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OIL AND GAS IN OKLAHOMA

THE GEOLOGY OF THE OIL AND GAS FIELDS OF STEPHENS COUNTY, OKLAHOMA

By

Frank Gouin

Duncan, Oklahoma

NORMAN

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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.

The Chapter on Stephens County, Oklahoma, has been prepared by Mr. Frank Gouin of Duncan. Mr. Gouin has spent several years in this county and is well acquainted with the geology of southwestern Oklahoma.

CHAS. N. GOULD,
Director

September, 1926.

OIL AND GAS IN OKLAHOMA

THE GEOLOGY OF THE OIL AND GAS FIELDS OF STEPHENS COUNTY, OKLAHOMA

By

Frank Gouin

INTRODUCTION

GENERAL STATEMENT

It is the purpose of this report to present to the reader very briefly the geology of the oil and gas fields of Stephens County so that one unfamiliar with the county may get a general idea of conditions in the present producing pools and what might be expected from future pools yet to be discovered. To properly cover such a subject it is necessary not only to discuss the geology but the related subjects of drilling and production. It is much easier to evaluate a prospective area when one knows how much profit has been derived from pools in the vicinity. Thus considerable space is devoted in this report to production figures of the various pools. Much could be written on any one of several subjects covered in this report but it is hoped that the salient features of these various subjects have been mentioned. If this report results only in a little more care being taken in the drilling of wells in southern Oklahoma the writer will feel that his efforts have been amply rewarded.

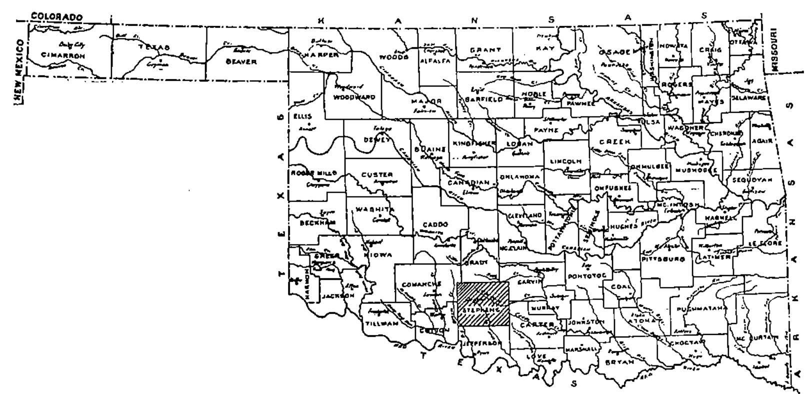


Figure 1.—Index map of Oklahoma showing area covered by this report.

LOCATION

Stephens County is located in the south-central part of the State, being one of the second tier of counties north of Red River. It extends from T. 2 N., to the center of T. 3 S., inclusive and from R. 4 W. to the center of R. 9 W., inclusive, embracing an area of some 891 square miles. Duncan, the county seat, lies in the west-central part of the county. Fig. 1.

ACKNOWLEDGMENTS

The writer wishes to acknowledge the following individuals and companies who have furnished data for this report: The Amerada Petroleum Corporation, Sidney Powers, Chief Geologist and R. A. Birk, Division Geologist, who furnished the base maps and copies of monthly pipe line runs from the producing properties listed in this report; E. D. Luman and F. A. Bush of the Atlantic Oil Producing Company, Knox Garvin and Harry Hanbury. In addition acknowledgment is due to the following fellow geologists in southern Oklahoma who have given valuable suggestions: F. W. Floyd, P. G. Russell, George Burton and Ed. W. Owen. The writer is especially indebted to Dr. Chas. N. Gould for much helpful assistance in the preparation of the manuscript.

EXAMINATION

Although oil and gas have been produced in the county since 1912, very little information has been published concerning the oil and gas pools within its borders. Wegemann's[1] bulletin on the Cruce and Loco fields was the only information on the county until late in 1917 when Bulletin 19, Part II. of the Oklahoma Geological Survey, entitled "Petroleum and Natural Gas in Oklahoma" was published. The Stephens County portion of this bulletin was merely an elaboration of Wegemann's earlier work for these were still the only producing pools in the county at the time the U. S. Geological Survey bulletin was written. In 1919 the U. S. Bureau of Mines published a bulletin on the Comanche pool entitled, "Underground Problems in the Comanche Oil and Gas Field," by T. E. Swigart[2]. This report was published in cooperation with the State of Oklahoma. Short sketches of the shallow pools of Milroy and Velma in the eastern part of the county by Storm[3] appeared in 1924. This is the whole of the published material to date on the county on this subject. Numerous references to the general area of southern Oklahoma are present in the literature pertaining to regional geology, stratigraphy and paleogeography.

