacco and oats, with some wheat, the average yields being about thirty-five bushels of corn, ten of wheat, and about eight hundred pounds of tobacco per acre.

*Oak and Hickory or Timbered Uplands.*—This designation is popularly applied to those lands having a larger timber growth than what are known as the Barrens or original prairies. They comprise nearly all of the county uplands, and resemble in their features the lands similarly designated in other counties. The surface is much broken and washed into gullies and deep ravines, presenting, on hill-sides, a more or less serrated appearance.

On the divides between the streams the surface is quite level or undulating, affording broad tracts of good farming land. The eastern part of the county is more broken than the western, but the soils of the hills are very similar throughout. The timber growth is red, white and black oaks, hickory and persimmon. The soil is a brownish loam, light and warm where well drained, but where ill-drained is compact, whitish, cold and impervious to water. Decayed vegetation darkens the surface to the depth of an inch or so.

The under-clay, at a depth of about three feet, is also a loam lighter in color, and usually permeated with seams of a light-grey silt, which is almost entirely free from clay.

The entire depth to the underlying gravel is from ten to twenty feet.

The soil is so light and loose that on hill-sides it is readily carried away by rains, the result being the formation of deep gullies. Such are very commonly seen in old fields, and is one of the causes of their abandonment. No analyses have been made of the upland soils of this county, but judging from those made of similar soils of other counties, there is a deficiency of both lime and phosphoric acid, and a fair amount of available potash. While, therefore, the soils would bear cropping for a few years, there will soon be a need of supplying both lime and phosphates.

*Upland Barrens.*—The area embraced in the country known as the Barrens is only about twenty square miles, and lies in the southern portion, being a mere border or offshoot from the large central region of Graves and Calloway counties. The outlines of the region are very irregular, reaching north from Wadesboro about three miles or more, and from the East fork westward to within a couple of miles of the West fork of Clark's river, and beyond the latter to the county line. The streams within this area are usually bordered by a narrow upland belt of larger timber. The soil of the Barrens differs but little from that of the Oak and Hickory Uplands already described, and has a growth of black-jack and red oaks. It is regarded, however, as being especially suited to the cultivation of tobacco.

*Flatwoods.*—This name is used to designate a broad and level upland region lying a few miles south-west of Benton, and covering an area of about ten square miles. It lies on the uplands that separate the waters of East and West fork of Clark's river.

The surface is undulating, a large portion so level as to be glady, poorly drained, and, in consequence, having a soil that has become whitish, impervious to water, more or less covered or filled with small "black gravel" or bog iron ore, and almost untillable, except by a system of drainage. In those places where there is good natural drainage, the soil is similar to that of other timbered uplands in character and fertility.



The growth of this flatwoods region is post and black oaks, hickory, a little white oak, dogwood and sassafras. On the glades post oak is prominent.

*Valley of the Tennessee.*—This region, bordered on one side by the Tennessee river and on the other by the high and rather abruptly rising uplands, has a width varying from a mile at the Calloway county line and northward to Gilbertsville, to about two miles on the north of Calvert City, and embraces about forty square miles.

The surface of the valley is uneven, a low river front or bottom lying on the east, and a slough or gum flat occupying considerable space on the bluff side, leaving a low elevation of fifteen feet in the center through its entire length, except where cut in two by an occasional stream in its course to the river. The timber of the valley is white and red oaks, hickory and dogwood. The valley is now much under cultivation, especially in that portion from Gilbertsville southward along the central elevation, and toward the mouth of Big Cypress creek on the north. The crops are chiefly corn and oats.

The soils vary from a stiff clayey and crawfishy nature in the flats, to a light micaceous loam on the higher central lands, where natural drainage prevails.

In the broad portion of the valley, north of Calvert City, most of the land is very level and ill-drained, and the soil, in consequence, has a whitish, leached appearance, and is compact and impervious to water. Analyses of these glady lands (given in the general report) show the presence of a fair percentage of potash and probably of phosphoric acid, but there is a great deficiency in lime, which, if supplied, would doubtless improve the mechanical texture of the soil, if drainage was attended to, and would also render available much of the large percentage of insoluble potash-minerals present. The glady lands near the mouth of Jonathan creek show a great deficiency of potash and lime in the soil, though the subsoil has a large percentage of the former. The phosphoric acid is present in fair amounts. In the insoluble condition there is a large percentage of potash awaiting the action of lime and weathering

The better class of valley land, lying at a higher elevation, shows no improvement in composition, its fertility being entirely due to good natural drainage. The soil is said to yield from fifty to sixty bushels of corn, or fifteen of wheat, per acre.

*Clark's River Valley Land.*—The broad flats or valley of Clark's river south of Paducah, in McCracken county, extends up the south side of the East fork into this county. It lies between the river bottom on the one hand and the uplands on the other, in a belt about a mile or less in width, and reaching up the river, with a narrowing width to, and a few miles beyond Benton. Its surface is quite level, and is timbered with chiefly a post oak growth; and its soil is whitish, compact, crawfishy and impervious to water. The absence of any natural drainage makes it cold and unsuited to tillage. Comparatively little undergrowth appears, and the valley is, in consequence, quite open. These lands are probably best adapted to the growth of grain.

*Bottom Lands.*—The bottom lands of the county comprise but a small proportion of its area, and lie chiefly along Clark's river and the smaller streams. On the Tennessee river there is scarcely any land lower than the valley, the bottoms appearing only here and there and in very narrow strips. On the East fork of Clark's river the bottoms lie chiefly on the north side (the valley flats on the opposite or south side), extending from the McCracken county line nearly to Benton, with a width of about a mile; beyond Benton they continue into Marshall county, and chiefly on the west side. In the region of Wadesboro they widen out because of the junction of several small streams. The bottoms are subject to yearly overflow, and have a good timber growth of red, black, water, post and white oaks, hickory, maple, sugar-tree, lynn, iron-wood, walnut, poplar, black and sweet gums, some red gum, elm, catalpa, sycamore, cypress, hornbeam, beech and papaw.

The soil is, for the most part, a whitish clay, compact and undrained, and is derived from the washings from the bordering uplands. Because of this heavy nature it is generally untillable, and scarcely under cultivation. The surface portion is darkened by decayed vegetation from the forest growth. An analysis of a sample of the soil from near Benton shows a deficiency in available potash and lime, and a rather fair amount of phosphoric acid. In the insoluble portion there is, however, a large amount of potash which liming would, doubtless, render available.



West fork of Clark's river crosses the corner of the county with a wide bottom well timbered with beech, poplar, gum and oak. The soil is a dark loam, containing more available potash and lime than the specimen from the East fork, though still deficient in these elements. The percentage of insoluble potash is more than one and a half.

The bottom land of Big Cypress Creek, in the northern part of the county, is limited to that portion of the creek lying in the uplands, for on emerging into the Tennessee valley the stream cuts its way in a narrow channel westward to the river. The bottom is flat, about two and one-half miles in width, and with a length of about six miles from the valley; it receives a number of small and short tributaries. It is largely covered with water, and has a prominent growth of cypress.

The bottom lands of other streams are of no special interest, the soil being more or less crawfishy in character and well timbered.

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## GRAVES COUNTY.

Graves county has an area of 540 square miles, very nearly all of which is upland. It was cut off from Hickman county and organized in 1842.

In the southern part of the county, and within four miles of Tennessee, occurs the highest portion of the entire Purchase Region, forming an imperceptible plateau ridge, lying nearly east and west, between Lynnville and Pilot Oak. From this water-divide, small streams flow southward into the State of Tennessee, while on the north are the head-waters of Bayou de Chien, with a westerly course, of the Obion flowing

north-westerly, and of Mayfield creek, whose course is almost due northward (bearing slightly to the west), through the county into McCracken, and thence west through Ballard into the Mississippi river.

On the north-east the West fork of Clark's river drains a small area northward into the Tennessee river. The east banks are abrupt and broken, the west much less so.

The basin of Mayfield creek is narrow, and northward beyond Mayfield lies almost exclusively on the west of the creek. On the east it is bordered by high, and, for the most part, abrupt bluffs, from whose summit the waters flow eastward into Clark's river.

On the west the country rises gradually for about four miles to another divide, which, trending north and south, turns the waters of this north-western part of the county westward into Ballard county, where they empty into this creek.

South of Mayfield the streams spread out on either side, the main stream having its extreme source in the south-west corner of Calloway county.

The drainage basin of Obion creek, in this county, is wide, but, as in the case of Mayfield creek, lies chiefly on the south and west, the tributary streams on the north and east being very short and insignificant. The north side is, however, not marked by high and abrupt bluffs as is Mayfield creek.

The divide between Mayfield creek and Clark's river, with that on the south already alluded to, marks the highest portion of the county, with approximate elevations above the sea varying from 455 feet on the north near the McCracken county line, 475 at West Plains, 515 east of Mayfield, and also east of Farmington, to 550 at Lynnville, 625 four miles west, and 550 at Pilot Oak, the ridge passing thence south-westward into Tennessee.

The divide separating the waters of Mayfield creek from those of the Obion, varies from 490 feet at Cuba, 440 near Sedalia, 460 between Mayfield and Dublin, 440 at Mayfield to 400 east of Pottsville. Extreme high water from the Tennessee and Ohio rivers reaches, on Clark's river, to a point



three miles above Carter's mill or Kaler post-office; on Mayfield creek that from the Mississippi does not reach into this county.

## GEOLOGICAL FEATURES.

The Subcarboniferous and Cretaceous formations of the adjoining counties of Calloway, Marshall and McCracken, are not exposed at any point in Graves. Their material had been completely removed to a great depth before the deposition of the succeeding Tertiary beds, and in their place we now find only the clays and sands of the latter formation, and the still later gravels, sands and loams of the Quaternary period.

TERTIARY.—The lowest geological formation represented in this county is the Porter's creek (Tennessee) group of black "soapstone" or joint-clays belonging to the Lignitic division of Eocene Tertiary. It is found outcropping only in the north-eastern part of the county, notably in the banks of Clark's river, at Lyell's mill, west of Symsonia.

