

OIL AND GAS DEVELOPMENT IN NORTH-CENTRAL OKLAHOMA.

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INTRODUCTION.

LOCATION AND EXTENT OF AREA.

The region considered in this report includes lands formerly within the Pawnee, Otoe, Ponca, Kaw, and Tonkawa Indian reservations, comprising about 82 miles from north to south and 60 miles from east to west in Grant, Kay, Osage, Pawnee, Noble, Garfield, Logan, Payne, and Lincoln counties. (See Pl. V.) The principal towns are Guthrie, Pawnee, Perry, Ponca, Newkirk, and Blackwell, and the principal railroads are the Atchison, Topeka & Santa Fe Railway, the Missouri, Kansas & Texas Railway, and the St. Louis & San Francisco Railroad.

PREVIOUS WORK.

Very little geologic work has been attempted in this region, although a number of geologists¹ have visited it from time to time while studying either the Pennsylvanian-Permian contact or the red beds. Their work, however, has been of a reconnaissance character, so that little information is available regarding the outcropping formations or the geologic structure; therefore, only the broadest general features of the geology will be presented in this report. Perhaps the most detailed work that has been done in the region

¹Gould, C. N., Stratigraphy of the McCann sandstone: Kansas Univ. Quart., 1900, pp. 175-177; Notes on the geology of parts of the Seminole, Creek, Cherokee, and Osage Nations: Am. Jour. Sci., 4th ser., vol. 11, 1901, pp. 185-190; On the southern extension of the Marion and Wellington formations: Trans. Kansas Acad. Sci., vol. 17, 1901, pp. 179-181; Geology and water resources of Oklahoma: Water-Supply Paper U. S. Geol. Survey No. 148, 1905. Adams, G. I., The Carboniferous and Permian age of the red beds of eastern Oklahoma from stratigraphic evidence: Am. Jour. Sci., 4th ser., vol. 12, 1901, pp. 383-386; Lithologic phases of the Pennsylvanian and Permian of Kansas, Indian Territory, and Oklahoma: Science, new ser., vol. 15, No. 379, 1902, pp. 545-546. Beede, J. W., The bearing of the stratigraphic history and invertebrate fossils on the age of the anthracolithic rocks of Kansas and Oklahoma: Jour. Geology, vol. 17, 1909, pp. 710-729; Origin of the sediments and coloring matter of the red beds of Oklahoma: Science, new ser., vol. 35, No. 896, 1912, pp. 348-350. Kirk, C. T., A preliminary report on the contact of the Permian with the Pennsylvanian in Oklahoma: Third Bien. Rept. Oklahoma (Terr.) Geol. Survey, 1903-1904, pp. 5-14.

was carried on during the summer of 1911 by J. W. Beede for the Oklahoma Geological Survey. His work, however, had very little areal extent, being confined to a narrow zone along the outcrop of the Neva limestone of Kansas, which crosses the eastern part of this region. The report of his field investigations has not yet been published, but a summary of his observations appeared in a recent number of *Science*.¹ In view of the fact that little if any attention has been given in these studies to the geologic relation of oil pools in this field no attempt will be made to use the data of others in this paper.

CHARACTER AND EXTENT OF PRESENT WORK.

The writer spent three weeks during January and February, 1912, in visiting the localities where producing wells and test holes have been sunk. An effort was made to get the exact location of all borings, the depth of each hole, the product and amount obtained if any, and wherever possible a detailed log or record of the formations passed through by the drill. In addition to collecting well data, the writer made some observations on the structure and character of the formations exposed at the surface, but attempted no areal mapping. On account, however, of the abrupt changes in the character of formations along their outcrops these observations were not sufficient for accurate correlation of strata throughout the area. Nearly all locations of wells and all information concerning them were furnished either by oil companies or by citizens in the neighborhood of the wells. The writer traveled mostly by rail but made many side trips away from the railroad lines, in order to obtain a comprehensive idea of the geology and oil development of the whole region.

TOPOGRAPHY.

Considered as to its surface features this area may be divided into three parts—the northeastern, which lies east of the Atchison, Topeka & Santa Fe Railway and roughly north of Arkansas River; the western, which lies west of that railroad; and the southeastern, which lies east of the same railroad and south of Arkansas River. In the northeastern part of the area the rugged benchlike terrace and escarpment features known in Kansas as the Flint Hills are typically developed. This form is due to erosion acting on slightly westward-dipping, alternating hard and soft strata. In the western part of the area the surface is rolling and the few streams have low, broad, undissected divides. The surface rocks are almost entirely soft shale. The surface features in the southeastern and southern parts of the

¹ Beede, J. W., *Origin of the sediments and coloring matter of the red beds of Oklahoma*: *Science*, new ser., vol. 35, No. 896, 1912, pp. 348-350.

area resemble those of both the northeastern and western parts to some extent, and the region is characterized by eastward-facing escarpments intermingled with rolling hills. The escarpments are the southern continuation of some of the limestone benches of the northeastern area together with other benches formed by hard sandstones that develop toward the south, whereas the rolling hills between are produced by the erosion of interbedded shale and soft sandstone, extremely diverse in thickness and hardness within short distances along their outcrops. Along the rivers are large areas of river sand, high above the present flood plain. This sand is readily dissected and in places small streams have cut deep ravines through the soft blanket of unconsolidated sand to the harder strata beneath. In the western part and along the north sides of Cimarron and Salt Fork rivers are large areas covered with typical dune sand. As a rule these dunes are covered with bunch grass, bear grass, and sand plums and are stationary, although some are bare of vegetation and are continually shifting with the wind. The region is almost treeless except along the streams and the outcrops of sandstone formations and in areas covered with river sand, which are generally overgrown by blackjack oak.

The benches or escarpments are roughly parallel and are crossed by the major streams, whereas the minor streams flow parallel to them. The vertical range between the tops of the highest hills and the floors of the lowest valleys is about 500 to 600 feet, the highest part being near the northwestern corner and the lowest in Arkansas and Cimarron River valleys where these rivers cross the eastern boundary. Thus it will be seen that the area, viewed as a whole, slopes eastward or southeastward at an average rate of 8 or 10 feet to the mile. The relief in any locality is not very great, the maximum being in the Flint Hills region, where differences of 150 to 250 feet from hilltop to valley floor are not uncommon.

The master streams are Arkansas and Cimarron rivers, to which all the drainage is tributary except a few small streams in the northeastern and southeastern parts. The beds of these rivers are choked with sand and the rivers have flood plains averaging for the most part from 1 to 2 miles in breadth. Most of the tributaries have high mud banks and little sand in their beds. In the lower parts of the larger minor streams the valleys are wide and the flood plains are well developed, as in the master-stream valleys. The two large streams are perennial but are fed largely by surface run-off and melting snows from the Rocky Mountain region. On this account fluctuations in height are extreme and rapid.

GEOLOGY.

STRATIGRAPHY.

The strata exposed at the surface in this region are referred to the upper part of the Pennsylvanian series and the lower part of the Permian series. There is no evidence of unconformity between the two and only slight lithologic differences, so the only criterion for their separation is the fossils which they contain. In the late reports of the Geological Survey of Kansas the boundary between the Pennsylvanian and Permian has been placed provisionally at the base of the Wreford limestone, but subsequent study has brought to light evidence pointing to the Permian age of the Neva limestone, which crosses the Kansas-Oklahoma line somewhere near the eastern boundary of the Kaw Reservation. This limestone trends nearly southward, bearing a little to the west, and passes near Burbank, Ralston, Pawnee, and Ripley. The hasty nature of the field work forbade the possibility of correlating the strata throughout the region, and therefore only meager and tentative suggestions can be made by using both the observed surface data and those furnished by some of the well logs.

Along the north side, beginning at the east and extending westward to the main line of the Santa Fe Railway in T. 29 N., R. 2 E., is a thick mass of limestone and blue and red shales with very little sandstone. The beds of limestone are very prominent, some of them being 25 or 30 feet thick. The shale is mostly light colored at its outcrops, but traces of red are noticeable and much red shale is recorded at this horizon in wells drilled at Arkansas City, 5 or 6 miles northwest of the northwest corner of the Kaw Reservation. The limestone for the most part is white and massive and at least one bed is to be utilized for the manufacture of cement about 4 or 5 miles east of Arkansas City, where a large plant is now in course of construction. A few miles to the south a very pronounced change is evident. The limestone beds are much thinner and more shaly, whereas the shales and sandstones, mostly soft and red, thicken. In the railroad cuts between Kaw and Ralston are many examples of the abrupt change of the limestone from massive to shaly and from the prevailing white color in the region north to the red colors of the shales above and below it. Just south of Arkansas River most of these beds of limestone die out, but a few in the eastern part of the region persist southward, though much diminished in thickness. Beede¹ has noted an example of a limestone giving way to sandstone in a few hundred feet horizontally along the strike. Many of

¹ Beede, J. W., Origin of the sediments and coloring matter of the red beds of Oklahoma: Science, new ser., vol. 35, No. 896, 1912, pp. 348-350.

the red sandstones seem to have very little cementing material. They are so soft that they have little more effect on the topography than shale and they can be crushed readily beneath the foot or between the fingers. In the southern part of the region they are extremely variable in character, in many places giving way to red clay in a hundred yards along the outcrop, and then in an equal distance in some places the clay changes back to sandstone. Extreme variations in character and thickness of sandstone can be seen in cuts along the Missouri, Kansas & Texas Railway southwest of Cushing and also between that place and Tryon. There is a very noticeable difference, however, in the amount of sandstone showing at the surface in the southern part of the region as compared to that showing in the northern part. Between Cushing and Guthrie, where the Atchison, Topeka & Santa Fe Railway follows Cimarron River, there are good exposures of heavy sandstone making high and steep bluffs. Practically all the formations outcropping along this line are red, and no limestone was noticed between Ripley and Guthrie. No outcrop of solid rock could be followed and mapped west of the main line of the railway, which corresponds roughly with the strike of the rocks. This railroad may therefore be considered as marking the approximate boundary between the hard formation below and the soft shale of the formation above.