1. Wegemann, C. H., The Duncan Gas Field, Oklahoma and the Loco Gas Field Oklahoma: U. S. Geol. Survey, Bull. 621, Part 2, pp. 31 and 43, 1915.
2. Swigart, T. E., Underground Problems in the Comanche Oil and Gas Field, Oklahoma: U. S. Bureau of Mines Bull. 1919.
3. Storm, W., The "2-4" Shallow Field and the Velma Oil and Gas Field, Oklahoma: Am. Assoc. Pet. Geol. Bull. vol. 5 No. 5, p. 626, 1924.

TOPOGRAPHY

Stephens County is located within the red beds plains region of Oklahoma. The general nature of the surface of the ground is that of a gentle hilly country. Since all of the drainage is to the south and east the highest elevations are in the northern and northwestern part of the county—around 1,400 feet above sea level, while the lowest are in the southern part—less than 800 feet. The western half of the county is drained by Beaver Creek and its tributaries into Red River; the central portion of the county by Cow Creek, Mud Creek and their tributaries draining also into Red River, while the eastern part of the county is drained by Wildhorse Creek which drains into the Washita River.

STRATIGRAPHY

SURFACE GEOLOGY

GENERAL STATEMENT

The surface rocks of the county all belong to the Permian system[4]. An areal map of the surface formations is shown in Plate I. The outcrop boundaries for this map from the Duncan sandstone up were taken from the geological map of Oklahoma by H. D. Miser, published by the U. S. Geological Survey in cooperation with Oklahoma geologists and oil companies. Those below the Duncan sandstone are by the writer. Roughly a little more than half of the southern part of the county is covered by rocks belonging to the Wichita-Clear Fork formation, while a little less than half of the northern part of the county is covered by rocks belonging to the Enid formation. The escarpment of the Duncan sandstone, which is a noticeable topographic feature, is the dividing line between these two formations.

The rocks of the Wichita-Clear Fork division consist of brick red and gray colored shales, sandstones and mudstone conglomerates. They vary locally, both as to color and character. Horizons in this division can be traced in an east-west direction across the country when followed as zones rather than by attempting to follow any particular bed. The normal dip, which is slightly east of north, is probably about thirty feet to the mile. These rocks are gently folded over their areal extent in the county. An elongated dome is the most common form of folding with a closure generally of from twenty to thirty feet.

The Duncan sandstone, rests unconformably (?), upon the top of the Wichita-Clear Fork formation. This sandstone derives its name from the city of Duncan, the escarpment being within a mile of that city. It is a heavy-bedded reddish sandstone, locally gray, having a thickness from about 75 to 150 feet. In the central portion of the county there are three main beds of sandstone interbedded with light colored shales. The top member is the most consistent throughout the

4. Gould, Chas. N., Index to the Stratigraphy of Oklahoma, Oklahoma Geological Survey Bull. 35, 1925.

county. Above the Duncan sandstone is the Chickasha formation, which is composed of vari-colored shales, red shades predominating, and lenticular reddish sandstones. These sandstones are locally gray. This formation has a thickness of about 200 feet. Horizons in this formation are difficult to trace with assurance for any distance. The Duncan sandstone dips to the northeast in the northwestern part of the county at the rate of 60 to over 100 feet to the mile. Folds on the Duncan sandstone are very steep as compared to those on the underlying Wichita-Clear Fork rocks. It is this difference in the rate of dip and type of folds which suggests an unconformity between these two formations.

Above the Chickasha formation in the extreme north-central part of the county, named in order from the oldest to the youngest formations, are the Blaine gypsum, Dog Creek shale and Whitehorse sandstone. The Blaine gypsum in the county does not contain the massive beds of gypsum and dolomite that are a part of that formation farther northwest, but is composed mainly of red clay shales and thin beds of gypsum and gypsiferous shales. This is also true of the horizon of the Dog Creek shale. The area covered by the Whitehorse sandstone can easily be identified by the high hills northeast of Marlow that are covered with loose sand weathered from this friable formation. Otherwise the description of these formations is as described in Bulletin No. 35 of the Oklahoma Geological Survey.