The clay is overlaid by the dark-greyish micaceous sandstone that accompanies it in McCracken county, and over this by the Quaternary deposits. The following is a section of the exposure at Lyell's mill:

| | |
|---|---|
| Loam and superficial soil, etc., at top of the hill | 20 feet. |
| Gravel and yellow clay | 4 feet. |
| Ledge of gravel conglomerate | 2 inches. |
| Red sand and a little gravel | 3 feet. |
| Gravel, clay and yellow sand | 15 feet. |
| Black joint-clay (soapstone) | 3 feet. |
| Greyish micaceous sandstone | 2 feet. |
| Black joint-clay (to water) | 8 feet. |

The gravel is coarse, some of the pieces being four by four by two inches. Large geodes (Keokuk), crinoid stems, and white, flinty and brown hornstone gravel occur in the mass. The bed seems to dip slightly to the east.

The micaceous sandstone contains rounded pieces of the black clay; no fossils could be found, though casts of Eocene shells are abundant in the same bed in McCracken county. Seams of this sandstone frequently penetrate the underlying clay in different directions, and cross each other, and are from two to ten inches thick.

The "soapstone" or black clay bed is continuous north-westward toward Paducah, covered deeply by gravel and loam. It has been found in digging wells near Hard Money post-office. It is dark or blackish when freshly exposed or when wet, and is very brittle, having a rounded jointed fracture, the joints sometimes stained with yellow ochreous clay. On drying it is greyish in color, and inclined to shale or crumble into fine pieces, and is very tenacious when applied to the tongue.

The bed passes south-eastward into Calloway county. Apparently overlying this Porter's Creek group or "soapstone," or at least at a higher elevation, and occurring ten miles south of it, we find the Lignitic beds that in Ballard county occur near Wickliffe. They are exposed in the banks of Panther Creek, a little north of east of Mayfield, on the places of Mr. O. Whitts and of Q. A. Cromwell. The bed is best exposed at the former, and is thought to have a thickness of six feet, three feet being exposed above water's edge. The upper portion is full of broken leaves, stems, etc., and breaks up in blocks and plates. The middle portion has more of a massive and brownish appearance, as if of lignitic peat, so firm as to require a hatchet to cut it. It resembles in every respect the bed near Wickliffe, Ballard county.

A stiff, plastic clay is said to underlie the lignite bed at Mr. Cromwell's. It has a thickness of but a few inches, over a bed of coarse and variegated colored sand. A few hundred yards south of the lignite is a bluff exposure of a bluish, sandy clay, ten feet in thickness, disappearing below the water, but doubtless overlying the lignite. These clays also appear in the Wickliffe section.

Westward and southward these black clays and lignite seem to have been removed to a depth of one hundred or more feet, for in wells of that depth they do not appear, but in their stead is the group of sands and interstratified clays (the latter in thin layers), which has been designated by Prof. Safford, in Tennessee, as the *Lagrange Group.*

*Lagrange Group.*—The true relationship of this to other groups has not been fully determined, owing to an entire absence of fossils.



Leaf impressions have been found in the clay bed at Boaz, a little station on the C., O. & S. W. R. R., in the northern part of the county, and have been reported elsewhere.

The thickness of the group has not been ascertained, but it is probably one hundred and fifty to two hundred feet. But few deep wells have been dug into it, and then the underlying formation was not reached. Water is seldom obtained at easy depths after passing through the gravel and upper bed of sand, and digging is soon abandoned. In bored wells, work is sometimes continued for one hundred feet without finding abundant water, and is then stopped. Cisterns are most commonly resorted to all over the county for supplies of water for domestic uses.

The sand is mostly fine and white, with admixtures of colored streaks, and also micaceous; irregular stratification is generally observed in exposures.

North and north-west of Mayfield, wells have depths varying from thirty to fifty feet, a thick stratum of pipe-clay affording an impervious bed for the waters of the gravel and sand, a sufficient flow or supply being found at that point. But at Mayfield and southward, we find wells of over one hundred feet depth, and in some instances no water found. In Stubblefield, south of Mayfield, eighty-five feet of sand and clay were penetrated after going through thirty of loam and gravel. At Mayfield, variegated colored clays and micaceous sands were penetrated to over one hundred feet. Leaf impressions were found in a white clay at eighty feet.

On the narrow dividing ridge between Mayfield creek and Clark's river, east of Boaz, wells are from sixty to one hundred feet deep, passing through twelve to fifteen feet of loam, four or five feet of gravel, fifteen to twenty feet of white sand, and then sand and clay. Leaf impressions were found in pipe-clays at one hundred feet.

QUATERNARY.—The gravel beds of this formation cover the entire county southward to the high land between Lynnville and Feliciana, beyond which it apparently disappears. It begins to thin out south of Sedalia and Wingo, and is then often entirely absent in exposed bluffs near the Tennessee State line. Lynnville and Boydville are within the gravel

region, which reaches eastward through Calloway county to the Tennessee river, the bed being from five to ten feet thick.

The deposit is thickest and composed of the coarsest material on the east of Mayfield creek, though varying much, even in neighborhoods. In the region of Symsonia and Hard Money, in the north-east part of the county, it is twenty feet thick. Southward, it varies from ten to fifteen feet at West Plains and Clear Spring, Mayfield, five miles south of Mayfield, Stubblefield, and west to Wingo and Baltimore.

On the west of Mayfield creek it is from four to six feet thick very generally as far south as Dublin.

Its material is uniform with that of other counties, and composed of hornstone and cherty fragments, rounded more or less at edges, coarse and fine in thick beds, but becoming smaller as the limits of the gravel region are reached; it is always associated with small and round, smoothly-water-worn quartz pebbles, sometimes variously colored, but often clear and limpid. Crinoid stems and other fossil impressions from the Subcarboniferous are more or less abundant. Pieces of siliceous oolite rock were found near Pryorsburg and Mayfield.

The gravel is always more or less clayey and sandy, usually highly stained with ferric oxide to a red color. These beds are then known as "cement gravel," and are sometimes used on streets, becoming hard and firm after packing and a short exposure. In places, especially in some of the railroad cuts south of Mayfield, the beds are of a *white* gravel, in large bodies, this either being the color at the time of deposition or the result of some leaching process by which the iron stain has been removed.

The gravel is usually more or less interstratified with coarse red sand, as also occurs in fine and coarse fragments. Near Mayfield a bed twenty-five feet thick shows the following:

| | |
|---|---|
| Upper gravel bed, not stratified but mixed | 5 feet. |
| Coarse red sand with gravel in irregular layers | 5 feet. |
| Gravel in layers of fine and coarse material, some of the fragments black, and inclosing some blue clay and sand | 15 feet. |
| Whitish sand exposed at base | 1 foot. |

The strata are mostly inclined westward.



Gravel and sand conglomerate, formed by cementation by ferric oxide, is common to all of the thick gravel beds, in large and small masses, in irregular thicknesses and different degrees of hardness.

The deep railroad cuts along the line of the C., O. & S. W. R. R. afford excellent opportunities for examining the gravel deposits, their material thicknesses and method of deposition, as well as the character of the underlying material. Such a cut occurs one and a half miles north of Boaz, in the northern part of the county. (See section on page 67.)

The sand of the cut is hyaline, or of a clear, light-bluish tint in character, and the beds contain purplish ferruginous concretions.

The purple clays at the base are mostly covered with debris from the bluff. They are exposed again near Boaz, on the east, and contain fossil leaf impressions. The clay is very plastic, the upper three feet being of a creamy-white color, and the lower two feet a purple, both holding the leaves.

South from Mayfield, after passing the first gravel bed whose section is mentioned above, the railroad cuts, for two miles, expose below the brown superficial loam a red sandy clay, containing only a little fine gravel. The hills are higher than Mayfield, and it would seem as if their elevation was above the general plain of gravel deposition. At three miles, beneath five feet of brown loam, is seen a yellowish clay five feet thick, then a mottled light-colored clay five feet in thickness, holding some scattered white gravel. On the south end of the cut the gravels again appear in a red sandy clay, and eight feet thick. The greater part of the gravel is white, some easily crushed, and resembling strongly the material along the border of the Subcarboniferous. Some brown hornstone appears among it.

Thence to Pryorsburg the beds vary from five to ten feet, and are largely white, the chert being rounded only on their edges. Much rounded quartz pebbles occur, in color varying from white, green and red to black. The gravel is mostly fine and thinly stratified with red sand. Toward Wingo the beds increase in thickness, and near town are fifteen feet thick, mostly of brown hornstone and stratified. Portions

of the bed are cemented into a ferruginous conglomerate in plates from one to six inches thick.

Continuing south from Wingo, the thick gravel beds continue for a mile or more, and are associated with some gravel conglomerate. Much is coarse, one piece of chert containing, probably, eight cubic inches. Some quartz pebbles occur also. Near Brush creek, a stiff plastic clay, from yellow and drab to purple in color, is exposed in the railroad cut below the gravel. It is somewhat sandy and six feet in depth.

Beyond Brush creek the gravel beds become thinner, and red sands and clays appear above them.

In what is known as the "Big Cut," no gravel appears. The superficial loam is six feet thick. It is underlaid by a bright red sand mixed with lumps of clay, and standing out from beneath the upper stratum, presents a striking appearance with its brightly colored perpendicular face. It is four feet thick, and crumbles on drying. Underlying this second stratum is eight feet of an indurated sandy clay, permeated with seams of a lighter material. Beneath this are purple, yellow and red sandy clays four feet thick, and underlaid by an indurated yellow sand, banded with white and red and even horizontal seams. This hill is seventy-five feet above Water Valley, and, as with the hills near Mayfield, seems to be above the gravel plain, for on going southward we find, in the next cut, a bed of gravel two feet thick, which is much lower. We here find, also, six inches of variegated pipe-clay beneath the gravel, underlaid in turn by an indurated red sand, inclosing specks of pipe-clay. The lowest exposure is a yellow and bluish clay, porous and sandy, and four feet thick. Towards Fulton very little gravel is seen.

At Baltimore and vicinity, west of the railroad, along Bush creek, a massive and coarse gravel conglomerate outcrops from the side of the hill, and is about four feet thick. The rock is very firm, the fracture reaching evenly through the gravel itself. Gravel overlies the rock for about ten feet.

The superficial *brown loam* that overlies the gravel and sand all over the county varies in thickness from ten to twenty feet, and is quite uniform in character everywhere.



The upper two feet is usually of a brownish-yellow color, that underlying being heavier and more indurated, and often impervious to water. The lower bed is permeated with many seams of a lighter colored silty material to some depth, as if produced by infiltration of the grey silt into cracks.