The well records of the region do not throw much light on the geologic formations, though on careful study some very general correlations may be attempted. With few exceptions the drillers do not recognize any particular bed of rock in different places, and hence it is to be supposed that the formations are extremely variable. It is known from personal study that the sandstones which deeply underlie this region are variable in thickness along their outcrops to the east. Detailed work in that region has shown that along certain zones the sandstone is variable, in places being thick and massive and in other places thin and insignificant. In the places where it is thin it is generally indurated and is frequently mistaken for limestone by the drillers. Some higher sandstones, however, are more continuous and uniform along their outcrops, as reported by Smith,¹ who has surveyed the Pawhuska quadrangle, just east of the northern part of this region. Most of the limestone beds are more persistent throughout the general region but are known to change abruptly toward the south in both lithologic character and thickness. This fact, however, does not account for the vast difference in the records of wells separated from each other by only a few miles. In the drill records the beds of red shale appear to be the most constant and therefore some suggestive correlations will be attempted in order to

¹ Smith, C. D., personal communication.

make a rough determination of the thickness and number of the oil-bearing sands.

On comparing the lowermost red stratum of a series of three at 1,165 feet in the well near Ralston, in the NE. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 3, T. 24 N., R. 5 E., with the lowermost red stratum of a series of three at 1,975 feet in the 101 Ranch well No. 1, near Ponca, in the SE. $\frac{1}{4}$ sec. 25, T. 25 N., R. 1 E., it is found that this bed is about 800 feet higher in the former than in the latter well. Then by estimating the distance between these wells at right angles to the strike to be 24 miles, and assuming that the mouth of the Ponca well is about 80 feet higher than the mouth of the Ralston well, it seems that 30 feet to the mile might be taken as the general westward dip. On the basis of a dip of 30 feet to the mile, certain provisional correlations may be made. It is known that in the Cleveland field, just east of Blackburn, several producing sands are found at the following approximate depths:

Producing oil sands in the Cleveland field.

	Depth in feet.
Sand	500
Sand	1,000
Layton	1,300+
Sand	1,400-1,500
Cleveland	1,570-1,700
Skinner	2,200±
Bartlesville	2,400±
Tucker or Meadows	2,600-2,800

The sands mentioned above, however, are not found in all the wells and where encountered are not always productive. If the dip of 30 feet to the mile holds throughout this region, these sands should be 200 to 250 feet lower in the Blackburn well and from 1,000 to 1,100 or perhaps 1,200 feet lower in the wells at Ponca than in the Cleveland field. Further, it follows that the gas sand at a depth of about 550 feet at Ponca is above the mouth of the wells at Cleveland and outcrops between the two places, and perhaps the Ponca oil sand, which is encountered at about 1,550 feet, is the equivalent of the 500-foot or first productive sand at Cleveland. The sand in which a "showing" of oil was encountered in 101 Ranch well No. 1, near Ponca, at a depth of 2,520 feet, is provisionally correlated with the Cleveland sand at Cleveland, although it may be equivalent to the sand about 150 to 200 feet above the Cleveland sand. On this basis, if the lower sands are persistent, the Bartlesville sand would be about 3,400 to 3,600 feet and the Tucker or Meadows sand about 3,700 to 3,900 feet below the surface at Ponca. There is no evidence that these zones of sand persist as far west as Ponca, but judging from their persistence where they are exposed and from their outcrops to the region of Cleveland, they would

naturally be expected to continue westward under much if not the whole of this area. No unconformities are known within the oil-bearing rocks, and it is therefore believed that most of the sands are fairly regular and persistent. On the other hand, the base of the Pennsylvanian series rests unconformably on the Mississippian series, and if the region of the continental sea was west of the Ozark uplift of Arkansas and Missouri during the deposition of these rocks then there might be formations still lower in the Pennsylvanian than those which form the base of that series at its outcrop.

STRUCTURE.

The region under discussion lies wholly in the great monocline which flanks the western side of the Ozark uplift, a broad, dome-shaped area occupying northwestern Arkansas, southwestern Missouri, southeastern Kansas, and northeastern Oklahoma. The term *Prairie Plains monocline* is usually applied to this western flank of the great uplift.

The geologic formations as a rule strike N. 5° to 10° E. and, judging from the known areas to the east and north and the evidence of the well logs, dip 25 to 40 feet to the mile westward. The dip varies from place to place, but it is thought that 30 feet to the mile may be the average dip.

No faults are known in this region and if present they are probably very small and insignificant. While making this reconnaissance two or three small folds, which break the monotony of the westward dip, were noted. These minor structures were not examined thoroughly as to amount of dip or areal extent, but they seem to be characterized by a slight reverse dip and then a comparatively steep (in places 1°) westward dip, which in a short distance merges with the prevailing dip of the monocline. The axes of the folds seem to be parallel to the general strike, and the longer and steeper limb of the anticline is on the west side of the axis. The number of these folds is not known, but evidences of anticlinal structure are seen at Ponca City, where the present producing oil pool is located, and along Arkansas River, about 5 miles east of Newkirk, where a dip of about 1° W. and, a short distance to the east, a slight dip in the opposite direction are apparent. Evidence of a similar structure was observed in the Osage Nation across the river, east of Ponca City and south of Kaw. It has been learned by personal conversation with members of the State Survey that anticlines have been noted on the Pawnee Reservation—one along the river north of Ralston and another about 6 miles east of Pawnee, where Black Bear Creek turns north to discharge into Arkansas River—but these reports were not verified by the writer. It is quite probable that other folds of this character exist, and if so, they may have had an influence on the accumulation of oil and gas.

OCCURRENCE OF THE OIL.

Oil and gas are usually found in porous sandstone, which serves as a reservoir or lodgment place, although gas is reported from a crevice in a well near Blackwell and oil from a sandy limestone in a well near Ralston. These, however, are the exceptions rather than the rule in this region. The sands have the same characteristic of variable thickness that distinguishes them in the better-known and more widely developed territory to the east. The sands recorded by drillers seem to hold their thickness and character in any direction for only short distances, and then to thin materially or disappear, but if one disappears another sand usually appears at no great distance at about the same horizon. It is possible to strike oil or gas at almost any depth, for even in the wells north of Blackwell gas is often encountered at depths of 125 to 150 feet and in various sands below this depth. As these sands are high in the geologic section it is possible for them to be underlain by a great number of other oil and gas bearing sands, the number decreasing from west to east across the strike of the rocks and down the geologic scale. A fair idea of the number of possible oil-bearing sands at Ponca may be obtained by comparing the log of the 101 Ranch Oil Co.'s well No. 1, in the SE. $\frac{1}{4}$ sec. 25, T. 25 N., R. 1 E., with that of the Prairie Oil & Gas Co.'s well near Blackburn, in the NE. $\frac{1}{4}$ sec. 29, T. 22 N., R. 7 E. It is estimated that the horizon of the bottom of the Ponca well is about 1,600 or 1,700 feet below the surface in the Blackburn well. Then, by taking the entire log of the first well and hypothetically supplying the remainder of the section with the log of the second well below 1,600 or 1,700 feet, the total number of sands is found to be about 20. It should be understood, however, that this correlation is a mere assumption and that the sands of the Blackburn well might not be encountered, and, again, more and thicker sands might be found, as in some of the wells in the Cleveland district southeast of Blackburn.

Generally, though not invariably, in the Mid-Continent field, where the rocks are saturated with water, oil and gas tend to accumulate under low domes or anticlines. There are indications of many small anticlines in this region and nearly every well record shows an abundance of salt water at varying depths. It is thought that such places afford favorable locations for the accumulation of oil and gas in paying quantities should the quality of the sand be such as to furnish a reservoir for the purpose. It is interesting to note that the only decided domelike structure known to have been tested, that at Ponca, has yielded oil in paying quantities. There may be other places at which similar structures have been penetrated by the drill without result, but none was observed by the writer in his hasty examination.

DEVELOPMENT OF THE FIELD.

HISTORY.

Oil has been known east of these reservations in the Cherokee and Creek nations since the late eighties of the last century. Development started in the vicinity of Alluwe and Bartlesville, in the Cherokee country, and Muskogee, in the Creek country, in the early nineties, but owing to departmental restrictions governing leases little was done until the early part of the last decade, when the restrictions were removed and development began in earnest. In 1904 the Bartlesville, Coodys Bluff, Alluwe, Copan, and Hogshooter pools were opened with a large production and development continued south as far as Tulsa. During the same year a large producing pool was discovered at Cleveland, 8 or 9 miles east of the Pawnee Reservation. In 1906 the famous Glenn pool, near Sapulpa (about 30 miles east of the southern limits of the Pawnee Reservation), was discovered and it has proved to be a phenomenal producer. Father north and west of Bartlesville development has continued westward in the Osage Reservation as far as the original blanket lease extended. This was near the longitude of Pawhuska, beyond which drilling has been forbidden up to this time except on a few isolated tracts held under this same blanket lease. Encouraged by results obtained in the fields mentioned above, prospectors soon began drilling farther west and in the region embracing the five reservations under discussion. Foreign capitalists have sunk a number of holes in widely separated localities, and many local companies have drilled in an effort to reach oil or gas and incidentally enhance the value of their property and build up their towns. Owing to the shallow depth at which drilling ceased many of these tests were not adequate, yet results have been encouraging and prospecting continues with renewed vigor. This is due largely to the recent discovery of oil at Ponca, the steady rise in the price paid for the commodity, and the belief of the oil men that the region has unlimited oil and gas possibilities. Indications of oil or gas, or both, have been found at Meridian, Ripley, Yale, Hallett, Blackburn, Ralston, and other places; gas in paying quantities at Newkirk and Blackwell; and both oil and gas at Ponca and Cushing.