SUBSURFACE GEOLOGY

GENERAL STATEMENT

It might be in order here to set out some of the difficulties which present themselves to one who attempts to discuss the subsurface geology of southern Oklahoma and Stephens County. The foremost problem to combat is that throughout the entire Carboniferous system present in the county there is not one horizon marker which shows up in well logs by which one can correlate with assurance. The second big problem, which, if corrected might partially offset the first, comes by reason of the fact that probably over ninety-five per cent of all wells in the county have been drilled by the rotary method. This includes wildcats as well as those drilled in pools. This in itself would not be so bad were it not for the fact that in the majority of the rotary drilled wells no attention whatever seems to have been given to the cuttings except when it was thought that a sand was being drilled. In the absence of massive limestones and other definite markers which cover widespread areas in the northeastern part of the State, we lose our best point for correlation, namely, the colors of the shales. The third problem, a correction of which would entirely solve the second and which would without doubt clear up the entire situation, is that of saving cuttings as each well is drilled. When the practice of saving cuttings becomes general in this district, then will the subsurface geology and geologic history of the whole of southern Oklahoma become like an

open book and many thousands of dollars, now being expended in useless drilling, will be saved. In the discussion below, wherever correlations are mentioned that are based on identifications from well samples, this information is so stated. Where no such information is stated, it is to be assumed that the correlations are those of the writer based upon his own observations, none of which are from a paleontological standpoint. All correlations are made with the full realization that as time goes on and the saving of samples becomes a general practice, the writer will be found to be in error in many of his statements.

PRE-CAMBRIAN

The granites and other igneous rocks of the basement complex, presumably underlie the entire county, although no well has been drilled to it. The pre-Cambrian rocks can no doubt be reached at comparatively shallow depths on some of the buried hills in the county.

CAMBRIAN

It is also presumed that the Reagan sandstone is present on the pre-Cambrian rocks for it is exposed to the northwest on the northeast flanks of the Wichita Mountains and to the east in the Arbuckle Mountains. For a description of this sandstone, see "Index to the Stratigraphy of Oklahoma" by Chas. N. Gould, Bulletin 35 of the Oklahoma Geological Survey—page 11, 1925.

CAMBRO-ORDOVICIAN

The Arbuckle limestone probably underlies the whole county, unless there are buried hills not yet discovered, upon which this limestone has been entirely eroded before the deposition of the younger rocks. The following is a list of wells in the county which are known to have encountered the Arbuckle limestone. Included in this list are also wells which are thought to have encountered rocks of this age. There are other wells in the county which have possibly encountered Arbuckle limestone, but the evidence is too vague to be sure of it.

1. Amerada Petroleum Corporation, Blaydes No. 10, NE.¼ NE.¼ sec. 32, T. 1 S., R. 8 W. Arbuckle from 3,367 to 3,600 feet, total depth of well. Identification by Amerada geological department from samples. Personal communication from Sidney Powers.
2. Magnolia Petroleum Company, Hall No. 1, NE.¼ SW.¼ sec. 29, T. 1 S., R. 8 W. Arbuckle (?) from 3,500 to 3,860 feet.
3. Comanche Petroleum Company, Wilson No. 4, NE.¼ NE.¼ sec. 19, T. 2 S., R. 7 W. Arbuckle from 3,410 feet to 3,635, total depth of well. Ientification by V. V. Waite.
4. Magnolia Petroleum Company, Brown No. 1, SW.¼ NW.¼ sec. 19, T. 2 S., R. 7 W. Arbuckle (?) from 3,505 to 3,835, total depth of well.
5. Magnolia Petroleum Company, Brooks No. 4, NE.¼ SW.¼ sec. 25, T. 1 S., R. 9 W. Arbuckle (?) from 3,017 to 3,102 feet, total depth of well.
6. Magnolia Petroleum Company, Fleming No. 1, NE.¼ NW.¼ sec. 26, T. 1 N., R. 9 W. Arbuckle (?) from 2,880 to 3,250 feet total depth of well.
   All of these wells are on the axis of the southeast extension of the Wichita uplift.
7. Lone Star Gas Company, Ida Billy No. 2½, NW.¼ SE.¼ sec. 9, T. 3 S., R. 5 W. Arbuckle (?) from 1,560 to 2.520 feet, total depth of well. Goldston[5] states that the producing section in the Loco field rests upon the Ar-

5. Goldston, W. L., Jr., Differentiation and Structure of the Glenn Formation: Am. Assoc. Pet. Geol. Bull. vol. 6, No. 1, p. 12, 1922.

buckle limestone. He probably based his evidence on this well, but he does not state upon what the identification was based or who made the identification.

8. Magnolia Petroleum Company, NE.¼ SE.¼ sec. 26, T. 2 S., R. 6 W. Arbuckle from 2,725 to 3,680 feet, total depth of well.
9. Magnolia Petroleum Company, NW ¼ SE.¼ sec. 25, T. 2 S., R. 6 W. Arbuckle from 2,700 to 3,360 feet total depth of well.

