OKLAHOMA GEOLOGICAL SURVEY

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THE PONCA CITY OIL AND GAS FIELD.

By
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and
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ILLUSTRATIONS.

Ponca City is situated in Kay County, northcentral Oklahoma, 20 miles south of the Kansas line. The area treated in this report covers about 150 square miles in the southeastern part of the county. The southern limit of the field is drawn at the Salt Fork of Arkansas River, the northern extension being about the latitude of Newkirk. The accompanying sketch map (fig. 1) shows the location of the area.

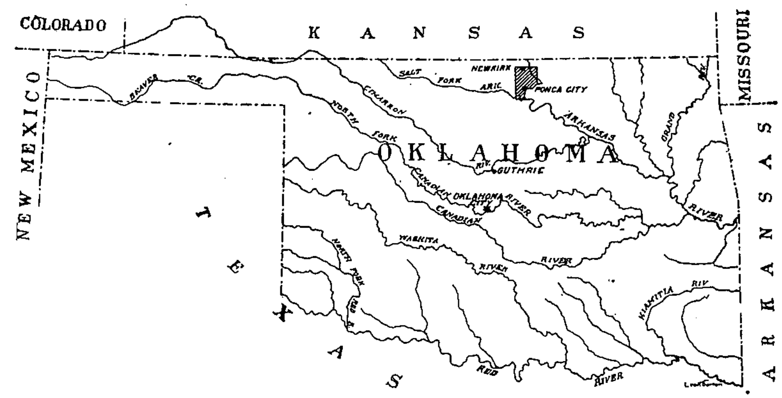

Fig. 1. Map showing location of Ponca City oil and gas field.

The field work of the area was carried on by the junior author during the first part of the season of 1912 and completed during the latter part of the season by the senior author. Doctor J. W. Beede of the Indiana University had previously made a reconnaisance geologic map of most of the region under the auspices of the Survey. The authors made liberal use of Doctor Beede's sketch map and acknowledge their indebtedness to him for numerous suggestions and valuable aid. Liberal use has also been made of available literature published by the Kansas University Geological Survey dealing with the geology of the region to the northward. The deeper formations encountered by the drill in the Ponca City field outcrop to the eastward in the Pawhuska and Hominy quadrangles which have been surveyed by Carl D. Smith and Robert H. Wood, respectively. These gentlemen have placed at the disposal of the authors many valuable data regarding the stratigraphy, thickness, and lithologic character of the formations at their outcrops.

The authors are deeply indebted to the 101 Ranch Oil Company for many valuable statistics on production and for numerous logs. Mr. C. W. Marland has also rendered valuable assistance. The LaClede Oil & Gas Company, the Hecla Oil Company, and the Kay County Gas Company have rendered substantial aid in securing logs and furninshing general information. The Gulf Pipe Line

Company has been generous in supplying blue print maps from time to time.

The structural sheet (Pl. II) shows the elevations of a large number of section corners. These elevations were obtained by Dr. Irving Perrine and Mr. Lawrence Trout of the State University of Oklahoma. These gentlemen also collected much valuable information regarding initial and present production of many wells.

GEOGRAPHY AND TOPOGRAPHY.*

The Ponca City oil and gas field lies in southeastern Kay County, Oklahoma, mainly between Arkansas River on the northeast and Salt Fork of Arkansas River on the southwest. The point of confluence of these streams is shown in the extreme southern limit of the map (Pl. I). The whole region lies in that physiographic division which has been termed the Great Plains. The western part is underlain chiefly by shale, the surface of this part being a well developed peneplain. To the eastward and southeastward along Arkansas River the streams have made deep incisions in the alternating limestones and shales. The general geologic structure of northern Oklahoma is a monocline with a low general westerly dip approximateing 30 feet to the mile, but within the present area it is probably less. The limestones therefore make more or less conspicuous eastward-facing escarpments, the sharpness and definition of which depend partly on the thickness and partly on the character of the limestone formations as well as on the thickness of the underlying shales.

STRATIGRAPHY.

General Statement.

The rocks of the area are exclusively sedimentary. With the exception of the terrace sands, the surface and probably the upper subsurface formations are of lower Permian age while the deeper subsurface formations are of Pennsylvanian age, the former lying conformably on the latter. Both the Permian and the Pennsylvanian rocks are composed very largely of shales, while limestones and sandstones occur in about equal abundance, but the two com-

*The following publications have been freely drawn upon in preparation of the present report: 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; The formations of the Marion stage of the Kansas Permian: Trans. Kansas Acad. Sci., vol. 21, 1909, pp. 248-256. Adams, G. I., Girty, George H., and White, David, Stratigraphy and paleontology of the upper Carboniferous rocks of the Kansas section: Bull. U. S. Geol. Survey No. 211, 1903. Haworth, Erasmus, and Bennett, John, General stratigraphy; Kansas Univ. Geol. Survey Kans., vol. 9, 1908, pp. 57-121. Wood, Robert H., Oil and gas development in north-central Oklahoma: Bull. U. S. Geol. Survey No. 531-B, 1912.

bined are subordinate to the shales. The area lies nearly within the zone where the light colored sediments of the Kansas Pennsylvanian and Permian begin to merge into the well known "Redbeds" of Oklahoma, hence considerable thicknesses of the shales and sandstones are chocolate, brown, and even red. The limestones on the other hand are of the usual gray and white colors prevailing generally throughout the Pennsylvanian and early Permian of the Great Plains. It will be convenient to include the discussion of stratigraphy in two parts, the surface formations and the subsurface formations.

Surface Formations.

As above noted the surface formations with the exception of the terrace sands are of lower Permian age. They embrace a total thickness of approximately 300 feet of sediments and consist of four limestone formations alternating with the same number of shale beds. Locally thin sandstones are present in the shale formations. The several formations will be discussed in descending order.

Terrace deposits.—Along both sides of Arkansas River a considerable thickness of sand and silt occurs overlying the several Permian formations. These deposits are of considerable thickness and extent on the east side of the river east of Newkirk. They were without doubt laid down by the river when it occupied a higher position than at present. They are in general much better developed and more wide spread on the east side of the river than on the west and appear to have been deposited by the stream as it slowly worked its way westward down the dip slopes of the limestone formations.

Shale.—The highest Permian formation studied is a shale which lies above the Herington limestone. This shale contains thin limestones locally. Neither the shale nor limestones are important in the present discussion.

Herington limestone.—The Herington is the highest prominent limestone exposed in the area. It is 18 to 20 feet thick, being massive below and thin bedded above. Near the base is a stratum about 18 inches in thickness which is usually honey-combed in a very conspicuous manner where the formation has been long exposed to weathering. This cavernous feature serves readily to distinguish the basal part of the formation.

The Herington limestone makes a prominent escarpment on the west side of the anticline from a point a few miles northeast of Ponca City northeast to Arkansas River. East of the anticline it caps many of the outliers in the vicinity of Uncas and makes a low escarpment south from that place to Arkansas River. It is not exposed north of the river in the area. Three miles southwest of Ponca City good exposures are seen on the hills in secs. 8 and 17, T. 25 N., R. 2 E. Along the west bank of Arkansas River south of Ponca City it may be seen at irregular intervals. It is without doubt persistent here but it is concealed beneath the alluvial and terrace deposits. Many springs issue along the upper contact where it is exposed. Where the contact is concealed, springs abound and it is therefore believed that the limestone is present. This exposure along the bank of the river is about 100 feet below that on secs. 8 and 17 above mentioned, the eastward dip being therefore about 40 feet to the mile.

Uncas shale.—Between the Winfield and Herington limestones in Kansas lies a thin bedded, flaggy, cellular limestone which is followed by about 35 feet of vari-colored shales. To the limestone Doctor Beede applies the term Luta, while the superjacent shales are called the Enterprise. In the present area the Luta limestone has not been recognized. Beede states that it is probably absent from the section at Arkansas City, Kansas. To the interval between the top of the Winfield and the base of the Herington the name Uncas shale is here provisionally applied, the name being from the town in the eastern part of the area in the vicinity of which the shale is well exposed. The Uncas shale is about 50 feet thick, being composed largely of more or less pure clay beds of alternating red and lighter color. These redbeds are the highest red sediments observed in the area.

