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Chas. N. Gould, Director

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OIL AND GAS IN OKLAHOMA

GEOLOGY AND OIL AND GAS DEVELOPMENT IN OKMULGEE COUNTY, OKLAHOMA

By

Robt. W. Clark

Okmulgee, Oklahoma

NORMAN

DECEMBER, 1926

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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.

Okmulgee County is one of the older of the oil producing counties in Oklahoma and few if any counties in the State, have more oil wells than has Okmulgee. Dr. Clark who has prepared this report, has watched the development for a number of years, and is well qualified to write on the subject. It is believed that his presentation will aid in future development, especially in the deeper sands.

CHAS. N. GOULD,
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INTRODUCTION

GENERAL STATEMENT

For eight years the author has been studying the conditions controlling the accumulation of oil and gas in the oil fields of Okmulgee District of Oklahoma. The larger and more productive pools in the fields have been found to lie on the tops of domes mapped on the producing sands, while the surface beds give but slight indication of the presence of such subsurface conditions. In other words, domes in the deeper lying formations are not reflected at the surface. In fact, this situation caused many geologists, in the early period of the development of the area, to pass it by as improbable territory, while as a matter of fact, it has already produced appromixately one hundred million barrels of oil.

The purpose of this report is to set forth the oil and gas development of Okmulgee County, Oklahoma, and to show the conditions under which oil and gas have accumulated.

ACKNOWLEDGMENTS

In the preparation of this report various sources of information have been consulted and used without direct reference. Among them are Oklahoma Geological Survey Bulletin 19, Part II, Petroleum and Natural Gas in Oklahoma; Bulletin 35, Index to the Stratigraphy of Oklahoma, by Chas. N. Gould; also the U. S. Geological Survey folios by Joseph A. Taff on the Coalgate and Muskogee quadrangles. My thanks are hereby expressed to Messrs. W. E. Wood, W. C. Newman, J. P. Rossiter and E. H. Galligan, who have been operating in this area since the beginning, for information contained in the paragraphs on the history of development of the county. Grateful appreciation is also expressed to Chas. I. O'Neil, Secretary of the Okmulgee District Oil and Gas Association, for compilation of the data on drilling operations and production in the county.

LOCATION

Okmulgee County is located in the east-central part of the State. It extends from T. 11 N. to the middle of T. 16 N., and from R. 11 E. to the middle of R. 15 E., in its widest parts. There are 16 entire townships and 7 half townships or a total of 702 square miles in the county.

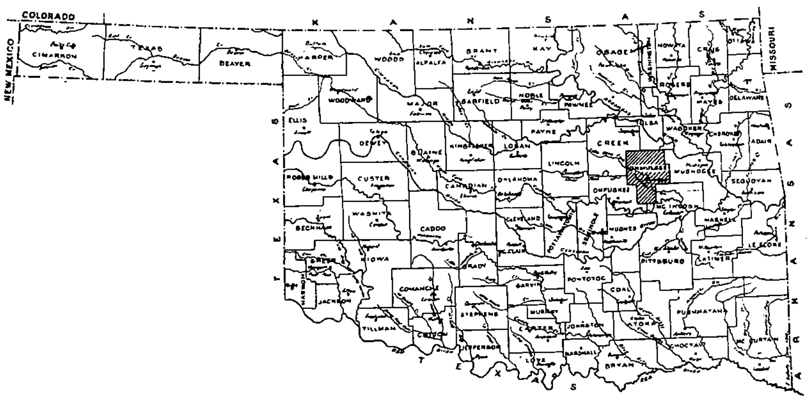


Figure 1.—Index map of Oklahoma showing area covered by this report.

TOPOGRAPHY

Okmulgee County lies within the sandstone hills region. The topography consists of roughly parallel sandstone ridges between which are rather broad shale valleys. The ridges have very steep to vertical eastward facing slopes, but have gradual slopes to the west on the west side corresponding to the dip of the rocks. In other words, the west slopes are dip slopes while the east slopes are escarpments. The sandstone hill zones have been deeply dissected by streams, giving a rather rough topography. The surface ranges in elevation from less than 600 feet to more than 1,000 feet. The lowest point is where the Deep Fork of the Canadian River leaves the county in sec. 33, T. 12 N., R. 14 E. The highest point is in sec. 19, T. 15 N., R. 13 E.

The northeast portion of the county is drained by tributaries of the Arkansas River. The largest stream in the county is the Deep Fork of the Canadian River which flows through the west and central portions of the county and drains at least two-thirds of its area. The extreme southern portion of the county drains directly into the North Fork of the Canadian River, which crosses the southeast corner of the county in sec. 36, T. 11 N., R. 13 E.

STRATIGRAPHY

SURFACE GEOLOGY.

GENERAL STATEMENT

The surface rocks in Okmulgee County are Pennsylvanian in age with the exception of recent sands and gravels along the stream valleys. The following formations outcrop in the county beginning with the lowest: Boggy shale, Thurman sandstone, Stuart shale, Senora formation, Calvin sandstone, Wetumka shale, Wewoka formation, Holdenville shale, Seminole conglomerate. Coffeyville formation, including the Checkerboard limestone, and the Nelly Bly formation. These formations cross the county in a northeast and southwest direction so that the lowest one has its widest extent in the southeast part of the county and the topmost one just crosses the northwest corner of the county. Description of these formations has been briefly and conveniently outlined by Chas. N. Gould in Bulletin 35 of the Oklahoma Geological Survey. A more detailed description follows.

The Nelly Bly formation, which outcrops across the southwest corner of T. 16 N., R. 11 E., consists largely of shale with some interbedded sandstones. Farther north in Creek County the sandstones become massive and cap the high ridges and afford a rather rugged topography. The total thickness of the formation is not exposed in Okmulgee County.

The Coffeyville formation consists largely of clay shales with a few shaly sandstone beds in its lower part. The upper part has more of the sandstone beds, some of which become quite massive. Near the base of the Coffeyville is the Checkerboard limestone, so-called because of a double system of joints whereby it breaks into cubical blocks which on the top look like the squares of a checkerboard. Exposed surfaces of the lime are yellowish in color while a fresh fractured surface is bluish. It is about three feet thick and outcrops in draws and on the down dip slopes, rarely on the east facing steep slopes. The thickness of the Coffeyville is about 400 feet.

The Seminole conglomerate is a sandstone with beds and lenses of chert conglomerate. These beds seldom exceed two feet in thickness in the county and the angular chert particles are from one-eighth to one-quarter of an inch across. South of Okmulgee County the chert pebbles are much larger in places and the conglomerate beds may be considerably thicker. The total thickness varies from 15 to 35 feet.

The Holdenville shale has an average thickness of 180 feet. It is predominately clay shale with a few thin beds of sandstone more or less shaly, which do not form continuous ledges. In the street on the hill in the west side of Beggs there is a limestone in the

Holdenville shale. This limestone is about three feet thick but cannot be traced for any distance along the strike of the formation.

The Wewoka formation is about 450 feet thick and is predominately a sandstone with beds of clay shale between the sandstone beds. The lowest member is a sandstone bed about six feet thick that is very persistent in its outcrop. The middle part of the formation is a massive sandstone member that can be traced continuously across the county and for many miles beyond in both directions. The upper part of the Wewoka formation is more cross-bedded and contains more shale and shaly sandstone than the middle and lower parts. It grades into the overlying Holdenville shale in such a manner as to make the contact quite indefinite.

The Wetumka is essentially a clay shale formation with occasional thin sandy shale beds in it. A thin limestone that is quite persistent also occurs in this formation. The thickness of the Wetumka shale is 120 feet.