Note—Wells 8 and 9 above are located on the upthrow side of a large subsurface fault. For this reason and because of the thickness of limestone drilled, it is assumed that this is Arbuckle rather than Viola limestone. As noted below, many wells in this township have drilled ino the Viola limestone. For a description of the Arbuckle limestone, see Bulletin 35 of the Oklahoma Geological Survey, p. 13.

ORDOVICIAN

The Simpson formation is found resting upon the Arbuckle limestone with the Viola limestone occurring next above. Due to the immense amount of erosion which took place subsequent to the deposition and elevation of the Viola limestone, all of the Viola and Simpson, which at one time covered the entire county, has been eroded from the tops of many of the buried hills. This is especially true along the southeast extension of the Wichita Uplift. The following wells are known or are thought to have encountered either the Viola limestone alone or both the Viola limestone and Simpson formation.

1. Lone Star Gas Company, Martin No. 1, center of the east line of sec. 7, T. 2 S., R. 6 W., Viola from 3,407 to 3,480 feet, total depth of hole. Producing a small amount of oil in breaks in the Viola.
2. Magnolia Petroleum Company, southeast corner SW.¼ sec. 14, T. 2 S., R. 6 W. Viola (?) from 3,540 to 3,710 feet. Shows of oil in this lime.
3. H. F. Wilcox Oil and Gas Company, norheast corner sec. 17, T. 2 S., R. 6 W. Viola from 3,410 to 3,625. Hole full of water in top of Simpson at 3,655 feet, total depth of well.
4. The Texas Company, NW.¼ SE.¼ sec. 19, T. 2 S., R. 6 W. Viola from 3,012 to 3,184 feet, Simpson formation from 3,184 feet to a total depth of 3,570 feet.
5. Magnolia Petroleum Company, northeast corner SE.¼ sec. 22, T. 2 S., R. 6 W. Viola (?) from 3,300 to total depth of well of 3,610 feet.
6. Magnolia Petroleum Company, NE.¼ SW.¼ sec. 24, T. 2 S., R. 6 W. Viola (?) from 3,473 to total depth of well of 3,692 feet. A show of oil was encountered in this limestone at 3,550 feet which was shot but failed to produce in commercial quantities. Samples of the Viola were obtained when blown out after the shot.

For a description of these two formations, see Bull. 35, Oklahoma Geological Survey, pp. 14-15.

POST-VIOLA—PRE-PENNSYLVANIAN ROCKS

There is no evidence of any rocks of an age between the top of the Viola and the base of the Pennsylvanian in any well that has been drilled around the Wichita Mountains, or in any well which has been drilled in Stephens County to the knowledge of the writer, therefore, it is presumed that this area was a positive element during these periods and that there was no deposition representing that interval of geological time. If there are rocks representing that time interval they are present in the regionally lowest places in the county, which would be in the extreme southwestern and notheastern parts. It is also quite likely that if present at all they are extremely thin, possibly being something like the equivalent interval in the section north of the Llano-

Burnett Uplift in Texas, part of which is described by Roundy, Girty and Goldman[6].

PENNSYLVANIAN

Up to the time of this writing geologists working in southern Oklahoma have been puzzled as to the part of the Pennsylvanian section that is represented in this county and south-central Oklahoma in general. Pennsylvanian fossils have been noted in the cuttings from various wells throughout this general district, but paleontologists have not been able to correlate such fossil horizons with a known section from some type locality. Now that the immense value of the study of micro-fossils is becoming generally known, a study is being made of well cuttings throughout the country. With the increasing importance of production from the Glenn formation in southern Oklahoma, an intensive study of the micro-fauna of that formation is now being made by microscopic paleontologists of several of the major oil companies. E. D. Luman and F. A. Bush of the microscopic division of the geological department of the Atlantic Oil Producing Company, have kindly taken the time from their work to make the correlations listed below. With just these few correlations a wonderful start is made toward the solution of the problem of the differentiation of the Pennsylvanian section in the Duncan district.

While drilling a well for the McMan Oil Company in the Empire pool in the southeast corner NW¼ sec. 33, T. 1 S., R. 8 W. some three years ago, the Garvin Drilling Company took a core of blue shale at a depth of 2,617 feet. Because the core was full of fossils Mr. Knox Garvin gave it to the writer. Luman and Bush have lately examined this core with the result that they state that it is older than the Deese member of the Glenn formation, but whether it is equivalent to the Cup Coral or Otterville limestone members their present studies of the Glenn have not progressed far enough for them to say. This core was taken 400 feet stratigraphically below the Blaydes sand.

