T. 27 N., R. 8 E.

By K. C. Heald.

INTRODUCTION.

The field work on the western half of T. 27 N., R. 8 E. (see fig. 1), was done by the writer in the winter of 1916, and the geologic structure of this part of the township was described in a bulletin issued in February, 1918.[1] The mapping of the township was completed in the spring of 1917 by K. C. Heald, D. E. Winchester, W. B. Emery, and K. F. Mather.

The entire township was mapped with plane table and telescope alidade. Horizontal distances were determined by triangulation and stadia work, and vertical distances by trigonometric and direct leveling.

ROCKS EXPOSED.

GENERAL FEATURES.

The rocks exposed in T. 27 N., R. 8 E., are all of upper Pennsylvanian age and include shales, sandstones, and limestones. (See fig. 34.) The shales predominate but are usually concealed under a mantle of soil and débris from the more resistant limestones and sandstones, so that their character can be learned only from freshly made exposures in stream gullies, road cuts, and other excavations. In general, however, the outcrops of individual sandstone and limestone ledges may be traced long distances, although the entire thickness of a bed is rarely exposed because the soft shales tend to slump so as locally to conceal the underlying rocks. In such places the position of the sandstones and other hard beds is shown only by benches on the hill slopes, where there is no actual outcrop of the underlying bed, although fragments of float from it may litter the surface.

Some of the beds that were most helpful in determining the geologic structure of the township are described in detail below.

[1] Heald, K. C., Geologic structure of the northwestern part of the Pawhuska quadrangle, Okla.: U. S. Geol. Survey Bull. 691, pp. 57–100, 1918 (Bull. 691–C).

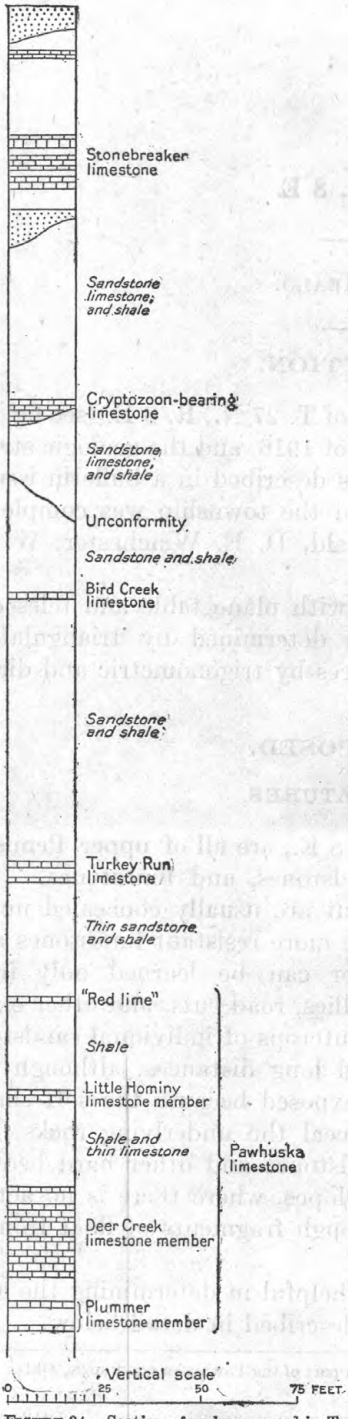


FIGURE 34.—Section of rocks exposed in T. 27 N., R. 8 E.

KEY BEDS.

Stonebreaker limestone.—The Stonebreaker limestone was used as the key bed for determining the geologic structure over much of the northwestern part of the township. Its top is about 250 feet below the base of the Foraker limestone and about 240 feet above the "red lime," which is the highest bed of the Pawhuska limestone. To the north of T. 27 N., R. 8 E., the Stonebreaker seems to consist of a single bed of limestone, but in this township it thickens and is made up of two to four beds of limestone with intervening shales. The thickness of the entire series is about 16 feet near the western edge of the township. The limestone is hard, tough, and sparingly fossiliferous in most localities, but in a few places it has been observed to contain an abundance of *Fusulina*, crinoid segments, and other small fossils; and in the western part of T. 27 N., R. 7 E., there is one bed that also carries many Cryptozoa, some of which have a fragment of a bryozoan as a nucleus. The weathered surface of the Stonebreaker limestone is in most localities strongly stained with limonite, which gives it a dirty-yellow, blotched appearance; the fresh surface is dark blue to light gray, with ocher-yellow limonite stains.