There are no true sandy uplands in the county, though they occur but a few miles southward in Tennessee.

## ECONOMIC GEOLOGY.

*Brown Coal or Lignite.*—There is no stone-coal in the county, the formations all being of a much later age than the Carboniferous. The only thing approaching it in appearance is the brown coal or Lignite found on Panther creek, a tributary of Clark's river east of Mayfield. Some persons have supposed that this was but the outcropping of what, on tunneling into the vein, would prove to be stone-coal, but this idea is erroneous.

The Lignite on Panther creek has a thickness of from six to eight feet, and while portions of the bed show some pieces of lignitic woody fragments, the body of the mass is of a chocolate-colored peaty character, converted into lignite by age. Numerous vegetable leaves occur in the upper portion. The following analysis shows its composition dried at 212° F.

LIGNITIC PEAT OR BROWN COAL FROM PANTHER CREEK.
No. 2144.

| | |
|---|---|
| Hygroscopic moisture | 4.13 |
| Volatile combustible matters | 16.22 |
| Fixed carbon in the coke | 10.25 |
| Light ash, nearly white | 69.40 |
| | 100 00 |
| Total volatile matters | 20.35 |
| Total pulverulent coke | 79.65 |
| | 100.00 |

"The ash was found to contain a considerable proportion of alumina, some little lime and magnesia, as well as a trace of phosphoric acid. As this material is only a little more than thirty-six per cent. of combustible matters, it could

scarcely be made available as a fuel. Possibly it may find use as a cheap pigment." (*Dr. Peter.*)

CLAYS.—Throughout the county white pipe-clays are abundant, and are penetrated in almost all wells that reach below the gravel beds. Outcrops are also frequent in deep ravines, and from these the clay can be easily obtained for use.

Along the line of railroad, from the northern part of the county southward, the cuts frequently expose beds of clays, sometimes of several feet thickness, suitable for either pottery, fire-brick, terra-cotta or tiling. Deposits of sand or gravel and loam always overlie them to depths varying from a few feet to as much as twenty feet.

In the cut, three miles north of Boaz, and underlying six feet of loam and two feet of a yellowish clay with some gravel, is a pipe-clay, white and variegated in color, and holding some small white quartz pebbles. The bed is four feet thick, and is underlaid by three feet of yellow sand. The upper part of the clay crumbles easily; the lower three feet is plastic when wet but hard and indurated when dry, strongly resembling the siliceous earth of the Subcarboniferous chert beds near the Tennessee river.

The cut, a mile or more north of Boaz, has already been described. The clay here exposed is highly plastic, and colored white and purple, and has a thickness of several feet. The same bed exposed at Boaz is five feet thick, the two lower having a light purple color, and is rich in fossil leaf impressions. The bed also occurs in the bluff south of Boaz a short distance. Southward of the latter no clays are exposed in the cuts until one and a half miles south of Pryorsburg, where we find white and purple clays in thin strata of one and two inches in thickness, inclosed in beds of thinly laminated fine yellow and red sands. No thick strata are exposed until two and one-half miles south of Wingo, where, in a cut, we find, under thirteen feet of loam and gravel, a bed of plastic clay, white and yellow to purple in color, and in places somewhat sandy with a white hyaline sand. The bed is six feet thick. A pottery was once in operation near here, the clay being obtained in the bank of a branch, but, owing, probably, to lack of "tempering," the vessels cracked after burning, and the works were abandoned.



The clays in the next or "Big Cut" are of white, purple, yellow and red colors and somewhat sandy. Their thickness is four feet and they are underlaid by sand.

The bed is again exposed three miles north of Water Valley, and is the last outcrop to that station and Fulton on the State line.

Near Pryorsburg there is a bluff on the creek, in the eastern part of town, which shows the following strata:

| | | |
|---|---|---|
| 1. | Loam and gravel, the latter exposed one foot | 20 feet. |
| 2. | Yellow ochreous clay, plastic but crumbly | 1 foot. |
| 3. | Purple clay, more compact, somewhat sandy and easily worked | 3½ feet. |
| 4. | Bluish and purple joint-clay, more plastic than the above and lighter colored. In fine laminæ with fine micaceous sand, and penetrated by rootlets. Probable thickness | 5 feet. |
| 5. | Light blue and fine sandy clay, grey when dry | 2 feet. |
| 6. | White sandy clay, compact or indurated, very fine | 6 feet. |
| 7. | Thin layer similar to No. 5 and six inches thick | |
| 8. | Similar to No. 5 but indurated, dark when wet but white when dry | |
| 9. | Plastic earth changing to a light yellow mottled appearance | |
| 10. | Covered by debris from bluff | 15 feet. |

The lower fine strata are chalky or earthy in character, and dip to the north-east at about five degrees, some of them at a greater angle. The compact and fine earth, No. 6, would be useful as a polishing powder.

On Panther creek, a hundred yards or more south of the Lignite, on Obediah Whitt's place, there is a blue sandy clay in the eastern bank; eight feet exposed to the water's edge. It is in places sandy and micaceous in character, containing, as shown by analysis, a little more than one per cent. each of iron and potash and a trace of lime.

"It is quite plastic, and burns of a light salmon color; does not become very hard unless exposed to a very high temperature. It is refractory before the blow-pipe. It contains more potash than the German glass-pot clay, which may possibly cause it to be less available to the glass-maker. It could, no doubt, be made useful for many purposes as a fire-clay, as well as for various pottery applications." (*Dr. Peter.*)

An exposure of very plastic clay, of several colors, is seen at the School-house spring, one mile south of the Lignite bed. Thickness not known.

A very fine plastic clay occurs three miles west of Lynnville, and is being used by Mr. J. W. Pittman in his pottery, which is located two miles south of town.

The clay is massive, and when dry very hard. It is prettily marked on the vertical section by fine lines, the edges of laminæ, and when cut with a knife, shows a polish. It varies in color from white to grey and light purple; the stratum is several feet thick, and is underlaid by sand.

For ordinary pottery it is too intractable and is, therefore, mixed with a more sandy variety which occurs near the establishment. It contains nearly three per cent. of iron, a trace of lime, and a little more than one per cent. of potash. A test at the Rookwood Pottery gave a milky-white unglazed biscuit, which shows a shrinkage of about ten per cent.

Another clay locality is in the north-western part of the county, in the east bluff of the creek near Lowe's post-office. The bed is about four feet thick, and is rather silty in character. White sand underlies it here and also in wells in the neighborhood.

A bed of bluish plastic clay is also exposed on the McCracken county line on the old Dolly Gillson place, near Mrs. Houser's, on the road from Paducah to Mayfield. It is four feet in thickness, exposed in the bed of a branch, and is overlaid by about twenty feet of loam.

Another bed of fine plastic clay occurs at Bell City, on the east side of Terrapin creek. Its thickness is not known, but four feet is exposed above ground, covered by eight feet of loam. The clay is variegated in color, but chiefly a creamy-white, and in places contains purple ferruginous concretions filled with sand. The clay is being used at the pottery of Mr. Howard near by, and a good ware is made from it. It is infusible before the blow-pipe, and analysis shows the presence of over two per cent. of iron, a trace of lime, and nearly one per cent. of potash. The amount of alumina is greater than that of Pittman's clay bank, mentioned above.

South of Bell City, along the east bluff of the creek, there are other exposures of clay, but rather sandy in character.

The *sand* that accompanies these clay beds is often of sufficient purity for ordinary glass, though the slight iron stain and the small particles of clay that are usually intermixed with it, unfits it for the finer glassware.



The *brown loam* that forms the superficial deposit over the county makes good building brick when well burnt.

*Iron Ore.*—In the northern part of the county, on the place of Mr. J. R. McClure, two and one-half miles south of Hard Money, there occurs a red hematite iron ore in plates of from one to one and a half inches in thickness. It belongs to the Quaternary gravel beds at whose base it lies; and some of the plates are attached to and hold some gravel in their irregular outlines. While there is much of the ore in the neighborhood, it is not probable that there is a sufficient amount to warrant any expense toward utilizing it.

Some of it has specular faces, and the edges are capable of receiving quite a polish. It resembles that from Mrs. Alexander's place, in McCracken county, an analysis of which showed 58.68 per cent. of iron, 8.3 per cent. of water, 6.60 per cent. of silica, and 1.30 per cent. of other ingredients.

Thick beds of ferruginous sandstone also occur at Mr. McClure's, but of too soft a nature to be of value.

## AGRICULTURAL FEATURES.

The slightly rolling character of the greater part of the uplands of Graves county renders them well-fitted for agricultural purposes, and we find them very generally under fence or cultivation. This is especially true of the uplands away from the water-courses.

The most broken part of the county lies on the east side of Mayfield creek below the town of Mayfield, where the dividing ridge, rising abruptly from the creek to an elevation of seventy-five feet, is furrowed eastward by many ravines and branches, whose courses are to Clark's river. This is especially the case in that narrow portion of the ridge east of Boaz and Viola, while north and south the ridge widens and presents broader and more level lands.

Another broken region is embraced by the head-waters of Bayou de Chien and Obion creek, in the south-western part of the county.

The lands are all derived from the Quaternary loams, which form a superficial deposit over the county of from fifteen to

twenty feet thickness, except where thinned by denudation. The upper layer of about two feet is a brown, loose and light loam, which, when lying suitably for good drainage, is of excellent fertility. When in flats, where the water can accumulate on the surface and remain until evaporation, this loam becomes packed, leached and whitened, the iron of the soil, with some phosphoric acid, being converted into small black gravel or bog iron ore. Such flats become glady and crawfishy, and suitable for little else than grasses. They may be reclaimed by thorough drainage, deep cultivation, and the application of suitable fertilizers or manures.

The lands all wash readily on slopes into gullies and ravines, and no efforts are made in cultivated fields to restrain this tendency by either horizontalizing or ditching.

The uplands are divided into two general classes, viz.: the "Red Oak Barrens" and the "Post Oak and Hickory Timbered Lands."

