CONTRIBUTIONS TO ECONOMIC GEOLOGY, 1925

PART II. MINERAL FUELS

PALEOZOIC FORMATIONS PENETRATED BY WELLS IN TISHOMINGO COUNTY, NORTHEASTERN MISSISSIPPI

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USEFULNESS OF DRILL CUTTINGS

One of the greatest obstacles to the success of the oil prospector is lack of accurate information regarding the character, age, and correlation of the formations through which he drills.

This is particularly true in regions where formations vary greatly in thickness and character between areas only a few miles apart, such as southern Tennessee and northern Mississippi and Alabama. Where such information is lacking, the different formations can be distinguished and identified only by the most painstaking geologic work. Otherwise costly and absolutely hopeless drilling may go ahead, with the operator looking for an oil-bearing formation that study of the drill cuttings would have told him was absent, or a well may be abandoned because a certain formation was not found at the expected depth when accurate correlation of the formations would have shown that a thickening of certain formations carried the bed looked for much deeper below the surface; or the conditions may otherwise be misinterpreted, with consequent arousing of unjustified hope or equally unjustified discouragement.

Careful work on drill cuttings with positive identification of formations is also essential to the advancement of geologic science, as such work gives data regarding the variations in thickness and distribution of different formations, which otherwise must be merely inferred from evidence that may be extremely meager. A well record should supply the stratigrapher with an excellent section of the rocks that are below the surface, but if only the driller's log is available the stratigraphic section thus furnished is of doubtful value. If the

drill cuttings are studied by a geologist who has also studied the stratigraphy of the district he may be enabled to make a very definite contribution to the known stratigraphy of the general region.

PROSPECTING FOR OIL IN AND NEAR TISHOMINGO COUNTY

A number of the wells drilled in northeastern Mississippi, northern Alabama, and adjacent parts of Tennessee, in the attempt to obtain oil from the Paleozoic rocks that elsewhere contain petroleum, have given some shows of oil and gas. The structure and oil and gas, prospects of the Waynesboro quadrangle, which includes nearly all of Wayne County and narrow strips of Hardin, Decatur, Perry, Lewis, and Lawrence counties, Tenn., and a narrow strip of Lauderdale County, Ala., have been described by Miser.[1] The logs of several of the wells in this region have been plotted in the accompanying chart (Pl. I), on which tentative stratigraphic correlations have also been indicated.

The old Goyer well No. 1, drilled in 1890 in sec. 29, T. 7 N., R. 6 W., Lawrence County, Ala., had an estimated initial daily production of 25 barrels of high-grade oil but was immediately flooded out owing to casing trouble. This oil was encountered at a depth of about 1,500 feet or about 500 feet below the top of the Ordovician. It was a dark-green oil of 0.831 specific gravity. A report by the Alabama Geological Survey states that

> The oil is said to have risen in the well to a height of about 200 feet. Some 8 barrels of this oil is said to have been pumped out, and from the distance the oil was lowered in the well by the drawing out of this amount, the well was estimated by Doctor McRae as about a 25-barrel (per day) well.

