STRUCTURE OF THE VICKSBURG-JACKSON AREA, MISSISSIPPI, WITH SPECIAL REFERENCE TO OIL AND GAS.

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INTRODUCTION.

Many facts have combined to lead the people of Mississippi to believe that oil and gas may be found in that State, among them the extensive development of the oil and gas fields in Louisiana; the situation of the State between the Appalachian fields and those of the coastal region; the supposed indications, such as gas seeps and iridescent films resembling oil found on stagnant pools of water; and finally the results of the work of so-called "oil experts," who have located "streams" of oil crossing the State. Though the United States Geological Survey does not consider these reasons conclusive, others of a general geologic nature are considered worthy of investigation and of sufficient significance to justify the hope that the oil and gas pools of the Coastal Plain may not be confined to Louisiana and Texas but may extend eastward into Mississippi. The presence in that State of beds which are of the same geologic age as those that bear oil in Louisiana, which are similar in composition to those beds, and which were deposited under similar conditions, and the possibility of finding rock folds here like those of that region, are considered significant.

It has been shown that the inclination or dip of the beds of rock, commonly called geologic structure, is the most potent factor in influencing the accumulation of oil in commercial pools. Consequently the study of the attitude of the rocks of the region and the location of rock folds, particularly arches (anticlines) and domes in the beds, leads to the location of areas in which oil and gas are most likely to be present. Such a study is of value to the oil prospector in that it makes possible the separation of favorable from unfavorable areas, and increases his chance of success. It should be understood, however, that any drilling outside of proved territory is in the "wildcat" class, even though the wells are drilled on anticlines, for other conditions, which can not be detected at the surface, may prevent the accumulation of oil and gas.

The object of this report is to show which of the areas in west-central Mississippi that were examined by the Survey are considered favorable and which unfavorable for the accumulation of oil, to discourage drilling in the unfavorable localities and thus to aid those interested in making conclusive tests to determine the presence or absence of oil and gas in the region.

Examination of the geologic structure in this region shows that sands corresponding to or possibly identical with those of northwest Louisiana dip deeply beneath the younger formations which compose the surface rocks, and that the rock beds in this region are similar to those in northwest Louisiana. The most pronounced fold is found near Jackson, and this fold appears more promising for wildcat testing with the drill, because if oil or gas are present this structure is more favorable for their accumulation. Other folds, one near Vicksburg and another near Eldorado, also invite tests. It must not be forgotten, however, that the formations carrying the oil sands in the Caddo region are here much more deeply buried, and that the sands in this deeper part of the Mississippi embayment may contain water instead of oil and gas.

FIELD WORK.

The field work for that part of this report which deals with the area near Vicksburg was begun by G. C. Matson, E. H. Finch, and the author in March, 1915. In June the work was extended northward and eastward by the author from Vicksburg to Satartia and along Big Black River from Bovina to Bentonia, thus completing the work on the area covered by an advance notice given to the press September 1. In October and November, 1915, the author spent five weeks in extending the work eastward to include the region near Jackson.

The field work consisted largely of tracing out different beds of the Vicksburg limestone, which were used as keys to the structure, and determining the elevations of these beds at different places. Other beds, both above and below the Vicksburg limestone, were used locally to determine the dip and the general structure, although only those within the limestone formation itself could be traced accurately from place to place throughout the area. Because of the hardness of the middle limestone member of the Vicksburg, and consequently because of its better exposures, its top was used as the datum for the structure contours. The different parts of the Vicksburg have persistent features by which they can be clearly recognized, and, as the distance between them is known, the elevation of the top of the limestone may be estimated at places where it is not exposed. As the dip of the beds is slight, at few places greater than 60 feet to the mile, it was necessary to determine its elevation with considerable

accuracy. Elevations above sea level were accepted as determined by the United States Geological Survey in the Vicksburg, Jackson, Florence, and Raymond quadrangles; by the United States Coast and Geodetic Survey along the line of the Alabama & Vicksburg Railway from Brandon to Edwards; by the War Department along the east bluff of Yazoo River from Redwood to Satartia; and by the Agricultural Department along Big Black River from Bentonia south to Bovina. In the region east of the Big Black, the elevations of outcrops were determined almost exclusively from level lines run by plane table from the nearest bench mark. Some leveling was done in this way west of the river, but most of the work there was done with an aneroid barometer. This method is fairly reliable and was considered necessary, for the outcrops lay in deep, densely thicketed hollows along the bluffs of Big Black and Yazoo rivers, and it would have been impossible to complete the work within the time and money available if level lines had been run to them, and as the elevations were known at almost all points along the river valleys at the foot of the bluffs the elevations determined by the aneroid could be checked within a short time, before changes in atmospheric pressure could affect the results. Elevations in the area between Big Black and Yazoo rivers were not important, as few significant exposures were found there; some were determined, however, with an aneroid, which was carried between two bench marks and error eliminated by comparison with the barograph records of the United States Weather Bureau at Vicksburg.

ACKNOWLEDGMENTS.

The author is indebted to Mr. G. C. Matson for part of the field work and to a greater extent for his criticism and supervision. Mr. Matson traversed a large part of the area west of Big Black River and verified the results which the author had worked out in detail.

To Mr. E. H. Finch the author is indebted for a number of logs of wells at and near Vicksburg, some of which he obtained personally and others through correspondence.

To Mr. C. W. Cooke the writer is indebted for the identification of a number of collections of Eocene fossils taken from deep wells. The data thus obtained were used in estimating the thickness of the Jackson formation and the Claiborne group in this area.

The author has used freely the reports that deal with the region, especially those by Hilgard[1] and Crider.[2] From these reports, particularly from Hilgard's, a list of a number of obscure outcrops was obtained.

[1] Hilgard, E. W., Report on the geology and agriculture of Mississippi, 1860.

[2] Crider, A. F., Geology and mineral resources of Mississippi: U. S. Geol. Survey Bull. 283, 1906.

LOCATION OF THE AREA.

The area discussed in this report covers about 30 townships, or 1,080 square miles, and includes the greater part of Warren and Hinds counties, the southern parts of Yazoo and Madison counties, and the western part of Rankin County, in west-central Mississippi. It is roughly rectangular, 40 miles long and 25 miles wide, and extends from Vicksburg eastward a short distance beyond Jackson. Vicksburg lies in its southwestern corner and Jackson occupies an east-central position within it. It is bounded on the west by Yazoo and Mississippi rivers, and is traversed roughly from north to south by Big Black and Pearl rivers in its western and eastern parts, respectively. (See Pl. VIII, in pocket.) The Alabama & Vicksburg Railway crosses the area from east to west in its south-central part; the Yazoo & Mississippi Valley Railroad runs north and south through Vicksburg in its western part; and the Illinois Central and the Gulf & Ship Island railroads cross its eastern end through Jackson.

TOPOGRAPHY.

The topography of the Vicksburg-Jackson area is no more diversified than that of other areas in the Coastal Plain where the maximum relief does not exceed 300 feet, the maximum elevation above sea level is not greater than 500 feet, and where there are only slight differences in the hardness of the rocks. The main features are the broad, flat valleys that cross the region in general from north to south and the interstream areas, which in the western part of the area are much dissected and have angular topographic features and in the eastern part are flat or rolling plains.