*Barrens.*—The Barrens cover a large proportion of the area of the county, extending from Mayfield, along the west side of Mayfield creek, northward to the county limit, westward to near Dublin, southward to the Tennessee line, and east to the county limits. The limits can only be approximately defined because of the gradual merging of the Barrens into the timbered region. From Mayfield creek, in the north-western part of the county, the Barrens extend around, east and south, of the head-waters of Brush and Wilson creeks along the county line southward to Fancy Farm, south-east to the east of Wingo, southward to the east of Feliciana and to the State line. Eastward, along the State line, we find the "barrens" beyond Dukedom a short distance, when they recede northward around the heads of the small streams that flow into the State of Tennessee, and around the head of Terrapin creek into the county of Calloway. They cover the county east of Mayfield creek, northward to a short distance beyond West Plains, and nearly to Spring Creek post-office.

Within the area thus outlined there is, usually, a narrow strip of "timbered land" along the edge of the bottoms of the larger streams.



Within the memory of many persons now living, this region was once an open prairie, with scarcely a tree or bush. One gentleman remarked: "In 1854, a person could hardly get a switch between Mayfield and the Obion creek. Prairie grass grew as high as the head of a man on horse-back, and devil's shoe-strings and Indian red root plant were abundant."

Since the opening up of this country to civilization, a growth of red oak and black-jack oak has sprung up over the entire region. These trees have, usually, a uniform height (excepting the undergrowth) of about twenty feet, and there is a notable absence of other varieties or larger growths, except, as remarked above, along the limits of the region or on bluffs of large streams.

This red oak and black-jack Barrens region is regarded as furnishing the best tobacco lands in the Purchase counties. The soil is, apparently, poorer than that of the timbered lands, and the plant does not run to weed so rapidly, thus producing a finer grade of leaf.

When the prairies existed, the lands were considered worthless for tillage; but since trees have sprung up, the soils have been improved by the yearly fall of leaves, etc., and are now of equal value with the timbered soils, each, however, for its own purpose. The yield on the Barrens is about fifteen bushels of wheat, eight of corn, or six to eight hundred pounds of tobacco per acre. If planted continuously in corn or tobacco, the lands are said to wear out in six or eight years. Clover not only keeps up the fertility of land but redeems old worn-out soils.

There is a large amount of flat or glady land on the broad water-divides, and especially on that on which Lynnville and Pilot Oak are situated. Some of the soil is so thoroughly leached as to be quite white and ashy, in fact, a white silt. In water it settles to the bottom quickly, leaving but very little clay in suspension. Small ponds are formed in these flats. Wade's pond, four miles west of Lynnville, covers about three acres, and with an average depth of three feet.

The glady land, when cultivated, is said to yield well in dry years, but in wet seasons the crop is drowned out. An analysis of a specimen of the soil and subsoil of the Barrens,

three miles north-west of Mayfield, shows the presence of insufficient amounts of lime, phosphoric acid and available potash, though there is a large percentage of the latter in the insoluble condition. The soil is sandy and requires the addition of lime.

*Post Oak and Hickory Uplands.*—The so-called *timbered lands* have a growth of red, white and post oaks and hickory, sassafras, and persimmon. The soil is very similar to that of the Barrens and gives about the same product per acre. Tobacco, however, yields a heavier grade. No analyses have been made of these lands, but they resemble in character those of the adjoining counties.

Cotton was once cultivated in patches of from two to five acres each, in the middle and southern part of the county, but seasons were too short to make it profitable. The weed grew from two to three feet high, and is said to have yielded about five hundred pounds of seed-cotton per acre. Planting season was the last of April or early part of May, and killing frost occurred, usually, about the first of October. The only cotton-gin accessible to this region is at Fulton.

*Bottom Lands.*—The lands lying along Mayfield creek and Clark's river are derived from the brown loam uplands, and are, usually, heavy, clayey, intractable and crawfishy, except near the uplands, where a slight slope gives sufficient drainage. The surface is usually black from decayed vegetation. The bottoms are from one-half to one mile in width in the lower portions of the streams, and much less in the upper, and are heavily timbered with poplar, gums, hickory, beech, white and red oaks, walnut, maple and cypress. Chestnut is found on Mayfield creek, south of Mayfield. The bottoms are valuable chiefly for their timber, as their lands are subject to overflow.

*Clark River Valley Flats.*—The flats (or valley) that in McCracken county form so prominent a region along Tennessee and Clark's rivers, extend up the latter stream into this county. At the county line, the belt begins to narrow to a little over a mile, and terminates just before reaching Carter's mill or Kaler post-office.



The valley is very level and open and lies above high water, and is well timbered with post oak and hickory. The soil is of a glady, crawfishy character, very compact and intractable, and is of but little value for tillage. It can be well utilized for grass and grazing purposes. Its timber is also valuable.

The bottom lands of Pryor's creek, east of Mayfield, are one-fourth of a mile wide, and nearly all in cultivation.

The soil is a loam, yielding ten barrels of corn or one thousand pounds of tobacco per acre. The growth is red, black, Spanish and water oaks, hickory, black walnut, red elm, poplar, black, sweet gum, slippery elm, birch, some catalpa and mulberry.

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## CALLOWAY COUNTY.

Calloway county was cut off from Hickman county and organized in 1822. It is the extreme south-eastern county of the Purchase, has an area of 403 square miles, and is bordered on the east by the Tennesseee river and on the south by the State of Tennessee.

More than one-third of the area is drained by the Tennessee and its tributaries, Blood river and Jonathan creek, the latter flowing northward a short distance into Marshall county. The basin of the Tennessee has an area of about 170 square miles. The rest of the county is drained by the East and West forks of Clark's river, which flow independently north and northwestward through Marshall county. The East fork basin has an area of about 160 square miles, that of West fork about 45 square miles. A small area on the south-west sends its waters into Mayfield creek, and southward into the Terrapin creek.

The eastern portion of the county, or that of the Tennessee river basin, is very hilly and broken, the hills rising suddenly above the river valley to 125 feet on the north and 160 feet on the south.

Newberg, or Warburg as it is often called, situated on the

river bank, is about 350 feet above the sea, or a few feet higher than Paducah, back-water from the Paducah overflow, in 1883, rising, it is said, fifty feet above low-water. The hills here are 475 feet above the sea, while southward, between Blood and Tennessee rivers, they rise to 560 and 540 feet. Toward Blood river on the west the altitude falls to 410 feet, but immediately rises again to 550 on the divide between the basins of Clark's and Tennessee rivers. On the Tennessee State line the altitude of the divide is about 600 feet. On the north, near the Marshall county line, it is only about 445 feet.

On the west of Clark's river, Murray, the county seat, has an altitude of about 510 feet, or 70 feet above Mayfield and 160 above Paducah. To westward, however, the county rises, and on the divide between the two forks of Clark's river we find the altitude varying from 540 to 560 feet, or 140 feet above Backusburg, in the valley of the West fork.

The above altitudes were determined by repeated readings of an aneroid barometer, and, it is believed, very nearly approximate the true elevations above the sea.

## GEOLOGIC FEATURES.

Almost the entire county is covered by thick beds of brown loam and gravel of the *Quaternary*, which hide the older formations so completely that their outlines are only to be ascertained by exposures along bluffs, creek banks, deep ravines and in wells.

*Tertiary* material occupies all of that part of the county west of the East fork of Clark's river. The Eocene division alone is represented.

*Cretaceous* sands and clays occupy a belt of country east of the Tertiary, only the Ripley group being observed.

Still eastward the *Lower Subcarboniferous* rocks are found outcropping at the base of the hills below the Quaternary, while in the valley of the Tennessee they are covered by the clays and sands of what seems to be the Port Hudson group; the river itself washes the base of the Subcarboniferous cliffs on the east.



There is very little true *alluvial* or bottom land along the river.

*Subcarboniferous Formation.*—Within this county the formation forms a narrow belt or peninsular between the Cretaceous region and the valley of the Tennessee, reaching northward through this county into Marshall. Only the lower or Siliceous beds occur.

On the south, at Fort Hindman, near the Tennessee line, the bluffs approach to within a very short distance of the river, and expose a vertical section of limestone, shales and dark flint inclosures, in all eighty feet in thickness, and capped by twenty feet additional of chert fragments and Quaternary gravel and brown loam.

The upper limestone strata contain a few Keokuk geodes and crinoidal stems. Westward, along Cypress creek, the limestone exposures are found near the bed of the creek for two and a half miles, or a half mile beyond the crossing of the Concord and Paris Landing road, though the sharp flinty fragments cover the sides of the hills for a short distance above the limestone, overlaid by heavy beds of Quaternary gravel and loam.

On Mr. Ed. Brown's place, down the river, half-way between the fort and Buffalo Landing, the most northerly outcrop of blue limestone in this county occurs. Its exposure is about twenty feet thick, and there is an absence of flint or fossils, except a few crinoids. Westward from Buffalo Landing, the angular flint fragments, which mark the Subcarboniferous, disappear at about three miles, the width of the belt from the Tennessee line northward to near Pine Bluff, being only about two miles. It here widens out, the western limit passing westward about a mile south of Brandon's Mill, to about a mile and a half west of the latter place, and thence turning north.

The angular flint fragments and strata on hill-sides, with siliceous clay, alone mark the formation. East of Brandon's Mill, and northward along the hills to Newberg and Highland, this siliceous debris lie as high as one hundred feet above the creeks and valley, but this elevation decreases westward until the beds of chert disappear at the edge of the Cretaceous shore-line.

On the road from Murray to Newberg the formation is first observed on the west side of Little Sugar-tree creek, ten feet being exposed, and thence eastward to the valley of the Tennessee, on whose bordering hills the vertical exposure was nearly one hundred feet.

In the region of Highland the belt narrows somewhat, or is more generally covered by Quaternary material, the most westerly exposure being observed in the valley of Ledbetter creek, two miles due west from the river.

*Quartzite.*—There is a large area of a quartzose sandstone resting upon the western limit of this Subcarboniferous ridge one-half mile north of the Buffalo Landing and Concord road. The rocks are large and massive, in ledges of five to ten feet each, and apparently forty or fifty feet in thickness altogether.

They outcrop in the bed of a branch, on the sides of the hills, and nearly at the summit, where their uppermost portions are surrounded by gravel and loam beds, and also covered by twenty to forty feet of the same.

The rock is greyish-white and sharp, rather friable in places, and a quartzite in others, the surface stained, to some extent, with ferruginous spots. The gravel is often found cemented to the sides of the sandstone, in one instance the cementing material, ferric oxide, having penetrated the sandstone for several inches, coloring it black and hardening it, gradually fading out into the color and texture of the sandstone, and showing regular horizontal upper and lower limits two inches apart, conformable with the thickness and position of the mass of cemented and adhering gravel. This was at the bottom of the gravel deposit, the line being quite horizontal both on this and other sand-rocks in the vicinity. The rocks are scattered elsewhere, and altogether cover here an area of probably a square mile.