Overlying the Stonebreaker limestone is a marine shale which in places is very fossiliferous. Below the limestone there is a thin shale and a lenticular bed of limestone which ranges in thickness from 1 to 10 feet. The Stonebreaker limestone is named from the Stonebreaker

ranch, in T. 29 N., R. 8 E., and is well exposed in the stream bed south of the ranch house.

Cryptozoon-bearing limestone.—The *Cryptozoon*-bearing limestone lies about 70 feet below the top of the Stonebreaker limestone in the northern part of the area and about 60 feet below it in the southern part of the area. North of T. 27 N. the interval between the two is occupied by shale, thin beds of limestone, and a thin bed of sandstone. In T. 27 N. the sandstone thickens and is in places the most prominent bed in the stratigraphic section, capping hilltops and littering the slopes with loose fragments. Some of the intervening limestones are locally prominent and may be of assistance in mapping the structure. None of them appear to be continuous, however, nor have they characteristics which make it possible to recognize them easily and with certainty. Both these last-named qualities are found in the *Cryptozoon*-bearing limestone, and because of them it is of great value in determining the structure of the region.

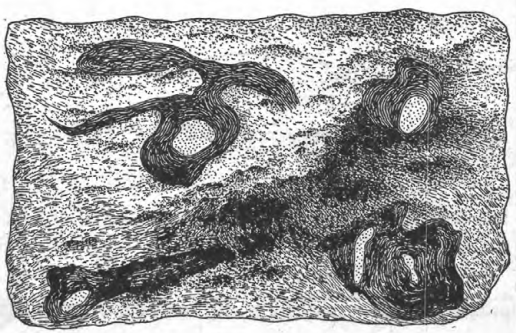


FIGURE 35.—Sketch of rock fragment showing characteristic shapes of Cryptozoa in the *Cryptozoon*-bearing limestone.

The bed is in most places from 1 to 3 feet thick. Although other layers of limestone may immediately overlie or underlie it, they can as a rule be easily distinguished from it by their physical character. The weathered surface of the limestone is usually of a characteristic dark-gray color; the fresh surface a clean dark blue-gray. The limestone is very hard and remarkably brittle and splits almost like glass under the blows of a hammer. It shows a lack of invertebrate fossils which is remarkable in view of the abundance of beautifully preserved forms in beds that may be in direct contact with it. The feature which makes it easily recognized is the presence of Cryptozoa, irregular forms that are the fossil remains of organisms whose nature has not been precisely determined. In many of these forms it is possible to detect a bryozoan, a fragment of shell, or a segment of crinoid stem near the center. These fossil remains were apparently the nuclei around which the Cryptozoa formed. Figure 35 is a rough sketch showing the general appearance of these fossils. Similar forms were seen in the Stonebreaker limestone and in a thin limestone above the Stonebreaker in the southern part of the area. Both these beds, however, are so differ-

ent in hardness, texture, and other physical characteristics from the *Cryptozoon*-bearing limestone that no confusion can arise.

There is a good exposure of the bed above described in a railroad cut between Pearsons Switch and Blackland. As shown in figure 36, the bed bearing the Cryptozoa is the only one that is continuous. Although it is improbable that this thin bed is absolutely continuous throughout the area, it is apparently very much more nearly continuous than associated beds, and the writer traced it for miles without detecting a break.

A short distance below the *Cryptozoon*-bearing limestone there is an unconformity, and as a result the sequence of beds below it is not even approximately the same in different parts of the area. Where erosion cuts the deepest into the underlying sandstone series hollows were scooped out in which three limestone beds with intervening shales were laid down, but locally one, two, or all three of these limestones may be absent.