The elevation of the broad river bottoms increases from west to east; that of Yazoo River is about 100 to 110 feet, of the Big Black 130 to 150 feet, and of the Pearl 260 to 280 feet. The hills between the Yazoo and the Big Black rise abruptly from the river bottoms to elevations of 250 to 350 feet above sea level. This area is deeply dissected by small streams that have carved into it an intricate system of deep hollows and steep ridges, which are characteristic of the loess that covers it and hides the underlying rocks.

East of the Big Black the loess becomes thinner and disappears and the rough country gives place to the broad, flat or rolling "prairie" lands of the Jackson clay. These rolling lands, which have a general elevation of 350 feet, prevail in much of this area but give way along the line between Hinds and Madison counties to the rough hilly country which forms the divide between Pearl and Big Black rivers. The hills that form this divide have a maximum elevation of about 475 feet and are outliers of high terrace deposits, of sands of the upper part of the Jackson formation, and in a few places, of Vicksburg limestone.

GEOLOGY.

STRATIGRAPHY.

FORMATIONS PRESENT.

All the rocks of the Vicksburg-Jackson region are sedimentary in origin and relatively young, the exposed rocks ranging in age from Claiborne (Eocene) to Recent, as shown in the upper part of the following table. The formations below the Claiborne will be reached in deep drillings.

Section of formations in Vicksburg-Jackson area.

System.	Series.	Group or formation.	Thickness.	Character.
			Feet.	
Quaternary.	Recent.	Alluvium.	.....	Sand, clay, and silt along present streams.
	Pleistocene.	Loess and yellow loam.	0–100	Clay, fine gray to buff, calcareous, and yellow to brown loam.
		Alluvial terrace deposits.	0–50	Sand, gravel, and clay.
Tertiary.	Pliocene.	Sand and gravel.	0–50	Terrace sand and gravel.
	Oligocene.	Catahoula sandstone.	0–75	Unconsolidated sands, sandstones, gray siliceous clay, and some lignitic material.
		Vicksburg limestone.	80–130	Marl and clay above, containing marine shells; limestone and impure limestone and marl below.
	Eocene.	Jackson formation.	250–500 (?)	Sand above, cross-bedded, green to yellow nonfossiliferous; gray clay weathering black below and sand beds at base. Both clay and sand beds contain marine shells.
		Claiborne group.	500–1,000	Marls, sands, lignitic clays, and lignite above; quartzite, clay stone, and marl below.
		Wilcox group.	850–1,500 (?)	Lignitic clays and sands, with sand predominating in middle part.
		Midway group.	100–300	Clay, dark gray to black, and micaceous sandstone, with hard limestone and sandy marl below.
Cretaceous.	Upper.	Ripley formation.	50–300	Sands, clays, marls, and impure limestones of marine origin.
		Selma chalk.	600–1,000	Chalky limestone with argillaceous and sandy beds.
		Eutaw formation.	300–400	Sands, massive and cross-bedded.
		Tuscaloosa formation.	100–300	Irregularly bedded sands, clays, and gravels, containing clay and lignitic layers at top.

Of these formations the loess and the Jackson underlie by far the greater part of the area, and the Vicksburg and Catahoula formations and terrace sand and gravel smaller areas. The Claiborne occurs in a very small area near Jackson. The lower formations, with the possible exception of the Wilcox, have not been penetrated, so far as known, in this area.

CLAIBORNE GROUP.

The only beds of Claiborne age in this area are exposed near the northeastern part of Jackson in the bottoms of some small branches. Good exposures are found along Moodys Branch, in the S. ½ sec. 35, T. 6 N., R. 1 E., and along another small branch a mile farther northeast in the SW. ¼ sec. 25 of the same township. These exposures consist of green micaceous sand and clay containing streaks and scattered particles of comminuted vegetable matter. Hilgard[1] says that "at the penitentiary well, after passing through 32 feet of surface material and fossiliferous strata of the Jackson age, lignitic clay was penetrated for 418 feet, after which a bed of shells 20 feet thick, extremely rich in greensand, was passed through into water-bearing sand." T. W. Vaughan[2] considers that the lignitic sand and clay intervening between the marine fossiliferous Jackson and the marine Claiborne occupy precisely the stratigraphic position of the Cockfield formation of Louisiana and applies that name to them here.

JACKSON FORMATION.

The weathered outcrops of the Jackson formation cover probably half the eastern part of the area and form the dark-colored sticky soil which characterizes so much of it. Its type locality is in and near the city of Jackson where, for such a soft, easily eroded material, it is well exposed. On lithologic grounds Lowe[3] has divided the formation into three members, called by him Moodys Branch marl, Yazoo clay, and Madison sand, which are clearly recognized, although it is questionable whether the "Madison sand" properly belongs to the Jackson or to the overlying Vicksburg.

The lower division, the Moodys Branch marl of Lowe, is so called from its exposure in a branch so named in the eastern edge of Jackson. Here it is composed of a dark-green to yellow glauconitic

[1] Hilgard, E. W., Report on the geology and agriculture of Mississippi, p. 123, 1860.

[2] Willis, Bailey, Index to the stratigraphy of North America: U. S. Geol. Survey Prof. Paper 71, p. 738, 1912.

[3] Lowe, E. N., Mississippi, its geology, geography, soils, and mineral resources: Mississippi Geol. Survey Bull. 12, p. 81, 1915.

sandy marl, containing an abundant marine fauna, and has a thickness of 25 feet, according to Lowe.[1]

The marl of Moodys Branch grades upward into the typical gray to yellow calcareous plastic clay, which is in places a clay marl, and has a total exposed thickness of about 80 feet at Jackson. This lithologic division of the Jackson outcrops in numerous small exposures along roadsides and streams over a wide area, and in the bluff at Yazoo City there is 120 feet of bluish-green fossiliferous marly clay containing gypsum in the upper part. Similar material, containing beds of fine-grained micaceous clay marl, outcrops at intervals for a distance of 15 miles south of Yazoo City, and 75 feet of similar material occurs in a hill 1 mile southeast of Satartia. This wide belt of outcrop suggests a considerable thickness if the dip is uniform; but as the beds do not dip uniformly here, no reliable estimate can be made. Some records of wells in the southwestern part of the area indicate a thickness of 350 to 500 feet for this division. (See well log, p. 120.)

These beds of clay have a marked tendency to slump or creep, as is well shown in the bluffs at Yazoo City and in any railroad cuts which expose this material, as those just south of Cynthia. When fresh these clays and clay marls are bright green to bluish green, massively bedded and jointed, as shown in a deep hollow half a mile northeast of Mechanicsburg. In weathering they form a lumpy or hackly clay of yellowish to brownish-yellow color and finally make a dark, sticky soil, which covers large areas in Hinds and Madison counties.

These clays grade imperceptibly upward into the "Madison sand," which is nonfossiliferous. The gradation of these sands into the marine Jackson below and Vicksburg above and the absence of fossils make it difficult to determine to which formation these nonmarine beds belong. From the lithology and from a consideration of this small area only a line of separation could be drawn best at the small lignitic bed below the base of the fossiliferous Vicksburg. In the absence of definite information regarding the age of these sand beds, the usage in previous reports will be followed in considering them Jackson, although the evidence presented under the heading "Vicksburg limestone" (see p. 103) seems to indicate that the upper part, at least, is Vicksburg in age.

[1] Op. cit., p. 81.

The following sections show the general nature of the beds between the marine Jackson and Vicksburg formations:

Partial sections of Jackson and Vicksburg formations.

