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OIL AND GAS IN OKLAHOMA

JEFFERSON COUNTY

By
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FOREWORD

In 1917 the Oklahoma Geological Survey issued Bulletin 19, Part II, entitled "Petroleum and Natural Gas in Oklahoma." This volume was so popular that the supply was soon exhausted and for several years copies have not been obtainable.

The present Director has seen the need of a revision of this bulletin. On account of the lack of appropriations he has not been able to employ sufficient help to compile the data, and has called on some twenty representative geologists throughout the State to aid in the preparation of reports on separate counties. These gentlemen, all busy men, have contributed freely of their time and information in the preparation of these reports.

It will be understood that the facts as set forth in the various reports represent the observation and opinion of the different men. The Oklahoma Geological Survey has every confidence in the judgment of the various authors, but at the same time the Survey does not stand sponsor for all statements made or for all conclusions drawn. Reports of this kind, are at best, progress reports, representing the best information obtainable as of the date issued, and doubtless new data will cause many changes in our present ideas.

Mr. John R. Bunn, of the Bunn-Marvin Drilling Co., of Ardmore, has had, through extensive core-drilling in the southeastern part of Oklahoma, obtained a great amount of excellent subsurface data for the accompanying report on Jefferson County. As a result of this new data he has been able to make a real contribution on the subject of the stratigraphy of the little-known red beds of southern Oklahoma. His report will also, in a large measure, help to clear up the question of the Pennsylvanian-Permian boundary between southern Oklahoma and northern Texas.

Norman, Oklahoma
May 1930:

CHAS. N. GOULD,
Director

JEFFERSON COUNTY

By

John R. Bunn

INTRODUCTION

This report summarizes the results of eighteen months surface and subsurface geological study and the actual supervision of some 50,000 feet of structure core-drilling confined entirely to Jefferson County, Oklahoma, in an attempt to locate undiscovered oil and gas structures.

Jefferson County was chosen for this intensive study and exploration because of its geographical location between the prolific fields of southern Oklahoma located in Carter and Stephens counties and the producing fields of north-central Texas included in Wichita, Archer, Clay, Cooke, and Montague counties; making this county as a whole, an area of probable oil and gas territory.

Furthermore, the same general stratigraphy and sedimentary conditions existing in the producing areas of southern Oklahoma and certain parts of northern Texas were thought to occur throughout Jefferson County. Likewise, regional structural highs or trends are known to be present. It would appear, then, that the location of commercial oil and gas deposits in Jefferson County will depend largely upon the discovery and drilling of minor flexures along the major structural highs, where sand conditions and source material are favorable for oil and gas accumulations.

NATURE OF WORK

Jefferson County is typical of southern Oklahoma in presenting many difficulties to the petroleum geologist. He is handicapped in search for favorable surface structure by lack of surface beds suitable for positive correlation and detail mapping. Subsurface work is likewise difficult, due to unconformity and overlap, scarcity of deep wells, and rather unreliable nature of certain well records. Because of these existing conditions, the geologist must work largely in generalities over a large area. However, the major geological features of Jefferson County are readily interpreted when studied in this manner.

The first steps in the geological survey of the county consisted of a subsurface study and mapping of the present producing areas

within the county and a study of their relationship with other pools in adjoining areas in southern Oklahoma and northern Texas. All available well records of outlying wells were obtained, plotted graphically, and a general subsurface contour map was drawn on the recorded depth to the base of the red beds. As has been previously pointed out by Burton,[1] and as will be discussed later, this method of determining general regional structure is infallible in the red bed area of southern Oklahoma.

Upon the completion of the subsurface work, a careful study was made of the surface exposures and structural attitude of mappable beds overlying the producing pools to determine the relationship of surface structure to that of the producing horizons. This work showed that in all instances where the surface could be accurately mapped there was a close relationship between surface and subsurface structure; also that the surface stratigraphy overlying the Jefferson County pools, as well as the Loco, Healdton, Hewitt, and other Carter County pools, had a very similar lithologic appearance, with a definite sequence of surrounding younger strata. An attempt was then made to differentiate and classify the surface stratigraphy of the entire county by a close reconnaissance survey. This work was satisfactorily completed after an expenditure of considerable time and effort. From the areal map of the surface stratigraphy, resulting from this work, it was possible to see at a glance the major structural features of the county. Furthermore, the structural features disclosed by the areal mapping coincided with the general structural features shown by the preliminary subsurface investigation.

The economic result of this general surface and subsurface study was the established location and proven existence of several major structural highs or trends, upon which to confine the detail mapping and study in the search for favorable anticlinal structure, the existence of which was to be proved by the structure drill. This method eliminated all but the most favorable and likely territory, cutting down to a minimum the expenditure in time and money for unnecessary and random core drilling. In the majority of cases it also enabled the acreage to be cheaply blocked or assembled on a core-drill contract previous to actual drilling, thus guaranteeing the acreage control should a likely looking structure be discovered.

LOCATION

Jefferson County is located in south-central Oklahoma. It is bounded on the south and southwest by Red River, which stream forms the boundary between this county and Clay and Montague counties, Texas. It is adjoined by Love and Carter counties, Oklahoma on the

1. Burton, George E., Relation of the base of the red beds to the oil pools in a portion of southern Oklahoma: Bull. Am. Assoc. Pet. Geol. vol. 5, pp. 173-177, 1921.

east, by Stephens County on the north and by Cotton County on the west. The area is approximately 793 square miles and consists of all or parts of Tps. 3 to 8 S., Rs. 4 to 9 W.

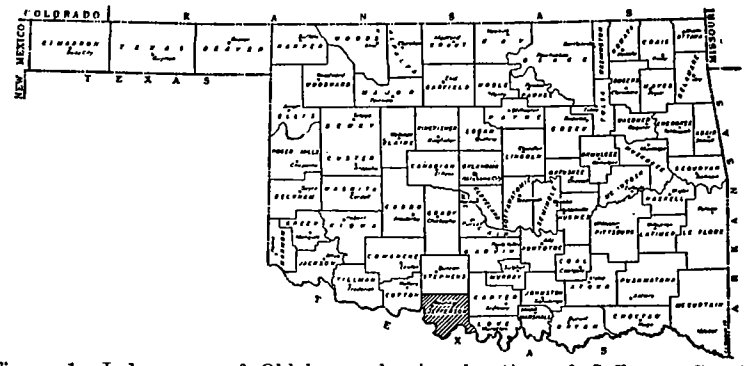

Figure 1. Index map of Oklahoma showing location of Jefferson County.

TOPOGRAPHY

Jefferson County is typical of the red beds plains region of Oklahoma, with a gentle rolling topography. The relief between stream valleys and divides is seldom in excess of 200 feet. Most of the county consists of rolling prairie land ideal for grazing purposes. The timbered areas are confined entirely to the stream valleys and certain sandstone outcrops.

The drainage of the entire area is south or southeast into Red River, which is the master stream of the area. The minor streams are East, West, and North Mud Creeks, Red Creek and Beaver Creek with its lesser tributaries. The surface elevation of the county ranges from 1,100 to 750 feet. The highest elevation is a point on Monument Hill, a few miles east of Addington, approximately 1,110 feet. The lowest point is in the extreme southeast corner of the county along Red River, with an elevation of approximately 720 feet.

Cattle and stock raising is the chief industry in the county. Comparatively little acreage is under cultivation. Cotton, corn, and feed stuff appear to be the principal agricultural products. The ranchmen of the area are high-type individuals, hospitable and inclined toward progressive cooperation.

The county possesses several well-maintained intersecting dirt highways. There are large areas taken in by certain large ranches in which the section lines are not open. However, if one will face the numerous gates of the ranchmen he may go anywhere by automobile.

Waurika is the county seat; other towns of the county are Ryan, Ringling, Addington, Hastings, Terral, and Sugden.

The main line of the Rock Island Railroad crosses the west half of the county in a north-south direction. Ringling, in the northeastern part of the county, is the terminus of a branch line of the Santa Fe from Ardmore. A branch line of the Fort Worth & Denver also runs from Waurika to Wichita Falls, and a branch line of the Rock Island runs from Waurika northwest through Hastings and Walters to Lawton.

STRATIGRAPHY

SURFACE FORMATIONS

To the writer's knowledge, there has never been any definite attempt heretofore to differentiate and classify the surface rocks of Jefferson County. These formations have been previously grouped together as an undifferentiated system in the red beds of lower Permian age. Preliminary surface study disclosed the possibility of differentiating the surface beds and showed the great value of this work in determining the general structural conditions.

It was found practical to separate the exposed stratigraphy into five mappable units. Certain of these divisions have a very characteristic appearance and are easily recognized and identified. The differentiation is based on the lithologic characteristics of the strata and regular sequence of certain sandstone and shale intervals. The areal map of the surface formations is shown on plate I. The map is, in general, strictly of a reconnaissance nature, and is to be taken as such, although certain of the areas shown have been closely detailed. In the outcrop tracing it was found practical to follow along the top of a given sand zone or horizon, rather than attempting to follow any particular bed.

For the sake of clarity and convenience in the following discussions and descriptions, the various divisions have been given local names that were adopted during the course of the field work and detail study.

POST-PERMIAN

Numerous areas in the county are covered by alluvium, valley fill, and unconsolidated sand and gravel deposits. These deposits have been classified as of Pleistocene, Tertiary, and Comanchean age, depending on type and locality. They are not classified on the accompanying map as their interest to the petroleum geologist lies only in the fact that they act as a blanket obscuring the underlying formations from which possible determinations as to structure could be made.

PERMIAN

ADDINGTON FORMATION

The uppermost member of the red beds exposed in this area has been termed the Addington formation. The outcrop of this unit is

from four to six miles in width, and extends in a northwest and southeast direction across the county. A change in strike occurs in the northwest corner of the county, the outcrop swinging west into Cotton County. The formation is not exposed north of the town of Hastings so the exact point where it enters Cotton County is unknown. It is confined principally to parts of T. 3 S., Rs. 8 and 9 W., T. 4 S., Rs. 5 to 7 W., and T. 5 S., Rs. 4 and 5 W. Typical exposures occur in secs. 3, 4, 8, 9, 28, and 33, T. 5 S., R. 4 W.; secs. 30, 32, and 34, T. 3 S., R. 6 W.; secs. 23, 24, and 26, T. 3 S., R. 8 W.; and secs. 23, 24, and 25, T. 3 S., R. 9 W.

This unit has very definite characteristics and can be easily separated from other exposed strata of the county. It is characterized by the brilliant red and vermilion hues of its shale members, which are often broken by white and light gray shale and sandy shale streaks.

The sandstones are characterized by their black red color and slabby appearence on weathering. The weathered slabs are extremely hard and resistant. When freshly broken they resemble a fine grained reddish quartzite. In general the sandstones of this formation always show a varying amount of pink or red color unless subjected to constant water saturation in which case they are sometimes soft and light colored. The outcrop is especially discernible in wet weather. The shales when wet become exceedingly slick and gummy, causing almost impassable road conditions.

The thickness varies from a comparatively few feet to several hundred, the maximum exposed thickness occurring on the high bluffs just east of Addington. The beds capping the bluffs here are above any exposed to the southeast.

The base of this formation was used in the reconnaissance mapping. It is generally characterized by a thin to massive, resistant, reddish sandstone. There is some evidence that these beds are not entirely conformable with the underlying older strata. The Addington formation contains the only beds in the county that are typical of the lower Permian red beds of Oklahoma.

In Jefferson County the outcrop of this series marks a pronounced synclinal area. Every well located within or adjacent to the outcrop of these beds has recorded a great thickness of red beds which are found low structurally. The occurrence of this formation marks an area in this county that, from all present data, has no oil or gas possibilities.