DESCRIPTION OF AREAS.

Cleveland and the region east.—Oil and gas found in the various developed parts of the Mid-Continent field come principally from sands in the Cherokee shale, but some exceptions are found to this rule as development is extended westward. The chief exceptions are the highly productive Cleveland sand in the Cleveland pool and other productive sands still higher in the geologic section at Ponca, Newkirk, Blackwell, and other places. The Cleveland sand is 200 to 300 feet above the Big lime, a formation familiar to the drillers and

usually recognized by them but sometimes confused with the Fort Scott ("Oswego") limestone just below, and the Big lime in turn is 150 to 250 feet above the contact of the Cherokee shale with the Fort Scott limestone. East of the longitude of Cleveland most of the oil comes from numerous sands in the Cherokee shale, which are usually named after the pools in which they were first found to be productive. The Bartlesville sand, in the Cherokee shale, named from the Bartlesville pool, where it was found to be productive at about 1,200 to 1,300 feet, carries oil throughout wide areas in the northern part of the Mid-Continent field. Probably this same sand has recently been found to be productive in the Cleveland pool at a depth of 2,400 to 2,500 feet and about 700 feet below the Cleveland sand. During the past few months a still deeper oil-bearing sand, the Tucker or Meadows, has been struck at Cleveland at a depth of 2,600 to 2,800 feet. This sand is in a thick mass of hard limestone (the "Mississippi lime" of the drillers), which in the author's opinion is probably referable to the Morrow formation, at the base of the Pennsylvanian series, or possibly to the Morrow formation and also the Pitkin limestone and Boone limestone, the latter two at the top of the Mississippian series. Since the writer's visit to this region oil has been found, according to newspapers and oil journals, southwest of Cleveland and along the eastern limit of the area shown on the map in a deep sand, probably corresponding to the Bartlesville sand, which flowed from some of the wells at the rate of 2,000 barrels or more a day.

The quality of the oil varies both with the pool and the sand containing it, and also from place to place in the same sand. According to David T. Day,¹ of the United States Geological Survey, who has analyzed many oils from the Mid-Continent field, Muskogee oil has the highest grade, with a gravity of 38° to 40° Baumé, whereas the lowest grade, except that of oil from the vicinity of Wewoka and farther south, is reported for oil from a 500-foot sand near Dewey, which has a gravity of 29.6° Baumé. The average for the field is between 32° and 36° Baumé. The oil at Muskogee has a pure paraffin base, whereas all the others reported have a mixed paraffin and asphalt base with the proportion of the constituents varying greatly. The greater part of the base, however, is paraffin.

Prospecting has been general, but large areas have still not been tested by the drill. Therefore, until such tests are made the field can not be classed as matured. New pools are continually being discovered and the loss in production of the old pools is equaled if not exceeded yearly by the increase due to "coming in" of new wells and new pools. In the youth of the field an isolated well was called a dry hole and plugged if it had not an initial daily production of 40 or 50 barrels, and a well was not considered good unless it produced

¹ Day, D. T., Analysis of crude petroleum from Oklahoma and Kansas: Bull. U. S. Geol. Survey No. 381, 1910, pp. 494-503.

a hundred barrels or more daily. It was not uncommon for wells to start off with a production of 1,000 to 2,000 barrels daily, and occasionally such a well is still "brought in," but conditions have changed now and a 50-barrel well is classed among the producers. Gas accompanies the oil in all wells and also occurs alone and in immense quantities in some pools, such as the Hogshooter and Collinsville gas fields. Water is also present in nearly all the wells in connection with the oil and gas and is often a menace to the life of the well, as it floods the sand and drives back the oil or gas.

Olive and Tiger Creek.—Within the past year drilling has been going on near Olive, in the NE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 17, T. 18 N., R. 8 E., and along Tiger Creek in the southwestern part of T. 18 N., R. 7 E., just southeast of the Pawnee Reservation. It is difficult to learn the exact results of these tests, but it is believed from evidence in hand that they are encouraging. A log of the well drilled at Olive shows a number of sands, but no information was obtained regarding their character. An unknown amount of gas was encountered in a 40-foot sand at a depth of 2,600 feet, which is thought to be about the position of the Bartlesville sand. Slick & Jones completed a well 3,015 feet deep in the NE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 28, T. 18 N., R. 7 E., during the early winter of 1911-12, a log of which was supplied the writer for study. At 1,526 feet a 20-foot sand was struck which was said to produce 30 barrels of oil daily. This sand, on account of similarity of section, is believed to be equivalent to the Layton sand at Cleveland. At 1,940 feet a 70-foot sand was encountered, which is called the Cleveland sand, and at 2,280 feet a 90-foot limestone, with a break near the middle, was encountered, which is called by the drillers the Oswego lime. At 2,400 feet a "stray" sand 80 feet thick with a "showing" of oil, said to have a gravity of 42° Baumé, was recorded. The remainder of the record is incomplete except for some thin limestones at the bottom in which the drill stopped. The operators were encouraged by what they found in this well and immediately began drilling two wells in the vicinity, one in the NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 34, T. 18 N., R. 7 E., and the other in the NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 32. Oil was found at 1,423 feet in the latter well early in March, 1912. Drilling was continued, however, and it is reported that at 2,200 feet more oil and gas was found about the 20th of March and that a stampede for leases resulted. The same company is beginning another well in sec. 11, T. 17 N., R. 5 E., and, according to report, will soon start at least two others.

Cushing and Ripley.—In 1901 and 1902 local capitalists at Cushing drilled a well to a depth of 800 or 900 feet in the NW. $\frac{1}{4}$ sec. 2, T. 17 N., R. 5 E. Soft red beds which caved badly were predominant and drilling was finally given up without finding a trace of oil or gas. In 1906 another company was organized and started a well nearer the town, in the NW. $\frac{1}{4}$ sec. 4, T. 17 N., R. 5 E. Much trouble

was encountered by the caving of the red beds and after a great outlay of money and the loss of the tools in the hole it was abandoned at a depth of a little over 1,100 feet.

In 1907 a well was drilled southeast of Ripley, in the SE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 4, T. 17 N., R. 4 E., to a depth of 2,600 feet and is reported to have been perfectly dry. No log of this well could be obtained. West of Ripley, in the NE. $\frac{1}{4}$ sec. 26, T. 18 N., R. 3 E., a well was drilled several years ago by B. M. Moorehead on his ranch to a depth of 2,200 feet. At 1,787 feet a 13-foot sand was struck which is said to have produced 3,000,000 cubic feet of gas daily and a "showing" of oil, but it was cased off and drilling resumed. As these wells are probably between 20 and 25 miles across the strike from the Cleveland pool, a dip of 30 feet to the mile would mean that this sand, which lies at a depth of 1,787 feet in the well west of Ripley, would be about 700 feet higher in the Cleveland pool, or at a depth of about 1,000 or 1,100 feet. It seems quite possible, therefore, that it may be equivalent to the oil-bearing sand found at a depth of about 1,000 feet in the Cleveland pool. It is planned to sink this well to a depth of 2,600 or 2,700 feet the coming summer in an effort to reach the Cleveland sand.

It is obvious that the two test wells at Cushing were inadequate, owing to their slight depth, unless some very shallow sand in the red beds should be locally productive. The well southeast of Ripley, if drilled to a depth of 2,600 feet, as reported, was probably a fair test to or nearly to the Cleveland sand, and the one west of Ripley is very encouraging with the strong flow of gas and "showing" of oil reported. The Cleveland sand, if persistent, should probably be struck in this well at a depth of 2,600 or 2,700 feet.

Stillwater.—Several years ago a local company sunk a hole in the southeastern part of the town of Stillwater, in the NE. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 23, T. 19 N., R. 2 E., to a depth of 1,200 feet without finding oil or gas. No log is available and it is not known whether any sands were encountered. The test was very inadequate, however, as the shallowest producing sands at Cleveland were probably not reached, for it is estimated that Stillwater is 800 or 900 feet higher in the geologic section than Cleveland. Deeper drilling will have to be done before the region can be regarded as thoroughly tested. It is estimated that the Cleveland sand, if persistent, lies about 2,700 or 2,800 feet below the surface at Stillwater.

Meridian.—A deep hole was sunk by local capitalists at the town of Meridian, in the NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 30, T. 18 N., R. 1 E., a year or so ago in search of oil or gas, and Mr. Miles Allen, of that town, has furnished the writer with a detailed log. The first thousand feet is composed almost entirely of soft red shale that gives the drillers much trouble by caving, and shale of this character is found in places below to a depth of 2,200 feet. Very little sand was found

in the upper part of the well, although about 20 feet of white barren sand was found at 900 feet and 40 feet of brown and white barren sand at 1,030 feet. At 2,050 feet, however, a 40-foot sand was found, the middle portion of which is gas bearing. At 2,145 feet a 10-foot gas-bearing sand and at 2,330 feet another one 25 feet thick were found. Two other white barren sands are recorded below this, one 30 feet thick at 2,550 feet and another 27 feet thick at 2,637 feet. At first thought this might be considered a fair test, but upon analysis it is believed that it reaches only the shallowest of the sands at Cleveland. One of the two 30-foot sands near the bottom may be equivalent to the Layton sand at Cleveland. In that event the gas-bearing sands above would be near the horizon of the sand found at a depth of 1,000 feet at Cleveland. This conclusion is reached by projecting these beds across the strike and down the dip from the Tiger Creek wells, a distance of about 35 miles, and allowing 30 feet a mile for westward dip. This would make a difference of approximately 1,050 feet in the depth of any given sand at the two localities. On such a basis many sands are found to be roughly common in the two wells, although they are 35 miles apart. If the foregoing suggestions are true, the Cleveland sand should be reached at Meridian at about 3,000 or 3,200 feet and the Bartlesville sand at about 3,700 or 3,900 feet.