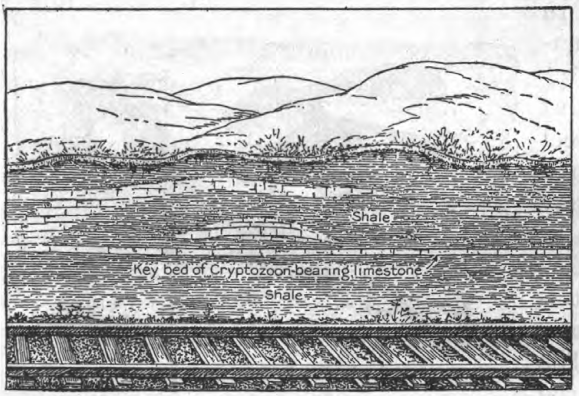


FIGURE 36.—Sketch illustrating conditions observed in railroad cut between Pearsons Switch and Blackland.

West of Pearsons Switch the *Cryptozoon*-bearing limestone is overlain in places by 12 feet of light-gray ocherized fossiliferous limestone, and its dull-gray surface is largely hidden by float from the overlying bed. This overlying bed is lenticular and is similar to beds of less thickness and extent observed in other parts of the area. On the assumption that continuous beds of limestone are laid down on planes that are approximately flat, it follows that if altitudes are taken on the uppermost bed of the overlying limestone instead of on the *Cryptozoon*-bearing limestone, which presumably will be used as a basis for determinations of altitude over much of the surrounding district, an error of 12 feet will be introduced.

Bird Creek limestone.—The Bird Creek limestone, named from its exposure on the valley sides of Bird Creek and its tributaries, is about 50 feet below the *Cryptozoon*-bearing limestone and a little more than 100 feet above the "red lime" at the top of the Pawhuska limestone. In most places where the limestone was seen there is but a single thin bed, about 2 feet thick, but in a few localities there are two beds, separated by about 6 feet of shale. The rock is hard

and extremely brittle, so that when struck with a hammer or other hard implement it shatters like glass into chips with sharp edges. Both weathered and fresh surfaces are of a dark bluish-gray color—so dark, in fact, that many samples might justly be called black. Fossil remains may rarely be seen on its weathered surface, but it is nevertheless characterized by a distinct brachiopod fauna, and in practically every locality where it was carefully examined the round, nutlike brachiopod *Enteletes hemiplicata* was discovered embedded in the interior of the limestone.

A good locality for examining the Bird Creek limestone is on the hill slope in the extreme northwest corner of sec. 28, T. 27 N., R. 8 E., just northwest of the large fill where the Midland Valley Railroad crosses Hickory Creek.

Turkey Run limestone.—About 70 feet below the Bird Creek limestone is the Turkey Run limestone, named from its excellent exposures near the head of Turkey Run, in T. 24 N., R. 8 E.[1] It is dark gray to bluish black and is very similar in appearance to the Bird Creek limestone but may be distinguished by the fact that it is in places oolitic and also by the absence of the fossil *Enteletes hemiplicata*. This limestone was used but little in the mapping of T. 27 N., R. 8 E., as it is not well exposed except in the extreme southeast corner, and its outcrop is not shown on the map (Pl. XXXIV). It is excellently exposed on the flanks of the large hill in the northeast corner of sec. 36 and near the south line of sec. 25, also west of the fault in secs. 26 and 35.

"Red lime."—The highest member of the Pawhuska limestone, about 30 feet below the Turkey Run limestone, was called in the field "red lime" because in some places it has a conspicuous outcrop of a rust-red color. Outcrops of similar color were observed in the *Cryptozoon*-bearing limestone and in the Lecompton limestone member, so this color is not in itself a reliable criterion upon which to base the identification of the "red lime." However, the prominent rust-red color is present in comparatively few places, and elsewhere the colors of the weathered and fresh surfaces are distinct from those of the underlying limestones.

The most frequently observed color of the weathered surface of the "red lime" is a distinctive brownish gray; that of the fresh surface a blue-gray with a reddish tinge. The greatest observed thickness of this bed is 7 feet, but the maximum thickness may be considerably greater, as the base of the bed is in most places concealed. In fact, as a rule the bed does not appear as a ledge but as a line of disconnected fragments of float.

[1] Heald, K. C., and Mather, K. F., report on Tps. 24 and 25 N., R. 8 E.: U. S. Geol. Survey Bull. 686-M, 1918.