They occur again on the hills in and around Murray, appearing in isolated outcrops, but always massive and thick. In and by the road going north from Murray, their most northern exposure is seen. South of Murray, on the hills to the west of the Paris bridge on Clark's river, they present large surfaces which are much weathered and water-worn. One of the rocks lies on the hill-side, and a deep and wide



groove is cut across its surface as if made by a rush of gravel or other coarse material.

A mile or more south-west of Murray, there are a number of other large sand-rocks exposed below the gravel beds in a ravine or branch, all similar to those first described.

One mile south-east of New Providence, other outcrops occur in a branch and with a thickness of several feet. A ledge of gravel conglomerate rests in the hills seventy-five feet above it.

*Cretaceous Formation.*—Cretaceous sands and clays occur in a belt reaching northward from the Tennessee State line into Marshall county; this is a continuation of the belt that passes from Mississippi northward through Tennessee, only the lower beds of the formation reaching the Kentucky State line. These lower beds are classified as the Ripley group, having been traced by Prof. Safford from Mississippi through Tennessee to the Kentucky State line. There is an entire absence of those fossils which characterize the group in Mississippi. The series comprise thick beds of fine and sharp micaceous sands, varying in color from white to yellow, with thin sheets or strata of white or bluish white pipe-clay. Over the sands are thinly laminated blue micaceous clays, the laminæ separated by fine micaceous sand.

In the region between Blood river and the siliceous ridge on the east, and from the Tennessee line north to the siliceous hills that reach the river south of Brandon's Mill, the presence of lower Cretaceous sand beds are everywhere noticed in deep ravines, hill-sides and in wells, the debris in the lowlands themselves partaking of the strongly micaceous sandy character. This is especially true of the valley of Beechy creek, south-east from Concord, and of McCulloch creek on the west of Blood river.

A well on W. McChristian's place, in a valley, five miles south-east from Concord, shows the sand at three feet from the surface, and its limit was not reached at sixty-five feet. Splendid water was obtained. In a deep ravine at the cross-roads between Beechy creek and Tan Branch east of Concord, there is an exposure of the sand bed showing a highly micaceous and fine sand, varying in color from white to yellow,

and with very sharp grains, a good polishing material for some articles.

On the west of Blood river, and near the State line, at Mr. Witherspoon's, there were penetrated in a well the following strata: Soil, loam and gravel and red sand, eighteen feet; white pipe-clay and yellow sand, three feet; sharp micaceous white clay, fifty-four feet. Still westward, near the head of McCulloch creek, or about three miles from the Paris and Murray road, there is, in a ravine by the road-side, a bluish and yellowish thinly laminated sandy clay twenty-five feet thick, overlying a fine, white and highly micaceous sand, only four feet of which is exposed. This is the last westward exposure of the Cretaceous, and we immediately enter the flatwoods region which is underlaid by the blackish joint-clays of the lower Tertiary, which make their appearance just south-west in Tennessee.

Northward, on the west side of Blood river, the dividing ridge is high and broad, and it is only in the eastwardly flowing streams that any Cretaceous exposures are seen. In the bed of the river, at Brandon's Mill, and still westward along Wild Cat creek to a mile or more beyond Pottertown, and still northward, on one of the branches of Sugar-tree creek, at F. H. Mahan's place, the blue clays are micaceous, and though more compact than the Cretaceous clays found elsewhere, I have referred them to that formation. The clay is pyritous.

In a well near the latter place the following strata were passed through: Loam, ten feet; gravel, twenty feet; white sand, twenty feet; white pipe-clay, two feet; bluish clay, eight to ten feet; then a thin sheet of ferruginous sandstone (which frequently occurs elsewhere below the clay), one inch and less, below which was the water-bearing bed of white micaceous sand.

At Shiloh and Hico, near the Marshall county line, the characteristic clays and sands are struck in wells forty or forty-five feet from the surface. The joint-clay of the Tertiary does not appear east of Clark's river.

*Tertiary Formation.*—In this county, the lower or Lignitic Eocene division alone is represented, and of this, the Porter's



Creek and Lagrange subdivisions of the Tennessee series pass through in a northerly course.

The dark joint-clays or "soapstones" that are characteristic of the Porter's Creek, and immediately overlie the Cretaceous beds, form a narrow belt from the Tennessee line (west of the Paris and Murray road) northward through Murray and Wadesboro into Marshall county, its western margin disappearing beneath the interstratified pipe-clays and sands of the Lagrange group. Clark's river, from Murray, northward, may be regarded as the eastern limit of the formation, as the joint-clay has not been observed east of that stream.

The joint-clay or so-called "soapstone" is a hard, compact slightly micaceous clay, blackish when wet, and jointed in structure, breaking with a conchoidal fracture; its seams usually ochreous, on drying by exposure it becomes grey and crumbles into a shaly mass. It is more or less pyritous, giving to the mass a fetid smell.

It is well exposed in the region of Murray, outcropping in the banks and bed of Clark's river near the Paris bridge, and also in the bank of the small streams respectively two and four miles north; of these, the best exposure is had two and one-half miles north-west of Murray, on the place of O. T. Foster, where the clay lies in thick layers in a bluff nearly twenty feet high, its ochreous jointed nature being well marked.

In another bluff, on Bee creek, the following section is exposed:

| | |
|---|---|
| Loam and gravel | 15 feet. |
| Whitish-grey clay | 2 feet. |
| Dark joint-clay with red seams and an occasional micaceous sand stratum | 4 feet. |
| Black clay, with a predominance of micaceous sand strata, and in places very shaly, to water | 10 feet. |

The lowest stratum is probably Cretaceous, bearing a strong resemblance to the beds of that formation.

Northward, near the Flint Spring post-office, the clay is again exposed by the side of the road. At Wadesboro, in the ravine in the rear of the stores, the gravel is underlaid by a yellow ochreous Tertiary clay, which changes at one foot into the black joint-clay.

In the north-western part of the county the black clays are found, in wells, below thick beds of white pipe-clays. The belt reaches southward, and appears in the east bluff of Clark's river at Backusburg. The clay here is light-bluish, changing to a blackish blue below the water's edge, and contains leaf impressions and fragments of lignite. In a well in Backusburg it was penetrated eight feet without being passed through. In these bluffs it is overlaid by the sands and clays of the Lagrange group, as shown in the following section:

| | | |
|---|---|---|
| Quaternary. | 1. Loam | 15 to 20 ft. |
| | 2. Gravel | 2 feet. |
| | 3. Ferruginous sandstone | 1 foot. |
| | 4. Gravel | 18 inches. |
| | 5. Sandstone | 12 inches. |
| | 6. Gravel | 2 feet. |
| | 7. Yellow sand | 4 feet. |
| | 8. Sandstone | 1 foot. |
| Tertiary. | 9. Fine yellow micaceous sand in white and yellow laminæ | 18 feet. |
| | 10. Mottled colored plastic clay | 18 inches. |
| | 11. More compact whitish clay | 14 inches. |
| | 12. Yellow sand | 2 feet. |
| | 13. Laminated purple, yellow clay and white indurated sand with leaf impressions | 20 feet. |
| | 14. Light bluish clays changing to black below the water | 3 feet. |

At Coldwater, a few miles southward, the black clay, sandy in character, is said to have been struck at twenty feet in digging a well in a creek bottom, while still southward, near Harris Grove, it was reached at one hundred and seventy-five feet in a well on the uplands or about fifty feet below that of the bottom. A log of lignite is said to have been cut in two at that depth.

The *Lagrange group* of interstratified pipe-clays and white and yellow sands overlie the blue clays in the western part of the county.

A section is shown in the bluff at Backusburg, as above given, and its upper beds of white pipe-clay (Nos. 10 and 11), are found northward near Wyatt's school-house, and southward at Bell City, the latter, however, being somewhat darker.

The white pipe-clays found elsewhere in the county, perhaps, belong to this bed, underlying, as they do, the gravel deposits.

*Quaternary Formation.*—The stratified drift and superficial brown loams cover almost the entire county, resting alike



upon the Tertiary, Cretaceous and the narrow Subcarboniferous belt lying between the latter and the Tennessee valley.

The *stratified drift* embraces a lower bed of coarse red sand, holding lumps or small sheets of whitish pipe-clay, mostly rounded, and an upper bed of rounded chert and hornstone gravel, with a few small quartz pebbles and Subcarboniferous fossils.

The sand is more or less stratified and often highly indurated and cemented by ferric oxide into ledges or blocks of ferruginous sandstone. A noted occurrence of the latter has been given above in the bluff at Backusburg. The sandstone is found in many localities, the beds at Concord being several feet in thickness.

On the west side of Blood river, in the valley of Panther creek, the red sand is indurated and stratified in wavy or irregular layers, and holds much white, plastic pipe-clay in rounded balls and sheets; it is said to be twenty feet thick.

Still further north, or about two and one-half miles south-east of Shiloh, on the place of F. H. Mahan, Esq., the same beds are found on Sugar-tree creek. The red sand holding the clay concretions are in irregular horizontal layers, and overlie a bed of evenly deposited sands in strata dipping to the north.

On the hill-side here they have been cemented into many rounded concretions of all imaginable forms, large and small, sometimes resembling, in some degree, the bodies of animals. The concretions usually inclose sand.

The *gravel beds* are irregularly distributed on the uplands, their greatest thickness being in the northern part of the county, where it varies from twenty to thirty feet. At Locust Grove, south of Murray, a thickness of twenty-five feet is said to have been passed through in wells, but this is local.

To the south and south-west the beds thin out to ten or fifteen feet at Murray and Harris Grove, and to but two to five feet at Bell City and Crossland, while two miles west of the latter place gravel is not found, deep sand beds alone appearing. The gravel also becomes finer as it thins out.

On the south-east, all the way to the State line, the average thickness of the bed is about ten feet.

On the Subcarboniferous ridge that forms the western border of the valley of the Tennessee, the gravel is chiefly found from the Tennessee State line northward for five or six miles; but thence nearly to Newburg, the deposit is usually very thin, if, indeed, it occurs at all, the summit of this older formation being almost above the horizon of gravel deposition.