Guthrie and Mulhall.—About 10 years ago the city of Guthrie sank several wells 300 to 500 feet deep in search of a supply of fresh water but found only salty artesian water. One of these wells, in the NE. $\frac{1}{4}$ sec. 17, T. 16 N., R. 2 W., was drilled to a depth of 1,400 feet, but soft red shale was encountered most of the way and neither oil nor gas was found. No log is available at the present time. A local company is sinking a test well just north of the town of Mulhall. This is practically in strike with the Guthrie well and stratigraphically should be very much like it. On March 1, 1912, it was 1,730 feet deep and drilling in a series of sandstones full of salt water, shales, and thin limestones. No oil or gas had been found. This well is about 45 miles across the strike and down the dip from the Tiger Creek wells and is therefore thought to be stratigraphically about 1,300 or 1,400 feet above that of the Tiger Creek wells. If so, the salt-water sandstone starting at 1,470 feet in the Mulhall well would be equivalent to the sandstones near the top of the Tiger Creek well. If this be true, the Cleveland sand should be about 3,300 to 3,500 feet and the Bartlesville sand about 4,000 or 4,200 feet beneath the surface at both Guthrie and Mulhall.

Jennings and Hallett.—After the discovery of the Cleveland pool some men were encouraged by the outlook immediately to the west and sank several test holes in the vicinity of Hallett and Jennings and just east of the Pawnee Reservation boundary. Exact data are

difficult to obtain, but it is known that oil and gas were found in several of the wells. The amount, however, is variously reported, for it is claimed by some that nearly all the wells were dry, whereas a few had a "showing" of oil or gas. A moderate statement by a reliable producer at Cleveland is that some of the wells produced gas in paying quantities and that at least two wells east of Hallett for a time produced oil. A log of a well 2,805 feet deep, drilled by the Prairie Oil & Gas Co. near Jennings, in the NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 30, T. 20 N., R. 7 E., shows the Layton sand 25 feet thick at 1,485 feet; the Cleveland sand 65 feet thick at 1,940 feet; either the Big lime or Oswego lime 100 feet thick, with one break near the middle, at 2,275 feet; and the Bartlesville sand 70 feet thick at 2,737 feet, in which drilling ceased. No oil or gas is reported. The proximity of these wells to the Cleveland pool renders detailed discussion useless, as the same stratigraphic conditions seem to exist, except that the formations are 150 to 200 feet lower. Oil and gas should be found in paying quantities where the structure is favorable.

Log of well 2 miles east and half a mile south of Hallett, in northwest corner of SW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 12, T. 20 N., R. 7 E.

	Thick- ness.	Depth.		Thick- ness.	Depth.
	Feet.	Feet.		Feet.	Feet.
Soil.....	15	15	Lime shell.....	5	1,050
Lime.....	3	18	Shale, white.....	96	1,146
Shale.....	32	50	Sand.....	5	1,151
Lime.....	10	60	Shale, white.....	64	1,215
Shale.....	40	100	Lime (gas at 1,215 feet).....	10	1,225
Red rock.....	20	120	Shale, white.....	28	1,253
Sand.....	50	170	Sand (gas at 1,253 feet).....	17	1,270
Shale.....	8	178	Shale, white.....	5	1,275
Sand.....	5	183	Lime shell.....	2	1,277
Shale.....	120	303	Shale, white.....	73	1,350
Shells.....	2	305	Shale, brown.....	102	1,452
Shale.....	5	310	Lime shell.....	3	1,455
Sand.....	27	337	Shale, white.....	70	1,525
Shale, pink.....	4	341	Sand, Layton (?).....	15	1,540
Lime.....	4	345	Shale, white.....	227	1,767
Red rock.....	17	362	Lime.....	10	1,777
Sand, water (20 bailers per hour).....	18	380	Shale, white.....	173	1,950
Red rock.....	35	415	Shells.....	20	1,970
Sand, water.....	10	425	Shale, white.....	120	2,090
Red rock.....	15	440	Shale, black.....	20	2,110
Shale, white.....	40	480	Lime.....	25	2,135
Red rock.....	5	485	Shale, black.....	40	2,175
Shale, white.....	5	490	Lime.....	40	2,215
Sand.....	35	525	Shale, blue.....	70	2,285
Red rock.....	25	550	Lime.....	4	2,289
Sand.....	3	553	Shale, blue.....	6	2,295
Red rock.....	12	565	Shale, white.....	115	2,405
Sand.....	18	583	Lime.....	15	2,420
Red rock.....	82	665	Shale, white.....	86	2,506
Shale, white.....	50	715	Sand, Bartlesville (?).....	135	2,641
Sand.....	5	720	Showing of oil at 2,424 and 2,510 feet.....		
Shale, white.....	70	790	Water in sand from 2,565 to 2,641 feet, hole full.....		
Red rock.....	10	800	Shale, white.....	9	2,650
Sand (little water).....	10	810	Lime.....	47	2,697
Sand (more water; hole full).....	8	818	Lime, light and very hard.....	109	2,806
Shale, white.....	10	828	Sand, Meadows (much water).....	14	2,820
Shells.....	3	831	Lime, black.....	20	2,840
Red rock.....	34	865	Lime, light and hard.....	10	2,850
Sand.....	5	870	Lime, dark.....	9	2,859
Shale, white.....	5	875	Lime, dark and hard.....	21	2,895
Sand.....	5	880	Lime.....	15	2,895
Red rock.....	5	885	Sand.....	37	2,932
Sand (water).....	45	930	Lime.....	4	2,936
Shale, white.....	115	1,045			

Maramec and Yale.—About the middle of the last decade a well was sunk near Maramec and two near Yale, in the Pawnee Reservation. No well logs are available, but it was learned that the Maramec well was drilled in the SE. $\frac{1}{4}$ sec. 33, T. 21 N., R. 6 E., and reported dry at a depth of 1,600 feet. The Yale wells were drilled east of that town, in the SE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 19 and the SE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 22, T. 19 N., R. 6 E. The former was drilled to a depth of 2,600 feet and abandoned in salt water and the latter to a depth of more than 2,000 feet. Traces of oil were found in both Yale wells, but the depth was not reported. The Maramec well probably reached the Layton sand, and the Yale wells penetrated beyond that depth. It is probable that the 2,600-foot well reached either the salt-water bearing sand just below either the Big lime or the Oswego lime at a depth of 2,400 feet in the Jennings well, or the sand at 2,620 feet in the same well just above the Bartlesville sand, whereas the 2,000-foot well evidently reached the Cleveland sand, which is found at 1,940 feet in the Jennings well.

Pawnee.—Two attempts have been made by local capitalists to find oil near Pawnee, one just east of the town, in the NE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 5, T. 21 N., R. 5 E., and the other about 4 miles northeast, in the SE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 20, T. 22 N., R. 5 E. These holes were drilled to about 1,800 and 1,975 feet, respectively. It was impossible to get satisfactory information concerning them, but Mr. Berry, of the First National Bank of Pawnee, is authority for the statement regarding their depth and says that they were both dry and that the deeper well encountered nearly 50 feet of sand, impregnated with salt water, at about 1,800 feet. When dip and distance west from Cleveland are taken into consideration, it is probable that the sand encountered in one of the wells at 1,800 feet is the Layton. If this is true, the Cleveland sand should be struck at a depth of about 2,200 or 2,300 feet and the Bartlesville sand between 2,800 and 3,000 feet. These tests were not adequate except for the shallowest producing sands of the Cleveland field.

Blackburn.—Two deep wells have been drilled near Blackburn, northwest of Cleveland, within the last few years. Five or six years ago the Southwestern Oil Co. drilled one 2 or 3 miles east of Blackburn, in the NW. $\frac{1}{4}$ sec. 15, T. 22 N., R. 7 E., to a depth of a little more than 2,600 feet, where the tools were lost in the Bartlesville sand and the hole abandoned. No log of this well is available, but it is reported that a "showing" of oil was encountered, presumably in the deepest sand. During 1911 the Prairie Oil & Gas Co. sank a well southeast of Blackburn, in the NW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 29, T. 22 N., R. 7 E., within 2 miles of the Pawnee Reservation, to a depth of 2,836 feet. In the detailed log of this well a number of thick sands are recorded in the upper measures, but all are reported barren of oil and gas. At 1,685 feet is recorded a 55-foot sand, barren of oil and gas, which is probably the equivalent of the Layton sand of the

drillers. From 1,910 to 2,010 feet are three sands from 10 to 25 feet thick interstratified with shale and a 5-foot bed of limestone. This is thought to be the Cleveland sand. A mass of limestone about 150 feet thick, thought to be the Big lime, is recorded at 2,170 feet, and a 30-foot gas-bearing sand is recorded at 2,365 feet. This, owing to its position below the Big lime, is supposed to be the Skinner sand, which is noted in many of the wells. The horizon of the Bartlesville sand shows no sand, but in its place, between 2,600 and 2,700 feet, 50 feet of soft black shale, 40 feet of soft red mud, and 25 feet of soft white shale were noted. This is followed by hard gray limestone for over 100 feet to the bottom of the hole. It may be that the 40 feet of red mud is the Bartlesville sand changed in character, for it occupies about the same position below the Big lime and above the hard gray limestone (probably Morrow, Pitkin, and Boone) that the Bartlesville sand usually occupies.