About ten feet above the base of the Uncas shale there is locally a bed of fossiliferous limestone 2 feet thick. It is not improbable that this may represent the Luta limestone of Beede. On the west side of the hill three miles southwest of Newkirk the following section was made:

	Feet
Limestone, massive in lower part, thin bedded above (Herington)	17
Shale, largely maroon, some red to brown sandstones	44
Massive limestone with clay nodules, abundance of Myalina and Aviculopecten	3
Shale	7
Thin bedded limestone, base not exposed (Winfield)	5

In the above section the basal limestone is Winfield and the topmost is the Herington while the 54 feet of intervening sediments comprises the Uncas. The three-foot bed of limestone may possibly be the representative of the Luta limestone of Beede.

Winfield limestone.—The Uncas shale is succeeded below by the Winfield limestone which has a thickness varying between 10 and 15 feet, the usually observed thickness being about 12 feet. The limestone is gray and massive. Near the base one bed about 1 foot thick abounds in the remains of small brachiopods. The upper part of the formation is arenaceous and platy, which feature serves to distinguish the limestone readily.

The Winfield outcrops chiefly on the west side of the anticline shown on the map. On the east side of the anticline it is found generally in outliners both north and south of the latitude of Uncas. To the northward beyond Arkansas River it outcrops only in the northeastern part of the area.

Doyle shale.—The Winfield limestone is succeeded below by the Doyle shale. The thickness of this formation is somewhat variable. Good exposures in the northern part of the area show about 22 feet, while to the southward this thickness increases to about 35 feet. The whole is comprised of clay shales some of which are, however, highly arenaceous. Beds of red color are common but exposures are not sharp enough to show what proportion of the beds are red.

The Doyle shale has a width of outcrop somewhat out of proportion to the thickness of the formation. It occupies a bench receding from the top of the Fort Riley escarpment. Its outcrop is continuous on both sides of the anticline from a point about 3 miles northeast of Ponca City northeastward to Arkansas River. Along the axis of the anticline immediately north of Arkansas River the Doyle shale seems to have been removed by erosion but it is seen farther to the north along the border of the area.

Fort Riley limestone.—Below the Fort Riley limestone in Kansas lines the Florence flint which has a thickness of 20 feet while the Fort Riley limestone has a thickness of 40 feet. In the Ponca City region the Florence flint as such is not distinguishable, its equivalent being probably included in what is here termed the Fort Riley limestone.

The Fort Riley limestone in the present aera consists of about 52 feet of limestone, the lower half of which is massively bedded, lenses of chert being common at the base. It is not improbable that these cherty beds represent the Florence flint of the Kansas section. The upper part of the Fort Riley is comprised of alternating beds of hard, resistent limestone and thin beds of shale or shaly limestone. The formation outcrops on both sides of the anticline from the Santa Fe quarry west of Uncas northward to Arkansas River. On the east side of the river the outcrop is very conspicuous where not concealed beneath terrace sands. Northward beyond the limits of the map it is well exposed along the banks of the smaller tributaries of the river.

The Fort Riley makes one the most conspicuous escarpments in the area, being underlain by the Matfield shales which are 70 feet thick. This escarpment is best developed just south of Arkansas River southeast of Newkirk where the crest of the anticline reaches its maximum elevation.

Matfield shale.—Below the Fort Riley limestone is the Matfield shale. This consists of about 70 feet of coarse arenaceous shale with rather abundant thin beds of red sandstone. Considerable thicknesses of shale also are red or brown. Sharp exposures are not common but where the shales come to the surface the coarser arenaceous red sediments so predominate over those of lighter color as to give the impression that the whole is deeply colored.

The Matfield shale outcrops in a narrow band on both sides of the anticline. While the thickness of the shale is nearly twice as great as that of the Wreford limestone, the width of the outcrop is very much narrower, owing to the fact that the shale almost always lies at or near the base of conspicuous escarpment which is capped by the Fort Riley limestone. The thickness of the shale is fairly constant throughout the area.

Wreford limestone.—The lowest limestone exposed in the area is the Wreford limestone. It has been described by Adams, Prosser, Beede, Haworth, and other workers in Kansas where it has a thickness of 40 feet. In that state it has been described as containing a large amount of flint, in this respect differing from the limestones lower in the series. In the Ponca City field it has much the same character as further north in Kansas. The lower part is much more flinty and siliceous than the upper part and is also much more massive, shales and shaly limestone being rather abundant toward the top. The Wreford outcrops along the anticline only from a point about two miles west of Uncas north to Arkansas River. Along the bluff of this stream are good exposures in the southwest corner of T. 28 N., R. 3 E. On the north side of the Arkansas are a few exposures but the limestone is here for the most part concealed beneath terrace sand.

Subsurface Formations.

The subsurface formations of the Ponca City area outcrop to the eastward in Osage, Washington, Nowata, and Craig counties. While the geology of the last three named counties and the eastern half of Osage is known in detail, very little is known of western Osage where the formations next below the Wreford outcrop. Everything considered it is deemed best therefore to discuss the subsurface formations under three heads although this method of treatment admittedly leaves much to be desired.

FORMATIONS OUTCROPPING IN WESTERN OSAGE COUNTY.

Of these beds, little is known except that a series of rapidly alternating shales, thin limestones, and occasional sandstones intervene between the base of the Wreford limestone and the top of the Elgin sandstone. The entire series approximates a little less than 700 feet thickness. It consists chiefly of shales but thin limestones are very abundant, and sandstones are not lacking. A succession of sandstone beds about 60 feet thick lies about 300 feet above the base of the series. Of this succession some individual beds have a considerable thickness, as shown in exposures along Buck Creek in the northcentral part of the county. It is probably the same series that is seen farther to the southwest, east of Fairfax. A tentative correlation of these sandstones is given below in the section on Character, Extent, and Correlation of Sands.

FORMATIONS OUTCROPPING IN EASTERN OSAGE COUNTY.

The formations in the western part of the Independence, Kansas, quadrangle extend southwest into eastern Osage County, Oklahoma. Here they are generally somewhat thicker than in Kansas, limestones are fewer and thinner, while sandstones are more numerous and thicker. The several formations are as follows:*

Elgin sandstone.—Associated with the Kanwaka shale in Kansas is a sandstone which has been termed the Elgin. This extends southward across the Pawhuska quadrangle and beyond to Arkansas River where it caps the hills in the vicinity of Cleveland. Just south of the Kansas line near Elgin, Kansas, the Elgin sandstone is 140 feet thick, and is made up of an upper and a lower member, separated by shaly sandstone. To the southward the Elgin becomes thinner and consists usually of but a single member which is in most places massive, containing practically no shale. At the southern border of the Pawhuska quadrangle the Elgin is between 50 and 75 feet thick. The probable westward extension of the Elgin beneath the Ponca City region is discussed in the section on Character, Extent, and Correlation of Sands.

Oread limestone.—The Elgin sandstone is succeeded below by the Oread limestone. It seems not to extend more than 10 or 12 miles into Oklahoma, although at the Kansas line it is 17 feet thick.

Buxton formation.—The Buxton formation of the Independence quadrange thickens southward into Oklahoma where in the Pawhuska quadrangle it embraces about 450 feet of sediments. A generalized section follows:

	Feet
Shale, sandy shale, and sandstones	140-155
Sandstone, exposed near Nelagony	50
Limestone, lentil	20
Shale, sandy shale, thin sandstones	100
Sandstone, exposed near Bigheart	140
Shale, and sandstone	180
Average total	630

The 50-foot sandstone of the above section is prominently exposed in the vicinity of Nelagony and is known to extend thence in both directions along the strike for a considerable distance. The limestone of the section is a lens and has but limited linear extent.

The sandstone at the base of this section is really composed of several distinctive sandstones separated by shale beds. All the beds, however, are closely associated, especially at Bigheart where they are well developed, several being thick and massive. They are known to extend from the eastern border of Osage County near Bartlesville southwest across this county and probably into Creek County.

*The writers are indebted to Carl D. Smith, Everett Carpenter, and Robert H. Wood of the United States Geological Survey for much information on the Elgin sandstone, Oread limestone, and the Buxton and Wilson formations.

FORMATIONS OUTCROPPING EAST OF OSAGE COUNTY.

The formations below the Buxton formation, liable to be met in deeper drilling in the Ponca City field outcrop in Washington, Nowata, and Craig counties which lie east of Osage County. The senior author has issued a preliminary report* on these formations and a general account of these as known at their outcrops may lead to some conception of what may be expected at depths at Ponca City, although it can hardly be expected that anything more than a broad similarity should be found existing between the formations at this place and at the outcrops, separated as the two are by 55 miles or more.