Forest Hill School, 5½ miles southwest of Jackson.

	Ft.	in.
Limestone, pure, white, partly weathered	3	0
Limestone or marl, soft, sandy, containing hard nodules and marine shells	3	0
Clay, gray, sandy, nonfossiliferous, containing lime nodules now altered to chalk	4	0
Sand, pure quartz	3	0
White chalk layer		1
Sand and clay, gray, laminated	4	0
Streak of earthy lignite		2
Clay, drab, sandy		6
Sand, medium to fine grained, containing thin ferruginous and clayey layers	6	6
Sand and clay, laminated, cross-bedded	2	0
Sand, hard, cross-bedded, containing some thin clay laminæ above and numerous thin platy layers of ferruginous sandstone throughout	12	6
Same as preceding bed; sand green when fresh and yellow when weathered, thick bedded below and thinner above	25	6
Clay, drab, sandy, grading downward into typical Jackson clay with plastic gray calcareous clay of Jackson formation below	10	0
	125	5

Rocky Hill Church, 10 miles north of Jackson.

Limestone, in hard and soft layers	25	0
Sand, massive, yellow	4	0
Clay, brown, carbonaceous, gypsiferous	1	0
Sand, micaceous, and numerous thin clay layers	12	9
Sand and small amount of clay	4	0
Sand, micaceous, and numerous thin clay layers	7	4
Sand alternating with thin clay beds	19	6
Sand, hard, yellow, and little clay	8	3
Sand, argillaceous, becoming dominantly clayey below	16	1
Clay, slightly sandy above, grading to plastic gray clay of Jackson type below	27	6
	125	5

These sand beds are well exposed in fresh condition at two localities, one in the northwestern part of the area and the other in the southeastern, and they have been found to be closely similar. In the southern part of sec. 15, T. 4 N., R. 1 E., 3½ miles south of Plain, there is exposed below a 6-inch bed of hard lignite, which occurs near the base of the fossiliferous Vicksburg, 30 feet of thinly laminated, micaceous, highly cross-bedded, nonfossiliferous sand, which is green when fresh and weathers to a rusty yellow color; it is car-

bonaceous above but is less so below and is underlain by a bed of stiff gray clay in the creek bottom. In a deep ravine near S. T. Dilley's house, 1 mile north of Phoenix, there is exposed 30 to 40 feet of bluish-green micaceous sand, thin carbonaceous streaks, grayish-green clay, and laminated sands and clays containing much comminuted vegetable matter. This section differs from the one south of Plain in the presence of more vegetable matter and clay. Here silicified wood is very abundant, and numerous trunks and fragments of trees may be seen in place. At the outcrop of these beds along Pearl River silicified logs are abundant in the river bed. The thickness of this sand member differs from 60 to 80 feet in this area.

VICKSBURG LIMESTONE.

The type locality of the Vicksburg limestone is in the bluffs near the city of Vicksburg, where almost its entire thickness is exposed. It is composed largely of limestone and marl, which represent the latest marine deposits in the area. From the area south of Vicksburg outcrops of this formation are found at intervals for a distance of 30 miles in a north-northeasterly direction along the east bluff of Yazoo River almost to Satartia; here the outcrop changes its course and crosses the State into Alabama in a fairly uniform southeasterly direction, with the exception of a U-shaped bend to the south around Jackson. The formation is thin and consequently its outcrop is narrow, but owing to the presence of relatively hard limestone beds near its middle part it outcrops at numerous places and can be readily traced across the area, except where it is covered with loess.

The following section shows the relationship of the Vicksburg to the Jackson below and the Catahoula above:

Composite section of Vicksburg limestone and parts of adjacent formations as shown near Vicksburg and along bluffs of Yazoo River.

	Feet.
Catahoula sandstone:	
Exposed near pesthouse, Vicksburg:	
22. Sandstone, medium grained, white, differing in induration from soft to quartzitic, interbedded with gray siliceous clays	20
21. Clay, gray, and soft sandstone layers; clay is deep blue when fresh and weathers through greenish to gray, in part plastic and in part highly siliceous	35
Vicksburg limestone:	
Exposed in bluff at Waltersville near Vicksburg:	
20. Sandy clay, chocolate-colored, fine grained, carbonaceous, nonfossiliferous	20
19. Sand, fine grained, laminated, nonfossiliferous	6
18. Marl, glauconitic, and soft marly limestone with some sandy, argillaceous layers; contains marine shells	35

	Feet.
Vicksburg limestone—Continued.	
Exposed at Haynes Bluff:	
17. Limestone, hard, brown, ferruginous	5
16. Limestone, hard and soft layers interbedded	17
15. Limestone, soft, marly, blue when fresh and gray to yellow when weathered	4
14. Limestone, hard, containing few fossils	3
13. Limestone and marly limestone, marine shells abundant; where exposed in bed of streams causes small falls	17
12. Clay, dark grayish green; contains marine shells	1½
11. Shell marl, carbonaceous, arenaceous	3
10. Shell marl, sandy; at top of lower falls very fossiliferous	3
Exposed near southern edge of E. A. Archer's property near Eldorado:	
9. Clay, carbonaceous, nonfossiliferous	10
8. Sand, green, calcareous; contains marine shells	4
7. Concretionary limestone layer with shells abundant	1
6. Sand	2
5. Shell rock, coquina	1
Jackson formation:	
Exposed near southern edge of E. A. Archer's property near Eldorado:	
4. Shale, brown, carbonaceous, with thin sandy layers	11
3. Sand, medium grained, orange to yellow	12
2. Sandstone, ferruginous	2
1. Shale, green, sandy, and sand interlaminated	5
	217½

The conditions at the close of the marine Vicksburg were very much the same as at the beginning, as the carbonaceous beds both above and below indicate. The small streaks of lignite at the base of the marine Vicksburg show that swamps existed immediately preceding the transgression of the sea, which caused the deposition of the limestone above. Although this change in many places is abrupt, there seems to have been continuous deposition or at least no interval of erosion from Jackson into Vicksburg time, and while shallow-water and nonmarine deposits were forming here, farther east in Alabama marine conditions continued without a break.[1]

At the close of the Vicksburg the conditions were similar to those at the beginning. The withdrawal of the sea led to the formation of carbonaceous clays and sands, which gradually gave place to the siliceous clays and sandstones that compose the Catahoula formation. Thus deposition is believed to have been continuous from the Vicksburg into the Catahoula.

[1] Smith, E. A. The underground water resources of Alabama, p. 19, Alabama Geol. Survey, 1907.

The Vicksburg may be conveniently divided into four parts. Its basal beds consist of dark-colored, in places highly carbonaceous, fossiliferous sand and clay, which grade upward into sandy marl and are separated from the nonfossiliferous sands below by a thin but fairly uniform bed of carbonaceous clay or lignite. These beds are 20 to 25 feet thick in the bluffs along Yazoo River and thin out to the east, so that in the vicinity of Jackson the limestones above rest directly on unfossiliferous sands and clays below. (See sections at Forest Hill and at Rocky Hill, p. 100.) This apparent thinning is doubtless due to the fact that these beds become more sandy and unfossiliferous to the east and thus appear to represent the top part of the sands below. In other words, part at least of the sand beds in the sections near Jackson are of Vicksburg age and were laid down contemporaneously with the lower fossiliferous beds along Yazoo River.