Log of well 1 mile south and 1½ miles east of Blackburn, in NW. ¼ NE. ¼ sec. 29, T. 22 N., R. 7 E.

	Thick- ness.	Depth.		Thick- ness.	Depth.
	<i>Feet.</i>	<i>Feet.</i>		<i>Feet.</i>	<i>Feet.</i>
Clay, yellow, soft.....	10	10	Lime, white, hard.....	35	1,380
Mud, red, soft.....	10	20	Shale, white, soft.....	20	1,400
Lime, black, hard.....	12	32	Lime, white, hard.....	15	1,415
Shale, blue, soft.....	15	47	Shale, white, hard.....	35	1,450
Sand, white, soft (water).....	15	62	Sand, white, hard.....	30	1,480
Mud, red, soft.....	10	72	Shale, white, soft.....	35	1,515
Lime, white, hard.....	5	77	Red rock, soft.....	8	1,523
Red rock, soft.....	35	112	Shale, blue, soft.....	23	1,546
Sand, white, soft (water).....	28	140	Lime, white, hard.....	8	1,554
Shale, white, soft.....	6	146	Shale, brown, soft.....	131	1,685
Lime, white, hard.....	36	182	Sand, white, hard (water at		
Red rock, soft.....	30	212	1,730 feet).....	55	1,740
Shale, blue, soft.....	40	252	Shale, black, soft.....	170	1,910
Lime, white, hard.....	4	256	Sand, white, hard.....	15	1,925
Red rock, soft.....	10	266	Shale, black, soft.....	10	1,935
Sand, white, soft (water at			Lime, white, hard.....	6	1,941
285 feet).....	36	302	Shale, black, soft.....	10	1,951
Shale, white, soft.....	40	342	Sand, white, hard.....	12	1,963
Sand, white, soft.....	15	357	Shale, black, soft.....	22	1,985
Shale, blue, soft.....	85	442	Sand, white, hard.....	25	2,010
Sand, white, hard (little salt			Shale, black, soft.....	140	2,150
water).....	15	457	Lime, white, hard.....	5	2,155
Shale, white, soft.....	70	527	Shale, black, soft.....	10	2,165
Sand, white, soft (hole full of			Lime, white, hard.....	45	2,210
water at 530 feet).....	85	612	Shale, black, soft.....	6	2,216
Shale, white, soft.....	60	672	Lime, white, hard.....	10	2,226
Red rock, soft.....	5	677	Shale, black, soft.....	8	2,234
Sand, white, soft.....	8	685	Lime, white, hard.....	9	2,243
Red rock, soft.....	24	709	Shale, blue, soft.....	19	2,262
Sand, white, soft.....	6	715	Lime, white, hard.....	36	2,298
Shale, white, soft.....	16	731	Shale, black, soft.....	14	2,312
Sand, white, soft (water).....	40	771	Lime, white, hard.....	8	2,320
Shale, white, soft.....	51	822	Shale, white, soft.....	45	2,365
Red rock, soft.....	25	847	Sand, white, soft (gas at 2,370		
Lime, white, hard.....	6	853	feet; hole full of water at		
Sand, white, hard (little			2,385 feet).....	30	2,395
water).....	10	863	Lime, white, hard.....	10	2,405
Shale, white, soft.....	54	917	Shale, black, soft.....	25	2,430
Sand, white, hard.....	35	952	Shells, black, hard.....	20	2,450
Red rock, soft.....	10	962	Shale, black, soft.....	30	2,480
Sand, white, hard (little			Sand, white, hard.....	6	2,486
water).....	30	992	Shale, black, soft.....	8	2,494
Shale, white, soft.....	28	1,020	Lime, pink, hard.....	14	2,508
Red rock, soft.....	10	1,030	Shale, white, soft.....	82	2,590
Sand, white, soft (little water).....	15	1,045	Lime, white, hard.....	6	2,596
Red rock, soft.....	10	1,055	Shale, black, soft.....	54	2,650
Sand, white, hard (hole full of			Mud, red, soft.....	40	2,690
water at 1,085 feet).....	215	1,270	Shale, white, soft.....	22	2,712
Shale, blue, soft.....	75	1,345	Lime, hard, gray.....	124	2,836

Ralston.—Eight or ten years ago a deep well was drilled just outside the town corporation of Ralston, in the NE. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 32, T. 24 N., R. 5 E. Much trouble was experienced in getting through the soft red beds, which were present to a depth of about 1,200 feet. Drilling was carried on intermittently for nearly a year, when a depth of 3,300 feet was reached. The only available log is incomplete, as the first 1,000 and the last 650 feet are wanting. The record is valuable, however, in that it shows a number of oil and gas bearing sands, as follows: At 1,000 feet, 20 feet of oil sand; at 2,140 feet, 85 feet of oil sand; between 2,380 and 2,480 feet, three "showings" of oil and gas; and at 2,640 feet, an unrecorded thickness of gas sand. The sand at 1,000 feet is tentatively correlated with the 500-foot or shallowest producing sand at Cleveland and the 1,550-foot producing sand at Ponca; the oil sand at 2,140 feet is likewise correlated with the Cleveland sand at Cleveland and perhaps the 2,520-foot sand at Ponca, although the last-named sand may be the one just above the Cleveland sand. The limestone between 2,505 and 2,650 feet would then be either the Big lime or the Oswego lime, and the gas sand just beneath it the Skinner sand of the Cleveland pool. The Bartlesville sand, if persistent, should have been struck at about 3,000 feet. It is thought that the Mississippian limestone was reached before drilling ceased at 3,300 feet. It is not known how much oil and gas was found in this hole, but there were sufficient "showings" to encourage operators to drill other wells in the vicinity, for one is now going down 3 or 4 miles south and another about the same distance northeast of this well. Gas and oil still bubble up from the imperfectly plugged hole.

Log of well 1 mile northwest of Ralston, in NE. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 34, T. 24 N., R. 6 E.

	Thick- ness.	Depth.		Thick- ness.	Depth.
	<i>Feet.</i>	<i>Feet.</i>		<i>Feet.</i>	<i>Feet.</i>
Unrecorded.....	1,000	1,000	Lime.....	7	1,378
Sand (oil).....	20	1,020	Do.....	8	1,386
Shale, red.....	15	1,035	Shale, blue.....	69	1,455
Salt sand.....	5	1,040	Lime.....	18	1,473
Shale, blue.....	5	1,045	Shale.....	15	1,488
Salt sand (water).....	15	1,060	Salt sand.....	15	1,503
Shale, blue.....	5	1,065	Lime.....	5	1,508
Sand, blue.....	25	1,090	Shale, blue.....	12	1,520
Shale, blue.....	5	1,095	Lime.....	5	1,525
Shale, red.....	10	1,105	Salt sand.....	10	1,535
Salt sand.....	15	1,120	Shale, blue.....	5	1,540
Shale, blue.....	20	1,140	Salt sand.....	5	1,545
Shale, sandy.....	10	1,150	Shale, blue.....	10	1,555
Shale, blue.....	15	1,165	Salt sand.....	195	1,750
Shale, red.....	10	1,175	Shale, blue.....	70	1,820
Lime.....	5	1,180	Salt sand.....	60	1,880
Shale, blue.....	40	1,220	Shale, blue.....	8	1,888
Salt sand.....	25	1,245	Salt sand.....	72	1,960
Shale, blue.....	45	1,290	Shale.....	70	2,030
Salt sand.....	15	1,305	Salt sand.....	20	2,050
Shale, blue.....	18	1,323	Shale, blue.....	75	2,125
Sand.....	28	1,351	Cap rock.....	15	2,140
Shale, blue.....	20	1,371	Oil sand.....	70	2,210

Log of well 1 mile northwest of Ralston, in NE. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 34, T. 24 N., R. 6 E.—Continued.

	Thick- ness.	Depth.		Thick- ness.	Depth.
	<i>Feet.</i>	<i>Feet.</i>		<i>Feet.</i>	<i>Feet.</i>
Sand, white.....	15	2,225	Shale.....	4	2,474
Shale, blue.....	50	2,275	Lime.....	5	2,479
Do.....	100	2,375	Shale.....	2	2,481
Shale, black.....	5	2,380	Lime (gas).....	6	2,487
Lime (oil).....	5	2,385	Shale, blue.....	20	2,507
Lime, sandy.....	20	2,405	Lime.....	20	2,527
Sand.....	5	2,410	Shale, black.....	4	2,531
Shale, sandy.....	30	2,440	Lime.....	40	2,571
Shale, blue.....	3	2,443	Shale, black.....	4	2,575
Lime (gas).....	6	2,449	Lime.....	40	2,615
Shale, black.....	5	2,454	Shale, black.....	4	2,619
Shelly lime.....	8	2,462	Lime.....	20	2,639
Shale.....	3	2,465	Sand (gas).....	5	2,644
Lime.....	5	2,470	Unrecorded.....	656	3,300

Kaw.—During the year 1906 some local capitalists at Kaw organized a company and drilled three shallow wells. Two were sunk on the edge of the town, one in the NE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 1, T. 26 N., R. 4 E., and the other in the NW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 2, T. 26 N., R. 4 E., to about 1,000 feet each, and a third about 3 miles southwest, in the SW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 4, T. 26 N., R. 4 E., to 1,220 feet. It is reported that no oil or gas was found in any of these wells and no logs are available. Much salt water is reported from the various sands. It is believed that the shallow gas-producing sand found at 550 feet at Ponca was penetrated within 200 feet of the top of these wells, and the oil and gas bearing sand found at Ponca at about 900 to 970 feet should have been penetrated in these wells at 700 or 800 feet. None of these wells reached the horizon of the 1,550-foot oil and gas bearing sand of Ponca, with the possible exception of the one farthest west, which reached a depth of 1,220 feet. On account of the shallowness of these wells they can not be regarded as adequate tests of the possibilities of the region.