RED UPPER PENNSYLVANIAN

CLAYPOOL FORMATION

Underlying the Addington formation are several hundred feet of shales and sandy shales in which occur one or more uniform sand-

stone members. This predominant shale series is quite different in lithologic appearance from the overlying formation. The shales are brown, gray, and yellow, predominantly brown with irregular gray and blue mottling. The sandstones are thin-bedded, gray to buff in color, soft, and friable.

The extent of this formation is shown on the accompanying areal map. Certain parts of the area shown in the outcrop of this series through Tps. 4 and 5 S., Rs. 6 and 7 W., warrant more detailed study than has been given. It is possible that certain lower beds have not been recognized in this particular area.

ASPHALTUM SANDSTONE

The most important sand horizon from the standpoint of areal mapping is the Asphaltum sand. This sand zone is exposed in the vicinity of the town of Asphaltum and occurs through parts of Tps. 3 and 4 S., Rs. 4 and 5 W. It marks the Healdton uplift showing up as a series of inliers along this major structural feature, with the overlying Claypool and Addington formations occurring progressively on either side. In every instance an exposure of this sand zone of any extent along this structural trend is indicative of local anticlinal structure. This sand zone is exposed over or around the Loco pool, the Healdton pool, the Hewitt pool, and other undeveloped anticlinal features along the Healdton uplift.

The Asphaltum consists of a series of gray to buff, yellow, calcareous sandstones, generally massive, friable, and medium-grained, but locally laminated and thin-bedded. The thickness of this sand ranges from 20 to over 50 feet and consists of one or more members, separated by intervening shale beds. A nodular limestone stringer from two inches to one foot in thickness occurs uniformly 12 to 18 feet above the top of the sand throughout parts of Tps. 3 and 4 S., Rs. 4 and 5 W. In parts of Tps. 3 and 4 S., Rs. 4 and 5 W., this sandstone is saturated with asphalt, and several seeps of gas and heavy oil occur. These seeps will be discussed later.

In the area just described this sandstone can be mapped in detail. Also observed local dips in individual beds are generally indicative of true structural dip.

RYAN SANDSTONE

A sandstone having the same general description and occurring in approximately the same stratigraphic position as the Asphaltum is typically exposed in the scarps immediately southeast and northwest of the town of Ryan. The sandstone here consists usually of one member, massive to thin-bedded, with a thickness of 17 to 28 feet.

The Ryan sandstone is exposed irregularly through parts of Tps. 6 and 7 S., R. 7 W. With very few gaps, it can be traced northwest

through T. 5 S., R. 8 W., and parts of T. 4 S., Rs. 8 and 9 W. It appears to thicken in this direction, and in the bluffs bordering "Dead Man's Gulch" in T. 4 S., Rs. 8 and 9 W., at least three distinct members are present, forming a sand zone with a thickness in excess of 60 feet. The sandstone can be traced irregularly northeast from Ryan through parts of T. 5 S., Rs. 5, 6, and 7 W., the strike gradually swinging in a broad loop, circling the plunging northwest end of the Nocona structural uplift. The sand is poorly exposed through this area, but can be followed by the cuesta-like topography, long dip slopes, sandstone float, and the sandy nature of the soil. It is characteristically exposed again through secs. 14, 15, 22, and 23, T. 6 S., R. 5 W., where the general normal northeast dip into the Ringling Basin can be clearly seen.

The Ryan sand can be correlated rather definitely with the Asphaltum sand previously described. It can be traced by well records across the Ringling Basin into the Asphaltum sand, as shown by the stratigraphic cross-section, plate II. Its general lithologic similarity and the stratigraphic repetition on either side of the Ringling Basin practically assure this correlation.

The Ryan sand makes a fair marker for general detail mapping. It is exposed only over areas structurally high, marking the northwest extremity of the Nocona high, and various anticlinal folds along the Waurika arch.

On the accompanying areal map (plate I) the Asphaltum and Ryan sands are shown as marking the division between the Claypool beds and the underlying beds above the Oscar sand.

OSCAR SANDSTONE

This sand series occurs from 100 to 125 feet below the top of the Ryan sandstone. The interval between these sand horizons is largely brown shale, with occasional thin sandy streaks. The surface outcrop is limited to the extreme southern portion of the county marking the higher parts of the Nocona uplift in Oklahoma. All of the members are well exposed at various localities in the high bluffs along the Oklahoma side of Red River. Good exposures occur through the southeast part of T. 7 S., R. 6 W., through T. 7 S., R. 5 W., the south half of T. 6 S., R. 5 W., and along the valley of Red Creek diagonally across T. 6 S., R. 6 W. Isolated exposures of the upper members of this series are thought to occur in and adjacent to secs. 35 and 36, T. 5 S., R. 6 W., where a large anticlinal fold has brought these beds to the surface.

A total stratigraphic section of approximately 300 feet is exposed over the area of outcrop. This section is composed largely of sandstone beds, with intervening beds of brown and gray shales. The individual beds vary from one to over 50 feet in thickness, and are very

lenticular. Certain beds contain conglomerate phases of varied coarseness. The sandstones of this series are massive- to thin-bedded, light gray to brown on fresh exposure, weathering to darker gray, brown, and black. Large brown to black concretions are common in the upper members.

In general, the individual beds are hard and resistant, forming good benches and scarps for detailed mapping. Certain of these bench-forming beds resemble typical Pennsylvanian sandstone beds more closely than any sandstones exposed in the county. The lowest bed stratigraphically of this series is exposed on Ketcham's Bluff along Red River, in sec. 24, T. 7 S., R. 6 W., and the adjoining section to the east. This bed is composed largely of conglomerate. The pebbles are mostly chert fragments; from small grains to pebbles two inches in diameter. Rounded pebbles of pure and impure quartz interbedded with thin stringers of coarse gray sand are also common. This conglomerate bed is ripple-marked and cross-bedded, and attains a maximum thickness of 50 feet or more. The conglomerate phases of the Oscar fade out to the north and northwest and become progressively coarser to the southeast.

The areal mapping of this series, as shown on plate I, outlines the top of this general sand series as exposed over the area. It is not to be interpreted as the outcrop of one continuous bed, but rather the top of a sand horizon of fairly uniform stratigraphic position. Part of this areal mapping is by Robinson,[2] who gives more detailed description and discussion of this series.

The interval from the base of the Oscar sandstone to the top of the Pontotoc conglomerate consists of a zone of brown and blue shale and sandy shales, with interbedded sandstone, fine- to coarse-grained with local gravel streaks.

PONTOTOC CONGLOMERATE

The top of this formation occurs from 650 to 950 feet below the Asphaltum and Ryan formations. It is a series of gravel beds characterized by pronounced conglomerate phases of varying arkosic nature, being quite similar in general description, and correlative with other beds occurring in Carter and Stephens counties which are thought to be the equivalent or part of the Pontotoc series as described by Morgan.[3]

The conglomerate phases of the upper member of this gravel series consist of chert fragments of irregular size, shape, and color, coarse grains of glassy and impure quartz, as well as feldspar, limestone, and hard shale fragments, all interstratified through coarse, loosely cemented to hard, consolidated gray sand. Particles of asphalt of depositional nature have also been observed. This general series appears to be absent over the higher structural points of the Healdton uplift, apparently being cut out by unconformity and overlap. It thickens rapidly off the southwest flank of this uplift into the Ringling basin. Certain wells drilled in the central part of this basin penetrated the top of these gravels at depths of 1,200 to 1,500 feet and recorded red beds and gravel to depths below 2,500 feet. This series thins again to 100-plus feet over the Nocona and Waurika structural highs, but according to present data the upper members are present even on the highest structural points. The conglomerate phases are markedly coarser nearer the major uplifts and are particularly well developed over and around the Nocona arch, but gradually fade out and are less conspicuous to the northwest away from this feature.

2. Robinson, Health M., Geologic structure and oil and gas prospects of a part of Jefferson County, Okla., U. S. Geol. Survey Bull. 726 F, 1921.
3. Morgan, G. D., Geology of the Stonewall Quadrangle: Bur. Geol. Bull. 2, Norman, Oklahoma, 1924.

This series lies unconformably on the more steeply folded strata of the Glenn formation. In Jefferson County it does not appear to be in contact with rocks older than Glenn. This gravel series marks the initial stages of a long period of erosion following the folding and deformation at the close of Glenn time.

Conclusions Regarding Upper Horizons

Immediately south of Terral, Oklahoma, across Red River in Montague County, Texas, a conspicuous sand zone is exposed in the river bluffs. This sandstone has been traced by Virgil Tims of the Shell Petroleum Corporation, into the Coleman Junction limestone, as exposed in Archer County, Texas.

A group of Wichita Falls geologists later accompanied Tims in a field conference to trace this outcrop and to attempt a correlation across into Oklahoma. It was agreed that the sandstone in the river bluff south of Terral was the equivalent of the Coleman Junction limestone, which marks the top of the Cisco formation in Texas and has generally been taken as the top of the Pennsylvanian section in that state.

A group of southern Oklahoma geologists, including the writer, met the Texas party at Ringgold to satisfy all concerned as to the continuation of the Cisco formation into Oklahoma. It was established that the Ryan sandstone, as previously described, was the equivalent of the Coleman Junction limestone of Texas, or was the first sand series below it. However, it is the writer's opinion that the sandstone in Texas, taken as the top of the Cisco formation, overlies the Ryan sandstone, and is the equivalent of the first sand series above the Ryan sandstone in the overlying Claypool formation previously described. This conclusion is based on the fact that the Ryan sandstone at the closest point to the critical area has a pronounced southwest dip apparently dipping completely under Red River and the Coleman Junction equivalent. Likewise the Coleman Junction can be traced up Red River on the Texas side for several miles until positive correlation is lost. With this approximate correlation established, it is evident that

most of the surface rocks of Jefferson County are uppermost Pennsylvanian age.

The entire section in Jefferson County, with the exception of the Addington formation, including the Claypool, Ryan, Asphaltum, Oscar, and the Pontotoc, appears to be one formation of general similarity; the shales are of very similar nature, predominantly brown, with blue and gray mottling and gradation. The sandstones likewise are quite similar; in general, they are light gray to brown and buff in color, and seem to be composed of the same type of material throughout.

Coarse conglomerates and gravels are more conspicuous and better developed in the lower members of these upper Pennsylvanian beds, but thin gravel streaks of local and irregular nature have been observed throughout the entire section. For this reason, the writer favors placing the entire section described, at least from the Ryan sandstone down, as Cisco in age, and all or part equivalent to the Pontotoc of the Oklahoma section.

SUBSURFACE FORMATIONS

Glenn Formation

The series of shales, limestones, and sandstones underlying the basal Pontotoc beds of this county are taken as belonging to the Hoxbar and Deese members of the Glenn formation of middle Pennsylvanian age, and equivalent to the Canyon and Strawn section of Texas. At the present time, there is very little definite information available concerning the exact correlation and extent of the different members of these formations throughout the county.

Unfortunately very few samples of the formations penetrated by the drill have been preserved for study. Furthermore, accurate paleontological work in outlying wells is difficult because of the reworked nature of many of the beds penetrated. This condition is quite confusing when it has been shown that reworked lower Pennsylvanian and Ordovician fossils have been found above younger Pennsylvanian formations.

Cambrian, Ordovician, and Younger Rocks

It is assumed that the entire Arbuckle Mountain section, including the Reagan sandstone. Arbuckle limestone, Simpson formation, Sylvan shale, Hunton formation, Woodford chert, and Sycamore limestone, or their equivalents, were deposited over all of Jefferson County. These formations are so well developed in the Arbuckle Mountain area, 25 miles from the northeast corner of the county, and are known to exist over such a widespread area in central and eastern Oklahoma, that any sudden termination southwest of the mountains in this short distance is considered unlikely, except by erosion.