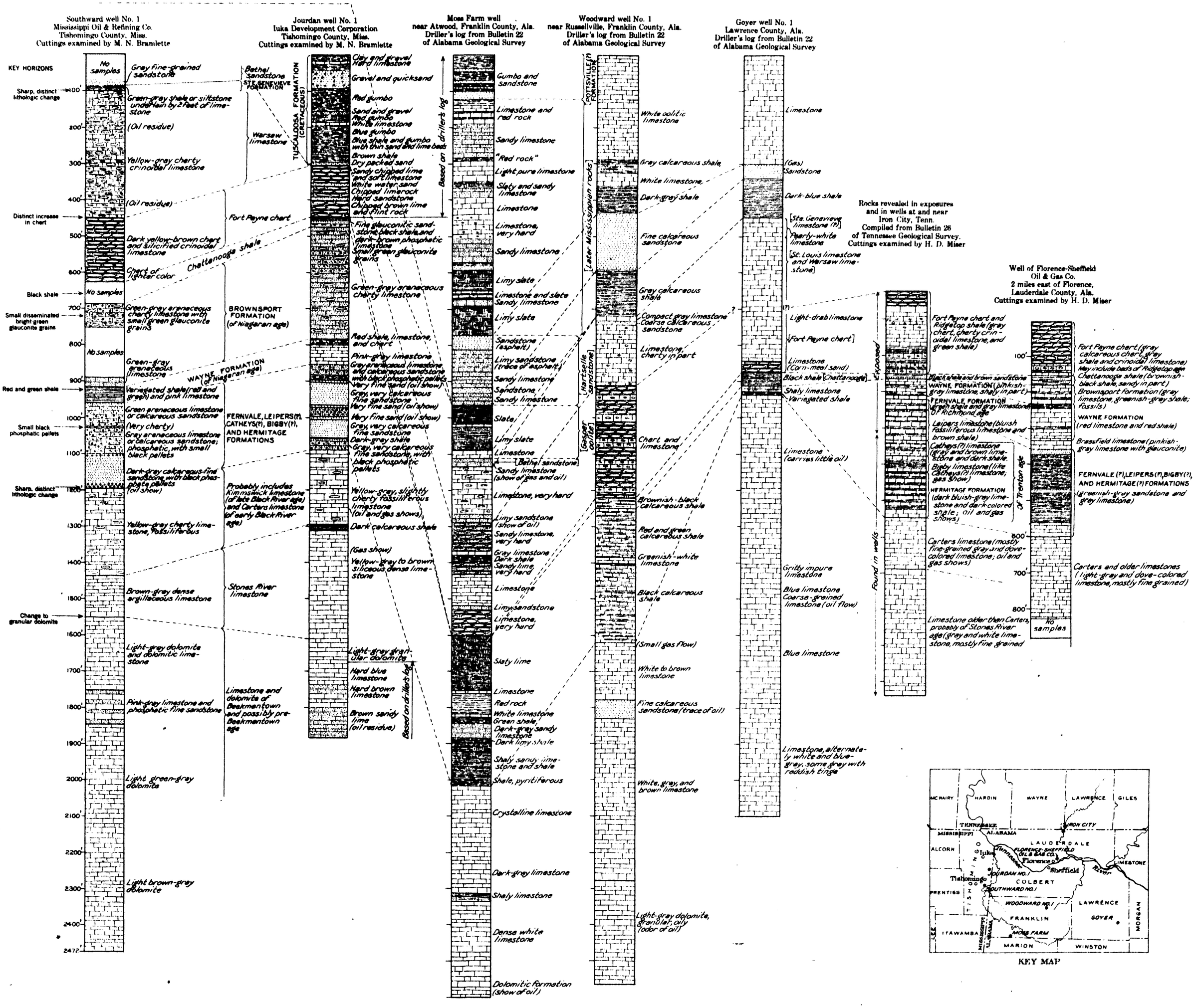
No oil was yielded by adjacent wells, but as none of these were drilled where the structure is most favorable, commercial quantities of oil may still be found in the region.

PRESENT STUDY

Cuttings for the present study were available from two wells in Tishomingo County, in northeastern Mississippi—the Southward well No. 1 of the Mississippi Oil & Refining Co., in sec. 18, T. 5 S., R. 11 E., and the Jourdan well No. 1 of the Iuka Development Corporation, in sec. 9, T. 4 S., R. 11 E. The comparison and proposed correlation of the strata penetrated in these wells with those penetrated in test wells in northern Alabama is based on the study of the driller's logs.

The well samples of drill cuttings were studied with the binocular microscope, thin sections of some samples were examined with the

[1] Miser, H. D., Mineral resources of the Waynesboro quadrangle, Tenn.: Tennessee Geol. Survey Bull. 26, 1921.