Wilson formation.—The Wilson formation of the Independence quadrangle, following the general rule, thickens to the southward. In southern Kansas the thickness is 280 feet but in the southeastern part of the Pawhuska quadrangle it is not much if any less than 400 feet, an approximate section being as follows:

	Feet
Sandstone, exposed near Torpedo	30
Shale, thin sandstones and thin limestones	240
Limestone (the Avant)	0-35
Shale, thin sandstones and thin limestones	45-90
Average total	350

The only part of this section that is of special importance in the present discussion is the 30-foot sandstone lying 100 feet below the summit of the formation. This is well developed and prominently exposed at the village of Torpedo on the Missouri, Kansas & Texas Railroad near the eastern border of Osage County. To the northeast of this place it caps the bluffs just south of Bartlesville while it is shown to extend southwest across the quadrangle and it probably continues beyond Arkansas River.

*Dewey limestone.***—Succeeding the Wilson formation below is a mass of limestone about 23 feet in thickness to which the senior author in his preliminary paper applied the name Dewey. It is well exposed in Bartlesville, near Dewey, and to the eastward and is prominent on the bluffs west of Ochelata and Ramona. Tentatively it is regarded as the equivalent of the upper part of the Drum limestone of the Kansas section.

Shale and sandstones.—About 75 feet of shale and sandstones intervene between the Dewey limestone above and the Hogshooter limestone below. No distinctive name has been applied to these beds but at present they are regarded as the equivalent of the middle part of the Drum limestone which splits just west of Coffeyville, Kansas. The sandstones of this interval are thin and lenticular.

Hogshooter limestone.—The name Hogshooter has been applied to 10 feet of limestone lying about 75 feet below the base of the Dewey limestone. Throughout its outcrop it is generally thin bedded especially about Ochelata and Ramona and probably for this reason has not usually been recognized by the drillers. It is at present regarded as the southern extension of the lower part of the Drum limestone.

Coffeyville formation.—Below the Hogshooter limestone lies the Coffeyville formation of the Kansas geologists. In the present connection it is considered to have a thickness of about 370 feet, the increase in thickness from the Kansas line southward being constant and rather rapid. For the most part it is comprised of shales but sandstones become prominent in the upper part. These are well exposed on the bluffs 4 miles west of Nowata and thence southward.

Lenapah limestone.—The upper Parsons limestone of Kansas becomes the Lenapah limestone of Oklahoma. It is well exposed in the quarry north of Lenapah where it is about 20 feet thick and on the bluff in the city of Nowata but is not known to extend south of that place, its position to the southward being marked approximately by the Dawson coal according to C. D. Smith.* The limestone, therefore, must be regarded as all but absent from the section considered in its relation to the Ponca City field.

Nowata shale.—The middle or shale member of the Parsons formation of Kansas thickens rapidly in northern Oklahoma being about 100 feet at Nowata and perhaps more in southern Nowata County. To this shale the senior author applied the term Nowata. A few thin sandstones are present in the formation.

Altamont limestone.—The Altamont, or lower Parsons, limestone of Kansas continues southward into Oklahoma with full thickness. It is prominently exposed at the top of the bluff east of Nowata and thence southward along the Verdigris River. It is quite uniformly about 30 feet thick and is therefore usually to be recognized in logs of wells in Washington and western Nowata counties.

Bandera shale.—The Bandera shale of Kansas lies between the Altamont and Pawnee limestones. At the Kansas-Oklahoma line it is 120 feet thick but this decreases rapidly to the southward until at Nowata, which is about on the line of dip from Ponca City, the thickness is only 40 feet, and at Talala, 12 miles south of Nowata the Bandera disappears from the section, the Altamont and Pawnee limestones coalescing.

Pawnee limestone.—Below the Bandera shale comes the Pawnee limestone. It is the well known "Big lime" of the drillers although it is certain that this name is applied also to the Altamont limestone

*The stratigraphy of the older Pennsylvania rocks of northeastern Oklahoma: Research Bull. State Univ. Okla. No. 4, 1910.

**Much of the information regarding this and the subjacent formations was obtained by the senior author working under cooperative agreement between the United States and Oklahoma Geological Surveys.

*Personal communication to the authors.

by some drillers. In northern Oklahoma it has a thickness of about 43 feet. The outcrop from Nowata southward is closely associated with that of the Altamont limestone, the two uniting at Talala by the pinching out of the Bandera, to form what is known as the Oolagah limestone.

Labette shale.—Succeeding the Pawnee limestone below is the Labette shale which has a thickness of 120 feet. From Nowata northeastward a heavy sandstone occurs toward the top of the formation. It is not improbable that this is the outcrop of the so-called Holland sand which is productive of oil in the vicinity of Ochelata in Washington County.

Fort Scott formation.—The Fort Scott formation underlies the Labette shale. Wherever the outcrop has been observed in Oklahoma, the formation is composed of three parts, an upper heavy limestone 20 feet thick, below which is a bed of black shale about 8 feet thick and beneath this lies a lower limestone about 10 feet thick, the whole therefore aggregating about 38 feet thickness. The formation, known among drillers as the "Oswego lime," makes a prominent escarpment from the Kansas line, northwest of Welch in Craig County, southwest past Centrailia, Chelsea, Claremore, and Catoosa to Arkansas River.

Cherokee formation.—At the base of the Pennsylvanian series lies a thick mass of shales, sandstones, limestone lenses and coal beds, the whole being grouped under the Cherokee formation. At the Kansas-Oklahoma state line the thickness is 450 to 500 feet but it increases to the southward and on the dip from Ponca City is not far from 600 feet. The importance of the formation in the present discussion lies in the fact that it contains several sands which produce oil and gas in Craig, Nowata, Washington, Osage, and other counties. The Bixler, Markham, Barnett, Bartlesville, and Burgess, named in descending order, lie in the formation. Of these the Bartlesville is of most importance. The heavy sandstone outcropping east of Welch, at Bluejacket, and northwest of Vinita is probably the Bartlesville. It has been recognized far to the westward beneath Osage County and to the southwestward in the oil fields of Tulsa, Creek, Pawnee, and other counties. Its relation to the Ponca City field is discussed in another connection.

Other sands in the Cherokee formation both above and below the Bartlesville are well known. These have been studied along their outcrops and also in numerous logs of the several oil fields.

STRUCTURE.

The structure of the field has been worked out with a fair degree of accuracy. The general structure of the whole of northeastern Oklahoma is that of a low monocline dipping gently westward. The dip along the Kansas-Oklahoma line east of Osage County is about 30 feet to the mile but it is greater to the south. From Pawhuska or Cleveland westward to Ponca City, however, the dip seems to be not greater than about 20 feet to the mile. Over the entire region this general westward dip is broken by the occurrence of occasional gentle anticlines, synclines, and domes. The most pronounced of these anticlines known to the writers occurs in the Ponca City field, and is shown in Plate II. It will be called the Ponca City anticline. The contours are drawn on the upper surface of the Herington limestone, the contour interval being 20 feet.

The position of the axis of the Ponca City anticline is sharply defined from Arkansas River in sec. 35, T. 28 N., R. 3 E., southwest to the latitude of Ponca City a distance about 15 miles. Its position from this point southward to Salt Fork could be determined only approximately owing to the limited number of outcrops of recognizable formations. The Herington limestone may be seen outcropping on the hill on secs. 8 and 17, T. 25 N., R. 2 E., 3 miles southwest of Ponca City. The eastward dip is shown conclusively by the presence of this same limestone on the west bank of Arkansas River, 3 miles east of the hill just mentioned. Another outcrop of this limestone should occur between these two, but the limestone has either been dissolved away, or, which is more likely, is concealed beneath what appears to be a terrace deposit of alluvium above the present flood plain of the Arkansas River. Hence the position of the axis of the anticline as shown on the map is only approximate in this vicinity, but that the anticline is present there is no doubt. No reliable means were at hand to ascertain whether the anticline extends south of Salt Fork but such evidence as could be secured is against such extension.

The northern extremity of the anticline is clearly defined. The eastward course of Arkansas River on secs. 25 and 26, T. 28 N., R. 3 E., is due mainly to the vanishing of the anticline. Two miles north of the river on section 24, all semblance of an anticline is absent. Terrace sand immediately north of the river concealing the older formations forbade details of structure.