The rock is very hard and brittle and under a heavy blow splits with a sharp, clean fracture. The bedding is massive, and fragments of float may be of considerable size and are characteristically of irregular form. The distribution of fossils in this bed is far from uniform. At one point the rock may be full of invertebrate remains; at another there may be scarcely a trace of ancient life.

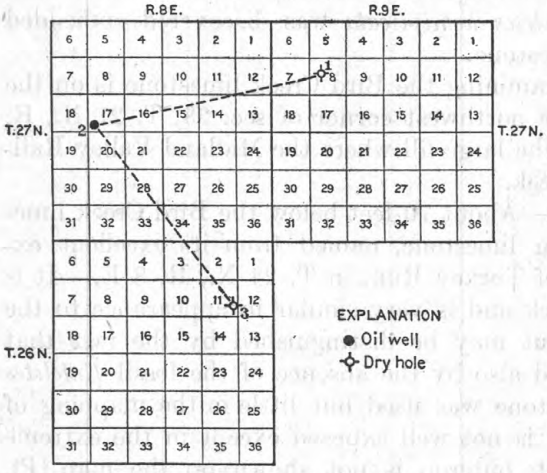


FIGURE 37.—Diagram showing location of wells whose records are given in Plate XXXV.

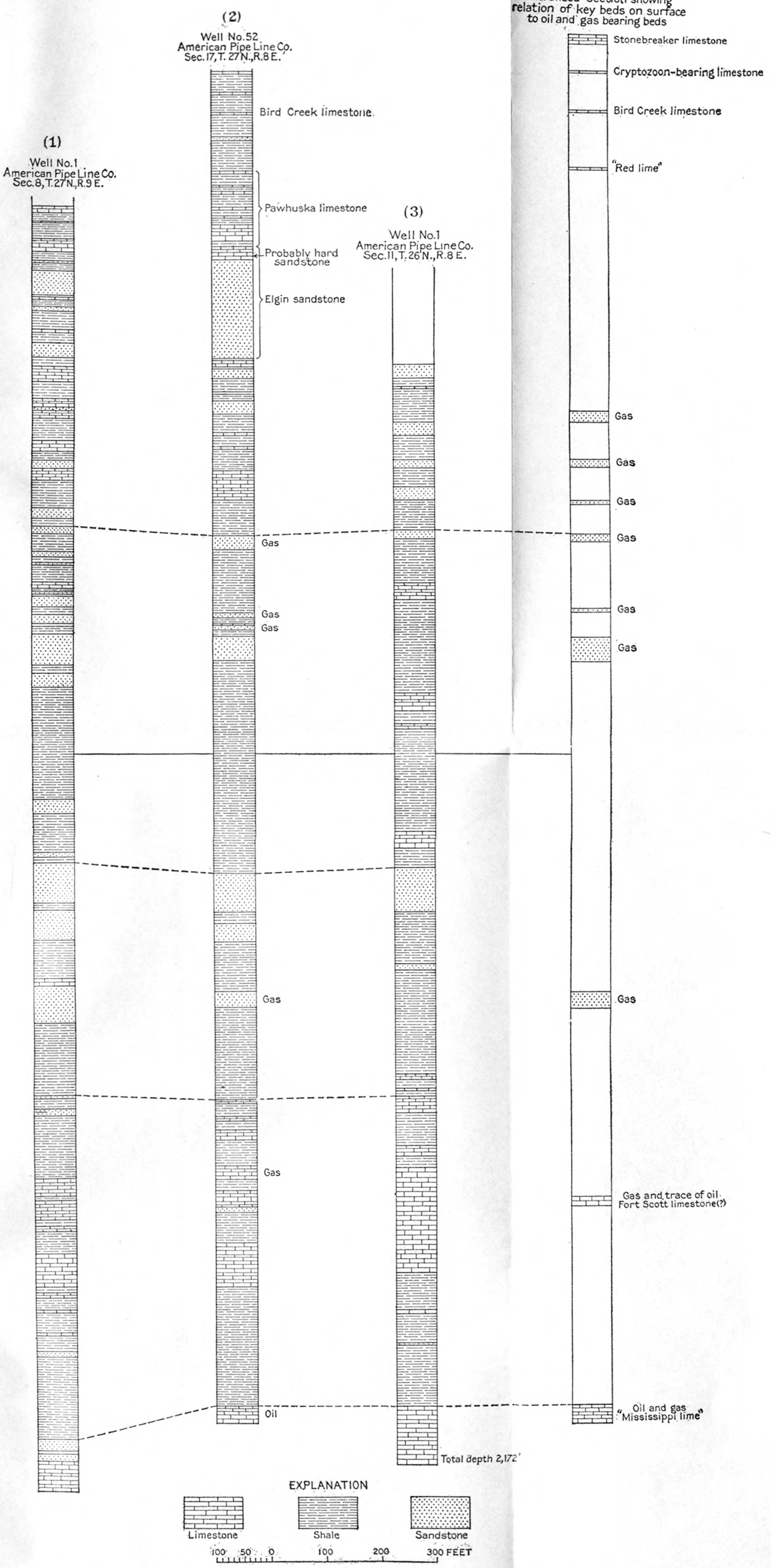
Above the "red lime" (the topmost bed of the Pawhuska limestone) is a series of sandstone. About 25 feet below it are the beds of light-gray limestone that make up the greater part of the thickness of the Pawhuska limestone. This 25-foot interval is in places occupied entirely by shale, but much more commonly it also contains sandstone which is not distinguishable in color and texture from that overlying the "red lime." A very thin limestone, so full of fossil *Fusulina* as to resemble a layer of dirty-yellowish rice, is also present in places and is extremely helpful as a horizon marker.