Above the fossiliferous sand, clay, and marls there are limestones, impure limestones, and marls interbedded in layers from 1 to 3 feet thick, forming numerous small bluffs. The harder beds of limestone are semicrystalline; the marly beds are soft when first exposed but harden on drying. Both the limestone and the marl are more or less glauconitic and are bluish gray when fresh, but weather to gray or yellow. These beds are the most easily and definitely recognized of the entire section in the region and have been used as the basis for structure contours. The thickness of this limestone unit decreases from 35 or 45 feet in the western part of the area to about 30 feet in the eastern part near Brandon and along Pearl River below Jackson.

This limestone unit is overlain by dark-gray micaceous sandy marl, shell marl, and some chalky limestone layers. It is less calcareous above and more argillaceous and in places carbonaceous. The thickness of this calcareous fossiliferous unit is 30 to 35 feet along the Yazoo bluffs and decreases to about 15 feet in the vicinity of Jackson. This marl is bluish or greenish when fresh and is usually somewhat glauconitic. Owing to its softness it weathers readily and is well exposed in few places.

In the western part of the area the marl is overlain by 5 to 10 feet of fine gray argillaceous sand, which is nonfossiliferous and which is succeeded by 20 to 25 feet of chocolate-colored fine-grained sandy clay, which grades upward into the gray siliceous clays of the Catahoula formation. To the east this unit thins so that on Big Black River near Edwards it is not over 18 feet thick. Beyond Pearl River, on the Gulf & Ship Island Railroad (see section, p. 104), the fossiliferous marls are immediately overlain by the gray, siliceous clays, characteristic of the Catahoula formation. Along the river south of Byram, however, the section is in every way similar to that farther west. (See section, p. 104.)

This upper nonfossiliferous unit is tentatively considered part of the Vicksburg because the fossiliferous beds at the top of that formation grade into this material and are interbedded with it. The dividing line is placed at the top of these beds, where they are in contact with typical Catahoula clay, although there are similar beds of carbonaceous clays and sands within that formation.

The thickness of the Vicksburg limestone decreases from 120 or 130 feet in the western part of the area to 80 or 100 feet in the eastern, due largely to the thinning of the lowest division.

The character of the individual beds of the upper division of the Vicksburg formation is shown in the following sections:

Partial section of Vicksburg limestone along south side of Wansley Bend on Pearl River in west-central part of sec. 36, T. 4 N., R. 1 W.

	Ft.	in.
Clay, carbonaceous, nonfossiliferous, in part massively bedded.		
Marl, green, glauconitic; contains marine shells	5	6
Limestone, hard, nodular, irregular layers		6
Marl, green, glauconitic, weathering gray to yellow	3	0
Limestone, hard ledge		9
Limestone, soft, or marl	1	1
Limestone, hard ledge	1	6
Marl, green, glauconitic	6	0
Limestone, hard ledge	1	6
Limestone, soft, chalky	3	0
Clay, light colored		6
Marly limestone, light bluish green; marine shells abundant	3	0
Marl, clayey in lower part	2	6
Limestone, hard ledge	1	6
Limestone, soft, marly	1	0
Water level in Pearl River.		
	31	4

A more detailed section of the beds which compose the limestone unit of the Vicksburg formation is given below:

Section of Vicksburg limestone on Gulf & Ship Island Railroad, 1½ miles southeast of Plain, Miss.

	Ft.	in.
Clay, gray, plastic, nonfossiliferous, weathering yellow	8	0
Clay, plastic, containing white chalky layers and concretions, light tan when fresh and dark brownish when weathered; marine shells abundant	5	6
Marl, light yellow, sandy; contains marine shells	4	6
Limestone, chalky, and marl, white to yellowish in color, containing abundant small white lime concretions	2	0
Shell bed, slightly indurated		4
Marl, ferruginous, sandy, containing hard limestone nodules and abundant fossils	1	0

	Ft.	in.
Shell bed, orbitoides, pectens, and the like		6
Marl, sandy; shells abundant, especially in lower part	1	6
Limestone, soft	2	3
Limestone, hard ledge, with irregular base	2	3
Limestone, medium soft	2	0
Limestone, soft, marly	1	0
Limestone, hard	1	6
Shell marl, soft	2	3
Limestone, hard	1	0
Limestone, soft, shelly	3	4
Limestone, hard ledge, light colored	2	9
Marl, soft, sandy; contains marine shells; concealed below	1	6
	43	2

CATAHOULA SANDSTONE.

The nonmarine sandstones and clays of the Catahoula formation underlie the southern part of the area and cross it in a general southeasterly direction parallel to the outcrop of the Vicksburg limestone. The type locality of the Catahoula is not far south of Vicksburg, in Catahoula Parish, La., opposite the exposures at Grand Gulf, from which the formation was formerly named, and practically duplicates them. The lower 25 to 50 feet of the Catahoula consists largely of bluish and greenish siliceous clays, which weather gray and are interbedded with soft white sandstones and plastic clays. Higher the formation consists of clays like those below—sandstones, quartzites, carbonaceous clays, and thin beds of lignite.

These materials do not extend over large areas as continuous beds but occur as disconnected lenses. The sands range in induration from almost loose materials through sandstones to dense quartzites, their hardness depending on how firmly the sand grains are cemented. The cement consists of white, opaque silica, which stands in sharp contrast to the translucent quartz grains and is a characteristic feature of the formation. Much of the so-called clay is composed largely of finely divided silica.

Section of Catahoula sandstone along road one-half mile west of Byram.

Clays, dark carbonaceous.	Feet.
Sandstone, bluish white, soft, and clay with some hard layers	20
Clay, siliceous, and sand, partly concealed	20
Sandstone, hard, white	3
Sandstone, thin beds, separated by gray clay	2
Clay and sand, gray to yellow	10
	55

Another section of the Catahoula, which shows its range in lithology, is as follows:

Partial section of Catahoula sandstone, sec. 19, T. 5 N., R. 1 W., 11 miles west of Jackson.

Hilltop.	Ft.	in.
Sand, fine, gray, containing thin clay layers	5	0
Sandstone, hard, medium grained		8
Sand and clay, hard, yellowish gray	1	6
Sandstone, medium fine grained, micaceous, cemented with opaque silica	2	0
Clay, hard, carbonaceous, siliceous	1	0
Clay, hard, gray, siliceous	20	0
Lignite, impure		4
Sand, gray, argillaceous	1	2
Sandstone, hard, fine grained; containing gray siliceous clays at foot of hill	1	0
	32	8

Only the lower part of the formation is exposed in this area, and where it occurs the structure is generally low and not favorable to accumulation of oil and gas; therefore this formation is not likely to be penetrated by the drill in testing the area.

SAND AND GRAVEL.

After the deposition of the Catahoula sandstone there was a period during which no sediments were laid down in this region and those that had been formed were gently folded and extensively eroded. Upon this eroded surface gravel and sand were laid down when the land surface was relatively much lower than now. Small remnants of one of the high terraces capped by these materials are now found in the eastern part of this region at an elevation of almost 500 feet above sea level. As the country was gradually uplifted and eroded other terraces were formed at progressively lower levels, and the wearing away of the upper terraces yielded a large part of the material for the lower ones.

The scattered remnants of terrace gravel, together with the weathered outcrops of some of the older sandy formations, were formerly classed as "Orange sand" by Hilgard,[1] who considered this material to represent a mantle of surficial deposits spread over the older rocks. Later the formation was more restricted and renamed "Lafayette."[2] Still closer study has led to the separation of most of that part of Hilgard's formation and also of the "Lafayette"

[1] Hilgard, E. W., Report on the geology and agriculture of Mississippi, pp. 5–46, 1860.