Drilling in Carter and Stephens counties has shown Pennsylvanian rocks of Glenn age to rest unconformably upon buried ridges of Ordovician rocks. It would appear that the present extent and occurrence of these older rocks under Jefferson County will depend entirely upon the extent of erosion and degree of unconformity previous to the deposition of Glenn sediments. This information can be obtained only by deep drilling.

Numerous wells drilled at different localities on the Healdton uplift have penetrated massive limestones identified as of Ordovician age. Likewise, many wells located on the Nocona and Waurika structural highs have encountered massive limestones at fairly shallow depths. In most all instances, drilling operations ceased after this lime had been penetrated a few hundred feet. Since these limestones were massive, hard and non-fossiliferous, it has been generally assumed they were likewise Ordovician in age.

Recently a well drilled in sec. 28, T. 5 S., R. 8 W., encountered a limestone series at 3,700 feet, drilled through this series into brown and blue shales at 4,408 feet. Paleontological study has shown this limestone to be of Deese or middle Glenn age, and the approximate equivalent of the Big Lime series of the Sholom Alechem and County Line fields of Carter and Stephens counties, Oklahoma. Reworked Ordovician forms were also observed in the cuttings from this well.

Since massive Pennsylvanian limestones are now known to be present in this area, the limestones encountered in adjoining townships, heretofore taken as Ordovician, may or may not belong to this same Pennsylvanian limestone series.

Pre-Cambrian Igneous Rocks

Granites and other igneous rocks of the basement complex underlie the entire county at unknown depths. Certain wells drilled on the Nocona uplift in Montague County, Texas, are reported to have penetrated granite; likewise, several wells drilled in T. 7 S., R. 6 W., area and the Spring oil pool in southern Jefferson County on this structural uplift, have reported granite at depths of 3,100 to 3,200 feet. It is certain that in several instances this recorded granite was a granite wash and not a solid granite ridge, as the drill passed out of the granite horizon into underlying shales and limestones.

STRUCTURE

Surface and subsurface study has shown the existence of three major structural highs or trends through Jefferson County. These highs occur in a general northwest and southeast direction, paralleling other structural features of central-southern Oklahoma. In the following

discussion these features will be referred to as the Healdton uplift, the Nocona uplift, the Waurika arch, and the Ringling basin, all being local names adopted during this course of study and investigation.

HEALDTON UPLIFT

This pronounced structural trend appears to be a northwest continuation of the Criner Hills uplift of Carter County, Oklahoma. It extends through the southwest part of Carter County, the northeast corner of Jefferson County, thence into the southeast part of Stephens County. On this structural trend a continuous series of *en echelon* anticlinal folds occurs. This includes the Hewitt and Healdton anticlines, at least four anticlinal structures in Tps. 3 and 4 S., Rs. 4 and 5 W., the Loco anticline, and other anticlinal folds into T. 2 S., R. 6 W., Stephens County.

This uplift is clearly shown by a broad arch in the surface rocks and a repetition of the stratigraphic section on either side of the general structural axis. On certain of these minor anticlinal folds, the Asphaltum sandstone is brought to the surface, flanked on either side by the overlying formations. These folds include the Hewitt, Healdton, Loco, and certain other anticlinal structures in Tps. 3 and 4 S., Rs. 4 and 5 W., and possibly other features to the northwest.

The Asphaltum and Claypool formations on the northeast flank dip under typical Permian red beds resembling, and here correlated with, the Addington formation. These beds mark the timbered area of red shales and sandstones through T. 3 S., R. 3 W., that apparently is largely synclinal. All or part of the section exposed over the Healdton uplift is again brought to the surface over the Graham and Fox anticlines. Off the southwest side of this feature these beds dip normally to the southwest into the Ringling structural basin.

Over parts of the Healdton uplift there occurs a general thinning of the so-called red beds, with a very pronounced thinning over the high structural points of the minor folds. This apparent pronounced local thinning has been shown by structure drilling to be in part a color change. This will be discussed later. Ordovician limestones have been encountered at shallow depths along this uplift, showing it to have been a structural high in the older rocks and likewise a topographic ridge, at least during upper and middle Glenn deposition.

RINGLING BASIN

This geosyncline parallels and separates the adjoining major structural highs. The general axis extends in a northwest-southeast direction across the north half of the county. It is shown on the surface by general dips off the paralleling uplifts and by the outcrop of the Addington formation. Wells drilled in this basin have encountered great thicknesses of red beds, and in no instance have penetrated massive limestones to their total depth.

NOCONA UPLIFT

The broad structural feature extending from Montague County, Texas, into south-central Jefferson County is here termed the Nocona uplift. This high has a general northwest and southeast axial direction, and is broader and flatter than the Healdton uplift. In Oklahoma, the Grogan anticline, the Oscar anticline, the Spring Pool anticline, the anticline in T. 5 S., R. 6 W., and probably other undrilled and unknown anticlines and structural noses, occur on this feature. This fold brings the Oscar sandstone to the surface. These are the lowest beds stratigraphically of any exposed in the county. The Ryan sandstone extends in a broad loop around this feature on its northwest extremity in Oklahoma.

Plate II shows a stratigraphic cross-section of the Nocona arch as interpreted from present information afforded by well records. A study of this cross-section shows that three series of limestones, separated by shale and sandy shale intervals, have been penetrated at various depths depending on structural position of wells. These limestone beds appear to be conformable and occur in regular sequence. There is, however, a thinning of the entire section over the higher structural points. The lower massive lime has generally been accepted as the top of an unconformable buried ridge of Ordovician limestone, presumably Arbuckle. However, since there are no prominent basal contact sand or gravel series recorded immediately above this limestone, it would appear that the upper portion, at least, of this limestone may belong to the same series as the overlying and apparently conformable limestone beds, and therefore it would not be the eroded surface of an older ridge.

Granite has been reported in several wells drilled on the Grogan anticline, and the Spring Pool anticline, also in certain wells in the Nocona pool and in the vicinity of Spanish Fort, Montague County, Texas. As previously stated, this granite occurrence in certain wells on the Oklahoma side has been in the nature of a granite wash. However, it seems certain that buried granite peaks occur in the near vicinity at shallow depths on this uplift.

WAURIKA ARCH

The Waurika arch is lower structurally, and lies *en echelon* with the Nocona uplift, with which it is closely associated, but not a direct northwest extension. This structural arch trends in a northwest-southeast direction, through T. 6 S., R. 7 W., T. 5 S., R. 8 W., T. 4 S., R. 9 W., and parts of adjoining townships.

The Ryan sandstone is the oldest bed mapped on the surface. However, certain sandstone stringers exposed near Red River through T. 5 S., R. 9 W., may represent the top of the Oscar. The lower Pontotoc beds thin over the entire arch, but there is considerably more

Pontotoc section encountered than on the Nocona and Healdton highs. Several dry holes have been drilled on each flank of this general high. From the recorded logs of these test wells it is possible to gain a general idea of the subsurface conditions. Seven tests in this area have penetrated limestones and suspended drilling operations while still in lime.

The Amerada Petroleum Corporation completed a dry hole in sec. 28, T. 5 S., R. 8 W. This test encountered a broken limestone and sand series at 3,530 feet to 4,008 feet, a massive limestone series was penetrated from this depth to 4,408 feet, where blue and brown shale and slate were penetrated to 4,490 feet. A hole full of water was obtained in a sandy dolomite at 4,512 feet.

The limestone encountered in this test has been correlated from fossil evidence with the Big Lime series of the Sholem Alechem field of Carter and Stephens counties. This limestone overlies the main producing horizons in this field, and is of middle Glenn age, probably Deese.

From surface reconnaissance, this test appears to be located down the southwest flank of this general high. Likewise, the limestone series encountered in this test occurred at a considerably greater depth than a very similar section of broken lime and sand, and massive limestones, recorded in other tests a few miles to the north, northeast, and northwest.

Locations of other tests in the immediate vicinity that encountered limestone series and the depth to the top of these series follow:

COMPANY	LOCATION	UPPER SERIES DEPTH	LOWER MASSIVE LIMESTONE DEPTH
Shawer & Sutter	31-4S-8W	2175	2915
Texas Company	21-4S-9W	2390	2955
Texhoma	31-4S-9W	2180[a]	.....
Knight & Hines	31-4S-9W	1880[b]	.....
Amerada	28-5S-8W	3530	4008
Pauline O. & G.	17-5S-8W	.....	.....

a. T. D. 2,415. b. T. D. 2,110.

From an oil and gas standpoint the identification of this limestone series in the Amerada well as middle Glenn and not Arbuckle is very important, and changes the aspect of the entire area for deep possibilities, since lower Glenn and Ordovician oil and gas horizons may underlie or flank this structural high, and are as yet untested.

Observed minor folds on this general structural trend include the T. 7 S., R. 7 W. anticline, the Ryan anticline, the anticline in T. 5 S., R. 8 W., undefined anticlinal feature in the bend of Red River adjoining the southeast corner of T. 4 S., R. 9 W., Dead Man's Gulch structure, and a lower parallel anticlinal feature in T. 4 S., R. 8 W.

OIL AND GAS DEVELOPMENT

To date there are 12 producing gas wells, 118 producing oil wells, and 109 dry holes drilled in this county. The present producing area on the Healdton uplift in Jefferson County includes a small portion of the northwest extremity of the Healdton pool, and one isolated gas well in sec. 21, T. 3 S., R. 4 W.

Three small pools have been developed on the Nocona uplift in Oklahoma; these include the gas area in T. 7 S., R. 6 W., the Oscar pool, and the Spring pool. There are no producing oil or gas wells on the Waurika arch, though several wells have recorded shows of oil and gas.

Of the 109 dry holes drilled in the county, 43 were drilled in outlining the present producing areas, 25 were drilled in or near the lower part of the Ringling basin, where there appears to be little chance for commercial oil or gas production. The remaining 37 holes were drilled at various points on or adjacent to the major structural uplifts. The dry holes drilled in Jefferson County have been comparatively shallow, in general from 2,000 to 3,000 feet in depth. The deepest test in the county, the Amerada well in sec. 28, T. 5 S., R. 8 W., was carried to a total depth of 4,518 feet.

Cable tools were extensively used in the early drilling, but at the present time practically all the production and wildcat drilling is done by rotary tools.

HEALDTON OIL POOL

Only a small restricted area of production on the northwest extremity of this great Carter County pool lies within Jefferson County. However, since several favorable undeveloped areas are immediately adjacent to this pool in Jefferson County, a brief summary of the salient features of this pool will be given.

Location. The Healdton pool occurs in a northwest-southeast direction, diagonally across T. 4 S., R. 3 W. and into the extreme southwest corner of T. 3 S., R. 3 W. This pool has a proven productive area of approximately 7,250 acres.

History. The discovery well was drilled in sec. 8, T. 4 S., R. 3 W., and completed in August, 1913 for an initial production of 25 barrels at a depth of 920 feet. The well was drilled on acreage block as-

sembled by Roy M. Johnson, Edward Galt, and Wirt Franklin of Ardmore, Oklahoma. The field was developed during 1914, 1915, 1916, and 1917, with comparatively little drilling since.

Production. The Healdton pool is by far the largest in southern Oklahoma in productive area and total yield. It is likewise one of the world's greatest shallow oil pools. The total production to date is approximately 153 million barrels, the peak production being 56,000 barrels per day in March, 1917. The present daily production is about 14,000 barrels, with an extremely low rate of decline. The average total production per acre has been approximately 21,000 barrels, while certain leases located in the northwest portion of the pool, and immediately adjoining Jefferson County, have produced from 80,000 to 100,000 barrels per acre. The oil ranges from 25° to 37°, averaging 31° A. P. I.