The Calvin sandstone is composed largely of massive sandstone in the southern part of the county, but toward the north it becomes more and more shaly. The massive sandstone on the hills at Henryetta is basal Calvin sandstone. The city of Okmulgee sits on the upper Calvin sandstone, but about a mile north of the city the sandstone disappears and the Calvin changes to a clay shale. Sandstones occur again in the Calvin in the Bald Hill area.

The Senora formation is 250 feet thick. In the southern part of the county it consists of massive sandstone beds alternating with beds of clay shale. Like the Calvin the massive sandstones pinch out toward the north so that the formation is nearly all shale north of T. 12 N. In T. 15 N., R. 14 E., there are again some massive sandstones in this formation, but they are not continuous with the sandstones in the southern part of the county. The Henryetta coal beds occur in the Senora formation.

The Stuart formation is a clay shale about 200 feet thick with a few thin shaly sandstone beds. In T. 14 N., R. 14 E., it cannot be differentiated from the shales of the Senora above and the Boggy below.

The Thurman sandstone consists for the most part of massive sandstone in the southern part of the area and gives rise to the rugged topography and timbered hills in the southeast corner of T. 13 N., R. 14 E. To the south in McIntosh County massive sandstones predominate, but the formation is predominately shaly in eastern Okmulgee County.

The Boggy shale is a formation that borders the east side of the county. Its total thickness is not exposed in the county, but it extends eastward into Muskogee County.

SUBSURFACE GEOLOGY[1]

GENERAL STATEMENT

Because of the westward dip of the Pennsylvanian and Mississippian formations the same sands are found at much greater depths in the western part of the county than in the eastern part. This statement does not apply, however, to sands below the Mississippian as will be explained later.

SALT SAND, GLENN SAND

The stratigraphically highest sheet sand in the county is called the Salt sand in the eastern part of the county and the Glenn sand in the western part. It is the equivalent of the Glenn sand of the old Glenn Pool, which in turn has been correlated with the Bartlesville sand. This is not the same as the Glenn sand of the Bald Hill area in T. 15 N., R. 14 E. Its depth varies from about 600 feet on the east side of the county to 1,900 feet on the west side and its thickness varies from 200 feet in the eastern part of the county to less than 50 feet in the western part of the county. It is a gas and oil pay sand and always carries water in its lower part, which has to be cased off in drilling a well to formations below it.

SHALLOW STRAY SANDS

In sections 26 and 35, T. 13 N., R. 12 E., a very prolific pool has been developed in a sand approximately 800 feet above the Salt sand. This sand has been found to carry oil and gas to the west of this pool and especially in T. 13 N., R. 11 E.

In the vicinity of the village of Morris oil and gas have been obtained from a sand about 325 feet above the Salt sand. This sand or its approximate equivalent has been found productive in several places in the eastern part of the county.

BOOCH SAND, TANNEHA, RED FORK

About 250 feet below the Salt sand is the first Booch sand, and about 100 feet below that is the second Booch sand. These sands are thin, generally not over 25 or 30 feet thick. In the Bald Hill area the lower Booch is called Red Fork but the true Red Fork is above the Salt sand. In the western part of the county the two Booch sands are represented by the Tanneha sand, which may be as much as 300 feet thick. The Booch sand has been the source of much of the oil so far produced in the eastern half of the county. It generally requires a heavy shot to make a well, but 1,500 to 2,000 barrel wells are not uncommon when only a small show was apparent before the shot.

1. Aurin, F. L., Clark, Glenn C. and Trager, Earl A., Notes on the subsurface pre-Pennsylvanian stratigraphy of the northern Mid-Continent oil fields: Bull. Am. Assoc. Pet. Geol. vol. V, No. 2, 1921.

DUTCHER, MORRIS, GLENN, FIELDS, AND YOUNGSTOWN SANDS

Below the Booch sand in the basal part of the Pennsylvanian system is a group of sands, sandy limes, and limes, known as the Dutcher group. They make up the Fayetteville formation. As many as three different sands can be recognized in this group and they have received different names in different parts of the county. In the eastern half they are in descending order: Morris, Glenn, and Fields sands. This Glenn sand is deeper than the Glenn sand referred to above as the equivalent of the Salt sand and is frequently called the "Glenn-of-Morris" sand to distinguish it from the other. It received its name when the first well was drilled in the Bald Hill area by a driller fresh from the Glenn Pool, because the two sands occur at the same depth. It is an important pay sand in the Bald Hill area. The Glenn and Fields sands often coalesce but are generally separated by a thin shale break. In the vicinity of Preston the Dutcher sands are often called First and Second Preston or Hamilton Switch sands while in the western part of the county they are known as First and Second Youngstown or First and Second Dutcher sands. In the southern part of the county the names Deaner and Kingwood are often used although these names were first applied across the line in Okfuskee County. Accumulation in the Dutcher sands appears to be due as much to lensing and variations in the character of the sand as to structure, although the large pools of big producing wells are always found on well defined dome structures. It is not uncommon for a dry hole in the Dutcher sand to be surrounded by large producing oil wells.

LYONS—QUINN SAND

Below the Dutcher group is a series of limes which belong to the lower part of the Pennsylvanian and the upper part of the Mississippian systems and correspond respectively to the Morrow and Pitkin limestones. In the southern and eastern portions of the county porous sandy zones occur in the Pitkin lime and are often productive of oil and gas. This is called the Lyons-Quinn sand. It is a pay horizon in the west side of T. 11 N., R. 12 E., in Turkey Pen Hollow just north of Henryetta and through the Hoffman, Morris and 14-14 area. In the northern and northwestern part of the county it has not yet been found productive.

The stratigraphic section below the Lyons-Quinn sand is well known to operators and field men in the county and will be discussed a little more in detail.

BOONE LIMESTONE

The Boone limestone is the uppermost member of the series. It is about 200 feet thick, and is black or brown in color. Often the top of it is soft and may be called slate by the drillers. It is frequently called the Mississippi lime.

CHATTANOOGA SHALE

Lying below the Boone limestone is the Chattanooga shale. It is black in color and about 40 feet thick. It is the lowest member of the Mississippian system and rests unconformably upon pre-Mississippian formations.

The pre-Chattanooga formations have been very ably described by White[2]. They dip to the southwest across Okmulgee County at the rate of about 40 feet to the mile. A period of erosion representing part of the Silurian and all of Devonian time followed the uplift which dipped these formations to the southwest so that the Chattanooga was deposited on the bevelled edges of these formations. It overlies and is in contact with the highest member in the southern part of the county and with successively lower members toward the north.

HUNTON FORMATION

This formation appears as a thin limestone below the Chattanooga in the extreme southern and eastern parts of the county. Some of the Wilcox sand wells at Hoffman and also those at Eram show this limestone. The Ratcliffe well in sec. 33, T. 13 N., R. 11 E., also shows it. It has come to be known as a pay horizon in other parts of the State, but not in Okmulgee County.

SYLVAN SHALE

Many wells in the southern half of the county show the black Chattanooga shale underlain by light shale that is often greenish in color. This is the Sylvan shale and varies considerably in thickness. In those places where the Hunton lime is present the Sylvan is directly below the Hunton but in the rest of the area it is directly below the Chattanooga.

VIOLA LIMESTONE

The Viola limestone is a coarsely crystalline white limestone that varies in thickness up to 60 feet. It is often called the "Buttermilk lime" in the field. Throughout most of the county, except in the extreme northern part, it lies just above the Wilcox sand and is an important marker for the drillers. Where the Sylvan is present the Viola lies just under it, otherwise it is in contact with the Chattanooga.