[2] G. C. Matson has recently applied the name Citronelle formation to the upper terrace deposits of Pliocene age. (Matson, G. C., and Berry, E. W., The Pliocene Citronelle formation of the Gulf Coastal Plain and its flora: U. S. Geol. Survey Prof. Paper 98–L, 1916.)

which represented the oxidized outcrops of the older formations from the true terrace sands and gravels, which in many places they closely resemble. In this region the weathered outcrop of the sands between the marine Vicksburg and Jackson formation commonly resembles the sandy terrace deposits.

These terrace deposits, which are progressively younger from the highest to the lowest, are composed of orange or yellow, medium to coarse grained sand and gravel and irregular layers and pebbles of clay. The gravels average probably an inch in diameter, but some are as much as 3 inches or more. They consist largely of fairly angular chert pebbles and of less numerous well-rounded quartz pebbles. The chert pebbles contain many fossils which show clearly that they came from the area of Paleozoic rocks to the north or northeast. The deposits range in thickness in this area from a few inches to 50 feet or possibly more.

The gravel is most abundant on high hills, as the upper terrace deposits were less sandy and contained a greater amount of coarse-grained material than the lower ones. Gravel beds of considerable extent occur at many places along the bluffs of Yazoo River, near Champion Hill, a few miles northeast of Edwards, and north of O'Neal schoolhouse near Tinnin. At a number of places these gravel beds are worked for road metal. Large exposures of sandy terrace deposits are found along the road one-third mile south of McRaven, ane one-half mile south of Taylorsville; orange-colored sand more than 50 feet in thickness is present.

LOESS AND YELLOW LOAM.

The loess is the most conspicuous formation in the western part of the Vicksburg-Jackson area and hides the older formations over a large part of it. Its western limit is the east bank of Mississippi and Yazoo rivers, where it has its maximum thickness of 50 to 100 feet. From this region it orginally spread east, diminishing in thickness and covering both hills and valleys for a distance of 15 to 20 miles.

The loess is a gray or buff calcareous material composed largely of fine sand and containing lime nodules and snail shells; the yellow loam is less calcareous and in part coarser grained and does not contain fossils. The loam is more variable in composition than the loess and in places contains a large amount of medium-grained sand. It underlies the loess. The loess forms smooth, almost vertical exposures; the loam forms equally steep slopes but develops a buttressed or crenelated appearance and on further weathering shows a roughened, cracked surface which differs from that of the loess. The loess gradually disappears a few miles east of Big Black River; the

loam, however, is well developed where the loess disappears and extends, though diminishing in thickness, 5 to 10 miles farther east. The loess gives rise to a peculiar topography (see p. 96), which is characterized by steep slopes and irregular drainage. Old roadbeds are in places entrenched 40 to 50 feet in it where the roads descend from the hills to the valleys, and in rough country the roads are worn to an even grade by traffic and running water acting on the homogeneous material. The loess shows very faint lines of stratification, if any, and appears to consist of a uniform mass of fine dust-like material. In many railroad cuts it shows distinct lines parallel to the surface configuration, which appear to represent a feature of surface weathering.

The loess is believed to be a wind-blown deposit, which was brought up from extensive mud flats that bordered the Mississippi below its bluffs during the glacial and interglacial stages and spread over the bluffs to the east of the river.

STRUCTURE.

GENERAL FEATURES.

The general structure of the Gulf Coastal Plain is simple. A series of beds slopes gently southward and passes successively deeper and deeper beneath more recent deposits toward the coast. This general dip toward the coast is interrupted by local steepening or flattening and in a few places by a reversal in direction. These irregularities of dip, which are of greatest significance in the accumulation of oil and gas in valuable pools, are well illustrated in the Vicksburg-Jackson area.

The principal structural features of this area are the Jackson anticline, the Vicksburg monocline,[1] and the Eldorado monocline. There are other features which are small, irregular, and not well outlined. The two monoclinal folds are believed to be older than the Jackson anticline, which has interrupted their eastern extension. These structural features are post-Catahoula in age and probably in large measure earlier than the highest terrace deposits.

METHOD AND ACCURACY OF REPRESENTATION.

Structure may be thought of as the surface form of a single stratum of rock, including its upfolds, or anticlines, and its downfolds, or synclines. The shape and location of such folds are best represented on a map by contours, or lines connecting points of equal ele-

[1] The term monocline here signifies the downward bend and tilted portion of a series of approximately horizontal beds. A series of such monoclines produces step folds with structural terraces between them.

vation on the stratum taken for reference, which in the area here considered is the Vicksburg limestone. On the accompanying map the lines are drawn at intervals of 20 feet and are marked with the elevation above sea level of the top of the hard middle limestone member of the Vicksburg. It is evident that the lines of different elevation will be close together where the rocks dip steeply and far apart on gentle slopes, and the dip is from the contour with the higher number to the adjoining one with a lower. Thus contours represent both the direction and rate of dip.

The hard limestone near the middle of the Vicksburg formation (Nos. 17 to 13 in the section, p. 102) was chosen as the datum of reference, or key rock, because it contains the most clearly recognized and easily traced beds in the region. Elevations were taken on all the outcrops of this limestone in the area, and where the outcrops are numerous the structure is definitely determinable and is outlined with solid contour. Where so represented the contours are believed to be correct within 10 feet. Where exposures of the limestone are far apart, and where other less well-defined beds were used for reference and the interval to the limestone calculated, broken contours are used. Finally, where the data were still less reliable the broken contours are questioned. In general, it is believed that the unquestioned broken contours are correct within 20 feet. Although much of the structure is outlined by broken contours, there are enough solid ones to show that the structure is essentially as represented.

JACKSON ANTICLINE.

The city of Jackson is situated near the center of a broad, gentle fold, which shows a domelike arch in cross section from northwest to southeast, and a terrace-like form from northeast to southwest, as shown on Plate VIII. Near the southwestern and southern parts of the anticline the dips are steepest, as much as 60 to 70 feet to the mile; and in the northwestern and southwestern parts the dips are gentle, at a rate of 30 feet and less per mile. The northern extent of this fold has not been determined, and as Hilgard[1] has stated the beds are at least as high at Jackson as at Canton, 25 miles farther north. The beds are nearly horizontal in the intermediate area, but have possibly a slight northerly dip. Thus the fold is more strongly developed here than farther north, even if it continues beyond the area mapped. This development of the fold necessarily follows from its transverse position with regard to the dip of the beds which, if the deformation were equal at both ends, would make the elevation of the beds lower on the south.

From a short distance north of Jackson there is probably a slight dip northward toward Madison Station, although the exposures are

[1] Hilgard, E. W., Geology and agriculture of Mississippi, pp. 128–129, 1860.

not sufficient to determine its amount. This dip is evident from the presence of lower beds at Jackson than are exposed in the area to the north. Just where the southerly dip observed at Jackson flattens and is reversed in direction can not be accurately stated, but it is certainly only a short distance north of town.

The anticline is represented on the accompanying map (Pl. VIII) as more flat topped than it really is, because it is not possible, with the information available, to locate accurately the contours above 460 feet. That the fold in the area rises above that level is proved by the presence of the middle clay member of the Jackson at such an elevation on the hills that if the interval between its top and the top of the limestone be added the limestone would lie at about 500 feet. This proves that the fold is at least that high, but how much higher can not be stated, because the clay is uniform in lithology, and no key beds have been recognized in it.