COLUMNAR SECTIONS OF ROCKS PENETRATED BY DEEP WELLS IN NORTHEASTERN MISSISSIPPI, NORTHWESTERN ALABAMA, AND THE ADJACENT PART OF TENNESSEE

The correlations of the Mississippian formations are in accordance with unpublished work of Charles Butts

polarizing microscope, and a few simple chemical tests were made. The subdivision and correlation of formations from well cuttings must rest on general lithologic features, characteristic texture, minerals, and fossils. The lithologic differences between some formations are so definite that no additional evidence is necessary, but even for these formations some obvious mineral or fossil characteristics may aid in further subdivision or in more certain correlation. A preliminary study of the heavy mineral content of the cuttings from various horizons was made and gave some promise of furnishing criteria for correlation, but this study was not continued, as more obvious and easily applied differentiations can be made. This mineral examination showed that zircon and iron-bearing tourmaline are present in most of the formations penetrated by these wells, though different formations contained very different amounts. These minerals were especially abundant in the fine sandstone of Trenton age. In the same sandstone some topaz was found, but as topaz is a mineral found chiefly in contact-metamorphic rocks and pegmatite, its occurrence in sedimentary rocks would probably be more or less local. Garnet in small quantity was noted in the Bethel sandstone. Other mineral characteristics could undoubtedly be discovered by further work, but their value for correlation could be assured only by the examination of samples from numerous localities.

Attempts to carry correlations of the formations discussed in this paper for considerable distances have shown great lateral variations in thickness and even in lithologic character, and the task is made more difficult by unconformities that cut out certain formations locally. However, the major units are easily correlated between the two wells only about 7 miles apart, from which samples were obtained, and they would almost certainly be recognizable for much greater distances.

CHARACTER AND CORRELATION OF ROCKS

According to Charles Butts, who has studied the corresponding rocks just over the State line in Alabama, the Bethel sandstone and Ste. Genevieve formation (both Mississippian) are the uppermost rocks penetrated by the Southward well. They consist chiefly of sandstone and siltstone or shale and are less than 100 feet thick. The Bethel sandstone is fine grained, gray, and calcareous and is underlain by siltstone or shale containing many fossils, which rests on 2 feet of limestone of Ste. Genevieve age. On the outcrop in Bear Creek valley, both north and south of Allsboro, Ala., the sandstone is 10 to 20 feet thick and is in places asphaltic. It is overlain by a varying thickness up to 30 feet of oolitic limestone that is also locally asphaltic, as, for instance, 2 miles south of Margerum, Ala. According to Butts, this oolite carries a Gasper fauna of *Talarocrinus*,

Pentremites, and *Campophyllum gasperense*, and as the Gasper directly overlies the Bethel sandstone in the standard Mississippian sections of the Ohio and Mississippi valleys, there can be no doubt as to the correctness of the identification of the sandstone here described a Bethel.

The siltstone or shale below the Bethel sandstone is fully exposed just across the line in Alabama, on the Iuka road immediately west of its junction with the Cherokee-Tishomingo pike about 2 miles north of Allsboro. Here it is a soft blue shale, often called marl, 60 feet thick. It is immediately underlain by a highly fossiliferous limestone 2 feet thick, the fossils in which are regarded by Butts as of Ste. Genevieve age. The shale itself is here unfossiliferous, but it also is considered to be of Ste. Genevieve age, for in its place west of the meridian of Courtland, Lawrence County, Ala., the typical Ste. Genevieve oolitic limestone comes in. In the Southward well there is a thin representative of this limestone, underlain by the Warsaw limestone, and as the contact is marked by a sharp lithologic change it should form a definite key horizon for correlations.

The Ste. Genevieve rocks of this section are underlain by thick strata of Mississippian limestone known in northwestern Alabama as the Tuscumbia limestone and in the Decatur-Huntsville region, Ala., as the Warsaw and St. Louis limestones.

The Warsaw has a thickness of about 350 feet in the Southward well and is notably uniform in its characteristics throughout this thickness. It is a bluish-gray crinoidal limestone which on weathering becomes silicified to a yellow-gray, highly fossiliferous chert. Fragments of the abundant crinoids appear in the cuttings as rhombic cleavage fragments of calcite several millimeters in maximum size, and an abundance of such cleavage fragments should be characteristic of well cuttings from this formation throughout the region. This limestone seems to thin down to about 200 feet in northwestern Alabama. The lower limit of the formation may be rather indefinite, as the change to the Fort Payne chert is gradational.