WILCOX SAND

The Wilcox sand is a very important oil producing horizon in Okmulgee County and is the goal of most of the present day developments in the county because it may be a very prolific pay sand

2. White, Luther, Subsurface distribution and correlation of the pre-Chattanooga ("Wilcox" sand) series of northeastern Oklahoma: Oklahoma Geol. Survey Bull. 40-B, 1926.

and the oil has the highest value of all. In the N½ of T. 15 N., R. 14 E., and the S½ of Tps. 16-13 and Tps. 16-14, the Viola lime is absent and the Wilcox sand lies directly under the Chattanooga shale. Throughout the rest of the county the Viola overlies the Wilcox sand.

MISENER SAND

Lying in the top of the Viola limestone a pay sand is encountered locally. It is called the Misener sand, and has been found productive in the west side of T. 15 N., R. 11 E. It consists of small lenses and is not a sheet sand. Accumulation in it is due to the lensing and not to dome structure. It has been correlated with the Sylamore sandstone and is much younger than any of the other formations in the pre-Wilcox series.

The Wilcox sand is the lowest pay sand at the present time in Okmulgee County. Its depth varies in different parts of the county, but not in the same way as the upper sand depths. It is shallowest in T. 15 N., R. 14 E., where it is found to produce oil at a depth of approximately 2,200 feet. In the Eram Pool in sec. 5, T. 13 N., R. 15 E., the Wilcox sand is 2,700 feet deep; in Pine-Smith Pool, secs. 1 and 12, T. 13 N., R. 13 E., the depth is 2,500 feet; at Hoffman 2,800 feet; sec. 9, T. 13 N., R. 12 E., 2,700 feet; sec. 30, T. 15 N., R. 11 E., 3,000 feet; Phillipsville Pool, sec. 22, T. 14 N., R. 11 E., 2,800 feet; Simms Pool, sec. 31, T. 12 N., R. 12 E., 3,300 feet.

HOMINY AND TURKEY MOUNTAIN SANDS

In a number of widely separated tests, shows of oil have been encountered in formations below the Wilcox sand. In sec. 19, T. 14 N., R. 13 E., the Wilcox sand was found at 2,600 feet. A good show of oil was found at 2,880 feet in a sand which is probably the Hominy sand (correlated by White as the Burgen). At 2,920 feet another good show of oil was found in a sandy phase of the Siliceous lime. This is probably the Turkey Mountain sand. In sec. 22, T. 14 N., R. 14 E., the Wilcox sand was found at 2,278 feet and after drilling through the Tyner formation a good show of oil was found in the Siliceous lime at 2,455 feet. This is thought to be the Turkey Mountain sand although it might be the Hominy as no cuttings were available to make a definite correlation.

In sec. 33, T. 13 N., R. 11 E., the Wilcox sand was found at 3,330 feet and was 200 feet thick. The Tyner formation is believed to be absent or very thin, and the Hominy encountered at 3,548 feet had a good show of oil. The Arbuckle limestone, with sandy phases corresponding to the Turkey Mountain, begins at 3,590 or 3,600 feet.

The character of the oil obtained from the various sands is different. The Wilcox sand produces the highest grade of crude oil in the county, and the upper Dutcher produces the lowest grade of crude. The data in the following table were furnished by Dr. A. P.

Bjerregaard, formerly chief chemist for the Empire Refineries, Inc., The samples do not cover the whole county nor every sand, but they are sufficient to show the general character of the oil from the different sands.

Character of Oil Obtained from Various Sands.

LOCATION	SAND	COLOR	GRAVITY DEGREES BAUME
7-13-15	Wilcox	light amber	44.4
1-13-13	Wilcox	light amber	43.6
22-14-11	Wilcox	light green	43.0
25-15-13	Lower Dutcher (Glenn)	dark green	35.7
16-14-14	Glenn	green	35.0
8-13-15	Lower Dutcher	light amber	37.7
4-14-12	Lower Dutcher	dark green	34.0
5-14-12	Lower Dutcher	dark green	37.6
32-13-11	Lower Dutcher	dark green	36.1
21-13-11	Lower Dutcher	green	35.3
8-14-11	Upper Dutcher	black	29.9
2-13-11	Upper Dutcher	black	24.6
18-15-11	Upper Dutcher	dark brown	31.3
14-13-12	Booch	dark green	35.6
24-11-11	Lyons-Quinn	green	40.1

STRUCTURE

SURFACE STRUCTURE

GENERAL STATEMENT

The strata in Okmulgee County belong to the Prairie Plains monocline. They strike about N. 25° E., and dip N. 65° W. The rate of dip in the west half of the county is 80 to 90 feet to the mile, while in the eastern half it is 50 to 60 feet to the mile. Local variations in the direction and rate of dip give rise to noses and terraces. These generally indicate the presence of closed structures or domes capable of trapping oil in the deeper formations.

STRUCTURAL FEATURES

Two anticlines are known to exist in Okmulgee County. The largest one of these is known as the Schulter anticline. It extends southwestward from the village of Schulter in sec. 17, T. 12 N., R. 13 E., toward the city of Henryetta. The highest part of this anticline shows a reversal or east dip of approximately 120 feet measured on the coal.

The second anticline extends from the village of Hoffman northeastward across T. 13 N., R. 14 E., T. 14 N., R. 14 E., and into T. 14 N., R. 15 E. The total height of this anticline cannot be measured on the surface rocks because they are mostly shales and do not form continuous mapable ledges. The east side of this anticline in Tps. 12 and 13 N., R. 14 E., is marked by a fault with the downthrow on the east side. The throw amounts to as much as 300 feet in places.

SUBSURFACE STRUCTURE

GENERAL STATEMENT

The structure of the buried sands is not parallel to that of the surface beds. The general attitude of the Salt sand and the Booch sand is that of a northwestward dipping monocline with many minor variations in the direction or rate of dip. Unlike the surface beds, small closed structures or domes are frequent although these are generally not very high and rarely more than a half mile across.

BURIED STRUCTURAL FEATURES

The Dutcher series thickens to the south and to the east across this area so that the interval between the Salt sand above the Dutcher and the Boone lime below the Dutcher is much greater in the southern part of the county than in the northern part. It is also greater on the east side of the county than on the west side. Figue 2 shows in a general way how this interval increases to the south and east. There are also local variations in this interval around the domes that produce oil from the Wilcox sand. It is thinner on the tops of the domes than on the flanks and may vary as much as 100 feet in one-quarter of a mile.

Closed structures in the Dutcher sand are generally higher or show more closure than do the overlying Booch and Salt sands. Production from the Dutcher sand is associated with domes and similar structural conditions but porosity and lensing of the sand also appear to be important factors in accumulation in the Dutcher sand. It is not unusual for dry holes to be surrounded by good producers even on favorable structural locations.

The structure of the Lyons-Quinn sand often varies considerably from that of the overlying formations and is in a general way parallel to that of the deeper lying Wilcox sand. A dome in the Lyons-Quinn sand generally has above it a lower dome in the Dutcher and upper sands but not all domes in the upper sands have Lyons-Quinn domes under them. On the other hand the structure of the Wilcox sand will be found to be nearly the same as that of the Lyons-Quinn sand except that the amount of dip and the shape of the Wilcox dome may be slightly different from that of the Lyons-Quinn sand dome.