There are two minor folds shown on the sides of the anticline that are of interest—one at Forest Hill School, which seems either to parallel the axis of the major fold or to be a continuation of it, and the other near Plain. Both are shown by slight deflections of the contour lines. The continuation of the one near Plain as a cross fold, passing northwest near Jackson, would account for the beds there being higher than farther north.

The general dip beyond the southern limits of the area contoured is southerly at the gentle rate of about 20 to 30 feet to the mile.

VICKSBURG AND ELDORADO MONOCLINES.

The folding west of Big Black River is much less pronounced and in a different direction from that near Jackson. Here the rocks are only slightly disturbed from their normal position, and, instead of having a general southerly dip over the entire area, the dip is accentuated at two places, forming monoclinal folds. In the intermediate area the rocks are practically horizontal, forming a structural terrace. Both these folds are more pronounced to the west, and they lose their individuality east of Big Black River in the long, gentle slope which forms the west limb of the Jackson anticline.

The downward bend of the strata which forms the Vicksburg monocline extends from Vicksburg northeast past Bovina to Big Black River, as outlined on Plate VIII. From this place the strata dip southward at an average rate of 18 feet to the mile, and the Vicksburg limestone gradually disappears under the overlying Catahoula sandstone.

North of this fold the beds remain flat for about 10 miles, forming a broad structural terrace which has a slight upwarp near its middle part. Beyond this level stretch the beds bend upward for a few

miles, forming the Eldorado monocline and flatten again. The crest[1] of this monocline extends from a point near Eldorado post office southeast toward Cox Ferry on the Big Black, where it is obscured by other folds to the east. (See Pl. VIII, in pocket, for exact location.) At the west end of the fold, as mapped, the dip to the south is about 25 feet to the mile from the crest of the monocline, and north of it the dip gradually lessens and the beds become horizontal and remain so to a point beyond Phoenix. The east end of the monocline is less pronounced and is obscured by other gentle folds to the east.

There are no exposures of the key rock in the area between Big Black and Yazoo rivers, and the contours are drawn across this area in the most direct way. The Vicksburg and Eldorado monoclines do not end abruptly at the bluffs on the east side of Mississippi and Yazoo rivers, but their western continuation can not be shown because of the absence of exposures in that direction.

MINOR STRUCTURAL FEATURES.

A fold of unknown form and magnitude is suggested by the contour lines near Brownsville. The exposures in that area have not been sufficiently studied to determine the exact character of the folding, which, however, may not be worth further investigation unless the main structures here outlined prove to be productive.

Another irregularity in the general dip of the rocks is found near Champion Hill. The Vicksburg limestone is exposed at about the same level near this station as it is 5 miles southwest on Jackson Creek, 1½ miles above the place where it empties into Bakers Creek and 3½ miles south-southeast of Edwards. The exposures here are not sufficient for an exact determination of the structure, which is believed to have the form suggested on the map (Pl. VIII, in pocket).

Near the middle of the broad structural terrace between the Vicksburg and Eldorado monoclines there is a low, gentle rise which dies out to the west and forms a projecting anticline from the larger fold to the east. The location of this anticline is only approximately shown, because of the absence of exposures over the area.

FAULTS.

Breaks in the strata, called faults, are not believed to be common in this area, and evidence of only two has been found; one occurs on Richland Creek, 5 miles southwest of Brandon, and the other on Pearl River, below Jackson.

[1] The line along which approximately horizontal strata are bent downward to form a monocline is called the crest of the monocline. It is analogous to the axis of an anticline. The position of such a line is different for each successive stratum. In this report the location of the crest is determined from observations on the top of the hard limestone of the Vicksburg.

One-half mile down Richland Creek from the crossing of the Brandon-Florence road a thick bed of Catahoula sandstone crosses the creek and dips at a high angle to the north. This outcrop is between two exposures of the Vicksburg on the same creek and appears to represent a part of the Catahoula exposed in the bluff of the creek near by. Its abnormal dip is believed to be due to a fault.

At Richmond Lake Bluff on Pearl River, 5½ miles by air line below Jackson, a prominent exposure of bluish calcareous clay with thin layers of earthy limestone of Jackson formation dips at the abnormal rate of 5°–6° S. This steep dip appears to continue for some distance downstream, and in the NW. ¼ NW. ¼ sec. 10, T. 4 N., R. 1 E., near the upper end of Steamboat Bayou, 30 to 40 feet of the overlying sand is exposed. Here the river bottom contains numerous silicified logs, which appear to have weathered out of the sand, a bed in which they are abundant. Around the bend to the east the underlying gray calcareous clay is again found, thus suggesting that the abnormal dip above mentioned is due to an eastward-trending fault which has a downthrow on the north side that brings the "Madison sand" into contact with the underlying clay (Yazoo clay of Lowe). As further evidence of this break, one-third mile below the supposed fault a long exposure in the west bank of the river shows a number of small faults which have throws of a foot or less, with the downthrow on the north side. These faults are clearly shown by a thin layer of limestone in a clay bed. The general dip here is about normal.

POSSIBILITIES OF OIL AND GAS.

GENERAL CONSIDERATIONS.

The occurrence of oil and gas in commercial quantities depends on a number of factors, among which may be mentioned conditions favoring the formation of oil or gas, the presence of a porous stratum, or "sand," between two impervious layers to act as a reservoir, and favorable structure for accumulation.

Although it has been said that "the best indication of oil is a little oil," there are a number of the important fields in this country which showed no trace of oil prior to the tapping of the productive sand by the drill. This was true of the Caddo, De Soto and Red River, and Corsicana fields and, with the exception of salt domes, seems to be particularly true of Coastal Plain fields, where the gentle folds have not been greatly faulted, and where the soft shale and clay may seal those faults that are present so as to prevent leakage. Thus the lack of seeps of oil can not be used as a proof of its absence in the underlying strata. Drilling, moreover, has not been deep enough to throw any light on the subject, for nowhere in this area or in the neighboring region has even the horizon of the shallowest

oil-bearing formation of northwest Louisiana been reached. Thus the absence of direct evidence here, and the distance from the nearest productive fields in northwest Louisiana, leaves this question unsolved, although the similarity in the geology of the two regions encourages the belief that oil may occur here.

The presence of a porous stratum to serve as a reservoir for the accumulation of the oil is practically assured, as sands approximately the equivalent of those that are productive in Louisiana, the Ripley and Tuscaloosa, are known to dip under this region, although their depth and nature here are imperfectly known.

The structures here described, though not so pronounced as they are in some parts of the productive Coastal Plain fields, are more pronounced than in others, and in many ways similar to them. The Jackson anticline is believed to contain the most favorable area for the accumulation of oil and gas because of its similarity to anticlines in northwest Louisiana. Although it is not possible to point out as accurately as desired the most favorable locality on this fold for testing; a well located anywhere on it inside of the 460-foot contour would have a better chance of success than the average wildcat well located without regard to structure.

MOST PROMISING AREAS FOR PROSPECTING.

The prominent structural features of the area, as described under the heading "Structure" (pp. 108–112), are the Jackson anticline and the Vicksburg and the Eldorado monoclines. The most favorable areas for oil and gas accumulations lie in these folds, as stated in the following paragraphs.