As shown in Plate II, the maximum development of the anticline is in the north part of sec. 36, T. 28 N., R. 3 E., where the upper surface of the Herington limestone attains an elevation of over 1,350 feet. From this point northward the anticline merges into the general monocline. To the south the axis of the anticline dips at the rate of approximately 16 feet per mile, until at a point three miles south of Ponca City the altitude of the upper surface of the Herington limestone on the axis is only 1,020 feet. Thus the anticline in longitudinal section is assymmetric the shorter and steeper limb to the northeast and the longer gentler slope to the southwest.

The small figures on Plate II show cross sections of the anticline, one at the northeast end the other at the southwest end. The degree of development of the anticline varies between these extremes. It will be noted that the southeast limb is by far the shorter and steeper and the northwest is longer and gentler. This latter limb in fact is simply a part of the general monocline, the dip being somewhat greater than that prevailing generally in the region.

The axis as shown in the map runs north-northeast at the south end of the anticline, and makes a well defined curve to the eastward at Ponca City, continues almost exactly northeast for six miles, turns again to north-northeast and so continues to Arkansas River. The trend is thus in the same direction at the ends of the structure but at the middle makes a wide angle with the trend at either end.

The syncline to the southeast of the anticline is also well defined. The axis lies between a mile and a mile and a half from that of the anticline. To the northeast the dip of the west limb is sharp, amounting in places to 30°, while that of the east limb is always much less. To the southwest the syncline spreads out and becomes shallower and is not traceable beyond Arkansas River.

DEVELOPMENT.

A local company in 1905 put down the first well in the Ponca City field, the site being in the southern part of that city. Gas was encountered at about 500 feet. This discovery gave a considerable impeus to prospecting, the principal activity being in sec. 34, T. 26 N., R. 2 E., and those sections immediately north and east. The amount of gas obtained was not flattering and the yield, which went for local domestic comsumption, soon began to wane. The local company in 1909 went farther northeast where the anticline already described is better developed and was rewarded by several wells ranging up to 5,000,000 cubic feet daily capacity, the gas coming from the 500 foot sand. During the next two years several wells were sunk by outside capital, all of which, while discouraging, served to test out the field somewhat thoroughly as regards the shallow sands. With probably but a single exception, however, these wells did not go deep enough to test the deeper sands. This exception is the well put down by E. W. Marland 5 miles southwest of the city on the 101 Ranch in the Ponca Reservation. In this well a showing of oil was reported 2,520 feet. The significance of this showing will be found discussed in the section on oil bearing horizons. It was not till June, 1911, that oil in paying quantities was obtained in the field, at which time a 75 barrel well was brought in. As was to be expected the discovery had an electrifying effect and the Devonian Oil Company, Gypsy Oil Company, Paova Oil Company, Iron Mountain Company, Minnetoka Oil Company, and Gunsburg and Foreman quickly entered the field. These companies subleased from the 101 Ranch Oil Company who held leases on most of the territory. Secs. 4, 8, 9, and 17, T. 25 N., R. 2 E., were the center of activity for several months.

At present (December 1, 1912) there are 30 producing oil wells in the field, about 31 per cent of the total. Of these the maximum initial production is 1,200 barrels, the average daily settled production being about 35.3 barrels per well as nearly as can be estimated from the data at hand.

This average is derived from the output of certain wells which are taken as being representative. Alberta Foureyes nos. 1, 3, 4, and 6 produced from April 22, 1912, to October 21, 1912, (129 days) a combined daily average of 153.7 barrels, an individual average daily production of 38.4 barrels. The average daily production of Carrie-sits-on-the-hill, nos. 2 and 3, is 25 barrels each; of Brett nos. 1, 3, and 4, 25 barrels each; and of one well on Running After Arrow lease, 75 barrels. These ten wells therefore show an average daily production of 35.3 each and this average may be taken as representing approximately that of the field.

The oil being obtained in the field is of a rather deep olive green color. According to information furnished by the 101 Ranch Oil Company the base is paraffin, while the gravity ranges between 44° and 47° Baume. These facts show the oil to be of very high grade.

A total of 24 gas wells, or 25 per cent of the total number, drilled have been reported to date. These show individual initial capacities up to 36,000,000 cubic feet daily in Brett No. 1. The total initial capacity is approximately 172,000,000 cubic feet daily, the average per well being therefore about 6,250,000. This does not include the 9 or 10 wells in the immediate vicinity of Newkirk most of which were either gas wells of small capacity or dry holes. The following is a list of the gas wells with their capacities:

WELL.	Location	Depth of sand.	Initial capacity.	Present capacity.
Alberta Four Eyes No. 1	4-25-2	513	3,500,000	3,500,000(e)
Alberta Four Eyes No. 3	4-25-2	576	4,000,000	4,000,000(e)
Alberta Four Eyes No. 4	4-25-2	515	7,000,000	7,000,000(e)
J. H. Barrett et al	24-26-2		2,000,000	2,000,000(e)
Geo. H. Brett No. 1	8-25-2		20,000,000	20,000,000
Geo. H. Brett No. 2	8-25-2	972	6,000,000	6,000,000(e)
		475	6,000,000	6,000,000(e)
Geo. H. Brett No. 4	8-25-2	930	5,000,000	5,000,000(e)
		1275	5,000,000	5,000,000(e)
Geo. H. Brett No. 5	8-25-2	540	4,500,000	4,500,000(e)
Jennie D. Burtt No. 1	8-25-2		22,000,000	12,000,000
L. A. Cann (2 wells)	24-26-2			
	24-26-2		4,000,000	4,000,000(e)
		564	6,000,000	6,000,000(e)
Carrie-sits-on-the-hill No. 1	8-25-2	1570	5,000,000	5,000,000(e)
		505	6,000,000	6,000,000(e)
Carrie-sits-on-the-hill No. 2	8-25-2	1522	2,000,000	2,000,000(e)
Emily Primeaux No. 1	8-25-2		8,000,000	6,000,000
Flossie-running-after-arrow		545	3,000,000	
No. 1	17-25-2	1568	6,000,000	5,000,000
William Kennedy	24-26-2		2,000,000	2,000,000(e)
Jessie Knowles	4-25-2	490	3,000,000	3,000,000(e)
		505	6,000,000	6,000,000(e)
Mary C. Primeaux No. 1	5-25-2	1542	2,000,000	2,000,000(e)

Mollie A. Miller No. 1	9-25-2			5,000,000
		495	4,000,000	4,000,000(e)
Mollie A. Miller No. 2	9-25-2	1300	Gas and oil	
Mollie A. Miller No. 3	9-25-2	506	4,000,000	4,000,000(e)
Mollie A. Miller No. 4	9-25-2	507	6,000,000	6,000,000(e)
Flossie-running-after-arrow No. 2	9-25-2		10,000,000	8,000,000
J. C. Schell No. 1 (Frank Four Eyes)	4-25-2	253	4,000,000	4,000,000(e)
E. Smedley	12-26-2		2,000,000	2,000,000(e)
W. Tauer	14-26-2		2,000,000	2,000,000(e)
		500	small	
Vashita Four Eyes	17-25-2	800	showing	
Ziegler lease			2,000,000	2,000,000(e)
Total			172,000,000	159,000,000

(e) Estimated.

Of the 97 wells so far completed 25 or 26 per cent, are dry holes. This number includes all the "wildcat" wells of the area. Many of these dry holes were sunk at considerable distance from the main oil and gas development and perhaps half the number were drilled in before the main field was finally discovered. This percentage is very high. A close study of the logs of these dry holes, however, reveals the fact that in almost every case drilling ceased when the 1,500-foot sand was reached if not before. When it is remembered that in the Cleveland field to the eastward the 3 most important sands are reached at 1,600 feet (Cleveland sand), 2,400 feet (probably Bartlesville sand), and 2,700 feet (Tucker sand), respectively, and that in the Cushing field the two sands are encountered at 1,400 and 2,100 feet respectively, the dry holes in the present area should not be regarded as condemning even the immediate vicinity in which they are located.

Of the above wells many were not drilled past the 500-foot sand. Those sunk to the deeper sands show also quite uniformly good volumes of gas at 950 feet and 1,500 feet with fair yields locally at 1,300 feet. On the whole the greater volume is found in the 550-foot sand, though this is not uniformly the case. The usual production in this shallow sand is between 4,000,000 and 6,000,000 cubic feet daily.

The following is a summary of all wells drilled and drilling in the area:

	South of Ponca City	North of Ponca City	Total
Oil	30	0	30
Gas	11	13	24
Dry	14	11	25
Abandoned	0	1	1
Drilling	8	0	8
Derrick up	0	1	1
Locations	8	0	8
	71	26	97

CHARACTER, EXTENT, AND CORRELATION OF SANDS.