Domes in the Wilcox sand are the highest and steepest of all. The Wilcox sand produces oil in paying quantities only from structures of the dome type. The area of production is rather small, usually not to exceed 160 acres although the total producing area of a few pools exceeds that amount. Dips in the Wilcox sand are generally quite steep especially on one side of a producing structure. Thus in the Eram Pool in sec. 5, T. 13 N., R. 15 E., the north dip amounts to 150 feet in a quarter of a mile. In the Brookins Pool in

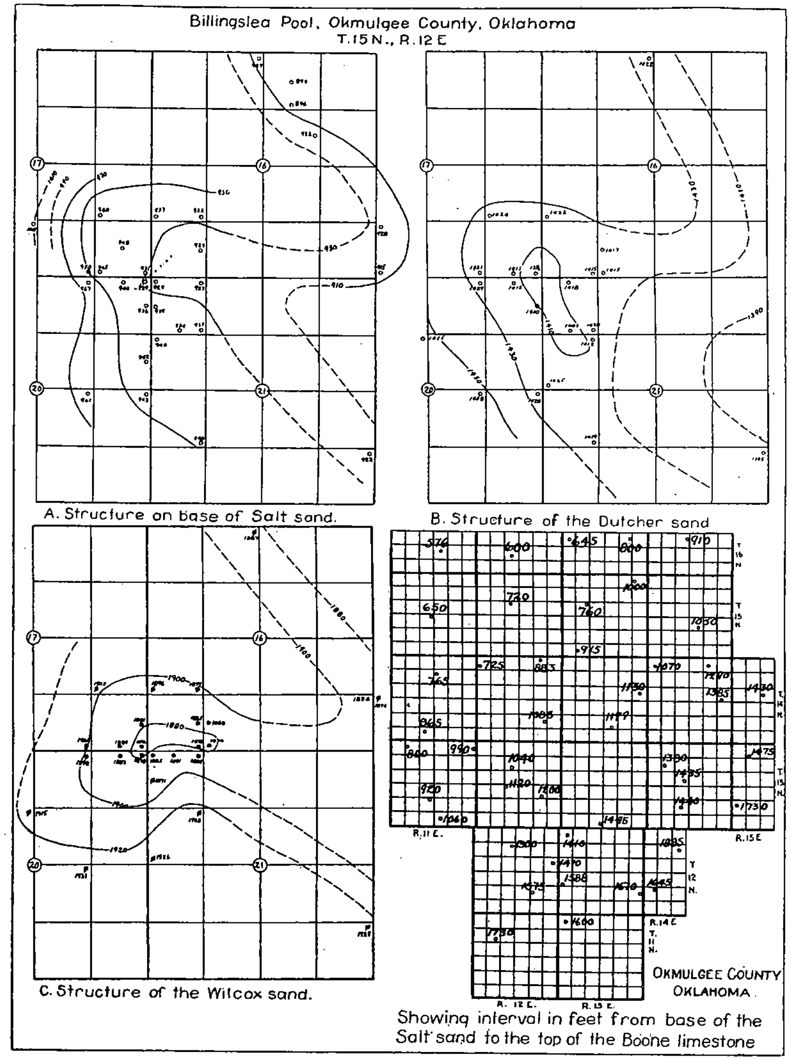


Figure 2.—Structures and intervals between sands in the Billingslea Pool.

sec. 9, T. 13 N., R. 12 E., the southeast dip amounts to more than 200 feet in a quarter of a mile.

Domes in the Wilcox sand are always reflected in the overlying formations. However the height of the dome gradually diminishes toward the surface until, in the surface beds, only a nose or terrace is present to indicate the possible producing structure below. The converse of this is not true. Not all noses or terraces or even all domes in the Salt or Dutcher sands indicate the presence of a Wilcox sand dome beneath them. This has become a very important factor in the present day development of Okmulgee County. A considerable area of the county has been developed in the Salt, Booch and Dutcher sands. The tendency today is to redrill all the old developed acreage in search of production from the Wilcox sand.

Locations are selected where the shallower sands show a good dome structure but it is further necessary to make a very careful study of the logs of the few scattered wells that have been drilled to the Wilcox sand in the vicinity of such a dome to see whether a Wilcox dome is possible under the shallower sand dome. Often the Wilcox shows a normal dip or is even synclinal under a good dome in the upper formations.

ORIGIN OF THE DOMES

GENERAL STATEMENT

Much has been written on the origin of the structures or domes of the Mid-Continent area. It is believed that any one theory will not explain all types of domes and anticlines in this broad area.

OZARK UPLIFT

Folding of the earth's sedimentary shell is the most frequently used explanation for the origin of domes and anticlines. A great positive land mass known as the Ozark Uplift lies to the northeast of this area. The principal uplift here occurred during and after Pennsylvanian time and resulted in the tilting of the beds in Okmulgee County together with the rest of northeastern Oklahoma forming the westward dipping monocline throughout this region. Had there been a thrust with this movement the closed structures of this area would be of the Appalachian type, i. e. elongated anticlines associated with thrust faults. With the two exceptions noted above all the structures of Okmulgee County are more or less circular and of very small areal extent, usually less than a square mile. Such closed structures are only found in the buried beds while overlying them the surface beds show only small noses and terraces. Some faulting exists in the surface beds of Okmulgee County, but all the faults are of the normal type. Thus, it does not appear that there has been any thrust in this area from the Ozark Uplift and folding cannot be assumed as a cause for the domes.

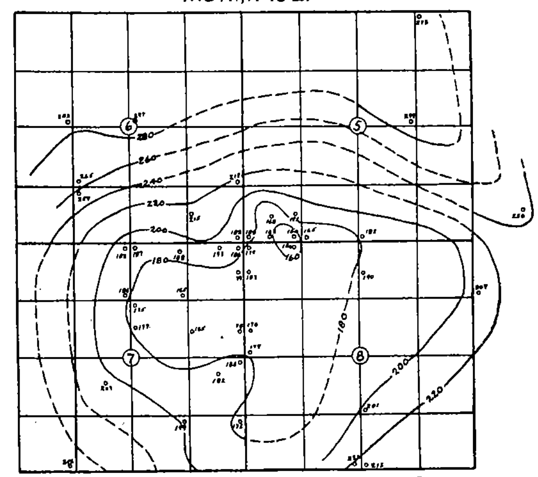
VERTICAL UPLIFT

In 1918 Gardner[3] ascribed the domes of the Mid-Continent to a vertical uplift caused by an igneous mass. It is very doubtful

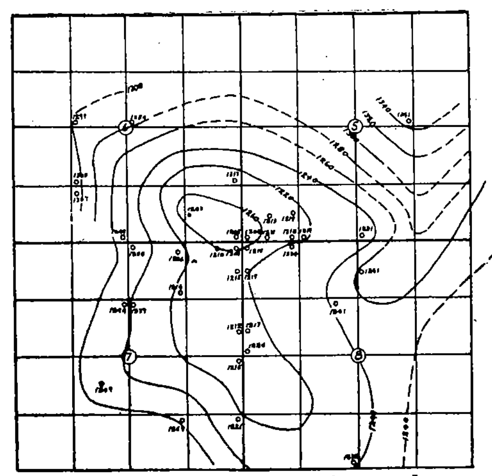
3. Gardner, James H.. The vertical component in local folding: Bull Am. Assoc. Pet. Geol. vol. I, 1917.

if such a cause could produce the small circular domes of this county. No well in the county has ever been drilled through the sedimentary rocks into the igneous rocks although one test in sec. 29, T. 13 N., R. 14 E., went to a depth of 4,023 feet or 1,400 feet below the top of the Wilcox sand. Another well in sec. 12, T. 14 N., R. 11 E., was drilled more than 1,100 feet below the Wilcox sand.