The same men examined a full set of cuttings from the Hanbury well drilled to a depth of 2,504 feet in sec. 12, T. 3 S., R. 7 W., with the result that they place the section from a depth of 1,852 feet to the bottom of the hole as belonging to the upper-middle portion of the Hoxbar member of the Glenn. In sec. 2, T. 3 S., R. 7 W., the Kay County Gas Company drilled a well to 3,015 feet. They identified a sample from this well from a depth of 2,140 to 2,165 feet, as tying into the Glenn section at upper-middle Hoxbar. They indentified the following forms:

Healdia near *simplex* in abundance
Bairdia beedei
Bythocypris sp.
Two unidentified species of gastropods
Productid spines and crinoids.

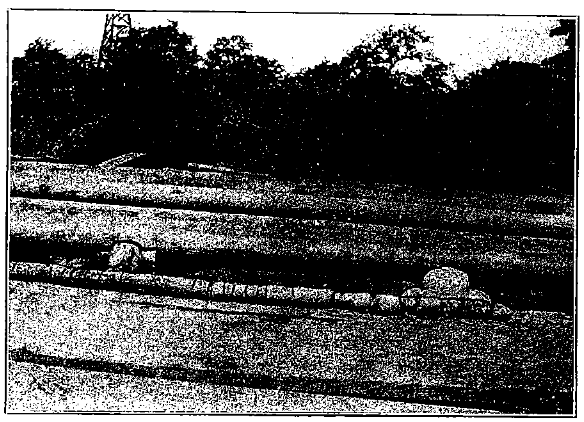
6. Roundy, P. V., Girty, Geo. H., and Goldman, M. I., Mississippian formations of San Saba County, Texas: U. S. Geol. Survey, Prof. Paper 146, 1926.

They examined the cuttings from a well drilled by the Atlantic Oil Producing Company in sec. 33, T. 3 S., R. 7 W., in Jefferson County, a little over two miles south of the Stephens County line which was drilled to a depth of 3,500 feet. The top of the Glenn was encountered slightly below 1,800 feet. The section from that depth to the total depth belonged to the Deese member of the Glenn. Two wells lately drilled in T. 3 S., R. 6 W., one in sec. 2 and the other in sec. 11, both to 2,000 feet, were identified by Carter Oil Company paleontologists, as being in the upper part of the Glenn formation from a depth of about 1,400 feet on down.

Besides the information given above, the following general information which has been determined by means of the identification of the larger fossils in cuttings from miscellaneous wells is of great help in this problem. Sidney Powers states that the cuttings from the Amerada Petroleum Company deep test Well No. 1 in sec. 32, T. 1 S., R. 8 W.,—under "Cambro-Ordovician," show that the Pennsylvanian-Arbuckle contact in this well was at a depth of 3,367 feet.

In several cases shale cores taken from around the Blaydes sand horizon (2,200 feet) in T. 1 S., R. 8 W., have been sent to various eminent paleontologists for their opinion as to the position of this horizon in the section. The general average of their opinions would favor placing this horizon not younger than middle Pennsylvanian. Their ideas were formed from comparing the larger fossils in the cores with type fossils in the section exposed in the Coalgate quadrangle.

PLATE III



CORE TAKEN FROM WELL IN SEC. 22, T. 1 S., R. 8 W.
Cutter head used in taking the core on left between core and drill pipe. Nine feet of core taken at one time and broken into sections for examination of the formation.

Considering all the evidence above with special emphasis being placed on the fact that the Pennsylvanian extends down to a depth of 3,367 feet in the Amerada well mentioned, the writer is inclined to place the horizon from which the McMan core was taken as belonging to the Cup Coral member. From this it is assumed that all of the producing horizons of this general district from the Surber sand zone (1,700 feet) down belong to the Cup Coral member. This would include the Empire, West Duncan, North Duncan, and the other small adjacent pools. Coupling this data with that from the Hanbury well in T. 3 S., R. 7 W., and the Atlantic et al well in T. 3 S., R. 6 W., it would seem that the amount of Glenn section now present in the county is dependent upon the relation any area has to the general highs. It is quite probable that the Glenn section in general thickens toward the eastern limits of the county in the direction of the thickest portion of formation which is in the Ardmore basin of Carter County. When the different factors which influenced the deposition and subsequent erosion of the Glenn formation prior to the deposition of the post-Glenn sediments are considered, it can easily be seen that a study of the cuttings from numerous wells scattered throughout the county will be necessary before the present distribution of the members of the Glenn formation is known.