The Fort Payne chert (Mississippian) at outcrops in northwestern Alabama is predominantly a fine-grained dark bluish-gray crinoidal limestone similar to the overlying Warsaw limestone. A distinguishing feature of the Fort Payne is its high degree of silicification, the rock being for considerable thicknesses an almost pure chert. These more massive chert layers show as yellow-brown angular chert fragments in the well cuttings. The Fort Payne has a thickness of almost 200 feet in the Southward well.

The typical black Chattanooga shale seems to be very thin in the Jourdan well to judge from the small quantity of black-shale fragments in the single sample representing 30 feet of strata at the approximate horizon of the Chattanooga. This sample shows that

a dark-brown argillaceous phosphatic limestone occupies the greater part of this 30 feet. Some fine sandstone with a little glauconite is also present, which may represent the Hardin sandstone member.

Beneath these beds there is about 300 feet of arenaceous, siliceous, and cherty green-gray limestone. The upper part of this limestone may belong to the Olive Hill formation (Lower Devonian), which is known to be present north of the Jourdan well, on the Tennessee State line. However, for the entire thickness of 300 feet the rock is very uniform in composition, except for a greater abundance of small disseminated grains of glauconite from 50 to 100 feet below the top. Fossils from a depth of 735 to 760 feet in the Southward well were stated by E. O. Ulrich to be of Niagaran age. Throughout there occur the remains of siliceous sponges (probably *Astraeospongia meniscus* and others) that appear as fragments of the reticulate spicular skeleton when the limestone cuttings are treated with dilute hydrochloric acid. This siliceous sponge is characteristic of the Brownsport formation (of Niagaran age), and the entire thickness of the beds containing it will be here classed as Brownsport. The glauconite mentioned above consists of small ovoid to fusiform pellets of crystalline glauconite disseminated through 100 feet or more of the limestone and apparently not much concentrated at any definite horizon. Glauconite thus uniformly distributed is not ordinarily characteristic of a distinct stratigraphic break and does not have the same significance as a marker of unconformities as concentrations of glauconite or occurrences of glauconite that are associated with phosphate and other indicators.

Underlying the Brownsport formation is 20 or 30 feet of variegated red (ferruginous) and green shale. In the Jourdan well about 50 feet of pinkish-gray limestone underlies the red shale. This zone probably represents several or perhaps all of the thin beds known collectively as the Wayne formation, also of Niagaran age, and including in descending order the Dixon, Lego, Waldron, Laurel, and Osgood members. Of these, the Dixon in the wells here described is a red shale.

The shale here classed as Dixon seems to represent a deposit of red clastic material whose color is due entirely to the source of supply and not to any oxidizing environment of deposition, for the shale contains glauconite grains, which could hardly have formed under oxidizing conditions. The red shale is of notably uniform grain without admixture of coarse clastic material—a fact which suggests that it was formed from transported sediment and is not a residual soil on a weathered land surface. However, these red clastic deposits may well have been transported from such an old weathered land surface, and it seems possible that the weathering of the impure

limestones of Richmond and Trenton age on the Nashville dome may have furnished a source for them, but according to H. D. Miser it seems probable that the red sediments came from a land area lying to the south or southwest. As a natural corollary, the pink to red limestones at this horizon may best be considered a calcareous deposit colored by the admixture of fine red clastic material from the same source, rather than a weathered limestone below a stratigraphic break.