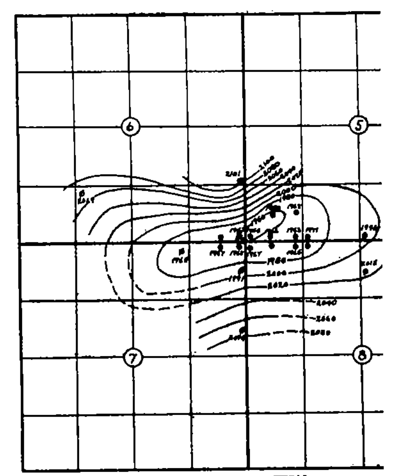
Eram Pool, Okmulgee County, Oklahoma
T.13N.,R 15E.



A. Structure on base of Salt sand.



B. Structure of the Dutcher sand.



C. Structure of the Wilcox san

Figure 3.—Structures in the Eram Pool.

In those anticlines like the Cushing structure and the Nemaha Mountain anticline of Kansas where granite is known to underlie the sedimentary rocks and was probably an important factor in the development of the anticline, the structures are long and narrow and not of the circular dome type that we have in Okmulgee County.

DIFFERENTIAL SETTLING

Blackwelder[4] believes the domes in the central Kansas oil fields are due to differential settling of the sediments deposited on an eroded topography, this settling having been caused by different degrees of compression of the various kinds of sediments under the load of overlying materials. He accepts as entirely within reason a condensation of 2 per cent in sandstones, 5 per cent in limestone and 15 to 35 per cent in shales. He shows that a pre-Pennsylvanian hill with a miximum relief of 700 feet would be sufficient to cause the gentle dips that are found on any of the domes of that area.

Monnett[5] in 1922 made a very general application of that theory to the whole Mid-Continent area.

In the same year Powers[6] carried this theory even further and showed the nature and cause of the pre-sedimentary topography in the major anticlines and domes of the Mid-Continent oil fields. An igneous mass is noted in all the major folds of that field, showing that the settling of sediments around pre-Cambrian hills or ranges is the cause of such structures.

In 1918 Mather[7] explained the cause of small domes by deposition of sediments around hills on an originally inclined floor. The sediments were deposited in an inclined position, giving rise to the dips that are now noted on them.

The formations below the Chattanooga shale are largely limestone, sandstones and sandy limes. At least 1,400 feet of these formations have already been noted in the test in sec. 29, T. 13 N., R. 14 E. Since the dips on the domes in the Wilcox sand are very steep and since the materials in this part of the stratigraphic section are the least compressible it does not appear that settling of sediments had very much to do with the domes that now exist in the Wilcox sand. However, such domes are fully explained by the theory that the materials were deposited originally in an inclined position on the flanks of a hill of pre-Ordovician or pre-Cambrian time. One objection to this theory is that such hills would have to be more or less circular knobs of rather small areal extent which could not be expected. If the beds were in a horizontal position the hills

4. Blackwelder, Eliot, The origin of the central Kansas oil domes: Bull. Am. Assoc. Pet. Geol. vol. IV, No. 1, 1920.
5. Monnett, V. E., Possible origin of some structures of the Mid-Continent oil field: Econ. Geol. vol. XVII, No. 3, 1922.
6. Powers, Sidney, Reflected buried hills and their importance in petroleum geology: Econ. Geol. vol. XVII, No. 4, 1922.
7. Mather, Kirtley F., Superficial dip of marine limestone strata, a factor in petroleum geology: Econ. Geol. vol. XIII, No. 3, 1918.

would be of the knob type rather than the ridge type and although the producing area of a Wilcox dome is rather small, never-the-less the formations generally show a gradual rise from all directions for several miles toward the top of the dome. The development of the domes in the formations above the Wilcox sand is apparently due to a combination of differential settling of sediments together with the deposition of materials on a slope too steep for them to remain in repose.

The shale interval between the Viola limestone and the Boone limestone is much thicker in those wells drilled down the flanks of the Wilcox sand domes than it is in wells drilled on the tops of the domes. Likewise the interval between the base of the Salt sand and

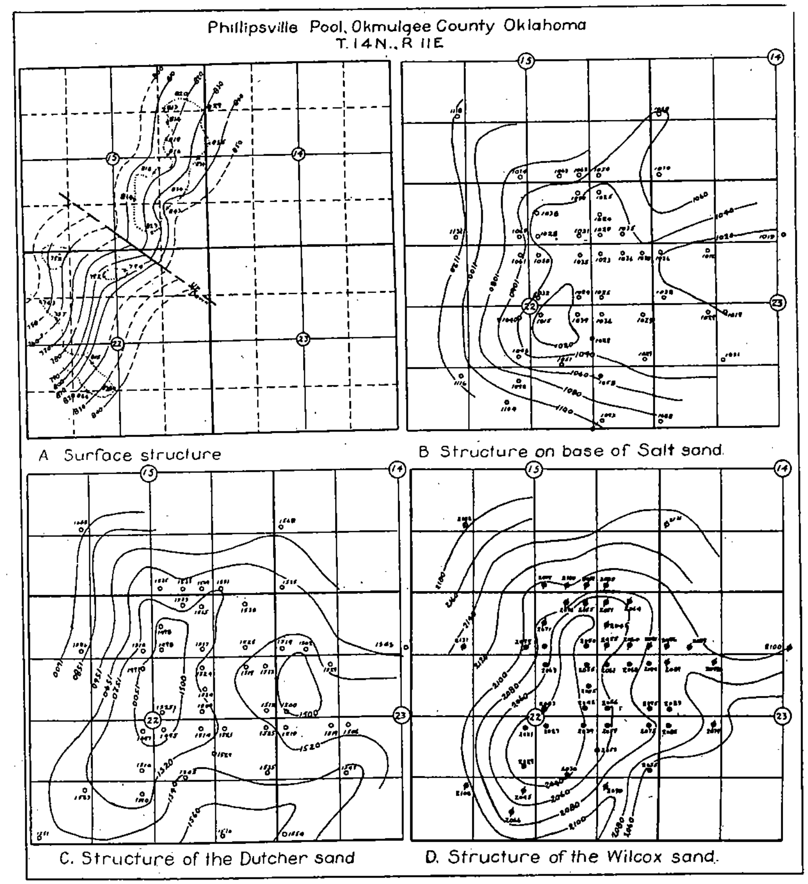


Figure 4.—Structures in the Phillipsville Pool.

the Boone is greater around the edges of the domes than on the tops. Following are some examples of this change if interval to be noted in passing from a well on the flank of a dome over the top to one on the opposite flank. The interval given in this table is that from the base of the Salt sand to the top of the Wilcox sand.

Change of interval between Salt sand and top of Wilcox sand.