In the Ponca City field there are several productive sands all of which are constant over that part of the field which has been developed or prospected, so far as continuity can be determined by available logs. But a careful study of the logs seems to indicate that many of the beds described as sand should rather be called sandy shale. Fully 90 per cent of the logs show more than half of the first 500 feet to be composed of sandstone. But fully 300 feet of these beds can be studied along their outcrops at no great distance from the wells. These outcrops show considerable thicknesses of shale between the limestones, but very little sandstone is present. This should be taken into serious consideration in discussing the probable presence of sands in the undeveloped portion of the area.

Frequent reference is herein made to the various sands in the Ponca City field. To show the exact position of these sands as encountered by the drills, as well as the general nature of the entire section, the logs of the Mary C. Primeaux No. 1, Flossie Running After Arrow, and Mollie A. Miller No. 2 are given below, these being chosen as types for the area. The logs of the 101 Ranch Oil Company's well on sec. 25, T. 25 N., R. 1 E.; and those of the deep wells at Ralston and Blackburn will be referred to and are also given herewith:

Log of well, Mary C. Primeaux No. 1, in E. ½ SE. ¼ sec. 5, T. 25 N., R. 2 E.

	Thickness Feet	Depth Feet		Thickness Feet	Depth Feet
Soil	6	6	Shale, white	70	930
Red clay	30	36	Sand (oil showing)	15	945
Sand	10	46	Sand, broken	7	952
Red rock	70	116	Slate	10	962
Shale	10	126	Lime	5	967
Lime	4	130	Shale	23	990
Sand and gas	8	138	Lime	5	995
Shale	7	145	Shale	65	1,060
Red rock	10	155	Lime	5	1,065
Lime	5	160	Shale	35	1,100
Red rock	3	163	Lime	20	1,120
Lime	10	173	Shale	5	1,125
Red rock	5	178	Lime	10	1,135
Lime	10	188	Shale	5	1,140
Shale	27	215	Sand	5	1,145
Red rock	50	265	Shale	5	1,150
Lime	10	275	Sand	10	1,160
Shale	5	280	Shale	25	1,185
Red rock	25	305	Lime	35	1,220
Sand and gas	21	326	Shale	65	1,285
Red rock	25	351	Lime	10	1,295
Lime	5	356	Shale	25	1,320
Shale	38	294	Sand and water	22	1,342
Lime	4	398	Shale	28	1,370

Log of well, Mary C. Primeaux No. 1, in E. ½ SE. ¼ sec. 5, T. 25 N., R. 2 E. (Continued)

	Thickness Feet	Depth Feet		Thickness Feet	Depth Feet
Red rock	41	439	Lime	5	1,375
Lime	5	444	Shale	30	1,405
Red rock	6	450	Lime	20	1,425
Lime	8	458	Shale	8	1,433
Red rock	10	468	Lime	8	1,441
Shale	39	505	Shale	30	1,471
Sand and gas	25	530	Lime	20	1,491
Shale	46	576	Shale	3	1,494
Lime	11	587	Lime	3	1,497
Shale	5	592	Slate	6	1,503
Lime	25	617	Shell	3	1,506
Shale	58	675	Red rock and slate	14	1,520
Red rock	5	680	Sand, broken	11	1,531
Lime	35	715	Oil sand, good (gas)	11	1,542
Shale	5	720	Sand, broken, and slate	6	1,548
Lime	50	770	Lime	2	1,550
Shale	90	860			

Log of well, Flossie Running After Arrow, in W. ½ NE ¼ sec. 17, T. 25 N., R. 2 E.

	Thickness Feet	Depth Feet		Thickness Feet	Depth Feet
Unrecorded	34	34	Lime	73	673
Red rock	56	90	Sand (gas)	10	683
Lime	10	100	Shale, sandy	22	705
Red rock	120	220	Red rock	10	715
Shale, brown	13	233	Lime	50	765
Lime, sandy	14	247	Slate, blue	15	780
Red rock	53	300	Lime shells	72	852
Lime	10	310	Lime	10	862
Red rock	26	336	Gray shale	43	905
Lime	31	367	Lime	7	912
Red rock	63	430	Sandy shale	13	925
Lime	14	444	Blue slate	45	970
Red rock	34	478	Sand (oil and gas)	24	994
Lime	4	482	Shale, gray	41	1,035
Red rock	63	545	Lime shells	15	1,050
Sand (gas)	30	575	Shale, gray	50	1,100
Red rock	25	600	Lime shells	50	1,150
Sandy shale	86	1,236	Shale, blue	10	1,395
Lime	14	1,250	Lime	14	1,409
Blue shale	30	1,280	Sandy shale	36	1,445
Lime	7	1,287	Lime	30	1,475
Red rock	13	1,300	Brown shale	33	1,508
Blue shale	20	1,320	Lime	22	1,530
Lime	20	1,340	Brown shale	17	1,547
Sandy shale	10	1,350	Red rock	7	1,554
Sand (oil)	13	1,363	Sand (gas)	14	1,568
Sand (water)	22	1,385			

Log of well, Mollie A. Miller No. 2, in NW. ¼ sec. 9, T. 25 N., R. 2 E.

	Thickness Feet	Depth Feet		Thickness Feet	Depth Feet
Soil	4	4	Sand (water)	35	965
Sand and gravel	50	54	Slate	25	990
Lime	10	64	Lime	5	995
Red rck	36	100	Slate	15	1,010
Lime	5	105	Lime	6	1,016
Red rock	30	135	Slate	22	1,038
Sand (gas)	5	140	Lime	12	1,050
Red rock	60	200	Slate	20	1,070
Lime	10	210	Lime	12	1,082
Red rock	50	260	Slate	6	1,088
Sand (gas)	15	275	Lime	12	1,100
Red rock	75	350	Slate	10	1,110
Lime	20	370	Lime	15	1,125
Slate, white	30	400	Slate and shells	25	1,150
Red rock	50	450	Lime	4	1,154
Lime	10	460	Sand	16	1,170
Red rock	35	495	Slate	12	1,182
Sand (gas)	45	540	Sand, broken	6	1,188
Red rock	15	555	Slate	24	1,212
Lime	13	568	Lime	8	1,220
Red rock	5	573	Slate	30	1,250
Lime	7	580	Lime	5	1,255
Red rock	13	593	Red rock	5	1,260
Slate	13	606	Lime	3	1,263
Lime	8	614	Slate	27	1,290
Red rock	6	620	Lime	9	1,299
Lime	20	640	Slate	12	1,311
Red rock	5	645	Sand (water)	30	1,341
Sand	8	653	Slate	5	1,346
Red rock	7	560	Lime	2	1,348
Lime	80	740	Slate	15	1,363
Black slate	15	755	Lime	5	1,368
Lime	8	763	Slate	32	1,400
Shale, white	20	783	Red rock	5	1,405
Sand, broken	12	795	Lime, sandy (water)	20	1,425
Red rock	5	800	Slate	8	1,433
Black slate	15	815	Lime	18	1,451
Lime	6	821	Red rocks	6	1,457
Slate, white	25	846	Lime	8	1,465
Lime	12	858	Slate	9	1,474
Shale, black	12	870	Lime	24	1,498
Slate, white	15	885	Slate	5	1,503
Lime	5	890	Lime	3	1,506
Shale	8	898	Black slate	10	1,516
Lime	12	910	Fed rock	7	1,523
Shale	20	930	Sand (oil)	14	1,537
			Slate, black	22	1,559

Log of well, 101 Ranch, in NE ¼ sec. 25, T. 25 N., R. 1 E.