JACKSON ANTICLINE.

As shown on Plate VIII (in pocket), the Jackson anticline is a broad, gentle, semicircular fold from which the rocks dip in three directions. Its northern extension is not known, and neither is the shape of its top, a feature of special significance in connection with the location of favorable areas for prospecting. The reasons for believing it is not as flat-topped as indicated on the map have been given. A gentle rise of the strata from the south edge of Jackson for about 2 miles north and the presence near the north edge of town of beds lower than any exposed farther north suggest the culmination of the fold near that place.

In the absence of definite knowledge regarding the exact form of the top of this fold there are two possible interpretations which are worthy of consideration because of their bearing on the possible accumulation of oil and gas: Either the fold has a well-defined axis from which the rocks dip gently but probably at an increasing angle or the top of the fold is flat and without a well-defined axis, and the dips become flatter above the 460-foot contour.

The evidence seems to indicate that the fold has a fairly well-defined axis, and that the anticline along this indefinite line is much higher than 460 feet. If minor folds cross this inferred axis, such cross folds would be eminently satisfactory as places to test the structure, for it is not believed that there are any synclines on the fold deep enough to trap the oil or gas and prevent migration to them. The best chance for success appears to be near the supposed axis, where the anticline is believed to be highest and where there is a suggestion of such a cross fold, as near the north edge of Jackson in sec. 34 or 26, T. 6 N., R. 1 E.

If the fold is flat-topped and the dip becomes decidedly flatter above the 460-foot contour, a favorable place to drill would be near this contour and at a place where the dip on the flank of the fold is shown to be steepest, as near Forest Hill School and near Clinton. A well about half a mile inside this contour and near these two places would probably be favorably located to test these areas and should at least make a showing if there are accumulations of oil or gas in the vicinity. Such tests might be made in the SW. ¼ sec. 14, T. 5 N., R. 1 W., near Forest Hill, and in the NE. ¼ sec. 29, T. 6 N., R. 1 W., near Clinton.

VICKSBURG MONOCLINE.

Oil accumulates in areas where there is a change in the rate of dip and under structural conditions similar to those shown to exist along the Vicksburg monocline, as outlined on the map (Pl. VIII, in pocket). This monocline extends from the southern edge of Vicksburg northeastward past Bovina to Big Black River near Askew Bridge, where it merges into the western slope of the Jackson uplift. The crest or upper axis of this fold parallels and practically coincides with the 120-foot contour, as the beds are flat north of it for a distance which is considerably greater at the western end than at the eastern. As the structure is more definitely located and is probably more pronounced at the western end, the most favorable location for prospecting is near Vicksburg and on or close to the crest of the monocline, which represents as accurately as can be shown the location of the downward bend of the strata. A belt a mile wide on each side of this line represents, according to the best information available, the location of possible productive territory.

ELDORADO MONOCLINE.

The Eldorado monocline is similar to the Vicksburg monocline in general features, though it differs principally in that it extends south of east instead of north of east. The crest of this fold, which represents the most favorable territory for prospecting, extends from a point near Eldorado toward Cox Ferry on Big Black River. Like the Vicksburg monocline, it shows larger dips at its west end,

as mapped, and offers more favorable conditions there for oil or gas to accumulate. This area probably could be tested best by wells located along the crest of the monocline, as shown on the accompanying map (Pl. VIII, in pocket), near Eldorado, for instance, in sec. 35 or 36, T 9 N., R. 5 W. Unless good indications of oil or gas were obtained from a well here, further prospecting on this monocline would probably not be justifiable.

DEPTH TO POSSIBLE OIL AND GAS BEARING FORMATIONS.

A list of formations into which the rocks of the Vicksburg-Jackson area have been divided is given in the table on page 97. Of these the upper part of the Claiborne and overlying formations are known at the surface and are described on pages 97–108. The formations below the Claiborne are known from well records and surface outcrops outside of this area. The best available information as to the character and thickness of the different formations is summarized in the table on page 97, but for the benefit of the driller this information is elaborated in the following pages. The formations will be discussed in the order in which they are penetrated in a well, so that they may be followed and compared easily with the well record.

The following table shows the succession of formations of northwest Louisiana and their approximate equivalents in Mississippi. The correlation here suggested is true in only the most general way, as these formations, especially those of the Cretaceous, represent different time intervals at different places in Mississippi.

Partial section of Cretaceous and Tertiary formations of Mississippi and Louisiana.

Geologic age.	Mississippi.	Northwestern Louisiana.
Eocene.	Claiborne group.	Claiborne group.
	Wilcox group.	Wilcox formation.
	Midway group.	Midway formation.
Upper Cretaceous.[a]	Ripley formation.	Arkadelphia clay. Nacatoch sand.
	Selma chalk.	Marlbrook marl. Annona chalk. Brownstown marl.
	Eutaw formation.	Eagle Ford clay.
	Tuscaloosa formation.	Woodbine sand.

[a] The correlations here suggested were made by L. W. Stephenson, who states that they are approximately true if a section along an east-west line through Okalona, Chickasaw County, Miss., is compared with that of northwest Louisiana.

In Louisiana oil and gas are found in the Nacatoch, in the upper part of the Eagle Ford, called the Blossom sand member, and in the base of the Eagle Ford or in the Woodbine sand, the reservoir of the deep oil and gas of Caddo Parish. The corresponding formations in Mississippi, the Ripley, Eutaw, and Tuscaloosa, are the most promising formations of the Vicksburg-Jackson area, not only because they are of approximately the same age as the productive formations of Louisiana and were deposited under similar conditions but also because they are composed largely of sand and are therefore capable of storing oil and gas.

In the oil fields of northwest Louisiana the Wilcox outcrops, and the productive formations are nearer the surface than in this area, where the Jackson and Vicksburg formations outcrop. In the vicinity of Jackson the Claiborne is near the surface, and is exposed over a small area. At its outcrop farther to the northeast it has an estimated thickness of about 500 feet and across Mississippi River in Louisiana it has a thickness, based on well records, of about 1,500 feet. This shows a rapid rate of thickening in that direction and indicates that this formation is considerably thicker at Vicksburg than at Jackson. In well records these beds are distinguished with difficulty, on the basis of their lithology, from the Wilcox beds below. The marine character of the Claiborne, as shown by the presence of fossil shells, and the generally nonmarine character of the Wilcox, however, should make the separation possible, even in well records. In its upper part the Claiborne consists of lignitic clays and sands, which are reported to have a thickness of 418 feet at Jackson (see p. 98); below are marine marls and calcareous sands and finally several hundred feet of sandstones, quartzites, and clay stones. The Claiborne contains fresh water in the neighboring area to the north and will probably be found barren of oil and gas here.

The Wilcox has been reached probably in only one well in this area—in the well at the Edwards House in Jackson. This well has a depth of 1,446 feet and yields a strong flow of salty water with a small showing of gas. So far the Wilcox has not yielded oil and gas in commercial quantities, but it has made showings of gas at a number of places and should be carefully watched when being drilled through. Its thickness is variously estimated from 850 to 1,500 feet, but it is probably not greater than 1,000 feet. Its upper and lower parts are very similar in composition and consist of lignitic clay and some sand; its middle part is dominantly sandy. In the region near Jackson the depth to the base of the Wilcox is estimated to be about 2,000 to 2,500 feet.