Hardy.—The only well known to have been drilled in the Kaw Reservation was sunk in 1904 or 1905 to a depth of 800 or 900 feet without finding oil or gas. Very little could be learned of the history of this well, but it was sunk near the town of Hardy, on the Midland Valley Railway, in the SW. $\frac{1}{4}$ sec. 20, T. 29 N., R. 5 E. Hardy is very nearly on the outcrop of the same geologic formation as Kaw, and the same conditions as to depth of sands should be expected at the two places. This well, therefore, on account of its shallowness, is not considered a fair test.

Ponca.—In 1905 or 1906 a local company began prospecting for oil in the southern part of the town site of Ponca and found gas at a depth of 500 to 550 feet. Other wells were soon drilled, extending the field 2 or 3 miles north from sec. 34 to sec. 22. Each of

these wells had a small initial production, ranging from 100,000 to 1,000,000 cubic feet daily. In two or three years their production began to run very low, and in 1909 the company prospected farther northeast and found much better wells, some of which ranged as high as 5,000,000 cubic feet of gas daily. The gas came from the 550-foot sand. The outlook was alluring to foreign capitalists, and in 1910 Mr. E. W. Marland, of Pittsburgh, began operations 5 or 6 miles southwest of the town, on the 101 Ranch, in the Ponca Reservation. The first hole was sunk 2,576 feet and reported dry except for a "showing" of oil at about 2,520 feet, which was almost concealed by a flood of salt water that rose nearly to the top of the well. The operators still had faith in the field, and subsequently they sank several other holes, in some of which they found an abundance of gas, but little oil. After having drilled eight or nine holes, however, their efforts were rewarded in June, 1911, with an oil well which produced probably 75 barrels a day. An era of excitement began, and other companies, including the Devonian Oil Co., the Gypsy Oil Co., the Iron Mountain Oil Co., the Paova Oil Co., the Minnetonka Oil Co., and Gunsburg & Foreman, came in and sub-leased tracts near this well from the 101 Ranch Oil Co., the original lessee of the whole area. These companies are each putting down one or more wells in the western part of T. 25 N., R. 2 E., in the immediate vicinity of the original well. Several dry holes have resulted, but at last report five producing oil wells and a number of good gas wells had been "brought in" in secs. 4, 8, 9, and 17 of this township. The confines of the pool have not yet been established, but it appears to be narrow, probably not over three-fourths of a mile wide. The southern limit seems to be near the south line of secs. 17 and 18, but the field is not thoroughly tested, and the producing area may extend farther south than seems probable at this time. At present development is extending about N. 35° E. toward Ponca. Several wells are being drilled about a mile southwest of the town, but at last report none of them had reached the sand, and therefore nothing is known concerning the northern limits of the pool.

There are strong indications of an anticline in this pool, the axis of which seems to be roughly parallel to the strike. The areal extent involved was not determined, but a hasty examination seemed to indicate that the anticline dies out between this pool and Ponca. No surface indications of an anticline in the gas pool 3 or 4 miles to the northeast are known, as it was not examined. This gas pool is practically in strike with the oil pool southwest of Ponca and may be due to an anticline produced by the same crustal movement. Deeper drilling may reveal the presence of oil.

The oil found at Ponca is of a very high grade; its gravity is said to be 45° or 47° Baumé. It is olive-green in color by reflected light and a dark wine color by transmitted light. An analysis furnished by the 101 Ranch Oil Co. shows that the base is a pure paraffin. The wells are said to yield from 40 to 150 barrels daily and some of them flow when first "drilled in." The oil is piped to White Eagle siding by gravity and there loaded on tank cars to be shipped to the refineries of the Pierce-Fordyce Co. in Texas.

The gas is a very valuable asset and the 101 Ranch Oil Co. has obtained franchises for distributing the product to several of the neighboring towns, including Tonkawa, Perry, Lamont, and Enid. The gas has already been piped to Tonkawa, where it is being distributed in the mains. In January, 1912, the combined capacity of the gas wells southwest of Ponca was estimated to be more than 125,000,000 cubic feet a day. The sand which produces in the old town-site gas pool and the one northeast at a depth of about 550 feet is also the most productive in the new pool southwest of the town. There are several other sands, as is shown by a study of the log of the 101 Ranch Oil Co.'s well No. 3, in the SE. $\frac{1}{4}$ sec. 8, T. 25 N., R. 2 E. In this well the gas-producing sands and amount of gas produced are reported as follows: Some gas in a 5-foot sand at 125 feet; a little gas in a 10-foot sand at 265 feet; 5,000,000 cubic feet daily from a 20-foot sand at 503 feet; 8,000,000 cubic feet daily near the middle of a 67-foot sand at 900 feet; and 20,000,000 cubic feet daily from a sand in which drilling ceased at 1,315 feet. In this well there are three good gas sands with a total production of 33,000,000 cubic feet daily. At least one other well reports 12,000,000 cubic feet daily from the 550-foot sand and some of the wells produce gas from a sand only about 10 feet above the 1,550-foot oil sand and separated from it by a "break" of blue shale. Much care is exercised in conserving the gas. For example, in the 101 Ranch Oil Co.'s well No. 3 each of the three heavy producing sands is cased off separately and all the product saved.

A tentative correlation of the sands at Ponca with those at Cleveland is suggested under the general head of "Stratigraphy" in this paper and need not be discussed further in this connection.

Log of well 6½ miles south and 3 miles west of Ponca, in the SE. ¼ sec. 25, T. 25 N., R. 1 E.

	Thick- ness.	Depth.		Thick- ness.	Depth.
	Feet.	Feet.		Feet.	Feet.
Soil, sandy.....	19	19	Shale, black.....	10	1,460
Gravel.....	40	59	Sand, very hard at top, soft		
Clay, white, with water.....	10	69	and white below (full of		
Red rock.....	12	81	salt water).....	56	1,516
Shale, gritty.....	8	89	Shale, black.....	6	1,522
Red rock.....	21	110	Sand, fine, hard.....	7	1,529
Shale, white, or clay.....	42	152	Shale, soft.....	20	1,549
Lime, shell.....	9	161	Sand, white (full of salt water)	28	1,577
Shale, white, or clay.....	44	205	Shale, blue.....	3	1,580
Red rock.....	26	231	Lime, gritty.....	5	1,585
Lime, shell.....	3	234	Shale, black.....	53	1,638
Red rock, lighter colored at			Lime, sandy.....	25	1,663
bottom.....	60	294	Shale, soft, black.....	22	1,685
Lime, brownish.....	4	298	Shale, red.....	5	1,690
Shale, black, hard.....	28	326	Sand, white.....	15	1,705
Lime, reddish.....	24	350	Shale, black.....	3	1,708
Red rock.....	35	385	Sand, white.....	28	1,736
Shale, gritty (water).....	20	405	Shale, black.....	20	1,756
Red rock.....	22	427	Lime, shell.....	7	1,763
Shale, white.....	8	435	Shale, soft, black.....	36	1,799
Lime, brownish.....	8	443	Sand, white (full of water).....	39	1,838
Lime, hard, grayish.....	22	465	Shale, soft.....	4	1,842
Shale, red.....	35	500	Lime, gritty, gray.....	10	1,852
Lime, shell.....	12	512	Shale, black.....	6	1,858
Red rock.....	58	570	Shale and shell.....	22	1,880
Sand, red.....	23	593	Shale, soft, black.....	5	1,885
Lime, hard, white.....	5	598	Shale, red.....	7	1,892
Shale, red.....	27	625	Lime, white.....	30	1,922
Sand, white.....	35	660	Shale, soft, black.....	13	1,935
Shale, red.....	42	702	Shale, soft, red.....	15	1,950
Sand, white, soft at top, hard			Lime, white.....	28	1,978
at bottom.....	34	736	Red rock.....	22	2,000
Shale, black.....	6	742	Lime, hard, gray.....	15	2,015
Lime, hard.....	38	780	Shell, lime.....	3	2,018
Shale, white.....	50	830	Lime, sandy, white.....	19	2,037
Lime, grayish.....	24	854	Shale, brown.....	3	2,040
Shale, black, with shells.....	18	872	Sand, white.....	5	2,045
Shale, black, with hard shells.....	24	896	Shale, white.....	13	2,058
Shale, black.....	6	902	Sand, white.....	30	2,088
Shale and shells.....	21	923	Shale, black.....	20	2,108
Shale, reddish tinted.....	37	960	Lime, hard.....	6	2,114
Shell, gritty, in black shale.....	45	1,005	Shale, black.....	49	2,163
Sand, white and black.....	12	1,017	Shell, hard.....	3	2,166
Shale, black.....	45	1,062	Shale, black.....	14	2,180
Shale and shell.....	4	1,066	Sand, hard, white.....	10	2,190
Shale, soft.....	85	1,151	Shale, red, brown.....	4	2,194
Lime.....	4	1,155	Shale, white.....	5	2,199
Shale, very soft, cavy.....	75	1,230	Lime, white, very hard (water)	43	2,242
Sand, white, hard.....	6	1,236	Shale, black.....	26	2,268
Shale, soft, black.....	24	1,260	Lime, dark.....	11	2,279
Shale, soft, dark, cavy.....	12	1,272	Shale, black.....	3	2,282
Lime cavings, dark shale.....	43	1,315	Sand, white a.....	18	2,300
Sand, white (water).....	19	1,334	Shale, dark.....	3	2,303
Shale and shells.....	33	1,367	Sand, very white.....	59	2,362
Cavings from 1,050 to 1,200 feet.			Shale, dark black.....	43	2,405
Hard lime.....	18	1,385	Lime, dark.....	6	2,411
Lime, dark, soft.....	10	1,395	Shale, blue.....	54	2,465
Shale, black, soft.....	23	1,418	Shale, white.....	20	2,485
Red rock.....	15	1,433	Shale, dark blue.....	35	2,520
Sand, white.....	17	1,450	Sand, white.....	56	2,576

* Full of water, very salty and sulphurous, hole filled up within 100 feet of top. This water ran into lower sand when well was finished. Show of oil in deep sand, but flood of water prevented an estimate of quantity.