PENNSYLVANIAN ROCKS NOT EXPOSED.

Below the surface of T. 27 N., R. 8 E., there are about 2,100 feet of sediments of Pennsylvanian age which resemble in general character the outcropping beds and which rest upon the Mississippian limestone. The exact horizon at which the Pennsylvanian rocks stop and the Mississippian rocks begin has not been determined, although it is known that the limestone called the "Mississippi lime" by drillers is either very near the top or at the top of the Mississippian series. The general sequence is shown graphically in Plate XXXV. The locations of wells whose logs are reproduced on this plate are shown in figure 37.

SANDS CONTAINING OIL OR GAS.

In the Pearsons Switch field, from which comes the only oil and gas produced in T. 27 N., R. 8 E., and in the Myers gas field, which is in the extreme northeast corner of T. 26 N., R. 8 E., most of the



RECORDS OF DEEP WELLS IN T. 27 N., R. 8 E., AND ADJOINING TOWNSHIPS, SHOWING DRILLERS' INTERPRETATIONS OF THE CHARACTER OF BEDS UNDERLYING THE SURFACE AND GENERAL POSITION OF OIL AND GAS BEARING STRATA.

gas comes from a series of sands the highest of which is about 630 feet below the Stonebreaker limestone and the lowest about 420 feet lower. Below these sands there is a barren series, about 670 feet thick, of alternating sandstones and shales, and next a sand about 30 feet thick which was reported to carry gas in one of the deep wells that has been drilled on the Pearsons Switch anticline, although no attempt has ever been made to utilize the gas.

Underneath this gas-bearing sand there is a heavy bed of shale, succeeded by a series of limestones and shales with very little sandstone. One bed of limestone about 2,100 feet below the Stonebreaker limestone carries gas and has given a showing of oil below the Pearsons Switch anticline, and from this circumstance, as well as from the relation of this bed to an underlying series of dark shales, it seems probable that this limestone occupies the general horizon of the Fort Scott ("Oswego") limestone. Some 360 feet lower there is a heavy limestone which carries both gas and oil under the Pearsons Switch anticline and which has given showings of oil in deep wells at short distances to the east and to the south of T. 27 N., R. 8 E. This bed is almost undoubtedly the "Mississippi lime," which yields oil in the fields near Pawhuska and farther east in the Osage Reservation.

STRUCTURE.

The rocks exposed in T. 27 N., R. 8 E., have a general westerly dip of about 35 feet to the mile. This dip is fairly uniform over much of the township but is modified in the south-central and west-central parts by the Hickory Creek and Pearsons Switch anticlines, on the flanks of which the rocks dip to the north, east, and south as well as to the west.

HICKORY CREEK ANTICLINE.