POOL-LOCATION	FLANK WELL	TOP WELL	FLANK WELL
Oklahoma Central	SW. Cor. NE¼	Cen. S. L. NW¼ SW¼	Cen. N. L. NE¼ SW¼
Sec. 22. T. 15 N., R. 11 E.	Sec. 28 975	Sec. 22 886	Sec. 22 908
Wilcox	SW. Cor. NE¼ SW¼	Cen. W. L. SW¼	NE. Cor. SE¼ SW¼
Sec. 34, T. 15 N., R. 11 E.	Sec. 34 1029	Sec. 35 920	Sec. 35 938
Billingslea	NE. Cor. NW¼ SE¼	NW. Cor. Sec. 21	NW. Cor. SW¼ SW¼
Sec. 16, T. 15 N., R. 12 E.	Sec. 20. 970	956	Sec. 15 976
South Beggs	NW. Cor. NE¼	Cen. SW¼ SE¼ NE¼	NW. Cor. NE¼ SW¼
Sec. 12, T. 14 N., R. 11 E.	Sec. 13 1006	Sec. 12 959	Sec. 7-14-12 979
Phillipsville	NE. Cor. SW¼ SW¼	NW. Cor. SE¼	SW. Cor. NW.¼
Sec. 22, T. 14 N., R. 11 E.	Sec. 22 1092	Sec. 22 1012	Sec. 23 1051
Brookins	NE. Cor. SW¼ NE¼	SW. Cor. SE¼	NW. Cor. SW¼ NW¼
Sec. 9, T. 13 N., R. 12 E.	Sec. 17 1330	Sec. 9 1257	Sec. 15 1382
Pine-Smith Sec. 12, T. 13 N., R. 13 E.	SE. Cor. NE¼ Sec. 11 1548	NE. Cor. SW¼ Sec. 12 1524	SW. Cor. NE¼ Sec. 7-13-14 1610
Eram	NW. Cor. SE. ¼ SW¼	SW. Cor. Sec. 5	SW. Cor. SE¼
Sec. 5, T. 13 N., R. 15 E.	Sec. 6 1810	1770	Sec. 5 1814

A cross-section through the Eram Pool in a north-south direction and another in an east-west direction also show this change of interval. All the pools that have been developed to the Wilcox sand in Okmulgee County show a similar condition. The slopes of the correlation lines are much steeper in the deeper formations like the Wilcox sand than they are in the shallower formation such as the Salt sand. A set of structure maps of the Eram Pool prepared on the base of the Salt sand, on the Dutcher sand and on the Wilcox sand, Figure 3, show that the deeper the formation the steeper are the flanks of the domes and also the higher are the domes, or the deeper domes show more closure. Every Wilcox pool in Okmulgee County shows this same condition and this set of structure maps may be taken as types.

The cross-sections through the Eram Pool, Figure 3, show the slopes of the correlation lines relatively great in the lower part of the stratigraphic section from the Wilcox sand to the Dutcher sand. From the Dutcher sand upward they flatten out quite rapidly. The fact that the interval between the base of the Salt sand and the top of the Wilcox sand is greater in the flank wells than it is in the wells on the tops of the domes is accounted for principally by an increase in thickness of the shale just above the Viola limestone and the shale just above the Dutcher sand. If the sediments deposited during the time interval represented by the series from the lower part of the Pennsylvanian downward, including the Wilcox sand, had been deposited on an irregular topography, of which the

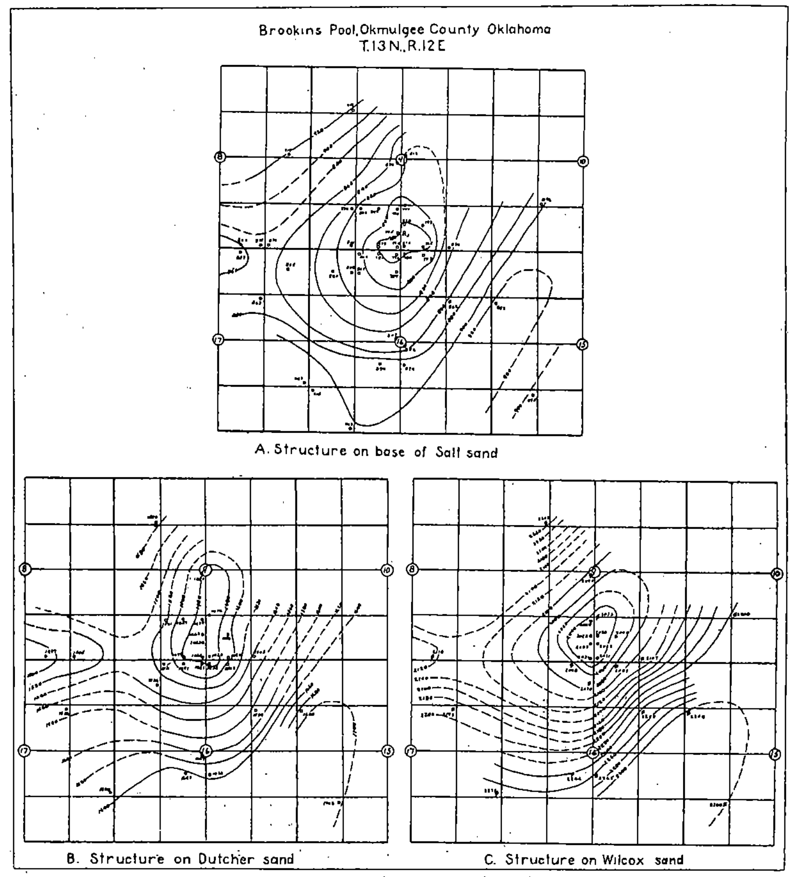


Figure 5.—Structures in the Brookins Pool.

slopes were greater than the angle of repose, gravity would tend to pull the clastic materials, of which the shales and sandstones are composed, down the side of the hills and pile it up around the flanks. This would cause such clastic sediments to be thinner on the tops of the hills than on the sides. A glance at the cross-sections through the Eram dome shows this to be the case. As the clastic material is piled up around the flanks of the hills there would be less initial dip in the successive layers of limestone and all the sediments would have a tendency to flatten out in passing upward from the Wilcox sand.

Opposing this phenomenon is the fact brought out by Blackwelder that the shales are much more compressible than the sandstones and limestones. Thus in those flank wells, where there is a greater thickness of shale between the Boone limestone and the Viola limestone, there is a greater shortening due to compression than in the top wells. This has a tendency to maintain the steep dips noted in the harder and less compressible materials. However, the compacting of sediments is not sufficient to offset the effect of piling up of materials around the flanks of the hills, and the steepness of the dips gradually diminishes in passing upward from the Wilcox sand.

Between the Dutcher sand and the surface the geologic column shows a preponderance of shale. By the time the Dutcher sand had been deposited the piling up of clastic materials around the sides of the hills had reduced the steepness of the slopes until the angle of repose was reached. After that gravitation ceased to pull material down from the top of the hill and pile it up around the flanks. The main factor causing the flatter dips of the formations above the Dutcher sand appears to be the differential compressibility of the sediments on different parts of the domes. Because there is more shale on the flanks than on the tops there is a greater compression on the flanks, which causes the dips in the upper part of the series of sediments. Passing upward toward the surface, the overload gradually becomes less and less, resulting in less compacting of the sediments until, at the surface, only minor irregularities in the normal dip occur.

HISTORY OF DEVELOPMENT

Prior to 1904 there were no producing wells in Indian Territory south of Red Fork. The Indian Bureau of the Interior Department had made no regulations for leasing the land and none was leased outside of townsites. Therefore, the first well drilled in Okmulgee County was a townsite well drilled near the site of the water tower in Okmulgee. It was drilled by the Citizens Oil and Gas Company to the Salt sand at a depth of 1,272 feet and shot on May 23, 1904. It produced six or seven barrels a day for about a week and was then abandoned. About the same time the Boggs

Drilling Company drilled a dry hole in Okmulgee where W. A. Hiatt's home now stands. This hole was 1,320 feet deep. The next hole was also dry and was drilled in the townsite of Beggs