Stratigraphy. The Asphaltum sandstone is exposed over and around the producing area in this pool. An underlying sand series is exposed over the central portion of the field. A local gravel phase occurs in certain sand members exposed in the eastern portion of the producing area. Well logs show that the lower Pontotoc does not carry over the top of the Healdton field, but overlaps the flanks. Glenn sediments are penetrated at depths from 200 to 600 feet over most of the field showing the extreme thinning of the younger overlying formations..

The chief producing horizon is a series of Pennsylvanian sands occurring from 800 to 1,200 feet in depth, probably Hoxbar in age. Production has been obtained in some instances from still lower Pennsylvanian sands overlapping the Ordovician core.

Ordovician limestone has been encountered at a depth of 800 feet on the highest structural point and occurs at various depths throughout the field. In certain wells, at least, this limestone appears to have been the Viola. Erratic production of high gravity oil has been obtained by a few wells in these Ordovician limestones.

Structure. Pronounced dips are shown by surface sandstone beds on the flanks of the structure where good exposures may be observed. These dips coincide closely with the underlying producing sands, but are much flatter.

The subsurface structure shows a distinct anticlinal feature, complicated by minor folding and faulting. The dip of the producing horizons steepens materially off the flanks of the buried Ordovician ridge.

PRODUCING AREAS ON NOCONA UPLIFT

Three small producing pools have been developed in southern Jefferson County. These pools were discovered in the early part of

1924. The discovery well was in every instance located on the crest of a recognized surface structure. These structures were mapped and are discussed in detail by Heath M. Robinson in U. S. Geological Survey Bulletin 726 F, published in December, 1921.

A brief summary of the general features of these pools follows.

OSCAR POOL

Location. The Oscar pool covers a producing area of approximately 400 acres in parts of secs. 33 and 34, T. 6 S., R. 5 W.

History. The discovery well was drilled by the Hambro Oil Company in the early part of 1924. This well was lost in attempting to complete it as a producer. The first completed producing well was drilled by the Humble-Hambro Companies as a twin to the lost hole. This well was located in the SE.¼, NE.¼, SE.¼, sec. 33, T. 6 S., R. 5 W., and was completed May 18, 1924, for an initial production of 120 barrels from sands at 1,247 to 1,264 feet, 1,303 to 1,313 feet, and 1,368 to 1,370 feet.

Previous to the completion of the discovery well, three dry holes had been drilled adjacent to the area that is now the producing field. These tests were located on the flanks of the surface fold and too low for production. Two of these tests were drilled within one-third mile of production.

Production. The Oscar pool covers a very restricted area, but has yielded handsome returns to operators of the best located leases. The oil is good gravity, being from 35° to 36° A. P. I. The wells are shallow and completed quickly and economically. In the early development wells of large initial production were completed.

The sand depth and initial production of the larger wells in the Oscar Pool

COMPANY	FARM	INITIAL PRODUCTION IN Bbls.	DEPTH SAND	DATE COMPLETED
Gypsy	Arpelar No. 1	3600	1458-1484	9-3-25
Carter	O. W. Seay	2175	1407-1428	12-31-25
Carter	Clara Seay	2560	1482-1503	12-4-25
Gypsy	Arpelar No. 8	1725	1444-1472	12-4-25
Humble	Seay No. 5	200	1241-1245	11-30-25

The average daily production of all leases in the Oscar pool for the month of November, 1928

COMPANY	FARM	LOCATION	NUMBER OF PRODUCING WELLS	TOTAL DAILY PRODUCTION IN BARRELS
Prairie	C. Seay	34-6S-5W	4	120
Prairie	O. W. Seay	34-6S-5W	1	8
A. C. Brown		33-6S-5W	5	115
O. V. Beck	O. W. Seay	34-6S-5W	2	35
Carter	O. W. Seay	34-6S-5W	3	95
Carter	D. Seay	34-6S-5W	1	20
Carter	C. Seay	33-6S-5W	2	15
Carter	J. Jones	33-6S-5W	4	110
Hambro	O. W. Seay	33-6S-5W	7	90
Humble	O. W. Seay	34-6S-5W	4	70
Gypsy	Arpelar	33-6S-5W	34	550
Total			67	1,246

Stratigraphy. The surface exposures consist of the upper members of the Oscar sandstone, which form good scarps and benches for detailed mapping. Red beds have been recorded from 300 to 600 feet over the field. However, the base of the Pontotoc probably occurs at a depth of 1,000 feet over the higher parts of the fold, and is represented by the sandy lime and boulder series recorded in certain wells at depths of 1,000 to 1,100 feet.

The top of the first producing sand zone occurs at depths of 1,160 to 1,270 feet. This zone consists of a 200 foot section of irregular sands, with interbedded blue shale members. The upper and lower sand members are the most uniform. A limestone from 2 to 20 feet in thickness occurs above the first oil sand. This lime makes a good datum for structural contouring. It is probably Hoxbar in age.

The second producing horizon occurs approximately 300 feet below the top of the first producing zone, and is recorded in producing wells at depths of 1,450 to 1,560 feet. This horizon is from 50 feet to over 100 feet in thickness. It is recorded as a lime and sandy lime, but is shown by cuttings to be largely a porous limestone. It is also quite fossiliferous.

There has been no deep test drilled within the producing area. A well drilled in the southwest corner of section 35 penetrated an unconformable series composed largely of sand and sandy lime from 1,800 to 3,358 feet.

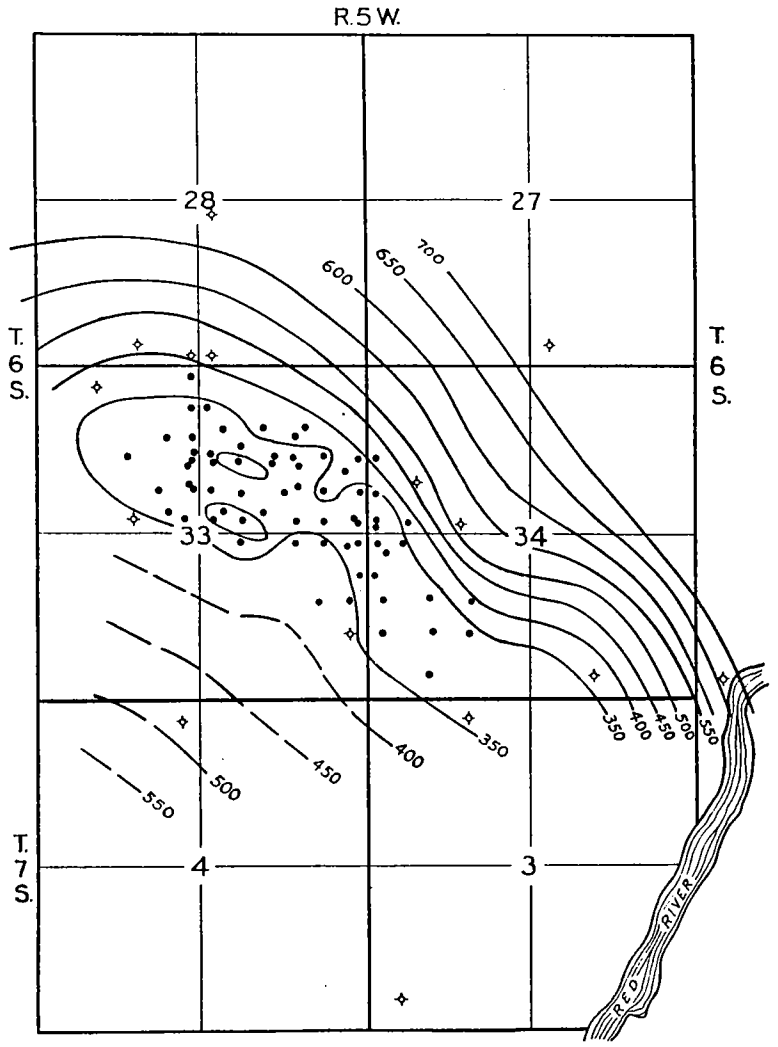

Figure 2. Structure map of the Oscar pool. Contour interval, 50 feet. Contours on datum lime. Datum, sea level.

Structure. The surface structure consists of a well-defined structural nose plunging to the northwest, with uncertain closure to the southeast. There is a pronounced northeast dip, amounting to 180 feet in a distance of two miles. The highest point from surface mapping appears to be in the center of the east half of section 33. The subsurface structure, as drawn on the upper producing horizon, follows the surface structure very closely, but is much steeper. A northeast dip of more than 600 feet to the mile is shown in the SE.¼ of section 34.

The subsurface structure consists of an elongated anticline which trends in a general northwest and southeast direction. The highest structural points occur in the center of the N.½ of section 33, and the SW.¼ of section 34. The structure is undefined to the southeast, but appears to close in sec. 3, T. 7 S., R. 5 W. The subsurface structure is shown on figure 2.

T. 7 S., RS. 5 AND 6 W. POOL

Location. The present producing area of this pool is included in parts of secs. 13 and 24, T. 7 S., R. 6 W., and parts of secs. 17, 18, 19, and 20, T. 7 S., R. 5 W.

History. The discovery well was drilled in the NE. cor. NW.¼ sec. 19, T. 7 S., R. 5 W. by Humble Oil & Refining Company. This well was completed as a gas well May 5, 1924, for an initial production of 44 million cu. ft. with 300 pounds rock pressure. The top of the gas sand was found at 690 feet and penetrated to a total depth of 702 feet.

Previous to the completion of the discovery well, the Simms Oil Company drilled a dry hole in the SE.¼ sec. 14, T. 7 S., R. 6 W. This well was drilled to a total depth of 2,730 feet, and was abandoned Sept. 1, 1920. Several gas oil showings were recorded.

Production. This structure, according to present data, is largely gas bearing. The gas wells at present are shut in as there is no market. The gas has a rather low B. T. U. value, probably because of a fairly high helium content.

Data on the gas wells of T. 7 S., Rs. 5 and 6 W. Pool

COMPANY	FARM	LOCATION	I. P. IN MILLION CU. FT.	DEPTH TOP SAND	TOTAL DEPTH
Humble	Busby No. 1	19-7S-5W	44	690	702
Humble	Alexander No. 1	19-7S-5W	40	590	1890
Humble	Smart No. 1	18-7S-5W	70	750	1050
Humble	Jones No. 1	18-7S-5W	Dry	790	2270
Okla. Southern	Smart No. 1	13-7S-6W	55.8	730	808
Humble	Smart No. 1B	18-7S-5W	14	676	790
Magnolia	Smith No. 1	24-7S-6W	13.5	730	803
Hivick	Smart No. 1	13-7S-6W	....	700	850
Gypsy	Busby No. 1	18-7S-5W	45	591	603

The present oil producing area is confined to the S.½ sec. 17 and the N.½ sec. 18, T. 7 S., R. 6 W. The oil of low gravity, around 24° A. P. I. The wells have small initial production and do not flow. However, the production holds up well, and, because of their shallow depths, these wells may be profitably operated.

Average production of the producing leases for November, 1928

COMPANY	FARM	LOCATION	NUMBER OF PRODUCING WELLS	TOTAL DAILY PRODUCTION IN BARRELS
Lesh & McCall	Peniston	20-7S-5W	13	250
McGinley-Sigler	C. Pfile	19-7S-5W	7	200
McGinley-Sigler	A. M. Clark	20-7S-5W	5	75
Gypsy	S. Busby	17-7S-5W	4	50
Total			29	575

Stratigraphy. Surface exposures over this area consist of lower members of the Oscar sandstone. Two core holes drilled in sec. 24, T. 7 S., R. 6 W. give very definite information as to the thickness and nature of the Pontotoc section over this field. The base of the Pontotoc was found at a depth of 920 feet in a core hole drilled in the NE.¼, SE.¼ NE.¼ of this section. This core hole started just above the sand and conglomerate bed exposed in the river bluff south of the location. A section composed largely of gray sand and blue-brown clay shale was penetrated to 450 feet. Two thin nodular, impure limestone stringers were encountered at depths of 460 feet and 535 feet. From this depth to the top of the gas sand at 680 feet, the formation was largely gray shale, mottled with light brown patches but of the same general appearance as the shales immediately below the surface. The gas-bearing horizon from 685 to 920 feet consisted of coarse sand and conglomerates separated by shale beds. The basal conglomerate was extremely hard and consolidated.