	Thickness Feet	Depth Feet		Thickness Feet	Depth Feet
Sandy soil	19	19	Black shale	6	1,522
Gravel	40	59	Fine hard sand	7	1,529

Log of well, 101 Ranch, in NE ¼ sec. 25, T. 25 N., R. 1 E.
(Continued)

	Thickness Feet	Depth Feet		Thickness Feet	Depth Feet
White clay (water)	10	69	Soft shale	20	1,549
Red rock	12	81	White sand (water)	28	1,577
Gritty slate	8	89	Blue shale	3	1,580
Red rock	21	110	Gritty lime	5	1,585
White shale or clay	42	152	Black slate	53	1,638
Lime shell	9	161	Sandy lime	25	1,663
White shale or clay	44	205	Soft black shale	22	1,685
Red rock	26	231	Red shale	5	1,690
Lime shell	3	234	White sand	15	1,705
Red rock	60	294	Black slate	3	1,708
Brownish lime	4	298	White sand	28	1,736
Hard black slate	28	326	Black shale	20	1,756
Reddish lime	24	350	Lime shell	7	1,763
Red rock	35	385	Soft black shale	36	1,799
Gritty slate	20	405	White sand (water)	39	1,838
Red rock	22	427	Soft shale	4	1,842
White shale	8	435	Gritty gray lime	10	1,852
Brownish lime	8	443	Black shale	6	1,858
Hard grayish lime	22	465	Slate and shell	22	1,880
Red shale	35	500	Soft black shale	5	1,885
Lime shell	12	512	Red shale	7	1,892
Red rock	58	570	White lime	30	1,922
Red sand	23	593	Soft black shale	13	1,935
Hard white lime	5	598	Soft red shale	15	1,950
Red shale	27	625	White lime	28	1,978
White sand	35	660	Red rock cavings	22	2,000
Red shale	42	702	Hard gray lime	15	2,015
White sand	34	736	Lime shell	3	2,018
Black slate	6	742	Sandy lime	19	2,037
Hard lime	38	780	Brown shale	3	2,040
White slate	50	830	White sand	5	2,045
Grayish lime	24	854	White shale	13	2,058
Black slate with shells	18	872	White sand	30	2,088
Black slate with hard			Black shale	20	2,108
shells	24	896	Hard lime	6	2,114
Black slate	6	902	Black slate	49	2,163
Slate and shells	21	923	Hard shell	3	2,166
Reddish tinted slate	37	960	Black slate	14	2,180
Gritty shell in black			Hard white sand	10	2,190
slate	45	1,005	Red brown shale	4	2,194
White and black sand	12	1,017	White slate	5	2,199
Black slate	45	1,062	Very hard white		
Slate and shell	4	1,066	lime (water)	43	2,242
Soft slate	85	1,151	Black slate	26	2,268
Lime	4	1,155	Dark lime	11	2,279
Very soft slate	75	1,230	Black shale	3	2,282
Hard white sand	6	1,236	White sand (salt		
Soft black slate	24	1,260	water)	18	2,300
Dark soft shale	12	1,272	Dark shale	3	2,303
Lime cavings	43	1,315	Very white sand	59	2,362
White sand (water)	19	1,334	Dark black shale	43	2,405
Slate and shells	33	1,367	Dark lime	6	2,411
Hard lime	18	1,385	Blue shale	54	2,465
Soft dark lime	10	1,395	White shale	20	2,485

Log of well, 101 Ranch, in NE ¼ sec. 25, T. 25 N., R. 1 E.
(Continued)

Soft black shale	23	1,418	Dark blue shale	35	2,520
Red rock	15	1,433	White sand	56	2,576
White sand	17	1,450			
Black slate	10	1,460			
Very hard sand	56	1,516			

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.

	Thickness Feet	Depth Feet		Thickness Feet	Depth Feet
Clay, yellow, soft	10	10	1,085 feet	215	1,270
Mud, red, soft	10	20	Shale, blue, soft	75	1,345
Lime, black, hard	12	32	Lime, white, hard	35	1,380
Shale, blue, soft	15	47	Shale, white, soft	20	1,400
Sand, white, soft			Lime, white, hard	15	1,415
(water)	15	62	Shale, white, hard	35	1,450
Mud, red, soft	10	72	Sand, white, hard	30	1,480
Lime, white, hard	5	77	Shale, white, soft	35	1,515
Red rock, soft	35	112	Red rock, soft	8	1,523
Sand, white, soft			Shale, blue, soft	23	1,546
(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		
Red rock, soft	30	212	(water at 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			Lime, white, hard	6	1,941
(water at 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			Shale, black, soft	140	2,150
(little salt water)	15	457	Lime, white, hard	5	2,155
Shale, white, soft	70	527	Shale, black, soft	10	2,165
Sand, white, soft			Lime, white, hard	45	2,210
(hole full of water			Shale, black, soft	6	2,216
at 530 feet)	85	612	Lime, white, hard	10	2,226
Shale, white, soft	60	672	Shale, black, soft	8	2,234
Red rock, soft	5	677	Lime, white, hard	9	2,243
Sand, white, soft	8	685	Shale, blue, soft	19	2,262
Red rock, soft	24	709	Lime, white, hard	36	2,298
Sand, white, soft	6	715	Shale, black, soft	14	2,312
Shale, white, soft	16	731	Lime, white, hard	8	2,320
Sand, white, soft			Shale, white, soft	45	2,365
(water)	40	771	Sand, white, soft		
Shale, white, soft	51	822	(gas at 2,370 feet;		
Red rock, soft	25	847	hole full of water		
Lime, white, hard	6	853	at 2,385 feet	30	2,395
Sand, white, hard			Lime, white, hard	10	2,405
(little water)	10	863	Shale, black, soft	25	2,430
Shale, white, soft	54	917	Shells, black, hard	20	2,450
Sand, white. hard	35	952	Shale, black, soft	30	2,480
Red rock, soft	10	962	Sand, white, hard	6	2,486

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. (Continued)

	Thickness Feet	Depth Feet		Thickness Feet	Depth Feet
Sand, white, hard	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 water at			Mud, red, soft	40	2,690
			Shale, white, soft	22	2,712
			Lime, hard, gray	124	2,836

Log of well 1 mile northwest of Ralston, in NE. ¼ SE. ¼ sec. 34, T. 24 N., R. 6 E.

	Thickness Feet	Depth Feet		Thickness Feet	Depth Feet
Unrecorded	1,000	1,000	Shale, blue	70	1,820
Sand (oil)	20	1,020	Salt sand	60	1,880
Shale, red	15	1,035	Shale, blue	8	1,888
Salt sand	5	1,040	Salt sand	72	1,960
Shale, blue	5	1,045	Shale	70	2,030
Salt sand (water)	15	1,060	Salt sand	20	2,050
Shale, blue	5	1,065	Shale, blue	75	2,125
Sand, blue	25	1,090	Cap rock	15	2,140
Shale, blue	5	1,095	Oil sand	70	2,210
Shale, red	10	1,105	Sand, white	15	2,225
Salt sand	15	1,120	Shale, blue	50	2,275
Shale, blue	20	1,140	Do	100	2,375
Shale, sandy	10	1,150	Shale, black	5	2,380
Shale, blue	15	1,165	Lime (oil)	5	2,385
Shale, red	10	1,175	Lime, sandy	20	2,405
Lime	5	1,180	Sand	5	2,410
Shale, blue	40	1,220	Shale, sandy	30	2,440
Salt sand	25	1,245	Shale, blue	3	2,443
Shale, blue	45	1,290	Lime (gas)	6	2,449
Salt sand	15	1,305	Shale, black	5	2,454
Shale, blue	18	1,323	Shelly lime	8	2,462
Sand	28	1,351	Shale	3	2,465
Shale, blue	20	1,371	Lime	5	2,470
Lime	7	1,378	Shale	4	2,474
Do	8	1,386	Lime	5	2,479
Shale, blue	69	1,455	Shale	2	2,481
Lime	18	1,473	Lime (gas)	6	2,487
Shale	15	1,488	Shale, blue	20	2,507
Salt sand	15	1,503	Lime	20	2,527
Lime	5	1,508	Shale, black	4	2,531
Shale, blue	12	1,520	Lime	40	2,571
Lime	5	1,525	Shale, black	4	2,575
Salt sand	10	1,535	Lime	40	2,615
Shale, blue	5	1,540	Shale, black	4	2,619
Salt sand	5	1,545	Lime	20	2,639
Shale, blue	10	1,555	Sand (gas)	5	2,644
Salt sand	195	1,750	Unrecorded	656	3,300

A good number of wells were put down in an attempt to reach deeper and more productive oil sands and it would appear that in this effort the drillers in some cases overlooked or neglected the shallower sands which may be made to yield oil or gas, especially the latter, in commercial quantities. Not a few logs record "some gas" or "showing of oil" at several horizons which were not regarded as producing in commercial quantities. What the significance of these vaguely recorded facts may be it is impossible to say, but they at least indicate that it would be profitable to attempt further development and to conserve the product at those horizons.