Beneath these variegated rocks lie more than 200 feet of dark calcareous fine sandstone and arenaceous limestone, through which many small greenish-gray to black phosphatic pellets are disseminated. These pellets are ovoid, some of them very much elongated, and average a little less than 0.1 millimeter in diameter. Their surfaces are smooth and rounded. Their composition is very difficult to determine, but they seem to include carbonaceous material as well as phosphate and iron sulphide. The origin of these pellets is uncertain but is probably organic. Amber-colored (in transmitted light), isotropic phosphate occurs as irregular-shaped masses in the matrix of the rock and is more abundant where the black pellets are most numerous. The well-known phosphate of Tennessee occurs in rocks of equivalent age and is universally associated with an abundance of small fossil gastropods (snails), although the exact connection between the fossils and the phosphate is not fully understood. It is probable that this Mississippi deposit had a similar origin. In the Jourdan well there are several intercalated uncemented fine sands at this horizon that gave indications of oil and gas. These sands are discussed on page 9. This series of calcareous sandstone and arenaceous limestone with phosphate was at first interpreted as the highest Ordovician (Richmond) of the region, as its lithologic character suggests beds above a major stratigraphic break, but only the uppermost part of the series is now regarded as belonging to the Richmond group. This part is assigned to the Fernvale formation, which is probably very thin in this region, however, as it is known to become thinner toward the southwest in adjacent parts of Tennessee. Comparison with outcrop samples from southern Tennessee shows the cuttings from this horizon to be similar to material from formations of Trenton (Middle Ordovician) age, including the Catheys, Bigby, and Hermitage formations, which are overlain by the Leipers formation, of Upper Ordovician age. These formations are phosphatic, contain small black pellets, and grow progressively more sandy toward the south. This arenaceous series belongs, then, to the Ordovician, and is here classed as including the Fernvale, Leipers (?), Catheys, (?), Bigby (?) and Hermitage formations. These impure limestones and sandstones seem to represent post-Black

River deposition resulting from the emergence of the Nashville dome and consequent shallow-water conditions. The detritus does not seem to have come from the erosion of that dome, however, as the land surface of the dome was a pure limestone and would not furnish the arkosic sandstone that was deposited in Trenton time. The presence of abundant angular fresh feldspar crystals and of heavy minerals in these sandstones suggests rather derivation from an igneous rock, or, if from a sedimentary rock, from an arkosic sandstone of similar composition. The increasing sandiness of the formations toward the south and away from the Nashville dome is even stronger evidence that the source of the clastic materials lay at the south. Moreover, the size of grains in the lower 30 feet of this sandstone in the Jourdan well averages less than 0.1 millimeter, whereas in the Southward well, about 7 miles farther south, the size of the sand grains from the same horizon averages almost 0.2 millimeter, a difference which suggests a source to the south.

A sharp lithologic change to a pure limestone marks the top of a series of beds that are here considered as including the Kimmswick limestone (of late Black River age) and the Carters limestone (of early Black River (Lowville) age). This series of beds is a little less than 200 feet thick and consists of cream-white to light brownish-gray fossiliferous limestone, with ostracodes that are stated by Ulrich to be of pre-Trenton and probably Black River age. The texture of this limestone shows rounded calcareous grains embedded in a finer calcareous matrix, as in an oolitic limestone, though the texture is not pronounced and the grains do not show the concentric structure characteristic of true oolites. They seem rather to be rounded fragments of calcareous organisms, and the texture is best observed in thin sections.

Limestones show various kinds of texture due to differences in origin and in degree of metamorphism. Two types seem especially worthy of more general recognition, however. One of these represents a consolidated carbonate "sand," which may consist largely of organic fragments and may have a pseudo-oolitic texture, the grains being more or less rounded. The other type has a finely granular or mosaic texture, a more dense appearance, and a somewhat conchoidal fracture and probably represents a consolidated calcareous mud. The limestone of probable Black River age in this region is a good example of a consolidated carbonate sand, and the underlying Stones River limestone of a consolidated calcareous mud.

The limestone succeeding the Carters in the Jourdan well for a thickness of about 300 feet is classed as Stones River, as fossils from a depth of 1,326 to 1,380 feet were identified by Ulrich as of middle Stones River age, and lithologically the limestone appears to belong

to that group. This limestone is quite distinct from the overlying limestone, being a dense, fine-grained rock of darker brownish-gray color. It contains very few fossils. In the Southward well there is only a little over 100 feet of this limestone, and thus there seems to be a distinct unconformity at this horizon. That some of the underlying dolomite in the Southward well may represent a subsequent dolomitization of beds belonging to the Stones River group seems a possibility, but the fact that a sandy zone about 200 feet below the top of the dolomite nearly parallels the top of the dolomite of the two wells indicates that the dolomite follows a definite stratigraphic horizon and that the unconformity is present.