The conglomerates of this series were composed largely of chert. The chert fragments were angular to rounded and white, brown, black, gray, and green in color. Fragments of limestone, feldspar, and quartz were also common.

Below 920 feet dark blue and black laminated carbonaceous shales of entirely different character were penetrated. These shales were fossiliferous. The section from 920 feet, as shown by deeper tests, consists of alternating limestone and shale beds to a depth of 1,800 to 2,000 feet. These limestone beds have a recorded thickness of 50 to 100 feet. This section is unconformable with the overlying beds.

Granite or granite wash has been recorded at depths of 1,930 to 2,200 feet in three wells. One of the wells drilled in sec. 14, T. 7 S., R. 6 W. penetrated this wash at 2,200 feet and drilled through it at 2,260 feet into lime and sandy limestone, to a total depth of 2,730 feet. The granite wash occurred in this well at the same stratigraphic point as penetrated in the two other tests which were abandoned after penetrating the granite or wash 30 to 58 feet.

The producing horizons, as development now stands, are confined entirely to the basal Pontotoc. The top of this producing horizon carries gas over the structural area. Oil is being produced on the northeast flank of the structure from a sand horizon occurring approximately 150 feet below the top of the first gas horizon. This sand, however, carries gas in the top of the structure. On the Oklahoma side, no production has been obtained on this structure below the base of the Pontotoc. However, in two of the three deeper tests drilled oil shows have been recorded 50 to 100 feet above the granite or granite wash.

Structure. The surface structure of this pool is very pronounced and easily seen. It has been termed the Grogan anticline in U. S. Geological Survey Bulletin 726 F.

The axis of this structure trends in a northwest-southeast direction through the NE.¼ sec. 24 and the center of sec. 13, T. 7 S., R. 6 W., plunging to the northwest. The highest structural point mappable on the Oklahoma side is on or near the center of the east line of section 24.

The fold is open to the southeast and appears to be a direct continuation of the Nocona gas and shallow oil area immediately across Red River in Texas. The southwest dip of this fold through the SE.¼ sec. 24, T. 7 S., R. 6 W., is the most pronounced surface dip observed in the county. A dip of over 100 feet in a distance of one-fourth mile is mappable. There is some indication of a minor fault shown in the river bluff in sec. 19, T. 7 S., R. 5 W.

The subsurface structure drawn on the top of the first gas horizon coincides closely with that shown by the surface beds, but is more pronounced. It is shown on figure 3.

SPRING POOL

Location. This pool includes a small number of producing wells in secs. 23, 24, and 25, T. 6 S., R. 6 W.

History. The first well was drilled by Dingwall & Sargent in the early part of 1923, and later carried to a total depth of 3,315 feet by Clarke and Cowden, where the hole was abandoned. The first producing well was a twin to the original well and was completed by Clarke & Cowden in March, 1924, for an initial production of 15 barrels from sand at 2,049 to 2,117 feet. Development was discouraged by the low initial production of the few completed wells and the drilling of several dry holes.

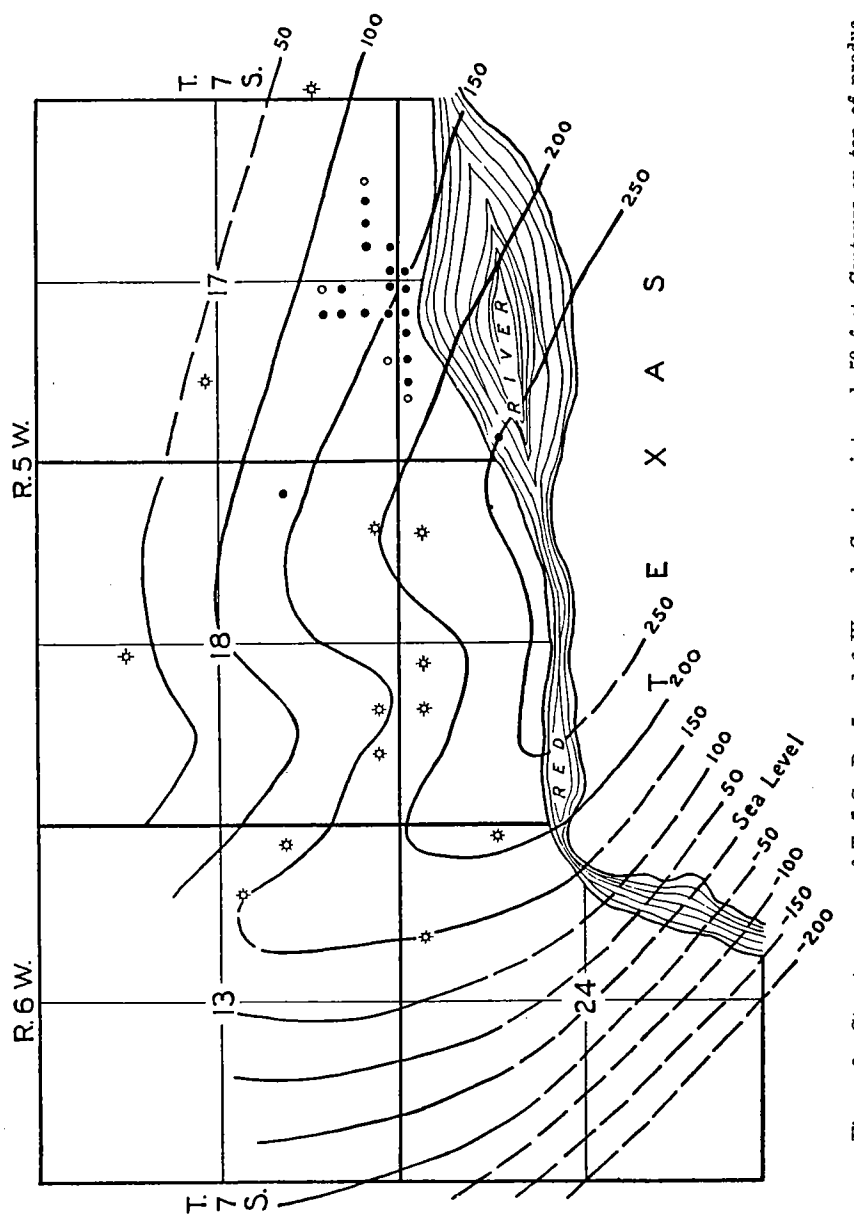

Figure 3. Structure map of T. 7 S., Rs. 5 and 6 W. pool. Contour interval, 50 feet. Contours on top of producing gas horizon. Datum, sea level.

In April, 1928, Bridwell & Heydrick completed a 225 barrel well in the NW.¼, SW.¼, SW.¼, sec. 24, T. 6 S., R. 6 W.

Production. The first wells completed in this pool produced from a sand 2,050 to 2,110 feet in depth. The wells completed in this sand had small initial production and were not profitable.

Several wells have been completed by Birdwell and Continental Oil Company in the SW.¼, section 24. These wells were completed in an upper sand series found from 1,650 to 1,730 feet in depth. Some of these wells on their inception produced from 100 to 225 barrels.

Production of Spring pool for the month of November, 1928

COMPANY	FARM	LOCATION	NUMBER OF PRODUCING WELLS	TOTAL DAILY PRODUCTION
Bridwell-Continental	Earl Spring	24-6S-6W	5	435
Skelly	Ryan	23-6S-6W	2	19
Magnolia	Spring	25-6S-6W	1	5
Magnolia	Ryan	23-6S-6W	1	11
Total			9	460

Stratigraphy. Upper members of the Oscar sandstone are exposed over the surface of the producing area. Pontotoc beds appear to occur to a depth of at least 1,200 feet from this point. A series of thin lime and sand bodies, separated by blue shale intervals of Hoxbar age, were penetrated to a depth of 2,000 to 2,100 feet. A series of thicker lime and sand bodies was then encountered to around 2,700 to 2,800 feet, where massive limestones were penetrated. Granite wash has been encountered from 3,000 to 3,300 feet in various wells. These lower limes are apparently unconformable.

Structure. As a whole, the surface dips of this structure are rather poorly defined. There appear to be good northwest and southwest dips and a poorly defined southeast dip. The beginning of the northeast dip is also uncertain. However, there is good evidence of a small anticlinal fold, with the highest structural point around the NE. cor. sec. 24, T. 6 S., R. 6 W.

The axis of the substructure trends in a northwest and southeast direction through the southwest corner of section 24. The highest structural point, according to present data, appears to be in the SW.¼, SW.¼ section 24. The substructure is open to the southeast, as shown on figure 4.

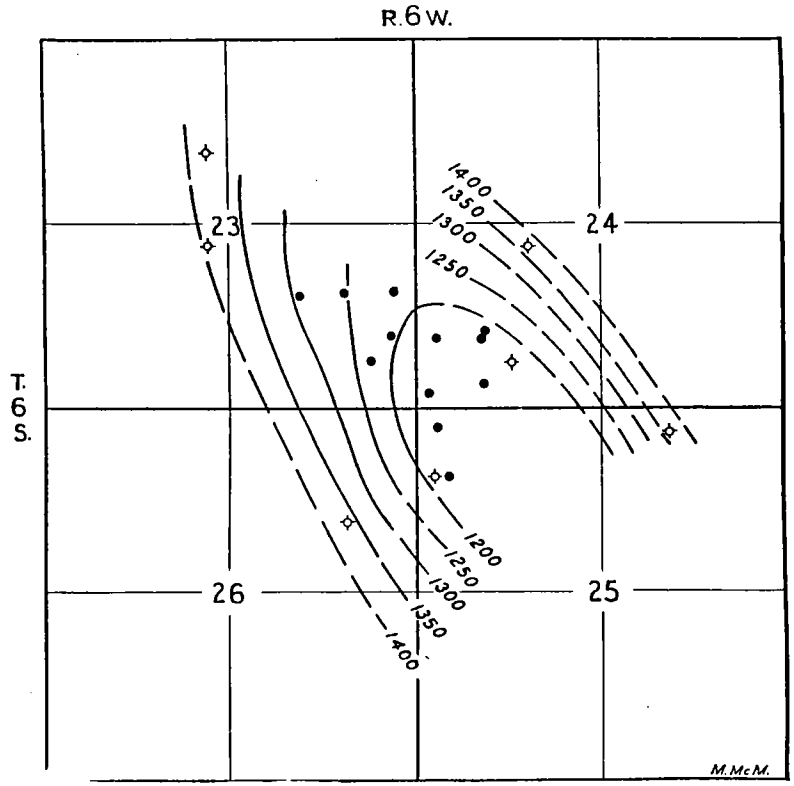

Figure 4. Structure map of Spring pool. Contour interval, 50 feet. Contours on lower producing horizon. Datum, sea level.

CORE DRILL EXPLORATION

Accurate correlation from structure drilling in Jefferson County is possible only when the core tests are closely spaced and carried to depths of 500 to 1,200 feet. There are no recognizable markers in the upper strata similar to those found in northern Oklahoma and Kansas.

The section drilled to a depth of 800 feet or deeper in most of the county consists entirely of shale and sandstone intervals. The sand intervals, as a zone, are more or less constant, but the individual beds are very lenticular and erratic.

Two methods of structure drilling may be carried on in this area; first, to locate structures in the upper Pennsylvanian red beds; or, secondly, to drill entirely through the Pontotoc section into the underlying Glenn, and to use the contact, or some reliable Glenn bed as a datum. The first method may be used economically over the entire county and will give satisfactory results, if properly conducted. The second method can be carried on over the higher parts of the Healdton uplift, but elsewhere in the county the Glenn is too deeply buried to make this procedure practical.