The Glenn formation discussed in this report is the Glenn of Taff[7] and Goldston[8] as amended by Girty and Roundy[9].

Overlying the rocks of the Glenn formation over a large part of the county is a section of rocks which the writer classes as belonging to the Pontotoc group. This correlation is based on lithology alone. The correlation of the Carboniferous rocks above the Glenn is an extremely difficult problem and one that has not yet been solved in southern Oklahoma. The paucity of fossil evidence at the outcrop of these formations makes this problem difficult of solution, hence it is still more difficult when the formations are underground. The evidence for the correlation has been collected by the writer while watching the drilling and collecting the cuttings from scattered wells in this and adjoining counties, and from a study of the logs of numerous wells. In the Hanbury well in sec. 12, T. 3 S., R. 7 W., between the base of the red shales at a depth of 1,270 feet, and the Glenn formation at a depth of 1,852 ft., there is a series of thick beds of coarse sands and conglomerates with some thin beds of blue shales. The coarse sands are composed of large grains of quartz, varying from about the size of a radish seed to that of a small grain of corn. The conglomerate is made up of limestones and cherts from pre-Pennsylvanian rocks with coarse sand filling the interstices. Since the conglomerate pebbles were broken up by the drill, their size is unknown. A piece of pebble, which had been possibly an

7. Taff, J. A., Preliminary Report on the Geology of the Arbuckle and Wichita Mountains in Indian Territory and Oklahoma: U. S. Geol. Survey Prof. Paper 31, 1904.
8. Goldston, W. L., Jr., Op. cit.
9. Girty, Geo. H., and Roundy, P. V., Notes on the Glenn formation of Oklahoma: Am. Assoc. Pet. Geol. Bull. vol. 7, No. 4, p. 331, 1923.

inch in diameter, was found in the cuttings which fits exactly the description of the banded pebbles in the Hart limestone member mentioned by Birk[10]. In fact, the interval between 1,170 and 1,852 feet in this well checks very closely with Birk's description of the Pontotoc group on the west side of the Arbuckle Uplift. In a well drilled by the Atlantic Oil Producing Company in sec. 2, T. 1 S., R. 4 W., between the base of the red beds at a depth of 1,850 feet and the total depth of the well 2,520 feet, there is a very similar section, except that there is much more of the lime conglomerate present. In order to find just what this material looked like before being drilled up, the writer had a core taken at 2,520 feet. The core was found to be coarse conglomerate of unevenly assorted pebbles, varying in size from a small grain of sand to pebbles two inches in diameter. The pebbles were composed of Viola limestone and other pre-Pennsylvanian limestones and cherts. There were some beds of blue shale interbedded with the conglomerate.

This group is absent on the southeast extension of the Wichita Uplift and on the top of the other known buried hills of the county, such as Loco, Velma, Cruce and Woolsey, but is noted on the flanks of all these highs. Naturally a formation of this sort as it is derived chiefly from the Arbuckle and Wichita uplifts, would be extremely variable both vertically and laterally[11 12 13] In the northwestern part of the county, this group is made up of arkosic sands and gravels, interbedded with brown shales. This material has been noticed in well samples as far north as the Chickasha gas field in T. 5 N., R. 8 W., Grady County. In the regional syncline in the southwestern part of the county the group has a thickness exceeding 2,000 feet, and in the southwestern part of the county a thickness exceeding 1,500 feet. The writer agrees with Birk in placing the top of the Pennsylvanian at the top of the Stratford formation, which is the base of the typical red beds, for to the northeast in Pontotoc and Seminole counties, and to the southwest in Montague and Clay Counties, Texas, the red color line crosses over the Permian-Pennsylvanian contact, taking in part of the Pennsylvanian rocks.

PERMIAN

With the Ducan sandstone of southern Oklahoma definitely correlated with the San Angelo sandstone of Texas[14], which is the base of the Double Mountain formation, we now have a definite horizon in the Permian rocks of southern Oklahoma which can be correlated with the Texas section. Between the top of the Pennsylvanian and the base of the Double Mountain formation of west Texas, are the Wichita and Clear Fork formations. Since the escarpment of the Duncan sandstone almost isolates the older Permian rocks of southern Oklahoma from the rocks of the same age in central and northern Oklahoma, the writer here suggests that the rocks of southern Oklahoma, between the base of the Permian and the base of the Duncan sandstone, be named the Wichita-Clear Fork formation. This formation covers all of Stephens County, the upper part of it being exposed at the surface over about two-thirds of the county, it has a thickness of about 600 to 2,000 feet. The section consists of brick red shales, some thin gray shales and gray and red sandstones.