An interesting feature that pertains to the gravel beds of this part of the Purchase is the large region over which a portion of the bed has been cemented into a hard *conglomerate*, forming a regular and apparently continuous bed beneath the superficial loam upon the unbroken uplands. This region lies between Clark's river on the west and the Subcarboniferous ridge on the east, and from the Tennessee line northward to Marshall county, covering the territory underlaid by the Cretaceous.

This conglomerate is similar to the more isolated masses of Marshall and McCracken counties, and its rounded hornstone gravel is so firmly cemented as to break regularly with the rock. The thickness varies from three to as much as twenty feet, the rock usually appearing in layers each two to four feet thick.

In the broad table-land forming the divide between the waters of Clark's and Blood rivers, the rock is said to be struck in almost every well that is dug, and its outcropping edges are found, very generally, on the hill-sides (unless covered by debris), where their continuity has been broken by erosion of the surface of the country. Such exposures are seen on the road east from New Providence, and also on the western upland bluff of Blood river, on the road leading from Murray to Concord, where it comes to the surface. East of Clark's river the rock is fifteen feet in thickness, though in wells further east it seems to be but two feet.

Northward, on the road from Murray to Newburg, at F. H. Mahan's, Esq., there is an interesting locality, which is locally termed "The Volcano," because of its rough and broken appearance, caused by the upturned masses of gravel conglomerate in the creek bottom. It covers an area of about three-eighths of a mile north and south, and one-half mile east and west on Big Sugar-tree creek.



The region shows, admirably, the effects produced by water currents in the undermining of rock strata and the breaking in of the table-rock, and subsequent disintegration and washing away of the smaller masses of debris. Here the summits of the hills are about one hundred feet above the creek, the upper portion composed largely of gravel and a conglomerate of gravel ten to fifteen feet thick. This originally rested upon a bed of stratified highly micaceous fine sand, probably Cretaceous, seventy or eighty feet of which is now exposed in the bluffs.

The creek, doubtless, removed these sands from beneath the conglomerate, and the latter, from their own weight, broke apart and fell into the deep chasm. These immense rock masses now occupy, in some places nearly horizontal, and in others almost vertical, positions, and dip or rather slope toward the center of the valley. A large part of them have been worn away, and those left occupy somewhat isolated positions. In the valley, and parallel with the bluffs, are low ridges composed almost altogether of loose gravel from the disintegration of the rocks.

There is a so-called cave known as Hogan's Hole, reaching now fifteen or twenty feet under one of the large and nearly horizontal rocks. It is said to have been, at the time of the first settling of the county in 1828 or 1830, the hiding place of a murderer, who was captured only by being smoked out by the posse of men.

In the northern part of the county the conglomerate is not as prominent, though frequently observed jutting out in bluffs beneath the gravel and loam.

On the east bluff of Clark's river, several miles north of Murray, there is an exposure of twenty-five feet of the hard conglomerate in layers of two to four feet.

The *Brown Loam*, comprising the upper part of the Quaternary, covers nearly the entire surface of the county. Its thickness varies from fifteen to twenty feet on the west and north-west, to six or ten feet at Murray, southward and eastward, and less than that toward the Subcarboniferous ridge, upon which it is very thin. Its characters are the same as in other counties, viz.: an upper two feet of brownish-yellow

and easily tillable loam, and an under-stratum of heavier but lighter colored loam, permeated with seams of a grey, silty earth.

In the Tennessee Valley the loams of the valley proper are similar to the above, but are somewhat micaceous.

*Port Hudson Group.*—This formation, represented by blue clays and lighter micaceous loams, occupies the valley of the Tennessee river, its initial point being at or near the point where the State line strikes the river, and where the high limestone cliffs almost reach to the water's edge. This point, too, may be regarded as the base of the long and narrow Subcarboniferous peninsular that reaches northward to Calvert City, a distance of thirty-five miles.

As shown at Highland Landing, at the Marshall county line, the beds embrace twenty-five feet of alternating deep blue or blackish clays and yellowish sands, in layers varying from a foot or more to only a few inches. A bright-blue mineral earth, Vivianite (a phosphate of iron), speckles the lower exposed blue clay bed. A brownish micaceous loam, seven feet in thickness, caps the blue clay and sand formation.

At Newburg the same beds occur, but the Vivianite was not observed. At Pine Bluff a section shows fifteen feet of micaceous loam, a few feet of stiffer, lighter clay, underlaid by the interstratified blue clay and yellow sands. Southward, or up the river, the formation is overlaid by a foot of gravel and several feet of red clay, which is a feature characteristic of the valley of the river a few miles southward in Tennessee. The valley has a width of about a mile.

## ECONOMIC GEOLOGY.

The chief natural resources of the county are its soils, timbers, clays and iron ores. Besides these, there is but little else worthy of mention. The first two will be treated of under the head of agricultural features.

CLAYS.—There are, within the county, quite a variety of clays, refractory and unrefractory, and in color from a creamy-white to blue and black. With cheap and easy transportation facilities, many of them would, probably, find a ready market for the manufacture of various wares.



The black joint-clays or "soapstones" so-called, occupy a belt from the Tennessee State line, northward through Murray and Wadesboro into Marshall county, being exposed at a number of points along the west side of Clark's river. They underlie the Flatwoods of the southern part of the county west of New Providence.

One of the most prominent of the exposures is in the north bluff of Clark's river at the Paris bridge, a mile south of Murray. The clay here is, as elsewhere, in jointed layers with a yellow ochreous clay permeating the seams. The joints have a conchoidal character. The clay is massive, blackish when wet or freshly exposed, and becomes of a grey color on drying, when it is also highly tenacious. Very fine mica scales give a more or less sparkling appearance to the clay.

Other exposures of ten to twenty feet again occur in the bluffs of creeks north of Murray, and in the ravines that border the road northward to Wadesboro.

The thickness of the bed has not been ascertained, and in the deepest wells of the region the clay has not been passed through.

At Wadesboro, the upper part of the bed, as seen in the ravine just back of the stores, is highly ochreous in character for six or more inches.

A chemical analysis of a sample from the Paris bridge shows the presence of but a small amount of lime, nearly one per cent. of potash, and three and a half of iron, after nearly forty per cent. of sand had been removed. Tests made at the Rookwood pottery show it to be refractory at a high temperature, producing a pinkish unglazed biscuit.

It cannot be glazed except by the intermixture of a large proportion of other more plastic clays, the glaze otherwise having a tendency to shiver. The specks of mica produce small black dots in the biscuit. The clay can, therefore, be used only for such ware as require no glazing.

Another class of black clays, more plastic in character, occurs east of the joint-clays just described, a prominent outcrop being on the place of F. H. Mahan, Esq., six miles a little north of east of Murray. It is also somewhat mica-

ceous, sandy and refractory in character, burning to a creamy-white biscuit.

An analysis shows that there are present in this clay nearly twice as much clay as in the joint-clay, a trace of lime, and about one per cent. each of iron and potash. It is highly refractory, and would, probably, make good fire-brick, etc., and differs from the celebrated German fire-clays only in a higher potash percentage.

A similar black clay occurs in the southern part of the county, immediately underlying a bed of white plastic clay, on the place of Rufus Morris, just west of Blood river. It contains small pyritous concretions.

*White pipe-clays* are abundant throughout the county, chiefly, however, on the east and west of the black joint-clay belt.

Beginning on the north-west, a highly plastic and white variety occurs in a branch bottom at the junction of the road from Mayfield with that extending south from Brewer's mill post-office to Backusburg in S.4, T.3, R.3E.

The thickness of the bed could not be ascertained, but must be several feet. It is in places of a pinkish tint; the upper eighteen inches is of a mottled white and yellowish color. On burning it gives a white biscuit, and is quite refractory in a high heat. The sample subjected to analysis was of the purer portions, and contains a very large percentage of clay, a trace only of iron, three-fourths per cent. of lime, and less than half a per cent. of alkalies.

The same clay appears in the branch south of this place, and also in the bluffs east of the river at Backusburg, where, however, it is only eighteen inches thick.

Southward to the State line the country is high, being the water-divide between the tributaries of the East and West forks of Clark's river, and, therefore, so little washed into deep ravines as to afford but very few exposures of clays, and none of these are of importance.

To the east of Murray, and of a line passing through it, north and south, there are several beds of white clays, and of these that of Russell's pottery, six miles east, is of the



most importance, producing, as it does, a beautiful cream-colored ware on glazing. There is, however, great difficulty in getting it to take a glaze without "crazing" or being permeated with fine cracks.

The bed underlies six feet of brown loam, four and a half feet of sandy clay, one foot of white clay, and one and a half of a dark clay, and is three feet in thickness, underlaid by a brownish sandy clay and yellow micaceous sand. An analysis shows the clay to contain but little lime, and more than one per cent. each of iron and alkalies.

Another locality of white pipe-clay is on the place of Mr. Rufus Morris, near Blood river, east of New Providence. It is exposed in a deep ravine, and above the bed of black clay mentioned above. It has a surface covering of ten feet of loam and gravel, and is interbedded with white sand in thicknesses of from two to eighteen inches, and in its thickest portion holds pockets of fine white sand. The clay is refractory at a high heat, producing a white biscuit, which, on glazing, becomes brownish-white in color. It is stained to some extent with yellow ochre. An analysis shows the presence of a little lime, about two per cent. of alkalies, and a little more than one and a half per cent. of iron.

Other clays are found in other parts of the county, but in beds so thin as to be of no value.

Iron Ores.—In the south-eastern part of the county, in the region known as the Coalings, there is found embedded in the gravel beds, nearly along the edge of the uplands facing the Tennessee valley, masses of iron ore in size varying from a pound or so to as much as fifty or seventy-five pounds. The ore is rather concretionary in character, sometimes inclosing clay or gravel and with bright specular inner surfaces. It is irregularly distributed through the gravel deposit, and requires the expenditure of much labor and time in its exposure and removal to the furnace, an expense apparently not commensurate with the amount of ore obtained. A furnace was at one time in operation near one of the ore beds, its charcoal or fuel being obtained from the surrounding timbers. It, however, ceased operations many years ago. From another bed, a mile or more north of the furnace, the ore has been shipped to furnaces in Tennessee.