Since accurate results in this area necessitated the drilling of numerous and deep tests, structure drilling with the conventional type drill, which was designed primarily for hard rock drilling, would be extremely slow and expensive. Accordingly, special machines were designed, combining the speed of the regular type rotary with the portability and accuracy of the diamond drill. These machines materially decreased the cost of exploration. They were equipped with high pressure pumps of large volume that brought the cuttings rapidly to the surface, and also increased drilling speed.

In the core-drill exploration, the soft formations were fishtailed and the hard members cored. Cuttings were taken continually and preserved for study. An accurate record was kept of each individual bit run, as to the time it commenced and finished rotation, the total footage made, and condition of bit when taken from the hole. This information made possible the plotting of a mechanical log, since softer formations drill faster and require fewer bit changes than harder ones. With the mechanical log, the driller's recorded log, and the log made from cuttings, absolute and accurate logs for comparison were insured.

Previous to the core-drill exploration, the surface was mapped in detail, to determine as closely as possible the structural area, so the tests could be located to the best advantage. The first test on a supposed structure was placed on the approximate crest and drilled to 800 feet or deeper; the reverse or critical dip was then proved by a cross-section of closely spaced holes. These first holes were located from one-fourth to one-half mile apart, and later increased up to three-fourths mile, if a constant section were encountered. The tests were always located with reference to some known surface outcrop, and were correlated on the entire section from the surface to the total depth.

Several interesting features were brought out by the structural drilling. It was observed that the sandstones were harder and more consolidated over the apex of the structure. Also, that the sand content in the shales materially increased over a structural high. This was especially apparent over areas of pronounced folding, such as the Grogan anticline, the Johnson anticline in T. 4 S., R. 4 W., and the Cruce anticline in Stephens County.

An interesting feature also observed was the color change in the upper formations over a pronounced structural feature. The brown shale horizons contained a greater percentage of light blue or gray color as the apex of the structure was approached. In a core hole drilled on top of the Grogan anticline, the shale cuttings and circulating fluid were largely light gray from the surface down to the total depth of 1,000 feet, yet these identical formations were recorded in a dry hole three-fourths mile down the structure as red beds, with some shales.

Another observed feature of importance is the occurrence of shallow gas or oil showings encountered over the higher structural points of practically every core-drilled structure found on the Healdton uplift.

FAVORABLE UNDEVELOPED STRUCTURES

Geologic study and core-drill exploration have disclosed four pronounced and one less pronounced anticlinal structure of positive existence. Seven other surface structures of uncertain nature and extent, but which are worthy of blocking and core-drill investigation, have also been disclosed. A discussion of the general features of these structures follows:

ANTICLINAL STRUCTURES OF HEALDTON UPLIFT

JOHNSON ANTICLINE

Location. This structure is located a few miles northwest of the town of Ringling, in secs. 28, 29, 32, 33, and 34, T. 3 S., R. 4 W., and secs. 2, 3, 4, 5, 9, 10, 11, 12, 13, 14, and 15, T. 4 S., R. 4 W.

The southeast extremity of the structure is approximately two miles from the northwest edge of production of the Healdton field. The Loco oil and gas field is located 4 miles to the northwest of this area.

Stratigraphy. The Asphaltum sandstone is exposed over the higher structural points of this fold. A thin nodular limestone occurs uniformly 17 to 20 feet above the top of this sand horizon where well exposed. This sand is also characterized by local asphalt saturation and tar seeps, pronounced jointing and veining of pyrite, and by steep local dips.

The surface outcrops of the Asphaltum sandstone occur as an inlier surrounded by younger beds. The areal geology is shown in plate I.

To a depth of 660 to 700 feet below the top of the Asphaltum sandstone, the formation consists of mottled brown and blue shales, and fine sandy shales, with intermediate beds of gray and blue sandstones, often capped by thin, hard brown and purplish nodular limestones and coarse, hard sand or gravel. The base of this brown series is marked by a thin, persistent bed of extremely hard, nodular limestone, consoli-

dated conglomerate and blue sand, that is easily identified and makes a reliable datum bed. This bed ranges from five to eight feet in thickness and is generally overlain by a soft blue shale. The top consists of three to five inches of hard brown nodular limestone, 12 to 18 inches of closely consolidated, coarse quartz sand and conglomerate, with angular fragments of limestone, chert, and glassy quartz, grading downward into softer blue sand three to five feet in thickness, and underlain by blue shale or blue sandy shale. The conglomerate member of the datum bed is of such hardness and so consolidated that it has been found impossible to cut through it with a fishtail bit, and no metal alloy set in drill crowns will penetrate it. Only diamonds can be successfully used in coring this bed, and often these stones are broken and shattered in cutting through pebbles of varying hardness.

A study of logs of cable-tool holes in the vicinity shows the presence of a series of blue shales, with interbedded sand bodies and thin limestones, below the formation described above. From all evidence these beds underlie the red and brown series unconformably, and are more highly tilted. Cores taken below the datum bed in some instances have shown 10° to 15° dips.

Heavy limestone beds have been penetrated in several wells in this vicinity at depths around 3,000 feet. Samples of this lime are not available for study, and it is therefore impossible to determine whether this is a Pennsylvanian lime or an extension of the buried Ordovician lime high thought to exist under the Healdton field at a shallow depth.

Structure. This anticline is a narrow elongated fold trending in a northwest and southeast direction, and bears the same *en echelon* relationship to the Healdton anticline on its northwest extremity that the Hewitt anticline bears on the southeast extremity.

Direct evidence of oil and gas accumulation. Surface evidence of oil and gas accumulation in the area consists of numerous exposures of asphaltic sandstone and tar seeps. An interesting asphalt outcrop occurs in the E.½ sec. 11, T. 4 S., R. 4 W. where there is likewise a pronounced surface reversal into the Healdton field. A large asphalt or tar seep occurs in the bed of Tar Branch in the SE.¼ sec. 31, T. 3 S., R. 4 W. Likewise, many shallow wells drilled for water in this area have encountered heavy oil, gas, and sulphur water.

In practically every core test heavy oil or gas showings have been encountered. In one core test gas encountered below 580 feet blew mud fluid twenty feet into the air as the drill pipe was being extracted. A sand showing lighter oil was also encountered at 835 feet to 840 feet in this test. The sands on the west flank of the structure show the greatest saturation of heavy oil; the saturation also extends farther down this flank. The core tests showing gas have been those located high structurally.

These showings of heavy oil and gas are important, in that similar showings are found in the shallow sands of the red beds overlying every field of Carter County, and adjacent territory, except at Brock where no red series is present. However, sulphur water is encountered on the edge of the Brock field, and asphalt deposits occur on the east flank, where a fault brings the Arbuckle limestone to the surface. The Loco, Healdton, Oil City, and Graham pools were directly located by surface indications, consisting of tar seeps, sulphur water, and shallow oil and gas showings found in drilling for water. These surface indications are also very pronounced in the Hewitt, Fox, and Robberson fields of this general area.

As the dips in the red beds are comparatively flat, the area of saturation in these beds is much broader than the highly concentrated accumulation in the underlying steeply tilted Glenn strata.

Possible oil and gas horizons. Possible producing horizons in the Pennsylvanian beds below the red series are in the Healdton and Hewitt producing sand zones, lower Pennsylvanian sands, and the Ordovician.

The Simpson formation of Ordovician age may be present under this structure and not eroded, as may be the case over part of the Healdton Ordovician high, since the Johnson antiline is lower structurally. Should this condition exist, there are possibilities of large production from the Wilcox or Simpson sands, the existence and depth of which can only be determined by the drill.

Development. Seven tests for oil and gas have been drilled in the vicinity of the Johnson anticline. Three of these tests were drilled slightly below 3,000 feet but were not located favorably as to structure.

A well drilled near the center of sec. 32, T. 3 S., R. 4 W., to a depth of 2,150 feet is reported to have produced some oil from the lower Healdton sand at a depth of 1,560 feet to 1,660 feet. This well is located down the west flank of the structure. A well drilled to a depth of about 1,650 feet near the center of sec. 15, T. 4 S., R. 4 W., also a showing of oil in the lower Healdton sand zone.

A well drilled along the south line of sec. 20, T. 3 S., R. 4 W., produced gas from shallow sand at 610 feet and obtained a showing of wet gas and oil in the top of a lime topped at 2,400 feet.

The Lone Star Gas Company is operating a well in the NW.¼ sec. 21, T. 3 S., R. 4 W., that is producing gas from a sand at 1,570 feet; also a gas well in the same horizon in the SW.¼ sec. 17, T. 3 S., R. 4 W.

STALLINGS STRUCTURE

Location. This structure is located through secs. 21, 22, 23, 25, 26, and 27, T. 3 S., R. 5 W., and near the old town of Asphaltum.

Stratigraphy. The Asphaltum sandstone and possibly lower members are exposed on the surface. These sandstones at various localities on this structure are heavily saturated with asphalt.

Structure. It is impossible from existing surface exposures to accurately define this structure. From surface observations, the highest structural point appears to be over the drainage flat in the NW.¼ section 26.

Production. There are numerous tar seeps, and the sandstones are heavily impregnated with asphalt on the higher structural points of this fold. This structure might be termed a "fossil" oil field, in that these surface saturated sandstones were once buried oil sands and are now exposed by erosion. The saturation of these upper beds is positive proof of existing structure or the intense shallow accumulation would not have taken place. There has been no observed indication of faulting.

The most prominent tar seeps and asphalt occurrences are in the SW.¼ sec. 24, the central part of sec. 25, near the west line of the NE.¼ sec 26, and in the NW.¼ sec. 27, T. 3 S., R. 5 W.

Some minor gas seeps were observed in section 25, and Mr. Jeptha Stallings, a ranchman who is a pioneer resident of this area, states that numerous and very strong gas seeps show when the flat in the northwest quarter of section 26 is under water. He describes these seeps as a constant agitation, with intermittent stronger flows that would throw water five feet in the air. This structure should be given a core drill investigation to determine the exact location of the higher structural points.

OTHER AREAS OF PROBABLE STRUCTURE ON HEALDTON UPLIFT

There is anticlinal folding through secs. 19, 20, 29, and 30, T. 3 S., R. 4 W., as shown by surface and subsurface study. This is likewise an area of asphalt saturation and seeps. Also through secs. 17, 18, 20, and 21, T. 3 S., R. 4 W., there is positive evidence of anticlinal structure. Two producing gas wells have been drilled on this fold by the Lone Star Gas Company. These wells are located in the SW.¼ section 17, and in the NW.¼ section 21 of this township.

The Shell Petroleum Corporation has carried on extensive core-drill explorations over these structural highs, the results of which are not yet available.

ANTICLINAL STRUCTURES ON NOCONA UPLIFT

T. 5 S., R. 6 W., STRUCTURE

Location. This anticline is located in secs. 22, 23, 25, 26, 27, 34, 35, and 36, T. 5 S., R. 6 W., and secs. 1, 2, 3, 11, and 12. T. 6 S., R. 6 W.

Stratigraphy. The top member of the Oscar sandstone outcrops in erosion cuts on both flanks of this structure. The overlying shale interval between this series and the bottom of the Ryan sandstone occurs around and isolates these lower beds. As shown on the areal map, plate I, the top member of the Ryan sandstone swings around the northwest extremity of this fold.

The nearest dry hole was drilled in the SW. cor., SE.¼ sec. 34, T. 5 S., R. 6 W. This well recorded red beds to a depth of 950 feet. Thin lime and sand ledges separated by shale intervals were recorded to 1,500 feet. From this depth to 1,700 feet the formation was largely blue shale with some thin sand streaks. A series of limestones and blue shales was found from a depth of 1,710 feet to the total depth of 1,815 feet.