The Hickory Creek anticline is a rather small plunging anticlinal fold whose axis extends from a point near the north quarter corner of sec. 27 northwestward to the NW. ¼ sec. 21. (See fig. 38.) It is a gentle fold, and the rocks dip smoothly to the northeast and southwest from the axis, which plunges to the northwest. There is no easterly dip along the axis.

At the time the field work on T. 27 N., R. 8 E., was completed no drilling had been done on this fold, but it is understood that more recently at least two wells have been drilled near its axis. It is reported that one of these wells found gas in paying quantity and had an initial production of 2,000,000 cubic feet a day. It is not known from what sand this gas was obtained, but probably it came from one of the shallow sands that yield gas in the Pearsons Switch field, 2 miles to the northwest. Nothing is known concerning the other well.

The structural conditions on this fold do not lead to a belief that it has been effective in bringing about the formation of any large pool of oil, for although similar anticlines which have no closure on the east have been found to overlie oil pools in other parts of the Osage Reservation, these pools have almost invariably yielded only moderate amounts of oil, even where the sand conditions are believed to be distinctly favorable. In view of the fact that a well drilled to the "Mississippi lime" on the Pearsons Switch anticline, only a mile west of the Hickory Creek anticline, yielded a large quantity of oil, it seems justifiable to recommend a test to the "Mississippi lime" on the Hickory Creek anticline, even though the structural conditions are not pronouncedly favorable. It should be borne in mind that the geologic structure is only one of the several factors which control the location of an oil or gas pool and that some one of the other factors may greatly enhance the value of territory where the surface indications are not particularly encouraging. Furthermore, the Hickory Creek anticline is believed to lie in a general zone of weakness along which some movement with consequent folding took place before the deposition of the rocks that are now at the surface, and this folding may well have resulted in the formation of anticlines which arch the "Mississippi lime" but are not reflected except in a general way by the surface structure. Such concealed anticlines are just as likely to have trapped large quantities of petroleum or gas as any of the well-developed anticlines that appear at the surface.

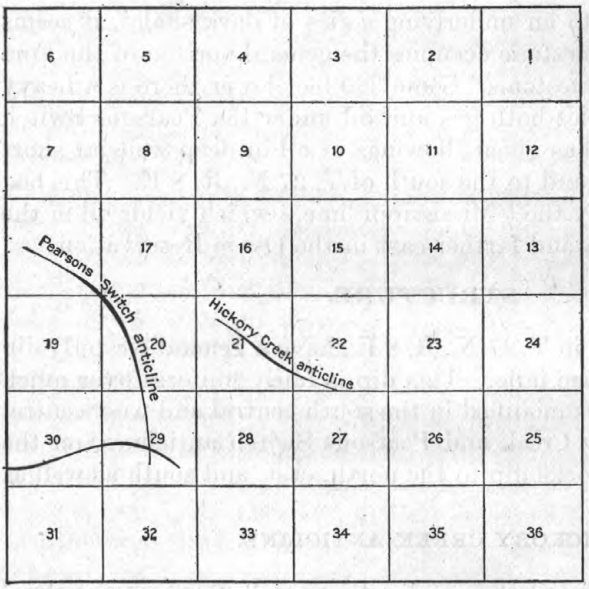


FIGURE 38.—Diagram showing position of anticlinal axes in T. 27 N., R. 8 E.

A good location for a test well on the Hickory Creek anticline is near the center of sec. 21. Wells drilled at this location should encounter the productive sands of the Pearsons Switch field at a little less depth than that at which they were found in well No. 52, sec. 17. (See Pl. XXXV.)

PEARSONS SWITCH ANTICLINE.