Bliss.—About the time the town site of Bliss was laid off, in 1906 or 1907, and lots offered for sale, Miller Bros. of the 101 Ranch, who were promoting the town site, started drilling for oil or gas just outside the town limits, in the NE. ¼ sec. 24, T. 24 N., R. 1 E. Much trouble was experienced in the red beds, which caved badly. The well was finally abandoned at 900 feet after the tools had been lost in the

hole and no oil or gas had been found. This well is located almost in strike with the wells at Ponca, but its head is perhaps 100 or 150 feet higher in the geologic section.

Mervine and Kildare.—The town of Mervine, about 6 or 7 miles northeast of Kildare, has the first oil well drilled west of the longitude of Cleveland in the Mid-Continent field. This well was drilled during the early part of 1903, in the NE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 15, T. 27 N., R. 3 E., and in April of that year oil and gas were found in a 13-foot sand at 960 feet, where drilling ceased. The well was shot and is said to have produced daily 2 or 3 barrels of oil having a gravity of 47° Baumé. It was drowned out by salt water in 1904, but gas and oil still escape from the imperfectly plugged hole. From the log of the well the sands can not be definitely correlated and it is impossible to determine the exact geologic position of its mouth. It seems, however, that the sand encountered at 960 feet is probably the same as that encountered at Ponca between 1,100 and 1,200 feet, but it may be the one about 125 feet lower. A few years after this first well was sunk another was drilled about one-half mile east, in the NW. $\frac{1}{4}$ sec. 14, T. 27 N., R. 5 E., to a depth of 1,115 feet. No log of this well is available, but oil and gas were found at about the same depths as in the hole just to the west. Drilling ceased at 1,115 feet in a sand impregnated with salt water, which is probably the same as the sand at Ponca between 1,300 and 1,400 feet, likewise usually full of salt water. Another well was drilled in this same locality, but farther west and near Kildare, in 1911. It is located in the NW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 19, T. 27 N., R. 3 E., and was sunk to a depth of 1,700 or 1,800 feet and reported dry. It is about in strike with the Ponca wells and the sands should be found at approximately the same depths. No log is available.

Newkirk.—About the time development started at Ponca a local company was organized at Newkirk and drilled a number of wells in and about the town site, in the southwestern part of T. 28 N., R. 2 E. The holes range from 600 to 1,688 feet in depth and it is reported that all produced gas from a sand at a depth of about 600 feet. None of the wells produced very heavily, each averaging from 100,000 to 200,000 cubic feet daily. Some of them are still supplying the inhabitants near by with fuel, but the most of them were drowned out by the inroads of salt water within a year or two after being drilled. It was not learned which have been abandoned, so all are indicated on the map as producing wells except the one drilled northeast of the town, in the SW. $\frac{1}{4}$ sec. 8, T. 28 N., R. 3 E., which had only a "showing" of gas. The wells at Newkirk are about in strike with those of Ponca, but their heads are probably about 50 or 75 feet higher geologically. With that correction allowed, the different sands should occur at about the same depths as at Ponca. This con-

clusion is strengthened by a detailed log of the well drilled to a depth of 1,688 feet south of the town site, in the NE. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 26, T. 28 N., R. 2 E. This log shows 10 feet of gas sand at 610 feet, 20 feet of barren sand at 1,360 feet, 10 feet of barren sand at 1,445 feet, and a series of barren sands interstratified with shale from 1,622 to 1,688 feet, the bottom of the hole. The presence of this gas, though not in great quantity, may be significant of a greater accumulation near by. It is regretted that some of the wells were not sunk about 5 miles farther east, where an anticline has been observed crossing Arkansas River.

Blackwell.—In 1904 or 1905 local capitalists began prospecting for oil and gas on the town site of Blackwell. Much trouble was experienced in drilling through the red beds and the first two or three wells were lost or abandoned without result. Indications of gas were found, however, and prospecting continued to the north. About this time another local company entered the field. Some gas wells were soon "brought in," with a daily production of 200,000 to 5,000,000 cubic feet, and drilling has continued intermittently ever since, until, when the writer visited the pool in February, 1912, 21 gas wells had been "brought in" out of a total of about 37 holes drilled. The pool, as developed, is nearly a mile wide and extends from the town site N. 5°–10° E. for 10 miles through the eastern part of Tps. 27, 28, and 29 N., R. 1 W. In February, 1912, two wells were being drilled in the northern part of the field, beyond any development. The wells range from 650 to 1,500 feet in depth, the main producing sand being found at an average depth of 750 feet below the surface. Gas is also found in other sands in this pool, from 125 to 985 feet in depth, though usually not in paying quantities. A number of logs were procured for study, and although the records differ materially from those at Ponca it is believed that the principal gas sand at 750 feet is equivalent to the 250-foot sand at Ponca, or possibly a sand found in some places about 100 feet higher. This pool is geologically the highest pool in the State and the lower sands which produce at Cleveland and other parts of the Mid-Continent field, if persistent, should be found from 200 to 300 feet deeper than at Ponca—that is, the Cleveland sand should be reached at 2,800 to 3,000 feet, the Bartlesville sand at 3,600 to 3,800 feet, and the Tucker or Meadows sand, in the "Mississippi lime" (?) of the drillers, at 3,900 to 4,100 feet. A "showing" of high-grade oil was reported from one of the wells just outside the town site to the northwest, in the NW. $\frac{1}{4}$ sec. 23, T. 27 N., R. 1 W., but the depth of the sand was not recorded. This well also produced gas. It was capped and the gas has been turned into the mains of the town and the oil ignored.

There are at present two distributing companies, the Union Oil & Gas Co. and the Blackwell Oil & Gas Co., supplying the town of Blackwell, and another company, the Junction Oil Co., is supplying Braman, a town 9 miles northwest of Blackwell. The Wichita Gas Co. is entering the field and hopes to supply the Chilocco Indian School and Arkansas City, Kans., with gas from this pool.

Tonkawa.—Two shallow wells have been drilled near the town of Tonkawa, on the Tonkawa Reservation, without result. One drilled to a depth of about 400 feet about 4 miles northwest of the town, in the SE. $\frac{1}{4}$ sec. 17, T. 26 N., R. 1 W., is said to have yielded a light flow of gas at about 125 feet, and another, drilled on the outskirts of the town to a depth of about 900 feet in the SW. $\frac{1}{4}$ sec. 34, T. 26 N., R. 1 W., is reported dry. These wells are approximately in strike with those at Blackwell, and the same geologic horizon should be encountered at about the same depths. A log of the 900-foot well at Tonkawa shows several barren sands between 600 and 900 feet which resemble those at Blackwell at about the same depths. These are inadequate tests, as the first-mentioned well did not penetrate the sand that is productive at Blackwell, and the 900-foot well was probably a fair test only to the sand equivalent to the 750-foot sand at Blackwell. One test like this should not condemn the region as not gas-bearing, even in the shallow sand, as has been proved many times in developed areas.

Adjacent western territory.—From time to time within the past five years wells have been sunk at various places west of this region, but none of them to any considerable depth. It is reported that a well was drilled 1,000 feet deep near Lamont and found dry; another was sunk about 960 feet deep a few miles south of Hunter, and a light flow of gas was struck; another was sunk 1,100 feet deep at Cropper, where a "showing" of oil was found; and still another was sunk 1,500 feet deep at Enid, where a little gas was found. No detailed information concerning these wells could be obtained.

Adjacent territory in southern Kansas.—Several wells have been drilled in southern Kansas adjacent to this region during the past eight years. In the vicinity of Cedarvale, about 20 miles northeast of the Kaw Reservation, several scattering wells have been sunk, in some of which oil and gas in paying quantities have been reported. It is reported that at Dexter, 8 or 10 miles directly north of the same reservation, a freakish gas was found at 300 or 400 feet. It is said that this gas will not burn in the open air, but when confined in a furnace or stove and brought into contact with a very hot flame it will ignite and burn, giving off intense heat. There are several wells in this vicinity, each producing a few hundred thousand cubic feet of such gas daily. At Arkansas City, which is in strike with Ponca and Newkirk, a gas field was developed about the year 1905 in T.

34 S., Rs. 3 and 4 E. of the sixth principal meridian. The gas was found at about 700 feet and some of the wells produced as high as 5,000,000 cubic feet a day, but the average was considerably less. One well, 5 or 6 miles northwest of Arkansas City, in the SW. $\frac{1}{4}$ sec. 3, T. 34 S., R. 3 E., was drilled to a depth of 2,202 feet. In this well gas was found at 620, 1,940, and 1,960 feet (the last-named sand lying just above coal), and oil with salt water was found at 2,175 feet.