The shallowest sand of any considerable consequence in the present field lies about 275 feet below the top of the Herington limestone. Inasmuch as most of the wells so far put down start at or near the upper surface of this limestone the depth of the sand is approximately coincident with the distance from the top of the Herington limestone. The thickness of this sand as shown by the logs ranges between 10 and 20 feet. It is not regarded as one of the valuable sands of the field. This shallowest sand is probably the one seen associated with the Matfield shale wherever this comes to the surface. Wherever seen the sandstone consists of several thin layers between which are intercalated beds of coarse sandy shale. The only observed outcrops of the Matfield are toward the north end of the field remote from development. It may therefore be reasonably expected that the sand will underlie the anticline along its entire length.

The second sand in descending order lies about 375 feet below the top of the Herington limestone. In this case little information can be had from the logs, bearing on the character of the sand. Its thickness ranges up to 25 feet, the average being about 17 feet. In several of the wells this sand yields gas in commercial quantities, but so far as known to the writers no oil has been obtained at this horizon.

One of the most valuable gas sands in the region lies 550 feet below the top of the Herington limestone. A number, especially of the older gas wells of the region, extend only to this sand. The maximum thickness recorded is 49 feet, but the average is probably between 25 and 30 feet. This sand is light in color, coarse and very porous. It is the best gas producing sand in the region. In several of the wells 7,000,000 cubic feet of gas per day are obtained from this sand.

Doctor J. W. Beede has indicated to the writer that it is in all probability this same sand from which gas is obtained at Dexter, Arkansas City, Elmdale, and Council Grove, in Kansas; and, further that it is probably the sandstone which is associated with the Emporia limestone in Kansas. It may then tentatively be correlated with the 60-foot series of sandstones exposed along Buck Creek in northern Osage County. Furthermore, so far as data at hand throw any light on the subject, this is the sandstone which outcrops southeast of Fairfax in Osage County. The elevation at Fairfax and at Ponca City being approximately the same, if a westward dip of 20 feet to the mile be assumed, the sandstone at Fairfax should lie about 500 feet below the surface at Ponca City. If these correlations be correct the 550-foot productive sand should be found underlying the entire field.

About 975 feet below the top of the Herington limestone is a fourth sand of the area in descending order. The maximum thickness recorded in logs is 50 feet, the average being about 35 feet. This sand produces both oil and gas. Several of the wells that are at present utilized for gas only might and probably will be brought to yield oil later.

Data on which to base a correlation of this sand are very meager. The first 1,000 feet of the log of the deep well at Ralston not being available one is compelled to go to the outcropping sandstones in Osage and Pawnee counties. The remoteness of these outcrops from Ponca City, however, makes even a tentative correlation hazardous. A suggestion may nevertheless be ventured. The persistence of the Elgin sandstone from southern Kansas, across Osage and Pawnee counties, Oklahoma, together with its great thickness and massive character, suggest that it may be present for a considerable distance westward along the dip. The altitude of this sandstone at Hominy, Osage County, is about 1,000 feet, the same as that of the region around Ponca City. The two places are separated 45 miles. Assuming a westward dip of 20 feet to the mile, the Elgin should lie about 900 feet below the surface at Ponca City. Again, the interval between the 550-foot and the 976-foot sand is 425 feet, while only 350 feet intervene between the Elgin sandstone and that exposed on Buck Creek. While, therefore, the 975-foot sandstone is 75 feet lower than the Elgin should be if the dip be 20 feet to the mile, and while the interval between the 550-foot and the 975-foot sands is 75 feet more than the interval between the Elgin and the sandstone on Buck Creek, nevertheless the facts considered in their entirety suggest that the 975-foot sand may be the westward extension of the Elgin, and the difference in the intervals between the sands is due to a thickening of the intervening shale to the west.

The fifth sand in descending order lies 1,330 feet below the top of the Herington limestone. It yields quantities of gas up to 6,000,000 cubic feet per day in certain wells but its importance lies in the fact that it is productive of oil also. Considerable of the oil of the area is yielded by this sand. It would appear that where gas only is encountered that the thickness of the sand is considerably less (15 feet) than where oil is obtained (35 to 40 feet). Information on this point is, however, too scant to warrant a statement that this condition would hold true in general. Little is known of the areal extent of this sand since it cannot at present be correlated with any

other localities to the eastward, unless that encountered at 112 feet in the Blackburn well be the same.

The deepest productive sand so far encountered in the area lies abount 1,550 feet below the upper surface of the Herington limestone. This sand is also productive of both oil and gas, and is the best oil producing sand in the area. In several wells which are recorded as gas wells showings of oil were encountered. Some of these gas wells yielded 10 barrels of oil natural on being brought in. The thickness of the sand is between 15 and 20 feet, the average being about 17 feet.

Mr. Wood has tentatively correlated this sand with the 500-foot sand at Cleveland, which correlation must be regarded as correct so far as it can be determined from available facts. The sandstone lying at 266 feet depth in the Blackburn well may tentatively be regarded as the same. Further, this sand may be tentatively correlated with the main mass of thick sandstones outcropping at Bigheart and extending thence along the strike for long distances in both directions. If these correlations be correct it may reasonably be expected this sand should be found beneath the entire length of the Ponca City anticline. Not only so, but since it is productive at two places so widely separated, it will problably be found containing oil and gas in the intermediate region where structural conditions are favorable for accumulation.

One sand of considerable importance is known to be present beneath the sands so far found to be productive in the region. In the well of the 101 Ranch Oil Company in the northeast quarter sec. 25, T. 25 N., R. 1 E., a sand 56 feet in thickness was encountered at a depth of 2,520 feet which yielded a "showing" of oil. This sand then lies 970 feet beneath the 1,550 foot sand and is therefore provisionally correlated with that encountered in the Ralston well at 2,140 feet, where a thickness of 70 feet was found.

As shown by Mr. Wood, this sand may be tentatively regarded as the 1,600-foot sand of the Cleveland field, widely known as the Cleveland sand. The depth, thickness, stratigraphic position, and productiveness all point to such correlation but make it by no means certain. Assuming the correctness of the correlation this sand should be sought not only at depths in the developed part of the Ponca City field, but it may reasonably be expected to the northward in the undeveloped portion.

If the correlations above indicated be correct then the horizon of the Bartlesville sand, which is one of the most productive at Cleveland, Tulsa, Bartlesville, and elsewhere in the mid-continent area, should be encountered in the Ponca City field at about 3,200 or 3,250 feet, and the horizon of the Tucker sand which is very productive, especially in the Cleveland field, should show up at about 3,450 or 3,500 feet. No drill has gone to this depth in the present area, and no well in the region should be regarded as a test which has not gone deep enough to reach the horizons of these sands.

It will appear from the above disucssion that the probable presence of the several sands in the northern end of the field, their continuity to the eastward, and their correlation, hang on several contingencies, all of which combined forbid any positive assertion. Nevertheless, each tentative conclusion indicated is in fair accord with all the data available. Some further color is given to these conclusions by the fact that, considered together and as a whole, a fair degree of harmony exists, as great in fact as can be hoped for in view of the remoteness of the localities compared.

The structural sheet (Pl. II) shows that the Ponca City anticline is best developed near the north end and there is no doubt but that conditions are here very favorable for the accumulation of oil and gas. The success attending the sinking of test wells will depend largely on the depth to which the drill is sent. As shown elsewhere in this report few holes extend below the 1,550-foot sand. Indeed several wells have been labeled "dry" although thy reached only the 1,330-foot sand. The dry holes northwest of Uncas did not go down a thousand feet, and therefore mean absolutely nothing as to whether oil and gas may or may not be found in that locality. The discovery of productive sands at 500 feet at Cleveland, 400 to 700 feet in the Cherokee shallow pool, 600 to 700 feet at Dewey, and 550 feet in the present area, while bringing quick returns on certain investments, has in the long run had a disastrous effect on the Mid-Continent field in general. In fact in none of the pools in north central Oklahoma does the productive sand lie deeper than 2,700 feet and in most cases at a much shallower depth, as in the Hogshooter, Dewey, Delaware, Coodys Bluff, Nowata, and Alluwe fields, where the hief sand—the Bartlesville—lies at a depth of 1,100, 1,300, 900, 700, 700, and 600, respectively. It is true that at Cleveland the three richest sands lie at 1,400, 1,600, and 2,400 feet respectively, and those at Cushing occur at 1,400 and 2,100 feet. But even these figures appear diminutive compared with depths reached by wells in West Virginia, where the deeper sands—the Gordon for instance—are reached at 3,000 feet or more. In the Santa Maria field of California many of the wells reach a depth of 4,000 feet and more. In Oklahoma many test wells are abandoned before 2,000 feet depth is reached and these abortive attempts have served only to frighten prospectors away from those localities. In the Ponca City region every part of the anticline should be tested down to a depth of not less than 3,400 feet, the approximate position of the Tucker sand. This deep drilling should be done whether oil and gas are encountered at higher horizons or not.