The Pearsons Switch anticline, named from its proximity to Pearsons Switch, on the Midland Valley Railroad, is by far the most pronounced fold in the township. It lies in secs. 17, 18, 19, and 20, and on its flanks are two small subsidiary domes, one in sec. 29 and the other in sec. 30. The highest point of the fold appears to be in the extreme southeast corner of sec. 19, and from this point the beds slope in all directions but most steeply to the northeast, where for a short distance the dip is about 100 feet to the mile. The vertical component of this dip is about 40 feet. The outline of the anticline is rather irregular, showing several spurs or scallops, the most pronounced of which is a long eastward-trending point at the extreme north end of the fold. The anticline is capped by a heavy sandstone that lies some 18 feet below the top of the Stonebreaker limestone. The shape of the fold was determined by elevations taken on this sandstone and on the *Cryptozoon*-bearing limestone, which crops out on the western, southern, and eastern flanks. It is possible for confusion to arise in mapping this anticline, as both above and below the *Cryptozoon*-bearing limestone there are beds of limestone which resemble it closely in color and brittleness. Also there is an unconformity below the *Cryptozoon*-bearing limestone, and the character of the beds a short distance below it may be entirely different at two closely adjacent localities.

The minor domes southeast and southwest of the main anticline are both low, oval, smoothly outlined folds. The eastern one, in sec. 29, has an axis about three-quarters of a mile long, trending northwest. The dip to the northeast does not exceed 10 feet in vertical amount and is at the rate of about 60 feet to the mile. That to the southwest is a little steeper. On the northwest and southeast the dips are extremely gentle. This dome is capped by the same sandstone that crowns the main Pearsons Switch anticline, and the structure was outlined from elevations on this sandstone and on the *Cryptozoon*-bearing limestone, which crops out to the north, east, and south. No actual dips to the northeast were seen, and the correctness of the mapping depends on that of the measured interval between the top of the sandstone and the top of the limestone.

The dome in the southwest corner of sec. 30 is more pronounced than the one just described, although it is not so large. This small dome is superposed on an anticlinal fold whose flanks dip to the northwest, southwest, and southeast but not to the northeast. The axis of this fold is more than a mile long and pitches southwest, and the steepest dip is in that direction. The dome is capped by the Stonebreaker limestone, and elevations on this limestone, supplemented by observations on the sandstone lying a short distance below it, were used in determining the structure. At this place the

Stonebreaker limestone is in two beds about 8 feet apart, and care must be taken not to confuse them.

The sands that yield oil and gas under the Pearsons Switch anticline are described briefly in a preceding paragraph (pp. 218–219), and their positions are shown graphically in Plate XXXV. Two oil wells have been drilled into the "Mississippi lime" on this anticline. The first one, whose record is given on Plate XXXV, is in the southwest corner of sec. 17, not far from the center of the crown of the dome. It penetrated about 30 feet into the "Mississippi lime," which yielded both oil and gas. Its initial production was 400 barrels a day. On November 6, 1918, a second well on this anticline obtained oil from the "Mississippi lime." The initial production was 7,000 barrels a day, and the yield is reported to have declined to about half that amount in four weeks. This well, which is not shown on Plate XXXIV, "offsets" the first well to the south. It is possible that elsewhere in this general locality a limestone layer which lies about 350 feet above the "Mississippi lime" and which has yielded showings of both oil and gas may contain commercial quantities of these minerals. There is also a possibility that deeper beds than any that have been reached by wells drilled in this general region may also contain oil and gas. The possibilities of the Pearsons Switch anticline can not be considered established until wells have been drilled at least 300 feet into the "Mississippi lime."

In view of the good results attained by drilling to the "Mississippi lime" on the main dome of the Pearsons Switch anticline it seems justifiable to drill similar tests on the two subsidiary domes to the south. Good locations for these tests are near the middle of sec. 29 and at the center of the SW. ¼ sec. 30. At the location in sec. 29 the "Mississippi lime" should be encountered at a depth of about 2,500 feet; at the other one it will probably be a little deeper.

UNFAVORABLE AREAS.

Over a large part of T. 27 N., R. 8 E., the geologic structure of the surface rocks is not such as is usually found in beds that overlie pools of oil or gas. Most of this township except the areas on or immediately adjacent to the two anticlines described above and a narrow strip near the eastern edge of the township may be classed as unfavorable. The unfavorable area includes secs. 2, 3, 4, 9, 10, 15, and 16, the S. ½ secs. 31 and 32, and all of secs. 33 and 34. This does not necessarily mean that there is no oil or gas under these portions of the township, but rather that they are so much less favorable than the remainder that it would not be justifiable to drill them unless exploration of the territory which is structurally more promising results in the finding of oil or gas fields that may be extended into these areas.