Forty-two wells were sunk in this pool and half of them are reported to have been producers when they were first drilled. Within the past year, however, the wells have been dying out. The superintendent at Arkansas City says the supply has not been exhausted, but that salt water is drowning out the field. Most of the wells are now abandoned and the city is depending upon the Hogshooter field in the Cherokee Nation for its supply. Gas is also reported from a shallow sand at Winfield, 12 miles north of Arkansas City.

FUTURE DEVELOPMENT.

Much interest is at present being manifested in the western extension of the Mid-Continent oil field and hundreds of thousands of acres are being leased and holes are being put down or will soon be put down in a dozen or more localities. Within the next year much more will be known of the field, as a result of actual drilling, than is now known. The whole region is being watched closely.

During March, 1912, the discovery of oil and gas on Tiger Creek, east of Cushing, was further substantiated, and at this writing it is reported that three rigs are in operation and that three more will start soon. All of the deeded land is being leased and many wells will probably be sunk within the next year.

A well, which has been mentioned previously, is now being put down at Mulhall, and is nearly 2,000 feet deep.

Drilling still continues in the region of Hallett and much of the land is held under lease. A well is now being drilled at Greenup, 2 or 3 miles northwest of Hallett, and another at Terlton, 6 or 7 miles southeast of the same place. Both of these are planned to be deep wells.

During the early part of March, 1912, a well was started near Morrison. Several hundred acres have been leased, and the operators plan to drill 2,000 feet or deeper unless oil or gas is found at a shallower depth.

A large block of land a few miles north of Perry, containing several thousand acres, has been leased by foreign capitalists, who planned to begin drilling in April, 1912. This company is under contract to drill at least three wells on the leased area, all of them to be more than 2,000 feet deep.

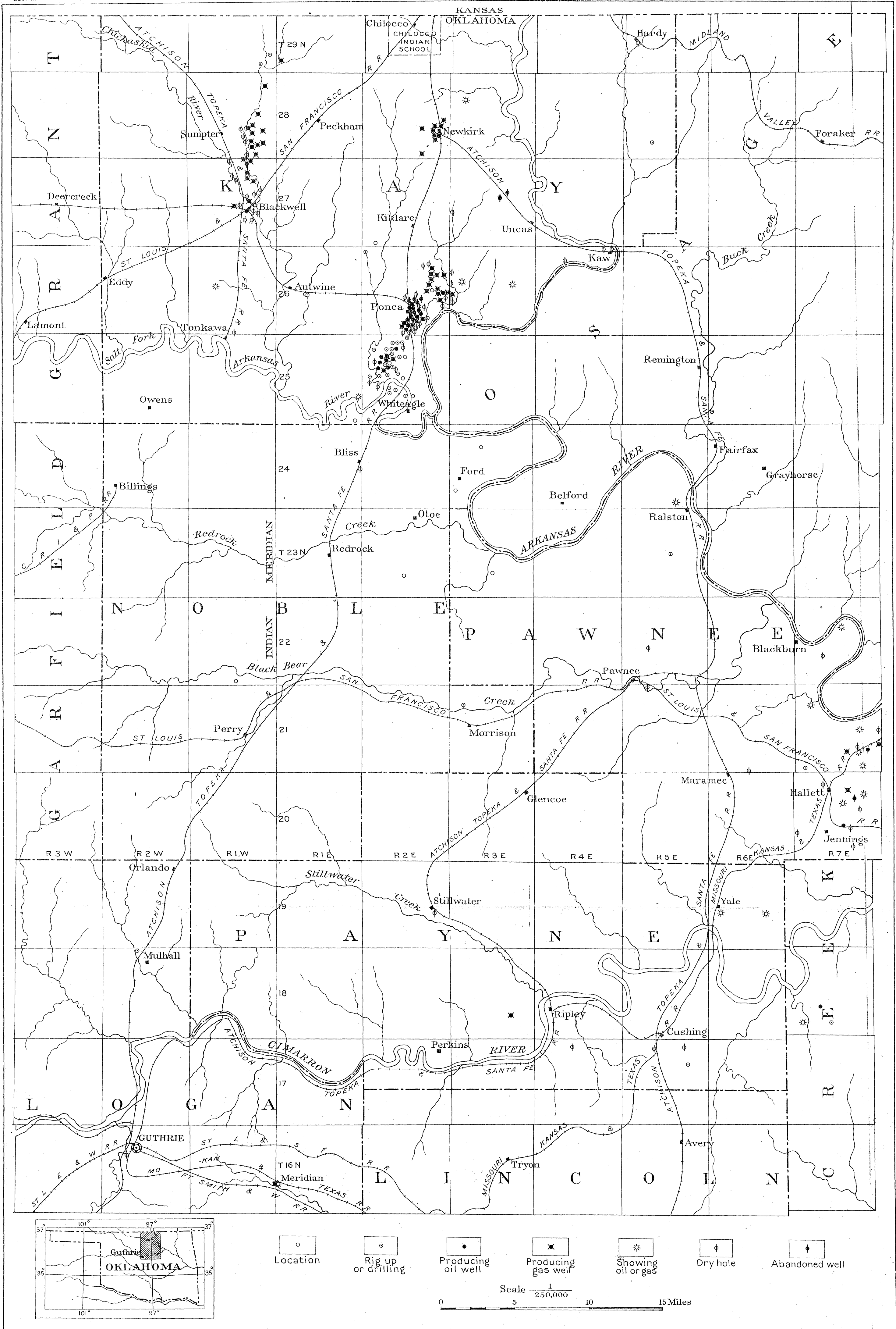
Two wells, both in the Otoe Reservation, are to be drilled east of Red Rock within the next few months. The company is said to have a large acreage of leases in T. 23 N., Rs. 3 and 4 E. If these wells are drilled, they will be the first holes sunk on this reservation in search of oil and gas.

Arnold & Perry, of Tulsa, are drilling a well 4 miles southwest of Ralston, in the NW. $\frac{1}{4}$ sec. 22, T. 23 N., R. 5 E., and on the 1st of March, 1912, the well was down nearly 2,000 feet. They are planning to go 3,000 feet or more in an effort to reach the Cleveland and Bartlesville sands. These men have leased all the available deeded land near by. To the north, across Arkansas River, the San Francisco-Osage Oil Co. is drilling just north of Fairfax, in the NW. $\frac{1}{4}$ sec. 31, T. 25 N., R. 6 E. This company plans to test its property thoroughly by drilling 3,500 feet if oil is not found before that depth is reached. Drilling started about the middle of February, 1912.

A well was recently begun on the Kaw Reservation in the SW. $\frac{1}{4}$ sec. 28, T. 28 N., R. 5 E., which is expected to go 3,000 feet or more. There has been only one other well drilled on the reservation, the Hardy well, and it was only 800 or 900 feet deep. Several thousand acres have been leased in the Kaw Reservation for oil and gas exploitation.

The field that is most attractive to producers seems to be that in the vicinity of Ponca. As has been said, more than a dozen wells are now being drilled in the immediate pool, though hundreds have been located and probably fifty contracted for, the drilling to start soon. A well now down more than 1,500 feet is located near Autwine, west of Ponca, and other "wildcat" or test holes have been located to be drilled this spring or summer. The 101 Ranch Co. is planning to drill at least two holes in the big bend of Arkansas River in T. 24 N., R. 3 E., this summer (1912), and one hole somewhere in each of T. 25 N., Rs. 1, 2, and 3 E. Two locations for immediate drilling have been made near the southwest corner of T. 26 N., R. 2 E. Aside from these, other wells are planned or are now being drilled a few miles south of the developed pool and on the south side of Arkansas River. Many of these will be drilled to a depth of 2,500 feet or more. Practically all of the Ponca Reservation and much of the Otoe also is leased for oil and gas, and it is said that one man alone holds oil and gas leases on 6,000 acres in the Otoe Reservation.

Only two wells are now being drilled in the Blackwell pool, and they are in the southwestern part of T. 29 N., R. 1 W. It is reported that they will be drilled 2,000 feet or more if oil and gas are not found above that depth. Leasing has also been extensive in this region during the past few months. Several thousand acres are under lease in the Tonkawa Reservation south of Salt Fork of



MAP SHOWING OIL AND GAS DEVELOPMENT IN NORTH-CENTRAL OKLAHOMA
By Robert H. Wood

Arkansas River, and practically all the land from Blackwell northward to the Kansas line in a strip 4 or 5 miles wide is taken. Much leasing has been done in the country lying between Newkirk, Blackwell, and Ponca. One company alone has leased more than 40,000 acres of this land and plans to drill on it within a year.

CONCLUSIONS.

After considering the data at hand concerning this region it seems certain that it must be regarded as possibly oil producing. This conclusion is based, in the first place, on the fact that all the productive sands of the main field to the east dip under the area at a low angle, and the lowest sand at the deepest point in the western part should not be over 4,200 feet beneath the surface. In the second place, there are a large number of sands throughout the geologic section, nearly all of which, from the highest at Ponca to the lowest at Cleveland, have been productive in some locality or other, and several sands have been found to be productive in the same well. In the third place, there are in several localities undoubted anticlines, which, in this region, are extremely favorable to the accumulation of oil and gas. The fact that a number of dry holes have been reported can not condemn even the immediate region around them, because very few of the wells are deep enough to be thorough tests. Besides, owing to the variability in thickness and porosity of the sand and the influence of structure, in developed territory dry holes are common alongside producers, and even near gushers. Therefore, the prospects for the development of a number of pools in this region seem to be good.