SANDS.—The beds of sand in the eastern part of the county, and especially those exposed in the hills bordering Beechy creek, are sharp-grained, and more or less tinted with iron. The ordinary glass could be made of it, but the sand is too impure for the finer qualities.

## AGRICULTURAL FEATURES.

The agricultural features of the county have the variety usual to the Purchase country, and embrace the upland timbered lands, barrens and flatwoods, and the lowland valley of the Tennessee river and creek bottoms. The alluvial bottoms and the cane hills of the western counties are here absent.

As already remarked, the surface of the uplands is rolling and in places more or less broken, though not so much so as to interfere seriously with cultivation.

The so-called *timbered uplands*, or oak and hickory lands, comprise the largest proportion of the county area. The soil is a brown loam, some two feet in depth, overlying a brownish clay loam, which is permeated with seams of a light grey silt. Where well drained, the soil is loose and easily tilled, producing good crops of corn, small grain and tobacco. Its growth is usually several varieties of oaks, hickory and a scrubby undergrowth. Where drainage is inadequate the soil becomes compact, whiter in color, and impervious to water, which stands on it in pools in rainy seasons. Such flat places are most frequent upon the dividing ridges between the streams.

This is especially so upon the divide between the East fork and Blood river east of Murray, which reaches north from New Providence to within a few miles of Shiloh post-office.

The timbered region is largely under cultivation, the soils being well suited to the growth of corn, oats and tobacco. The analysis of a sample of soil taken five miles east of Murray (as given in the general report), shows a deficiency in phosphoric acid and lime, and a fair amount of potash. The addition of lime or gypsum would, doubtless, render available much of the one and one-third per cent. of potash now existing in an insoluble condition. The deficiency in phosphoric acid is characteristic of nearly all of the "timbered uplands" of the Purchase counties.



In the south-eastern portion of the county there is a region known as *The Coalings*, because of the cutting away of its timber and its conversion into charcoal for use in the iron furnaces, a number of years ago, since which time it has grown up in a low growth.

The original timber was red, black, post and Spanish oaks and hickory. The area covered by this region reaches for about two and a half miles north from Shannon creek, and about three miles from the river bluff westward toward Concord.

The soil (whose analysis is given in the general report) differs from that of other uplands in being deficient in available potash, though there is a fair amount in the subsoil at six to twelve inches from the surface, and also more than one and a half per cent. in an insoluble condition. Very little of this region is under cultivation.

That portion of the timbered region known as the *Flatwoods*, in the southern part of the county, reaching from the Tennessee State line northward nearly to Murray, in an area about three miles wide and six long, is the northern end of that extensive and narrow belt that reaches southward through the State of Tennessee, across the north-east corner of Mississippi, and thence south-eastward into Alabama. Its surface is quite level and ill-drained, covered with a compact and whitish soil (apparently a leached brown loam), and has a timber growth of chiefly post oaks.

In this state it is hardly in cultivation, its soil being not only cold and ill-drained, but poor and deficient in all of the available elements of plant food. Even the presence of half a per cent. of lime seems not to have had any affect on the proportion of insoluble potash. The subsoil also is but very little better than the soil.

The remaining uplands of the county are comprised in the region known as *The Barrens*, formerly an open prairie, but now grown up in a low growth of red and black-jack oaks. The region covers almost the entire portion of the county lying west of the East fork, and is a part of that large central bar-

rens country that covers nearly all of the adjoining county of Graves. Along the immediate uplands bordering the streams there is, usually, a strip of land timbered with other growth. The southern limit of the barrens is the Purchase water-shed, which lies in a general east and west course nearly along the State line.

A large proportion of the region is quite level, especially along that broad divide separating the tributaries of the East and West forks of Clark's river, and reaching from Murray west to and beyond Harris Grove, and also north-westward to and beyond Kirksey. The slight rolling nature of the surface, however, gives to it a natural drainage, and much of the land is under cultivation, largely in tobacco.

An analysis of a fair sample each of the soil and subsoil, taken from four miles north-west of Murray, shows a great deficiency of available potash in the soil, and a large percentage in an insoluble condition, with scarcely any lime. The subsoil contains a fair amount of potash in an available condition, and it is, probably, to this that the land owes its reputation as being first-class for that potash-loving plant—tobacco. Phosphoric acid is deficient in its percentage, in both soil and subsoil.

The lands are said to yield as much as one thousand pounds of tobacco per acre.

The *Valley of the Tennessee*, bordered on the west by the high and, in places, quite precipitous upland bluffs, reaches from the State line northward into Marshall county, with a width varying from but a few hundred yards at the former to as much as one and a half miles toward the latter point.

The general surface of the valley is uneven, because of narrow strips of low bottom land along the river front, and low creeks, swamps or flats along the foot of the bluffs on the west, thus leaving an elevated plain along the central portion.

At the State line limestone outcrops high up in the bluffs, from whose foot to the river the land is flat, rather of a bottom character, but all under cultivation. Going northward, we find the limestone only at the foot of the bluffs, and the general surface features as just described begin.



There are then three soil divisions within the valley, viz.: the river bottom, the flats and creek bottoms, and the valley proper.

The former or *river bottoms* are narrow and of no special importance, occurring only at different points, and scarcely affording sufficient areas for cultivation, except on the south, as already mentioned. The timber of the first or lower bottom is hickory, white, water and red oaks, poplar, gum, linn, box elder, some ash, sycamore and black walnut.

The soil, alluvial in character, is said to produce as much as ten barrels of corn per acre. It is subject to overflow.

A kind of second bottom here has a timber growth of white and red oaks, poplar, black locust and hickory. Its soil is more clayey, and will produce about eight barrels of corn, one thousand pounds of tobacco, or fifteen to twenty bushels of wheat per acre. Both bottoms are excellent for clover and grasses.

In this portion of the valley the ridge that forms the central feature is said by Mr. Ed. Brown to be especially adapted to the production of a very fine grade of the bright tobacco. This land, beginning about one mile from the State line, reaches a distance of four miles, and is all under cultivation. Its soil is a dark loam, underlaid by a red or yellow clay subsoil at about six inches, and has a timber growth of red and white oaks, poplar and some gum, chestnut and black locust.

Northward, toward the Marshall county line, the ridge is very generally under cultivation. The soil is a light-brown micaceous loam, originally having a growth of red and post oaks, hickory and sassafras.

Analyses made of the above two characters of central valley lands shows quite a difference in the respective percentage composition; that of the valley generally having but a trace of lime, a low percentage of phosphoric acid and of potash, that of the southern and richer portion having much more lime, a low percentage of phosphoric acid, and a fair amount of potash except in the subsoil, which is very rich in the latter element. There is also more iron in the subsoil.

The flats that border the creeks lying on the west side of the valley have a surface soil very rich in decayed vegetation,

but at a few inches are underlaid by a stiff and yellowish-white crawfishy subsoil, impervious to water and cold in character. The growth of Shannon creek is white and red oaks, poplar, gum, hazel, hickory, and some walnut. An analysis of the soil shows a little lime, a good percentage of phosphoric acid, while that of the potash in the soil is fair, and in the subsoil quite large. These flats are but little under cultivation.

The *bottom lands of Clark's river* lie chiefly on the west side of that stream, varying in width from but half a mile or less south of Murray, to as much as a mile on the north.

They are subject to overflow, and, therefore, are under culture to but a small extent, except near the borders of the upland, whose washings have given the bottom a slightly higher elevation.

The soil is for the most part stiff and crawfishy in nature, its surface more or less permeated with decayed vegetation. The timber growth comprises white and Spanish oaks, poplar, hickory, sweet and black gums, walnut, dogwood, sassafras and papaw.

An analysis of a specimen taken near Murray shows a fair amount of available potash, and a deficiency in lime and phosphoric acid.

The absence of drainage also makes these lands unfit for any other crop than corn or grasses.

The bottom lands of Blood river and other streams are usually narrow, and their soils cold or crawfishy, and but little under tillage.

# APPENDIX III

## TO GENERAL REPORT.

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### THE PADUCAH WELL, BORED TO A DEPTH OF 1,250 FEET, SHOWS AN IMMENSE FAULTING OF PALEOZOIC ROCKS.

Just as the last pages of the Calloway County Report were being put in type, I received samples of material, taken at various depths, from the well recently bored in Paducah for gas. These have been closely examined, and the results are herewith briefly presented. The samples were taken by J. C. Farley, Esq., and forwarded to me by W. L. Bradshaw, Esq., of Paducah.

The well penetrated to a depth of 1,250 feet, and was abandoned because of the difficulties attending the work, such as the occurrence of caverns, cracks causing deflections of the auger, and especially the volumes of water entering the pipe. Streams of water were passed through down to a depth of 600 feet, or to the bed of calcareous shale; but beyond that the water came in volumes through the cracks and seams of the limestone; and altogether, the manager or contractor asserts that he had to contend with greater difficulties than in any of the many wells that he had previously bored in Ohio and Pennsylvania.