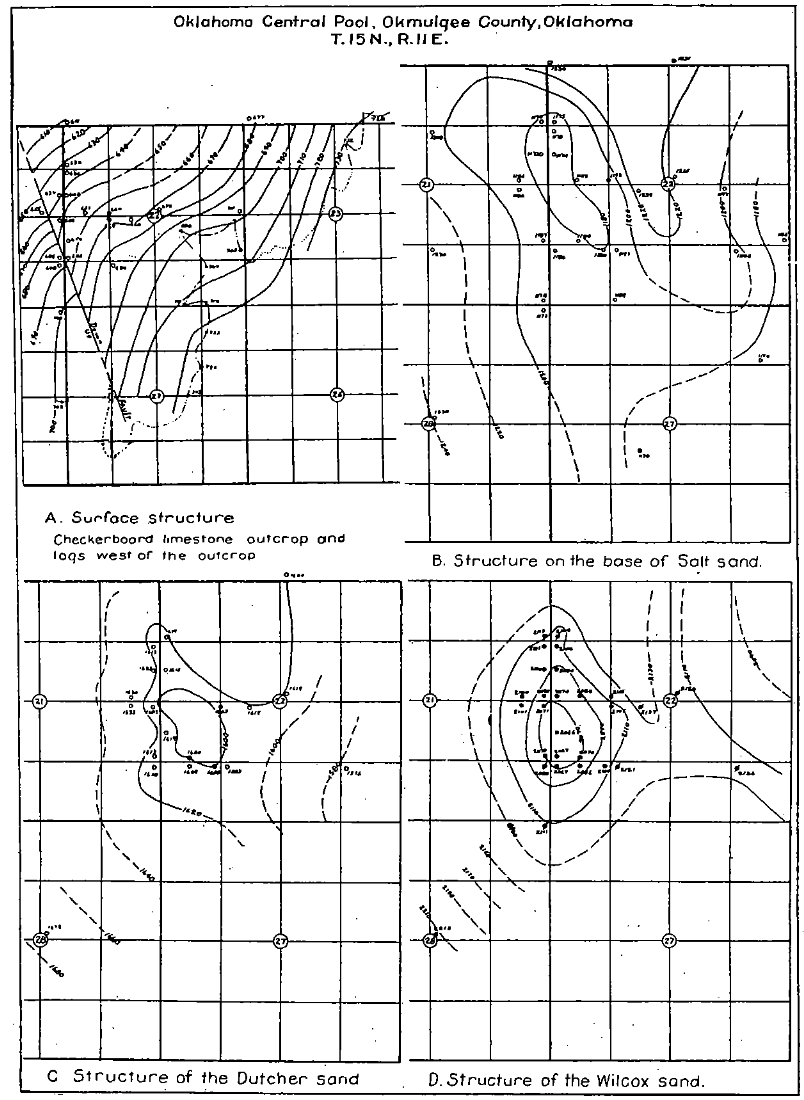


Figure 6.—Structures in the Oklahoma Central Pool.

by O. K. Peck et al, to a depth of about 1,500 feet. Late in 1904 a gas well was drilled in the south edge of Henryetta. It furnished gas to the city for a number of years. This well is still producing enough gas to operate a gin although it is twenty-two years old.

On April 21, 1904, Congress passed an act in which "All restrictions upon alienation of the lands of all allottees of either of the Five Civilized Tribes, who are not of Indian blood, except minors, are, except as to homesteads, hereby removed." This opened the way for extensive leasing of Indian lands in Okmulgee County and development began to increase rapidly.

In 1906 two gas wells were drilled in the townsite of Morris to the 1,200 foot sand, afterwards called the Booch sand. In the fall of that year Dr. L. S. Skelton laid a gas line to Okmulgee to supply that city with gas from the Morris wells. In the same year two gas wells were drilled in sec. 27, T. 13 N., R. 14 E., but this gas was not used extensively except for drilling in the vicinity. Another important well drilled in 1906 was located in the NW.¼ sec. 20, T. 13 N., R. 14 E., on the Booch farm and gave the name to the Booch sand, which afterwards became famous for large wells. This well, however, was only a 10 barrel well after a shot and was never commercially produced.

Early in 1907, C. A. H. deSaulles, representing the Tulsa Fuel and Manufacturing Company, a Guggenheim subsidiary, drilled a well in the southeast corner of sec. 20, T. 13 N., R. 14 E. It was completed to the Morris sand at a depth of 1,486 feet in March and produced about 5,000 barrels of oil after which it was shot and went to water. The diagonal offset to this well in the northwest corner of sec. 28, T. 13 N., R. 14 E., was completed in May, 1907, and is still producing, being nearly twenty years old. This started intense activity in the Morris area.

The Shulter Shoestring was opened up by Smith and Swan in 1907 with the "Picnic Well." This well was drilled in sec. 22, T. 12 N., R. 13 E., near where Coalton now is. It made 60 barrels from the 1,800 foot sand. A picnic was planned and people invited to come and see the well. They came from far and near bringing their lunches so this was called the Picnic Well. Later some very large wells were obtained in this pool.

The north end of the county was not neglected in this early day. In 1907, Smith and Swan got a gas well in the 2,100 foot sand in the SW. corner of section 20, T. 16 N., R. 12 E., and this one well supplied gas to Mounds for ten years.

In the early spring of 1908, Joe Burns and Lou Caton completed a well near the center of the NE.¼ sec. 6, T. 14 N., R. 14 E. The sand was 1,661 feet deep and the well came in for 400 barrels.

This is the first well in the Bald Hill area and started the development there. In the same year Bob Galbraith came down directly from the Glenn Pool and drilled a good well in sec. 22, T. 15 N., R. 14 E. He found the sand around 1,700 feet deep, and, being about the same depth as the pay in the Glenn Pool, he called it the Glenn sand. That name stuck but the correlation was not correct as this is a member of the Dutcher group while the real Glenn sand is the Salt sand.

In the spring of 1908 the Tiger Oil and Gas Company completed a well a little over 2,300 feet deep in the southeast corner of the W.½ NW.¼ sec. 10, T. 12 N., R. 12 E. It flowed 270 barrels a day for a few days until all the tankage was full when it was shut in. Two years later when it was opened up there was no oil there and the offsets were dry. The boiler and tools for this test were the first to cross the old wooden bridge across the Deep Fork in sec. 22, T. 13 N., R. 12 E., and the teamster demanded insurance on his team before he would take them over. The next year the Aztec Oil Company opened a small pool around the center of sec. 9, T. 12 N., R. 12 E., and some of these wells are still producing. The Mitchell Oil Company drilled its first well near the center of the NE.¼ sec. 30, T. 12 N., R. 12 E., in the early spring of 1913. The production here was in the 1,900 foot sand. This was the beginning of the development of the Tiger Flats area.

In August, 1909, Alex Preston completed the first well in the Hamilton Switch Pool. It was an edge well but started the development in sections 11 and 12, T. 14 N., R. 12 E., where wells of very large initial production were obtained in the Dutcher sand.

The Salt Creek Pool was opened by a well on the north line of the Tobler allotment in sec. 25, T. 13 N., R. 11 E., in October, 1910. The land was owned by Chas. Douglas who sold townsite lots under contract to have a well drilled on the townsite. Newman, Galigan and Sparks owned the leases and turned them over to the Prairie Oil and Gas Company for a consideration of $20,000.00, payable entirely in oil. The Prairie drilled the well to a depth of 2,367 feet and got about a 200 barrel well. The bonus on the lease was paid out and this was the first production in the western part of Okmulgee County.

The gas field lying east of Henryetta, partly in Okmulgee and partly in McIntosh Counties, was developed in 1909 and 1910. In the latter year there was so much gas in sight there that smelters were brought to Henryetta to furnish a market for the gas.

The area west of Henryetta was opened in August, 1912. After two or three failures had been made by others, M. C. French drilled the first successful oil well in the southwest corner of the SE.¼ SW.¼ sec. 8, T. 11 N., R. 12 E. The sand was 1,100 feet deep. Several wells were later completed to this sand and deeper sands were found.