Structure. This anticlinal feature is apparent on the surface and stands out as an immense topographic high, with gentle dip slopes from its structural apex. The top member of the Oscar sandstone can be traced up drainage cuts on both flanks of this feature and around its northwest extremity. Definite northeast dip and northwest dip can be observed in these beds. The southeast and south dip is rather poorly defined, but apparent from dip slopes and stratigraphic sequences. The normal dip is north and east.

Oil and Gas. There is no surface evidence of oil or gas in this area. The dry hole drilled in section 34 recorded four gas shows of uncertain nature.

Development in the immediate vicinity of this structure consists of an 1,815-foot dry hole located in the SW.¼, SE.¼ sec. 34, T. 5 S., R. 6 W., a dry hole drilled in the E.½ sec. 33, T. 5 S., R. 6 W., to a total depth of 2,118 feet, and a shallow hole drilled in the N.½ sec. 21, T. 5 S., R. 6 W.

BURNETT RANCH STRUCTURE

Location. This structure is located in secs. 29, 32, and 33, T. 5 S., R. 5 W., and secs. 4 and 5, T. 6 S., R. 5 W.

Stratigraphy. The Ryan sandstone is well exposed over most of the area of this structure.

Three dry holes drilled in the immediate vicinity of this structure record from 700 to 900 feet of red beds, underlain by an alternating section of sandstones and thin limestones, separated by blue shale intervals. This entire recorded section is quite similar to that observed in the Spring pool, located five miles southwest.

Structure. The surface structure may be worked on the top of the Ryan sandstone, where definite northeast, north, and north-

west dips may be defined; the southeast dip is obscure and uncertain. The highest structural point lies in the E.½ sec. 32, T. 5 S., R. 5 W.

Oil and Gas. Three dry holes have been drilled on the flank of this structure. All these wells recorded abnormally thin red beds, and appear to be high structurally. Several oil and gas showings were reported in each of these tests. These recorded oil and gas shows, and the existence of a subsurface high, as shown by these wells, were the basis for the surface and core-drill investigation.

OBSERVED SURFACE STRUCTURES ON NOCONA UPLIFT

STRUCTURAL NOSE IN T. 7 S., R. 6 W.

Location. A pronounced structural nose occurs through secs. 26, 27, 34, and 35, T. 7 S., R. 6 W.

Stratigraphy. The top members of the Oscar sandstone are exposed on the surface.

Structure. The mappable structure is a pronounced nose plunging to the northwest; definite northeast, northwest, and southwest dips may be observed. The nose is open to the southeast, with no control, as all outcrops are obscured in Red River bottom land. This structural nose occurs as a topographic high, with pronounced dip slopes to the north, northwest, and west. It should be possible to define this nose on the southeast by core drilling.

Miscellaneous. There are surface and subsurface indications of a small anticlinal feature of some type through sec. 36, T. 6 S., R. 6 W., and sec. 31, T. 6 S., R. 5 W.

Also structure drilling would probably disclose one or more lower anticlinal folds through Tps. 4 and 5 S., Rs. 6 and 7 W. There is uncertain evidence of a large, board, flat fold in this area.

ANTICLINAL STRUCTURES ON WAURIKA ARCH

NEESMITH DOME

Location. This structure is located in the northeast corner of T. 7 S., R. 7 W., and several miles southeast of the town of Ryan. The anticlinal axis passes through sections 2, 3, and 12 of this township.

Core Drilling. Seventeen core holes were drilled in an area of approximately four sections in defining this structure. These holes were drilled from 500 to 830 feet in depth. Close attention was given the location of these tests as to their starting point in reference to the Ryan sandstone. It was possible to trace this member over the entire structure by drilling, and thus obtain a positive starting point in the correlation of the various core tests.

Stratigraphy. The Ryan sandstone is exposed on the surface. The top of the Oscar sandstone occurs approximately 100 feet below the top of the Ryan sandstone which over this structure has a thickness of 18 to 25 feet.

A dry hole drilled near the center sec. 3, T. 7 S., R. 7 W., shows the base of the Pontotoc to have been reached at about 1,500 feet. A limestone and sand series was topped at 2,245 feet in this test.

Structure. The surface structure can be worked on the top of the Ryan sandstone, which is exposed in a continuous outcrop on the northwest end of the structure. On the southeast extremity the outcrops are confined to a few isloated exposures, which, previous to the structure drilling, could not be positively identified as the Ryan sandstone. However, good dip slopes and general stratigraphic relation pointed to structural closure in this direction.

The structure is reflected on the surface as a pronounced topographic high, certain points reaching an elevation of 975 feet. The crest of the fold is broken and in the early stages of erosion. The structure as defined by core drilling consists of a rather pronounced anticlinal dome, with approximately 44 feet of closure. It coincides with that part of the surface structure that can be accurately mapped.

KAURAUFF ANTICLINE

Location. This structure is located several miles southwest of the town of Addington and lies in secs. 2, 3, 4, 9, 10, 11, 14, 15, and 24, T. 4 S., R. 8 W. The Comanche and Empire pools are located 10 to 15 miles north of this area.

Core drilling. Nine core tests averaging 950 feet in depth were used in defining this structure. The shallowest test was drilled to a total depth of 760 feet, and the deepest to a depth of 1,428 feet.

From both a mechanical and geological standpoint, this area afforded better drilling results than encountered so far in southern Oklahoma. The thick shale intervals were conducive to rapid drilling, and with the regular occurrence of two hard sandstone ledges, afforded excellent correlations. This is the one spot so far found in southern Oklahoma, that core tests can be placed a mile apart and excellent correlations obtained. In fact, in this block any test will correlate smoothly with any of the other core tests drilled. After the first few wells were drilled it was possible to determine the depth of the lower marker within a few feet from the upper correlations.

Stratigraphy. The lower part of the Claypool formation occurs on the surface. A conspicuous sandstone member outcrops at various places over most of this area. This sandstone occurs from 125 to 150 feet above the top of the Ryan sandstone. It occurs at about the same stratigraphic position as the sandstone or the river bluffs in Texas, south of Terral, Oklahoma, which, as previously discussed, has been traced into the Coleman Junction limestone that marks the top of the Cisco formation of Texas.

A dry hole drilled in section 22 to a total depth of 2,745 feet recorded a section of alternating thin limes and good sand bodies, separated by blue shale intervals, from 1,400 feet to the total depth.

Structure. This structure is topographically high; the crest, however, is broken and eroded out on the northeast flank.

Conclusive evidence of some type of anticlinal folding is shown on the surface. Southwest, north, and northeast dips can be definitely mapped; the southeast dip is covered, and of uncertain amount and extent. The normal dip is to the northeast off the Waurika arch.

The core-drill structure consists of an elongated dome, the axis trending northwest and southeast, through sections 4, 10, 11, and 14. The reverse or southwest flank dips much steeper than the northeast flank of the fold. This structure has a positive closure of 40 to 50 feet.

RYAN STRUCTURE

Location. An anticlinal structure of uncertain closure occurs in secs. 16, 17, 21, 22, 27, and 28, T. 6 S., R. 7 W., and located on the east edge of the town of Ryan.

Stratigraphy. The Ryan sandstone occurs on or very close to the surface over the general area, and forms prominent scarps on the northwest, southwest, and southeast sides of the fold.

Structure. This fold trends northwest and southeast, the highest structural point appearing to be near the southwest corner of section 16. Fifty-two feet of northwest dip, 70 feet of southwest dip, and 60 feet of southeast dip may be definitely mapped. The northeast dip is the critical dip in this particular area. There is no definite control in this direction from surface exposures. Core drilling will almost certainly prove a northeast dip and establish closure of some amount.

Oil and gas. A dry hole has been drilled to a total depth of 3,300 feet on the east line of the SW.¼ section 16. This well had no oil or gas showings. It is located three-fourths mile east of the highest part of this structure.

DEAD MAN'S GULCH STRUCTURE

Location. This structural feature occurs through secs. 21, 22, 23, 24, 25, 26, 27, 28, 34, 35, and 36, T. 4 S., R. 9 W., and lies several miles west of the town of Waurika.

Stratigraphy. The Ryan sandstone occurs on the surface. The lower stratigraphy as shown by dry holes has been discussed previously.

Structure. The surface structure, as interpreted by the writer, is shown on figure. 5. The anticlinal axis is eroded out, leaving a dissected flat of badland topography. The Ryan sandstone occurs as a rim rock along the northeast flank and swings completely around the northwest extremity of the fold. This line of escarpment stands up above the surrounding country, as a topographic ridge, with cleancut dips sloping away from the anticlinal axis. As shown on figure 5, there is mappable northeast dip, northwest dip, and some amount of southwest and southeast dip.

This structural feature appears to be one of at least three closely related minor folds that make up a tremendous structural feature through Tps. 4 and 5 S., Rs. 8 and 9 W. These minor folds trend in a northwest-southeast direction, with parallel axes and *en echelon* relationship.

From surface observation, the higher structural points of the Dead Man's Gulch structure appear to be in secs. 26, 27, 35, and 36, T. 4 S., R. 9 W. A synclinal sag through section 34 appears to separate this fold from an undefined but similar parallel minor fold to the southwest. The location of this fold is uncertain, but from meager surface evidence the axis appears to pass through parts of secs. 31 and 32, T. 4 S., R. 9 W., and secs. 4, 5, and 9, T. 5 S., R. 9 W., and then across Red River into the river bend area in Texas.

The third closely associated minor fold occurs as a large topographic high diagonally across T. 5 S., R. 8 W. Reconnaissance mapping by the writer shows the anticlinal axis of this minor fold to occur in a northwest-southeast direction, through parts of secs. 8, 9, 15, 16, 22, and 26, T. 5 S., R. 8 W.

Oil and gas. There are no surface occurrences of oil or gas over the area of the Dead Man's Gulch structure, or the other associated minor folds on the Waurika arch. However, salt water in shallow water wells is reported to exist over the axial area of the Dead Man's Gulch structure.

Three dry holes have been drilled down the flanks of this structure and eight other tests have been drilled on or adjacent to the other two associated minor folds on the Waurika arch.

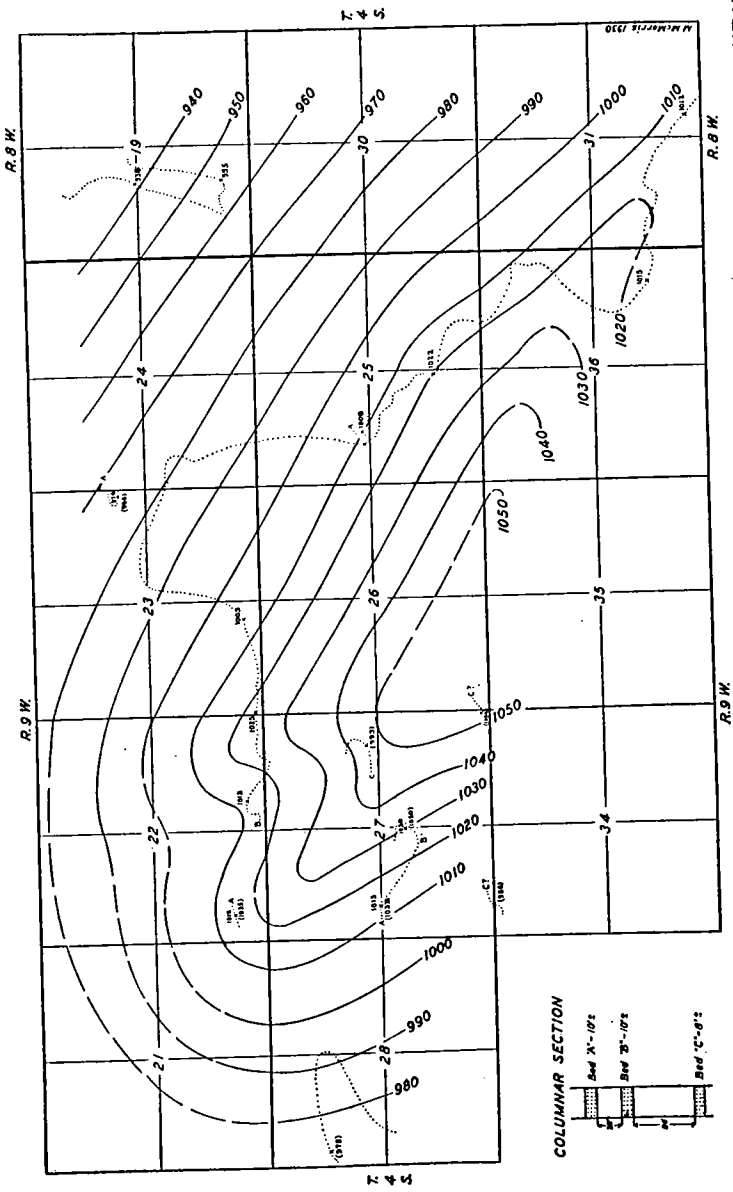

Figure 5. Contour map of Dead Man's Gulch structure. Contour interval, 10 feet. Contours on top of sandstone "B". Datum, sea level.