Underlying the Stones River is a finely granular or sugary-textured dolomitic formation of light blue-gray color that would seem to be of Beekmantown and possibly pre-Beekmantown age. This formation has not yet been completely penetrated, though the Southward well has gone through 900 feet of it. Oil showings occur at several horizons in this lowest part of the section penetrated in the Jourdan well. Their possible significance is discussed below.

POSSIBLE OIL HORIZONS

Showings of oil were found in the Mississippian, Silurian, and Ordovician beds.

The oil showings in the Warsaw (Mississippian) limestone consist of an oil residue in the cuttings which on being extracted with chloroform and the chloroform evaporated appears to be an inspissated or asphaltic residue. When 4 or 5 cubic centimeters of the cuttings from a depth of 200 to 211 feet in the Southward well are so treated a heavy coating of the asphaltic material is left in a 2-inch porcelain dish, and distinct though lesser amounts were obtained from cuttings from several other horizons, including the beds between 386 and 440 feet. More hydrocarbon could be extracted from this limestone than from any other formation penetrated, though no good porous reservoir rock is present. Commercial production from some bed in this Warsaw limestone seems possible, if it can be found under cover where the structural conditions are favorable.

A small showing of oil about 55 feet below the black Chattanooga shale came from sandy cherty limestone of Niagaran age in the Jourdan well. The cuttings when treated with chloroform as described above gave only the faintest amber color in the bottom of a 2-inch porcelain dish. This oil-bearing bed seems to be of about the same geologic age as the "Deep" sand in the deposits of Niagaran age in Warren and adjacent counties in Kentucky, which is of considerable commercial importance, and it must be regarded as a possible source of oil in northeastern Mississippi. Well logs indicate that this formation

thins rapidly toward the east in Alabama and seems to be absent in a well near Russellville, Franklin County, and in the old Goyer well, in Lawrence County. If the formation pinches out to the east, it must of course be excluded as a possible source of oil for northern Alabama, but in western Tennessee it is present within easy drilling depth at many places and is exposed at many others.

In the Jourdan well several fine-grained unconsolidated sands occur in the sandy phosphatic rocks of Trenton age. Small oil and gas showings were reported from these sands, and on treatment with chloroform a light film of oil was obtained in the 2-inch porcelain dish. These beds seem to be fair reservoir rocks. The sand is very fine, the grains averaging 0.03 to 0.1 millimeter in diameter. The hard calcareous sandstones occurring in the Jourdan well above and below these sands have grains of about the same size, but owing to cementation their pore space is negligible. The intercalated unconsolidated sands are not present in the Southward well. The mode of occurrence of these unconsolidated sands between highly indurated sandstones suggests that they may be unconsolidated because they contain oil rather than being oil sands because they were not cemented. That they are uncemented sands deposited between well-cemented sandstones is a possibility, but it seems quite as probable that the cementation to sandstone is a metamorphic change effected by circulating ground waters, and the lack of cementation in certain beds may be due to the fact that they have accumulated some oil and gas beneath more impervious beds and so have hindered the carbonate deposition or cementation.

The chief oil-producing beds of Ohio and Indiana are generally called Trenton, but there are reasons for regarding at least part of them as older than Trenton, and they are quite different lithologically from the rocks of Trenton age in Alabama and Mississippi. Some oil is also obtained from the beds of Trenton (?) age in Kentucky, and gas with showings of oil[2] is found in beds of undisputed Trenton age just across the State line at Iron City, Tenn. The character of the rocks and the showings of oil and gas indicate that this horizon is one of the most favorable for possible production in the general region. The log of the Goyer well seems to show that these formations are not present there.

The limestone beds of Black River age give very definite showings of oil and gas, and a distinct film of oil could be obtained from the cuttings when they were treated in the usual manner with chloroform. Gas showings were continuous for the upper 130 or 140 feet of these beds in the Jourdan well, according to the driller's log. Showings

[2] See Tennessee Geol. Survey Bull. 26, pp. 147–149, 1921.

of oil and gas were encountered at this horizon in the Woodward well, in Franklin County, Ala., and in a well at Iron City, Tenn. These beds would seem to be of possible commercial importance if they contain a good porous reservoir rock anywhere in the region.