From these beginnings development spread rapidly throughout the county. In 1913, T. A. Johnston and Northrup demonstrated the value of shooting the Booch sand in a well in the southwest corner of the NW.¼ sec. 1, T. 13 N., R. 14 E., and thus started an intense development campaign in the 13-14 and 14-14 area for Booch sand wells. Some of these wells would have only a show but after a heavy shot would produce up to 500 or 600 barrels. One Booch sand well in sec. 13, T. 14 N., R. 14 E., is reported to have made 5,000 barrels a day.

One of the most interesting wells in the county from the standpoint of its effect upon the county as a whole is the Huckaby No. 1, drilled by the Okmulgee Producing and Refining Company in sec. 25, T. 14 N., R. 11 E. It was completed in January, 1918, in the Youngstown sand and started the development in the Youngstown Pool, which was the beginning of a new era of prosperity for Okmulgee and Okmulgee County. The well was located without the aid of a surveyor and its location was later found to be wrong by 300 feet or more. Later development showed that if it had been drilled in the correct location it would probably have been dry and this pool might never have been opened or its opening at least delayed for some time. The year 1918 markd the beginning of deeper drilling to the Wilcox sand in Okmulgee County and development has been going on ever since all over the county in an effort to locate production from deeper sands, especially the Wilcox sand. The following table shows the year in which the principal Wilcox sand pools of the county were opened up.

Wilcox Sand Pools.

NAME OF POOL	LOCATION	YEAR OPENED
Brinton	9-13-12	1918
Deep Fork	26-13-12	1919
South Beggs	12-14-11	1919
Turman	35-15-11	1919
Wilcox	30-15-11	1919
Phillipsville	22-14-11	1920
Mose Carr	34-15-14	1920
Morris (Gas)	18-13-14	1920
Independent	22-15-14	1921
Oklahoma Central	22-15-11	1921
Eram	5-13-15	1921
Sheridan	22-16-12	1923
Pine-Smith	12-13-13	1923
Devonian	7-15-13	1925
Olean	14-15-12	1925
Roxana	15-13-14	1925
Jolly-Ogg	16-15-14	1926

Total Completions in Okmulgee County.

	Total Holes	Oil Wells	Gas Wells	Dry Holes
From June. 1907, to Dec. 31, 1921.	9,058	5,768	824	2,466
1922	661	335	103	223
1923	562	259	71	232
1924	110	188	51	171
1925	542	296	48	198
1st half 1926 to June 30	291	142	41	108
Totals	11,524	6,988	1,138	3,398
Percentages	100	60.6	9.9	29.5

Total Production of Okmulgee County.

(Barrels of 42 gallons each)

1918	6,128,437
1919	11,272,879
1920	17,401,316
1921	11,814,567
1922	9,110,780
1923	7,326,202
1924	7,164,543
1925	7,225,667
1st six months of 1926	4,219,923
Total	81,664,314

The above are actual pipe line runs from Okmulgee County. Previous to January 1, 1918, Okmulgee and many adjoining counties were not classified separately, but were grouped together and there are no available records regarding the actual production of Okmulgee County in the years preceding 1918.

All of the above figures are from the files and official records of the Okmulgee District Oil and Gas Association.

NATURAL GASOLINE

The manufacture of gasoline from natural gas is a very important industry in Okmulgee County. There are forty plants in operation in different parts of the county and they have a combined daily capacity of 73,075 gallons of gasoline. Both the compression and the absorption types of plant are in use and in some plants both processes are used. Following is a table showing the plants in the county January 1, 1926.

FUTURE POSSIBILITIES

Although a first glance at the production map, (Plate I) would seem to show that Okmulgee County had been pretty thoroughly developed, never-the-less there are several thousand acres of potential oil land in the county that have never been tested by the drill. Thousands of acres are now or have been producing

Gasoline plants operating in Okmulgee County

OPERATOR	Location	Type	Daily Average Production
Twitchell & Myers	12–14–14	1 Unit Comp.	200 Gals.
Denver P. & R. Co.	32–13–11	2 Unit Comp.	900 "
Burke Pet. Corp.	22–13–12	3 " "	350 "
Pure Oil Co.	9–13–12	2 " "	1,000 "
Okmulgee P. & M.	13–12–12	2 " Absorp.	1,200 "
Atlantic Pet. Corp.	19–13–13	2 " Comp.	750 "
Barbara Oil Co.	8–13–13	2 " "	Shut Down
Devonian Oil Co.	29–13–13	4 " Absorp.	3,000 Gals.
Cosden	12–13–13	4 " "	2,600 "
Chestnut & Smith	28–13–14	5 " Comp.	800 "
TNC Gasoline Co.	22–13–14	5 " "	5,000 "
TNC Gasoline Co.	11–13–14	1 " "	200 "
Tidal Oil & Ref'g Co.	36–12–13	4 " "	1,800 "
Twitchell & Myers	35–12–13	1 " "	75 "
Tiger Mt.	35–12–13	1 " "	250 "
Aztec Oil Co.	6–11–12	4 " Absorp.	2,500 "
Henryetta Ref'g Co.	8–11–12	4 " Comp.	Shut Down
Magnolia Petroleum Co.	1–11–13	1 " "	550 Gals.
Eagle Picher Lead & Zinc Co.	6–11–13	2 " Absorp.	2,500 "
Blue Ribbon Gasoline Co.	35–15–11	4 " Comp.	Shut Down
H. F. Wilcox	36–15–11	2 " "	1,000 Gals.
H. F. Wilcox	30–15–11	2 " "	1,500 "
Phillips Petroleum	11–15–12	10 " "	12,000 "
Benmo Oil Co.	28–15–14	Vacuum Sta.	
Highway Oil & Ref'g Co.	29–15–14	2 Unit Comp.	1,000 "
Invaders Oil Co.	31–15–14	3 " "	700 "
Sinclair Oil & Gas Co.	23–15–14	4 " "	1,800 "
Texas Company	22–15–14	4 " "	6,500 "
TNC Gasoline Co.	28–15–14	3 " "	2,200 "
Phillips Higrade	23–14–11	2 " Absorp.	7,500 "
Powers & Quinlan	11–14–12	4 " Comp.	1,200 "
Mid-Continent Oil Dev.	12–14–12	1 " Absorp.	300 "
Oil State Gasoline Co.	7–14–12	2 " Comp.	600 "
Polar P. & R.	5–14–12	Shut Down	
Texas Company	11–14–12	1 Unit Comp.	1,000 "
Waite Phillips Co.	6–14–12	8 " Absorp.	3,500 "
Highway Oil & Ref'g Co.	34–14–13	1 " "	600 "
Invaders Oil Co.	33–14–14	1 " Comp.	50 "
Elm Oil Co.	13–14–14	2 " "	300 "
Sequoyah Oil Co.	10–14–14	2 " "	Shut Down

from the shallowest sand like the Salt sand and the Booch sand and have never been tested below them while only a small portion of the county has been properly tested to the deepest known pay, the Wilcox sand. In other words, in addition to the virgin territory there is still a great area to be tested by deeper drilling and the extent of that area is directly proportional to the stratigraphic depth of the pay sand. A great deal of development is now going on throughout the county and the goal of each test is the Wilcox sand. However, it frequently happens that the test never reaches that depth because a good well is found in some one of the shallower sands. Possible pay horizons deeper than the Wilcox sand should also receive due consideration since it has been shown by tests in different parts of the county that the Hominy or Burgen sand and also the Siliceous lime or Turkey Mountain sand contain oil. It is quite probable that somewhere the conditions for accumulation are favorable and paying production will be obtained from these sands.