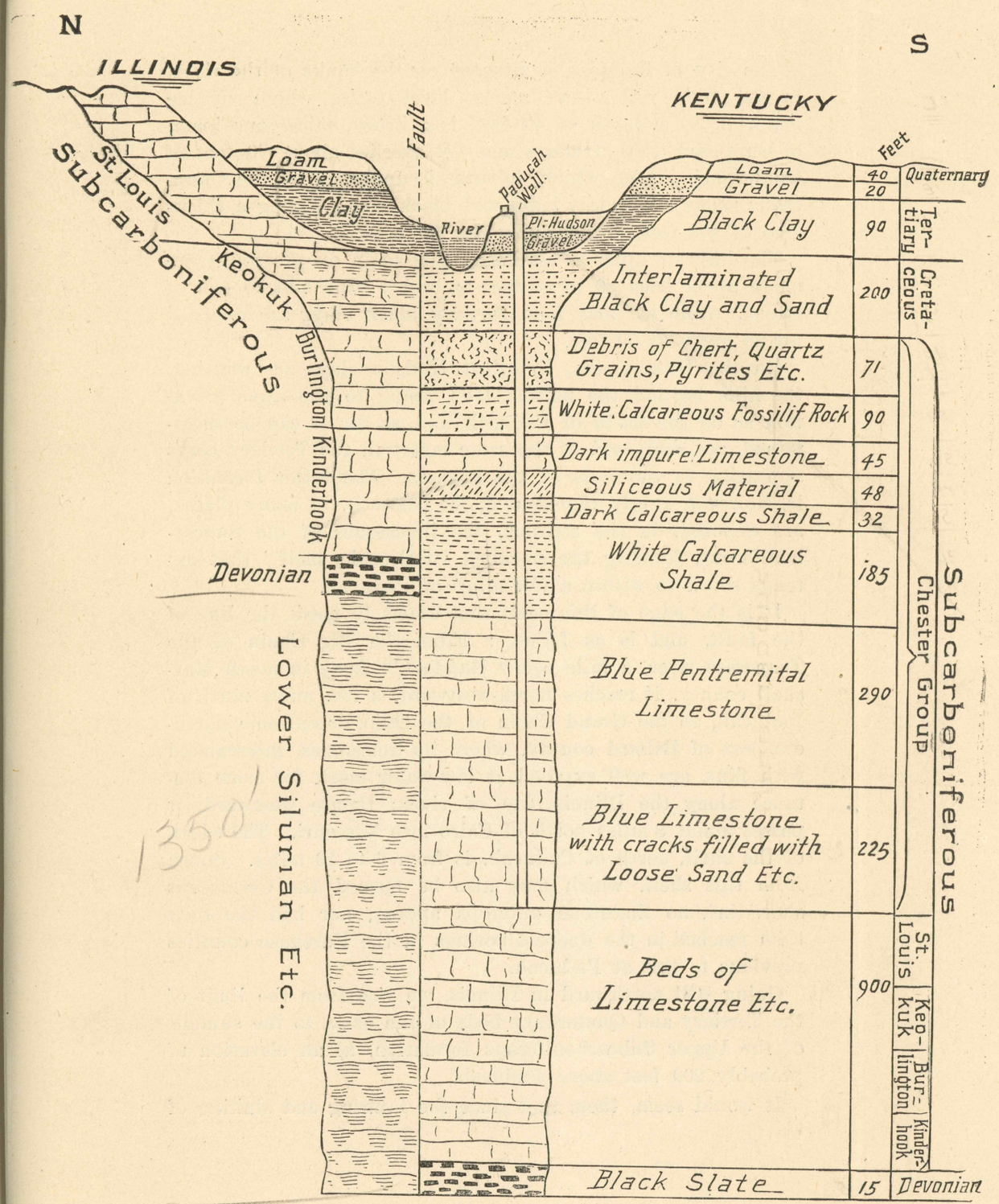
The boring of this well is extremely fortuitous, though not realizing the hopes of the projectors. It has revealed the depth of the Paleozoic rocks below the Quaternary surface of this portion of the gulf embayment, and the nature and thicknesses of the several formations that filled this basin; but, above all, bored in such close proximity to the Paleozoic shore line, or "shelf," as it is called in the report, it has indicated clearly, and almost beyond doubt, that this portion, at least, of the embayment is the result of the im-

mense faulting of the Paleozoic rocks, that portion south of the Ohio river sinking to a depth of more than 1,300 feet. That this occurred during the Chester or upper Subcarboniferous period is indicated by the presence of its beds at the depth of 264 feet below Paducah. The blue limestones that underlie these at 735 feet from the surface are unmistakably of the Mountain Limestone (Tenn. series), as shown by a characteristic *pentremites Godonii* brought up by the auger from the upper portion of the limestone.

The accompanying illustration is intended to represent the rock strata passed through, and also the faulting of the strata, with an ideal section of the formations on either side. The Illinois section is taken from Dana's Geology, the State Report not being at my command.

The following section gives the character of the material brought up by the auger:

| | Character of Material. | Feet. | | Geologic Formation. | |
|---|---|---|---|---|---|
| 1. | Micaceous brownish surface loam | 40 | | Quaternary. | |
| 2. | Rounded chert and quartz gravel | 20 | 60 | Quaternary. | |
| 3. | Fine micaceous sand and clay, interlaminated | 204 | 264 | Cretaceous. | |
| 4. | Debris of white and dark chert, hyaline sand, pyrites, and smoky quartz crystals. The lower 18 feet is cemented by a bright red iron ochre, and holds numerous crinoids, bryozoa, and plates and spines of the Echinoid *Archæocidaris* | 71 | 335 | Upper Subcarboniferous. | |
| 5. | White, porous, and slightly calcareous rock; also containing many crinoids, bryozoa, and echinoids | 90 | 425 | Upper Subcarboniferous. | |
| 6. | Dark impure limestone, with some crinoids and bryozoa, fragments of cemented calcareous material, and a small flat mass of quartz crystals; the rock is cavernous | 45 | 470 | Upper Subcarboniferous. | Chester. |
| 7. | Limestone and siliceous rock, dark and light colored; some calc spar, crinoids; cyathophyloid corals and pyrites in lower portion; rock is cavernous | 48 | 518 | Upper Subcarboniferous. | Chester. |
| 8. | Dark calcareous shale, blue marl and sand, with small crinoids, spines and plates of *Archæocidaris* and cyathophyloid corals | 32 | 550 | Upper Subcarboniferous. | Chester. |
| 9. | White calcareous shale, with calc spar, pyrites, and a few crinoids | 185 | 735 | Upper Subcarboniferous. | Chester. |
| 10. | Blue Limestone, with crinoids; a *pentremite* brought up from upper portion. | 400 | 1,135 | Upper Subcarboniferous. | Chester. |
| 11. | Blue Limestone, with crinoids. The bed, with the lower portion of that above, is permeated with cracks, filled with sand, etc., to bottom of boring | 115 | 1,250 | Upper Subcarboniferous. | St. Louis. |



The city of Paducah is situated on the banks of the river, in the Ohio valley—an almost level plain, whose surface material, to a depth of 40 feet, is a brown micaceous loam, of supposed Port Hudson age. It overlies about 20 feet of Quaternary gravel, which, in turn, is underlaid by the Cretaceous sands and thinly laminated black clays, having a thickness of 204 feet, as shown by the boring.

The hills or uplands bordering this plain on the south are made up of from 30 to 40 feet of brown loam and 20 feet of gravel, while at their foot Tertiary black clays are exposed for as much as 30 feet.

On the Illinois side, the Port Hudson clays are wanting, the hills beyond the bottom land rising to the same elevation as on the south of Paducah, and, so far as can be ascertained, are composed of the same material, the Tertiary clays appearing in the beds of the streams. The latter formation is, however, thinly represented, for below it, in many places, are exposed, in the streams, the limestones of the Subcarboniferous, forming the so-called "Paleozoic shelf" that extends south to within a few miles of Paducah.

It is the edge of this shelf that seems to mark the line of the fault, and is as follows: From the Big Chain of the Tennessee river, a mile below Haddock's ferry in north Marshall county, it reaches north-westward, a few miles north of Paducah, to the Grand Chain of the Ohio, or extreme northern part of Ballard county, where its limestones, intercalated with flint, are well exposed at low-water mark for some distance along the Illinois side of river; thence westward, it passes about 8 miles north of Cairo into Missouri. The width of the shelf, north of Paducah, is from 6 to 10 miles. South from this shelf, which may also be termed the Cretaceous shore-line, no limestone outcrops appear, nor had the rock been reached in the deepest borings in the Purchase counties previous to this at Paducah.

Going still northward in Illinois, we rise from the limit of the Tertiary and Quaternary beds of the basin to the summit of the Upper Subcarboniferous formation, at an elevation of probably 200 feet above Paducah.

It would seem, then, that since the faulting and sinking of



the rocks, the basin has filled up to a depth of 204 feet with Cretaceous beds (the oldest of the geologic series of the basin both here and in States south), to the upper edge of the so-called Paleozoic shelf, and that the Tertiary and Quaternary beds were deposited over this formation and upon the shelf to the Paleozoic hills on the west, north and east, leaving still a high bordering rim of the latter.

The deposit in the region of Paducah is shown by the boring to have an entire thickness of about 365 feet, from the bottom of the basin to the summit of the neighboring uplands.

The only rock masses referable to formations older than the Cretaceous are those quartzites occurring almost in a direct course from Palestine Church, 8 miles northwest of Paducah, south-eastward via Byers' place, 5 miles south of Paducah, to Murray, in Calloway county.

The character of this rock, and the general course of the line of its outcrop, led to the conclusion that it belonged to the Onandaga beds of Illinois, and it is so treated of in the report; but from the revelations made by the boring, it is more than probable that these quartzites are in reality the remnants of Chester sandstones, though highly quartzose in character.

The mass of loose material, 71 feet in depth, lying immediately below the Cretaceous (in the boring), and forming the bottom of the embayment basin previous to the deposition of sand, etc., was, doubtless, originally a part of the more solid underlying rock, as the character and fossils of both are similar; this portion, probably, being broken up by the violence of the waves along this shore-line, while at the same time it received accessions from the washings of the bordering highlands.

The fossils brought up by the auger from the series of strata as far down as the blue Pentremital limestone, embrace crinoid stems, bryozoa, cyathophylloid corals, the plates and spines of *Archæocidaris Norwoodi*, and of many undetermined elliptical crinoid stems. These beds are, in the aggregate, 471 feet thick, and their position above the Pentremital limestones, as well as the nature of their fossils, clearly indicates for them an Upper Chester age; marl beds characteristic of the formation were also present.

Below these strata, the auger penetrated 515 feet of blue limestone, in the upper part of which was obtained the *Pentremites Godonii* of the Mountain Limestone division already alluded to. The upper 290 feet is said to be "cavernous," while the remaining lower portion is "permeated with cracks which are filled with sand, etc., causing much trouble by deflecting the auger."

In Tennessee, near the Kentucky line, the Mountain Limestone has a thickness of about 400 feet, and assuming this as correct for this locality, it would appear that the lower 115 feet of the boring was in the St. Louis limestone. This latter division is not made to appear in the above ideal sketch.

*Depth of the Faulting.*—Taking the Mountain Limestone as a basis in determining the depth to which the rock strata on the south side of the fault have sunk from their original position, we have the following data: The limestone stratum in original position, at the level of Paducah on the Illinois side, is about 35 feet above the upper part of the Keokuk, as exposed at the Grand Chain of the Ohio; and the latter is 700 feet above the surface of the Mountain Limestone in the boring. From the Keokuk beds up through the overlying St. Louis and Mountain Limestone divisions there are about 650 feet, making in all 1,350 feet as the depth of the faulting.

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