About 500 feet below the top of the limestones of Black River age the formation is dolomitic and of a granular or sugary texture. This dolomite, considered to be of Beekmantown age, gives showings of oil in the Jourdan well and in both the wells in Franklin County, Ala. This formation is older than any known to yield oil in commercial quantities in the country, but there is no inherent reason why it may not contain petroleum.

NOTES ON PALEOZOIC ROCKS ENCOUNTERED IN A WELL NEAR FLORENCE, ALABAMA

By HUGH D. MISER

A well was drilled 2 miles east of Florence, Ala., in 1919 and 1920 by the Florence-Sheffield Oil & Gas Co., and the log shown graphically in Plate I and the brief description of the rocks here given have been compiled from the examination of cuttings.

The well started in the Fort Payne ("Lauderdale") chert, near the top of the formation, and passed through it at a depth of 155 feet. The upper part of the formation is exposed near the well and also farther south, at and near the Wilson dam, where it is composed mostly of a nondescript rock which may perhaps best be called a hard massive gray calcareous chert. The lower part of the formation consists of gray shale, blue flint, and light-gray crinoidal limestone and thus resembles the same part of the formation in its exposures at and near Iron City, Tenn., across the State line to the north.

The Chattanooga shale, either Devonian or Carboniferous, was found to be 27 feet thick in the well and thus much thicker than is usual in the exposures near Iron City. It is a brownish-black pyritic platy shale, parts of which are sandy.

Beds which are, from their fossil content, referable to the Brownsport formation (Niagaran) were encountered from 200 to 230 feet. They comprise fine-grained gray limestone, greenish-gray shale and red shale. This is so far as known to the writer the first recorded occurrence of the formation in Alabama, although, as pointed out by Mr. Bramlette, it is present in northeastern Mississippi. It is also widely exposed to the northwest along and near Tennessee River in western Tennessee, where it attains a thickness of 200 feet or more. The formation, however, thins out north of Florence before the State line is reached and is not present at any place in southwestern Lawrence County, Tenn.

The Wayne formation (Niagaran) was found to be 104 feet thick in this well and to consist of red fine-grained fossiliferous limestone and red shale. It crops out locally in northwestern Alabama north

of Tennessee River and is widely exposed in the adjacent part of Tennessee. Mr. Bramlette records its occurrence in two deep wells in northeastern Mississippi. (See Pl. I.)

The Brassfield limestone (Silurian), 22 feet thick, is a light-gray to pinkish-gray limestone which ranges in texture from fine to coarse grained. At Florence and also in its outcrops in Tennessee and Arkansas it contains small disseminated grains of glauconite and a little pyrite.

Below the Brassfield limestone there are 248 feet of beds which are probably referable to the Fernvale formation, of Richmond age, and to one or more of the Bigby, Leipers, and Hermitage formations, also of Ordovician age but older than the Fernvale. In the absence of fossils the beds can not be positively referred to these formations. The beds include earthy calcareous greenish-gray sandstone, greenish-gray calcareous shale, and gray fine-grained limestone, but the shale predominates in quantity. In lithologic character the beds resemble the Fernvale and Leipers formations exposed near Iron City, Tenn., and also the Bigby and Hermitage formations, which have been penetrated by deep wells at Iron City,[1] except that they contain less limestone than is found in the formations in Tennessee. There is also an increase in the amount of sand in the beds toward the south, but this feature is more strikingly illustrated by a comparison of the graphic logs of the two wells in Tishomingo County, in northeastern Mississippi, with the combined graphic section and log at Iron City, Tenn. As has been pointed out by Mr. Bramlette, this increase in sand suggests a southern source for the clastic materials of the beds under discussion.

The Carters limestone (of early Black River age) and older limestones (probably of Stones River age) were penetrated from 604 feet to the bottom of the well, 880 feet. The drill probably did not go deep enough to reach beds that are of the same age as the Knox dolomite (Beekmantown and older). These limestones are light gray, yellowish gray, and dove-colored and are very fine grained. Fossils were noted in some of the cuttings, and certain layers have an oolitic structure.

[1] Miser, H. D., Mineral resources of the Waynesboro quadrangle, Tenn.: Tennessee Geol. Survey Bull. 26, pp. 147-149, 1921.