10. Birk, R. A., An extension of the Pontotoc Series around the Western end of the Arbuckle Mountains, Oklahoma, Am. Assoc. Pet. Geol. Bull. vol. 9, No. 6, p. 983, 1925.
11. Morgan, Geo. D., Geology of the Stonewall quadrangle, Oklahoma: Bureau of Geology, Bull. No. 2, Norman, Okla., 1924.
12. Morgan, Geo. D., Arkose of the northern Arbuckle area. Okla. Geol. Survey, Cir. No. 11, 1923.
13. Birk, R. A., op. cit.
14. Gould, Chas. N., The Correlation of the Permian of Kansas, Oklahoma, and northern Texas: Am. Assn. Pet. Geol. Bull. vol. 10, No. 2, 1926.

STRUCTURE

WICHITA UPLIFT

The earliest period of folding for which we have definite evidence is that of the Wichita Mountain Uplift, which must have taken place not later than early Mississippian time. The fact that early Glenn rocks are resting unconformably upon the Arbuckle limestone in the Empire pool in T. 1 S., R. 8 W., in the West Duncan pool immediately west of the Empire pool, and in the North Duncan pool in T. 1 N., R. 9 W., that a well drilled in sec. 34, T. 1 N., R. 9 W., two miles west of the North Duncan Pool encountered Viola pebbles stratigraphically below the producing horizons of that pool appears to be evidence enough without citing others. This is in agreement with conclusions of Schuchert[15], Moore, Plummer[16] and others.

This uplift was a part of a movement that was of greater magnitude and more widespread than any movement which has taken place in the Mid-Continent in geologic time. Other highs which were formed at this time in Stephens County are Loco in T. 3 S., R. 5 W., Woolsey in T. 2 S., R. 6 W., Velma in T. 1 and 2 S., R. 5 W., and probably Cruce in T. 1 N., R. 5 and 6 W. To the southeast, in Carter County, Healdton and Hewitt were uplifted during this movement.

POST WICHITA UPLIFT

We have no evidence of any sedimentation in the county between the time of the Wichita Uplift and the depositions of the Glenn formation, with the possible exception of the regionally lowest parts of the county, it seems that most of the county was a positive element and therefore above water during this interval of time. This is also true for the greater portion of southern Oklahoma west of the eastern part of Stephens and Jefferson counties and south of the north limits of the Wichita Mountains. The Wichita Mountains are now the last small traces of what was once a grand mountain range that extended from central Stephens County, Oklahoma, northwest across the Panhandle of Texas into New Mexico, a distance over 350 miles. They

15. Schuchert, Chas., and Pirsson, L. V., Text-book of Geology, Pt. 2, p. 343, 1924.
16. Plummer, F. B., and Moore, R. C., Stratigraphy of the Pennsylvanian formations of north-central Texas; Univ. of Tex. Bull. No. 2132, June, 1921.

were over 40 miles in width at their widest point, which is between the towns of Gotebo and Altus in Oklahoma, and the summit raised its head well over 5,000 feet above the surrounding country. Such a range of mountains must have furnished an enormous amount of material to a vast territory. By the close of Mississippian time many of the peaks in the range had been eroded down, exposing the Arbuckle limestone.

PENNSYLVANIAN

At the beginning of the Glenn time all of the county became submerged, including that part of the southeastern end of the Wichita Mountain Range which lies within the county. This was a part of the Glenn sea which covered south-central Oklahoma. During this time a great thickness of sediments was deposited, much of the material being derived from the Wichita Mountains to the west. These sediments were deposited in fairly shallow waters, being especially shallow in the western part of the county, as evidenced by the very few thin limestones present in the section. At times much of the western part of the area must have been cut off from this main sea, as at intervals in the section there are beds of brown shale which are apparently non-marine. Girty (in a personal communication to J. V. Howell) mentions the presence of much non-marine material interbedded in the Pennsylvanian section in the Walters field in Cotton County, four miles west of the Stephens County line. The close of Glenn time was marked by the Arbuckle Mountain Uplift, at which time the eastern end if not all of the Wichita Mountain Range was again elevated, as were the other buried hills of the county.

POST-GLENN

The history of the remainder of Pennsylvanian time after the Arbuckle Uplift is that of the removal of material from the highs with the deposition of this same material in the lows. In other words the highs were large islands in the late Pennsylvanian seas. This was largely a period of rapid erosion which was unfavorable to life, hence the scarcity of fossils in this division. Before the close of Pennsylvanian time, the Wichita Mountain Range west of the county had become eroded down to the granite core, with the result that much of this arkosic material was distributed for great distances out from the mountains. By the close of Pennsylvanian time the highs had been so worn down and the lows so filled up with material from the highs, that the area in which Stephens County lies presented a fairly level aspect.