Below the Wilcox are the marine beds of clay, sandstone, limestone, and marl of the Midway group, which have a thickness of several hundred feet. In drilling these beds should be distinguished

from the overlying Wilcox by the difference in the rocks and by the presence of marine fossils. The composition of the Midway is such that it should serve well as an impervious cap for the Ripley sands below.

The Ripley formation contains large amounts of sand at its outcrop, and though its composition in this area is believed to be similar, it may be represented here by chalky limestone similar to that composing the Selma chalk. If found to contain sand it should be thoroughly tested, as it represents approximately the horizon of the Nacatoch sand, which yields the shallow gas and heavy oil in northwest Louisiana. It can probably be reached in the vicinity of Jackson between 2,500 and 3,000 feet.

Below the Ripley is the Selma chalk, which is roughly the equivalent of the "chalk" of northwest Louisiana and is similar to it in character. It should be an easily recognized formation in wells, as it differs strikingly from the formations both above and below. This formation has a measured thickness of 930 feet in a well at Livingston, Ala., where it consists of sandy and argillaceous chalky limestone.

The Eutaw formation, which lies below the Selma chalk, is composed chiefly of sand in the area of its outcrop and is believed to retain this sandy character in the Vicksburg-Jackson area, at least sufficiently to furnish a reservoir for the accumulation of oil and gas. Unless the overlying formations in this area are thinner than expected the Eutaw is the deepest formation that can be reached easily by the drill, if, indeed, it is not beyond easy reach. On the basis of the estimates referred to above it will be reached near Jackson at about 3,500 or 4,000 feet. This formation is in part the equivalent of the Eagle Ford formation of Louisiana and may contain beds which are of the same age as the deep oil and gas bearing beds of that region, although the Eutaw is generally considered somewhat younger than the Eagle Ford.

The estimates given above apply to the vicinity of Jackson; at the Vicksburg and Eldorado monoclines the depths to the various formations are greater, probably as much as 500 feet or even more, owing to the presence of higher beds of Jackson and Vicksburg age and to the thickening in that direction of the Claiborne and possibly also the Jackson. The depths in the valley bottoms at the Eldorado monocline are somewhat less, about 80 feet, than at the Vicksburg monocline, if there is no variation in the thickness of the underlying beds between the places. At best these estimates are only approximations, as they are based on somewhat uncertain estimates of the thickness of the formations at their outcrop some distance away. As it seems more likely that the formations increase in thickness from their outcrop in this direction rather than decrease, the maximum depths were estimated so as to allow for a moderate amount of thickening.

SUGGESTIONS TO DRILLERS.

That a single hole is not sufficient to condemn any considerable area around it has been demonstrated in the history of a number of oil fields, particularly in those in which there are minor structural features and local variations in thickness and porosity of sands, which cause the productive area to be "spotted." However, as deep drilling is expensive, a wildcat well should be so managed as to give the greatest amount of information, not only as to the presence or absence of oil under a particular tract of land, but as to whether the general underground conditions are favorable to the occurrence of oil in that vicinity.

To test this area adequately a deep hole must be drilled, and the hole should be bailed to test all the sands that are promising. This will require a large initial hole in order to accommodate successively smaller casings. The sands of the Ripley and Eutaw formations should be most carefully watched and tested by bailing, for a hole full of water heavily charged with mud may obscure or entirely hide traces of oil. Even a trace of oil in this area, which is so far from productive territory, may be of great importance in deciding which is the most promising sand and whether further drilling is justified.

An accurate log of the well should be kept, with samples of cuttings from each 20 feet, or less if the formation changes. Fossil shells should be carefully preserved, with a record of the depth from which they were obtained, for study by a specialist. By this means the different formations penetrated may be recognized and the position and thickness of the sands, and their relationship to known productive sands, may be determined. This information may aid materially in locating small isolated pools or the presence of oil in other parts of the folds.

WELL LOGS.

The following well logs indicate the general character of the formations in the Vicksburg-Jackson area:

Log of well of Kimberly-Wing Co., Cedars, Miss.

[Layne & Bowler Co., contractor and driller. Completed Dec. 28, 1910.]

	Thickness.		Depth.	
	Ft.	*in.*	*Ft.*	*in.*
Top soil and red clay	25	0	25	0
Vicksburg limestone:				
Blue clay	10	0	35	0
Sands, fine	29	0	64	0
Rock (limestone)	3	3	67	3
Gumbo	1	3	68	6
Rock		3	68	9
Gumbo	1	4	70	1
Rock	1	3	71	4
Gumbo	2	6	73	10
Rock	1	9	75	7
Gumbo	11	9	87	4
Rock	1	10	89	2
Gumbo	1	0	90	2
Rock	2	9	92	11
Gumbo	1	11	94	10
Rock		10	95	8
Gumbo		5	96	1
Rock		8	96	9
Gumbo	10	3	107	0
Rock		4	107	4
Gumbo	47	8	155	0
Jackson formation:				
Sand, fine	40	0	195	0
Gumbo	595	0	790	0
Claiborne group:				
Sand	106	0	896	0
Gumbo	4	8	900	8

Log of city well at Edwards, Miss.

[Layne & Bowler Co., contractor and driller.]

	Thickness.		Depth.	
	Ft.	*in.*	*Ft.*	*in.*
Red clay	58	11	58	11
Vicksburg limestone:				
Blue clay	55	6	114	5
Rock (limestone)	4	8	119	1
Soapstone	2	0	121	1
Rock (limestone)	2	0	123	1
Soapstone	3	8	126	9
Rock (limestone)	1	4	128	1
Soapstone	3	0	131	1
Rock (limestone)	1	10	132	11
Soapstone	6	2	139	1
Rock (limestone)	7	5	146	6
Packed sand	1	0	147	6
Rock (limestone)	1	6	149	0
Packed sand	32	1	181	1
Jackson formation:				
Gumbo	39	5	220	6
Sand, muddy, packed	26	10	247	4
Soapstone	3	9	251	1
Gumbo, sandy	41	4	292	5
Gumbo, blue	15	0	307	5
Sand, dry, packed	23	10	331	3
Rock, hard sand	19	9	351	0
Sand, hard, dry, floating	15	0	366	0
Gumbo	4	7	370	7
Sand, hard, dry floating	9	0	379	7
Gumbo	339	10	719	5
Undifferentiated Jackson and Claiborne:				
Sand	4	6	723	11
Gumbo	21	9	745	8
Sand	4	0	749	8
Gumbo	79	8	829	4
Sand	4	0	833	4
Rock	2	0	835	4
Sand	3	0	838	4
Gumbo	27	10	866	2
Claiborne group:				
Gumbo, chocolate-colored	33	6	899	8
Marl, brown	18	6	918	2
Sand rock	1	0	919	2
Soapstone	10	0	929	2
Sand, fine, packed	15	5	944	7
Gumbo, hard, sandy	47	10	992	5
Sand rock, very hard	23	5	1,015	10
Gumbo, sandy	15	0	1,030	10
Sand rock	16	6	1,047	4
Gumbo, chocolate-colored	16	8	1,064	0
Sand rock	46	4	1,110	4
Gumbo, sandy	3	8	1,114	0
Sand, very hard, packed	13	7	1,127	7
Sand, packed	19	9	1,147	4
Sand, very hard, packed	9	0	1,156	4
Clay, soft, yellow	9	0	1,165	4
Sand, packed	15	0	1,180	4
Clay, sandy	3	5	1,183	9