While some of these tests were fairly well located structurally, none were located on the highest structural points of these minor folds. With one exception these tests were not carried to sufficient depths to reach lower Glenn or Ordovician producing horizons.

Several tests in this area have recorded showings of oil and gas. A well recently drilled by the Amerada Petroleum Corporation in sec. 28, T. 5 S., R. 8 W., recorded a show of oil at a depth of 3,400 feet. This well appears to be considerably lower structurally than certain other tests drilled in this area.

POSSIBILITIES OF ORDOVICIAN PRODUCTION

The best possibilities for Ordovician production in Jefferson County are thought to exist over the northeast portion of the county, under folds associated with the Healdton structural uplift. The Simpson formation is known to have been deposited over this area; it may or may not now be present over the higher structural features. Comparatively little is known about the Ordovician section along the Nocona and Waurika arches. It would appear that if the Simpson has not been stripped off by erosion, it is radically different from the Arbuckle Mountain section; at any rate it has not been recognized in drill holes in this area. Regardless of whether the Arbuckle limestone is a source of oil and gas, deep drilling in the Oklahoma City field has shown that immense production can be obtained from the Arbuckle lime reservoirs. Whether or not the oil is indigenous to the lime in this field is uncertain and relatively unimportant. It does demonstrate, however, that unconformable Arbuckle cores are worthy of close consideration and investigation in certain areas, especially when known to be overlapped by younger petroliferous horizons.

A brief discussion of the Simpson formation and Arbuckle limestone as known in this general area follows.

Simpson Formation

A study of the Simpson formation as exposed in the Arbuckle Mountains with its thick bodies of massive porous sands, in many places heavily impregnated with asphalt on the outcrop, and the prolific production derived from equivalent sands of this formation throughout numerous fields in the Mid-Continent area, causes any geologist or operator with the slightest imagination to seriously consider the probability of Ordovician production on certain of the anticlinal folds south of the Arbuckle Mountains, especially in northeast Jefferson County.

A general study of the Simpson formation from the Ozark uplift to the Arbuckle Mountains shows this formation to thicken from a comparatively few hundred feet in southwest Missouri, to a total thickness of approximately 2,300 feet in certain localities

on the south flank of the Arbuckle Mountains. This thickening occurs throughout the entire section by the addition of shale, lime, and sandy phases. The thickening is especially noticeable from the base of the Viola limestone to the top of the Wilcox sand in a southwest direction from the Seminole area to the Arbuckle Mountains.

Along the south flank of the Arbuckle Mountains the shale interval between the lower Simpson sands and the Viola limestone becomes progressively more sandy from west to east. On the west extremity of the Simpson outcrop the upper 1,000 to 1,200 feet of the Simpson is largely shale with thin limestone shells; the lower sands, however, are present.

Surface exposures in the Criner Hills of Carter County, one isolated outcrop on the north flank of the Wichita Mountains west of Sedan, and the occurrence in certain wells drilled in Kiowa County, prove that the Simpson formation was deposited over a considerable area west and south of the Arbuckle Mountains. In these areas the Simpson formation appears to have the same general characteristics as in the Arbuckle Mountains, with several well developed sand horizons suitable for oil or gas reservoirs.

Several of the deeper holes drilled in T. 2 S., R. 6 W., T. 3 S., R. 5 W., T. 3 S., R. 4 W., T. 4 E., R. 3 W., and T. 4 S., R. 2 W. are known to have penetrated Viola lime and in some instances the upper portion of the Simpson formation. Likewise, a few wells in the Healdton and Hewitt oil fields of Carter County, are thought to be producing from the upper Simpson or lower Viola. The oil is of higher gravity than that which is found in the overlying Pennsylvanian sands.

Recently a well drilled in sec. 30, T. 2 S., R. 6 W., encountered the top of the Viola limestone at 2,922 feet and the top of the Simpson formation at 3,450 feet. This well is shut down at a total depth of 4,500 feet, after penetrating 1,050 feet of Simpson section composed of green shale and thin limestones. This test has not reached the sand members in the lower Simpson, which should be encountered with deeper drilling.

The absence of sand members in the upper Simpson formation, penetrated in this test is to be expected after a study of the outcrop exposed on the western extremity of the Arbuckle Mountains.

ARBUCKLE LIME

The upper portion of the Arbuckle limestone in the Arbuckle Mountains consists of alternating thin beds of shales and limestone. The limestones are more or less dark colored and bituminous on fracturing and give a petroliferous odor when freshly fractured.

The shales in most instances are dark colored to black. Near Crusher, Oklahoma, globules of free oil can be found in freshly fractured Arbuckle limestone. The upper Arbuckle could be and probably is an important source of oil and gas in certain areas.

A well drilled in sec. 9, T. 2 S., R. 6 W., Wirt Franklin No. 1 Bonner penetrated a limestone formation from 3,450 to 3,939 feet that is undoubtedly Arbuckle. Whether it is present due to faulting, unconformity, or redeposited Arbuckle boulders, is as yet uncertain. Certain cores from this lime show that it contains irregular cavities filled with a very heavy asphaltic oil.

CONCLUSIONS

NORTHEASTERN JEFFERSON COUNTY

The anticlinal folds along what has here been termed the Healdton uplift, including the Johnson, Stallings, and associated structures, are thought to offer the best possibilities for commercial oil and gas production of any undeveloped area in Jefferson County. Folds on this general high have excellent possibilities for both shallow and deep production from Pennsylvanian sands and possibly lower sands in the Simpson formation or the Arbuckle limestone.

The cheapest and most efficient method of prospecting the undeveloped northwest portion of the Healdton uplift, would be the drilling of four to six core-drill holes to a depth of 2,500 feet, or the Big Lime series on the higher parts of the minor structures as disclosed by surface mapping and shallow core-drilling. Data derived from these deep core tests would give accurate subsurface information as to the nature of the stratigraphic section, the oil, gas, or water contents of sands penetrated, and furnish excellent samples for identification and correlation of formations.

A deep test should then be drilled upon the most favorable location disclosed by this exploration. If located on the highest structural point this test should be carried at least 600 feet below the top of the Arbuckle limestone before abandonment. Should Ordovician rocks be penetrated at shallow depths and found devoid of oil or gas there would still remain excellent possibilities of production in overlapping lower Pennsylvanian sands on the flanks of the lime core.

WESTERN JEFFERSON COUNTY

The possibilities of new production in western Jefferson County along the Nocona uplift and Waurika arch are uncertain. Conditions as disclosed by recent drilling are extremely puzzling. During the latter part of 1928 and 1929 this portion of Jefferson County extending northwest into Cotton County was given a very extensive oil play and several critical wells were drilled.

Certain of these wells were located on geophysical information, including torsion balance, seismograph, and magnetometer work. Other tests were drilled on surface and core-drill structures. Certain of these wells ran abnormally high structurally and others ran low. In every case, however, each was abandoned as a dry hole with no appreciable oil or gas show, except in one instance and this well appears to correlate much lower than other tests closly adjacent. (Amerada, Edminson, sec. 28, T. 5 S., R. 8 W.)

Of the core-drill structures on the Waurika arch, discussed in this report, two have now been drilled without favorable results. The Neesmith dome has been tested by a well on the highest structural point to a depth of 3,939 feet. The drill was in Pennsylvanian rocks when abandoned, correlated by White of the Gypsy Oil Company as belonging to the lower Hoxbar.

The Kaurauff anticline has been tested by a well to a total depth of 3,008; this test was not located on the highest structural point on account of lease requirements. It was abandoned in rocks thought to correlate with the lower Hoxbar.

The test wells on both the Neesmith and Kaurauff core-drill structures correlate higher structurally than dry holes previously drilled down their flanks, and conclusively prove that the structure shown in the upper beds continues and increases as normally expected with depth. It would appear then that the undeveloped structures in western Jefferson County, so far tested, are barren of oil or gas or have not been adequately tested by deep drilling.

In this connection it is well to note that only one hole on the Waurika arch is definitely known to have penetrated rocks older than Pennsylvanian. This well, Amerada-Delana No. 1, sec. 31, T. 4 S., R. 9 W., Cotton County, penetrated a thick lime series from 1,534 to 3,200 feet, and encountered igneous material at 3,275 feet. Immediately above the granite Cambrian rocks are thought to have been penetrated. Most of the lime section is thought to be Deese. This well is unquestionably very high structurally. However, there is no reason to believe that this well is located on the very pinnacle of a subsurface high. A pool the size of the Oscar field could easily occur in the vicinity of this well. Core drilling to the top of the lime should be conducted adjacent to this well.

According to the surface structure, as interpreted by the writer, the DeLana well is located down the west and northwest flank of a structural nose open or at least undefined to the southeast. This structural nose appears to be a parallel minor feature off the Dead Man's Gulch structure. The location of the DeLana test is at least 100 feet lower structurally than the higher part of the Dead Man's Gulch anticline, which appears to the major structural high in this area as shown by surface mapping.

The present producing areas in Jefferson County, including, Healdton, Oscar, Spring and T. 7 S., R. 7 W. gas areas are all located on apparent surface structures that closely coincide with the structure of the producing sands. With the exception of Healdton, the production covers a very restricted area and is confined entirely to the highest structural points.

Also in every instance drilling has shown that unconformable older rocks occurring in buried lime hills or cores underlie the producing sands from 100 to 300 feet. The higher the buried hills the shallower and more extensive the area of oil and gas accumulation in the overlying beds. To the writer's mind this fact is evidence that the oil originated in strata below that where it is now accumulated, being derived possibly from overlapping lower Pennsylvanian beds or directly from the Ordovician.

It appears then that future exploration in western Jefferson County should be confined to the highest structural points on positive structures and drilled to a depth sufficient to reach the zone of contact and unconformity with rocks older than middle Pennsylvanian, or to unconformable lime cores.

The only structures discussed in this report that have had tests drilled on or adjacent to the highest structural points are the Neesmith and Kaurauff anticlines. Both of these folds may be considered flank structures as they are lower structurally than the higher parts of the Waurika arch and Nocona uplift. The older rocks should then be expected at much greater depths. It is certain that the tests drilled on these structures quit in formations well up in the Pennsylvanian section and probably did not reach the contact zone above any unconformable core.

The above discussion is made to show that, while development so far in western Jefferson County has been discouraging, there are possibilities of commercial pools in this area. The best possibility left for shallow production is the Dead Man's Gulch structure as this is the highest structural feature on the Waurika arch, and is as yet untested. Deep tests are thought warranted on the closed structures discussed in this report.