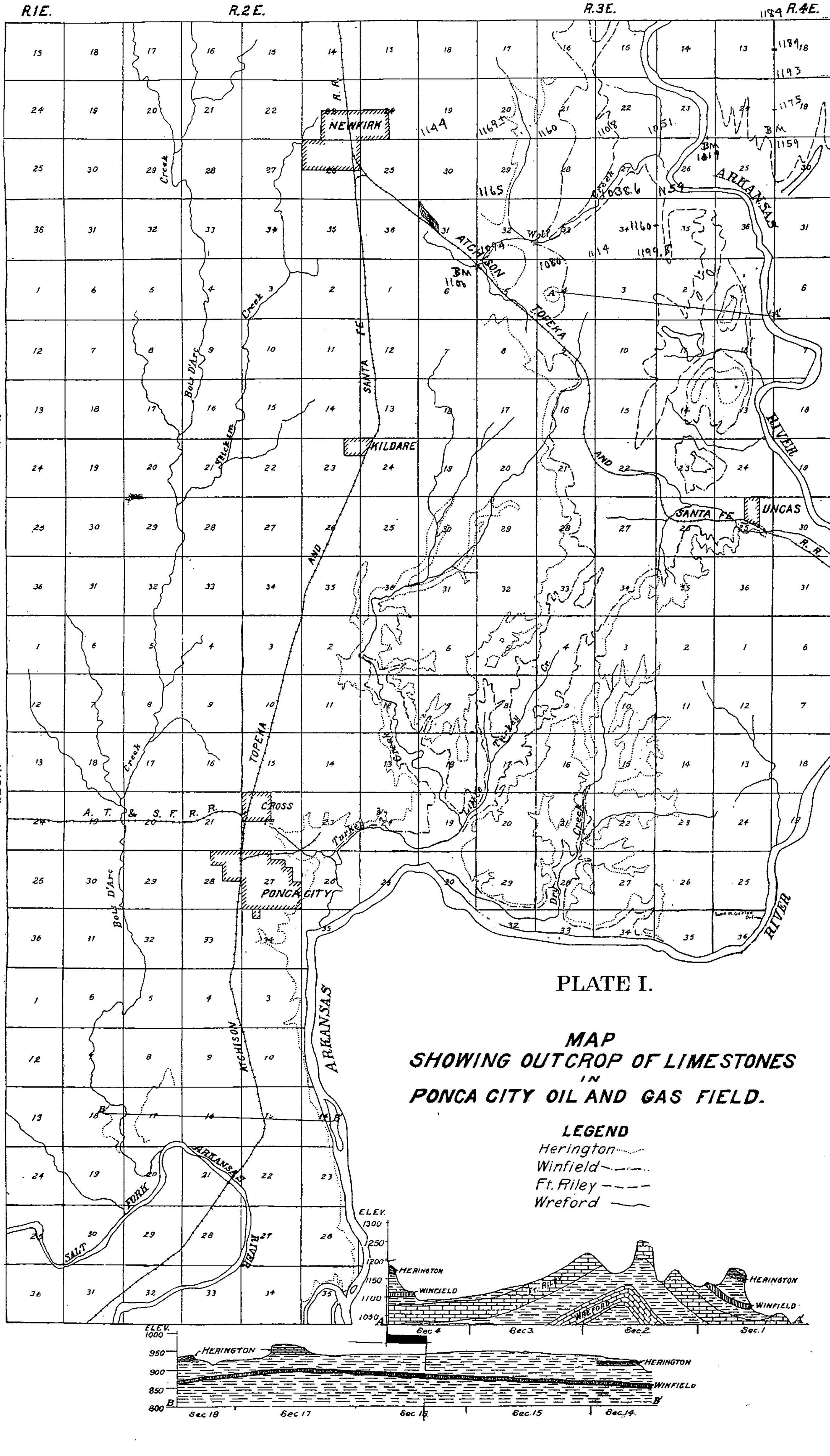

PLATE I.

MAP SHOWING OUTCROP OF LIMESTONES IN PONCA CITY OIL AND GAS FIELD.

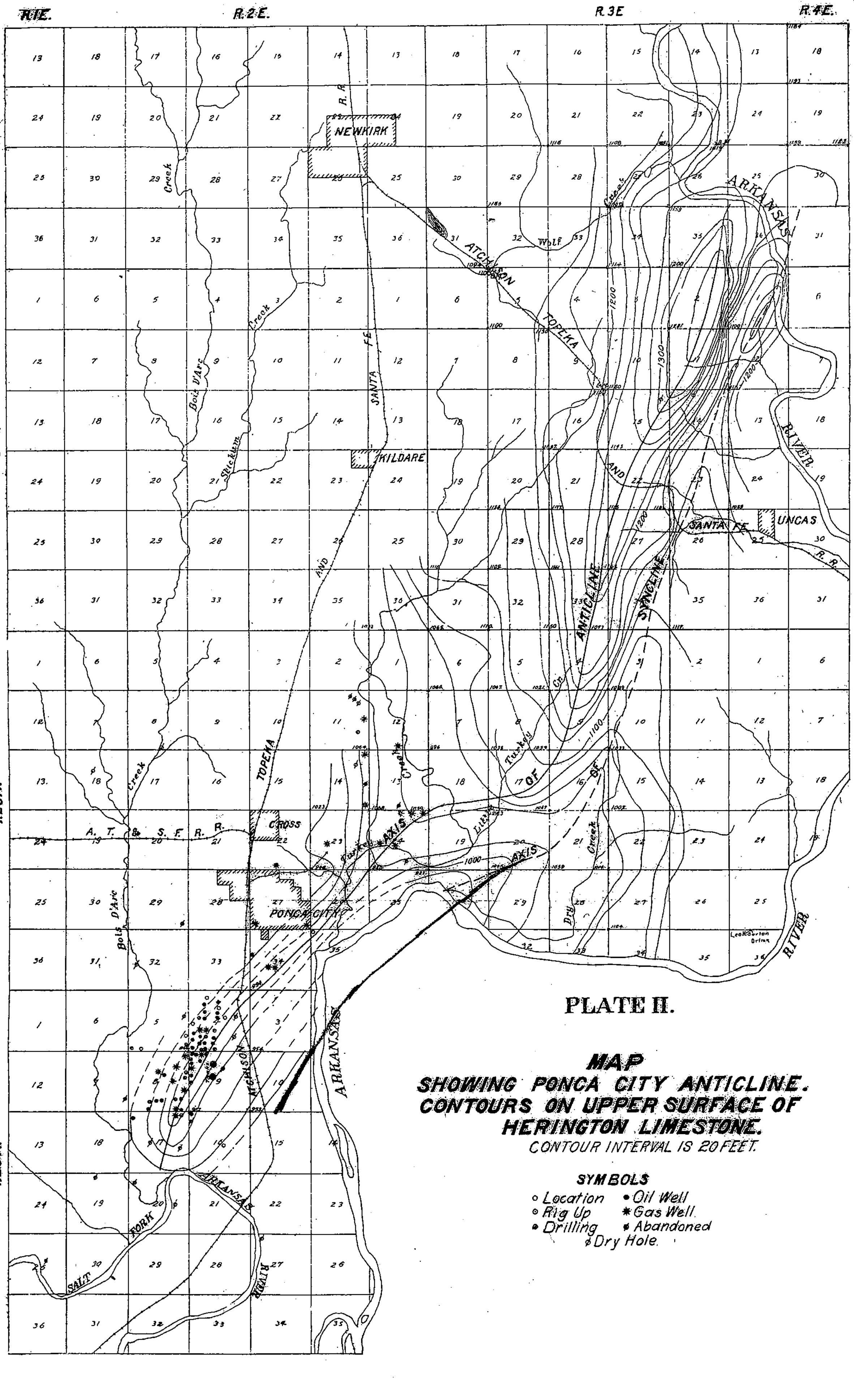

PLATE II.

MAP SHOWING PONCA CITY ANTICLINE. CONTOURS ON UPPER SURFACE OF HERINGTON LIMESTONE.

CONTOUR INTERVAL IS 20 FEET.

SYMBOLS

- ○ Location
- ◎ Rig Up
- ● Drilling
- • Oil Well
- ✱ Gas Well
- ⌀ Abandoned
- ⌀ Dry Hole