PERMIAN

We find with the opening of Wichita-Clear Fork time the shallow waters almost completely covering this area, with only the very tops of the buried hills above water. To the west, peaks of the now much reduced Wichita Range rose like islands out of the water, with a gradual transition between late Pennsylvanian and early Permian time, with little if any movement. The only difference was in the

source of the sediments being deposited. The Wichita-Clear Fork sediments consisting of red shales and fine-grained gray and red sandstones were evidently transported from a great distance, with most of the sediments coming from the west[17]. This resulted in the distribution of a fairly uniform thickness of sediments excepting upon the tops of some of the buried hills which were not covered until late in this interval of time. There was evidently some movement at the close of this time, for the apparent discordance in the dips on the surface rocks between the top of the Wichita-Clear Fork and the base of the Duncan sandstone is suggestive of an unconformity. The remainder of Permian time in this county is mainly a repetition of Wichita-Clear Fork time with the same source for the materials deposited. The distribution of the San Anglo-Duncan-Harper sandstone would suggest a more uniform sea.

There was a period of folding in late Permian time as evidenced by the sharp folds on the Duncan sandstone at Cruce in T. 1 N., Rs. 5-6 W. and to the northwest in Comanche County, also by the gentle folds on the surface rocks of the Wichita-Clear Fork formation. This folding evidently originated around the Central Mineral (Llano-Burnett) Region of Texas, for the north dip of the surface rocks to the north of that region continues northward into Oklahoma beyond Stephens County. This must have been a very gentle period of folding for many of the surface folds in the county are apparently not reflected in the lower rocks, in fact many of them are in areas that are regionally low. This applies to all of southern Oklahoma covered by Permian rocks. While the folding in the older rocks influenced this latter movement to the extent that there is some slight folding over the older structures in some areas, there are probably many subsurface folds which are not revealed in the surface rocks. Therefore, in all of southern Oklahoma covered by Permian rocks, the first and most important consideration, when looking for favorable areas to drill, is to thoroughly work out the regional geology. The structure of the surface rocks is the least and last important point to consider.

PRODUCTION

WELL SPACING

The subject of well spacing needs little attention in this county for the method of well spacing in vogue in this district seems to be satisfactory. This is discussed here in order that there will not be any radical change in the spacing in the future. In the northern part of the state the low price of oil from 1921 to 1925, together with the high costs of drilling wells, has caused the adoption of a program of spacing one well to ten acres, which spacing is too far apart for the average Pennsylvanian sands.

The chief factors, affecting the spacing of wells, in the opinion of the writer, are the pressure of the dissolved gas in the oil and the

17. Wegemann, C. H., op. cit.

viscosity of the oil, with the character and thickness of the sand and other such factors secondary matters. The general practice in western Stephens County has been to space nine wells on a forty acre tract. Where leases have been smaller than forty acres, six wells have been placed on twenty acres and four wells on ten acre tracts. In the last named arrangement, production figures prove that not only has much more oil been extracted than would have been the case were fewer wells drilled, but that more money has been made thereby. The following quotation from Swigart and Schwarzenbek[18] illustrates spacing conditions in a pool producing from the same formation as those in western Stephens County.

> "It is important to note that the actual cases used above indicate that considering average wells, four wells to ten acres is more profitable than one well to ten acres for the top Hewitt sand providing the wells average over 70 barrels per day for the first month. There is less danger from over-drilling than is commonly believed."

In the low gravity pools in the eastern part of the county wells should be spaced closer than in the western pools for the pressure of the dissolved gas is low due to the shallow depths, and the oil is quite viscous so that one well drains a very limited area.

GENERAL DESCRIPTION OF PRODUCTION

In the discussion of the various pools in the county, which follows, an attempt is made to show what the present pools have done and will ultimately do in the way of production. The chief reason for the inclusion of this data is for their use as a "yard stick" for future producing areas in this district. For the past seven years we have been talking in terms of barrels per acre, but with differences in the cost of drilling wells in different parts of the country, together with great variations in the spacing of wells, it is necessary to know the cost per barrel produced, in order to compare one district with another. In the production tables in this report the average production per well is given. Mention is also made of the average cost of drilling a well in the various districts of the county. These give a basis of comparison with other oil producing districts that the method of per acre yields will not give.

While the average production per well in the three Stephens County pools listed in the table is about one-third less than the other pools listed, the cost of drilling the wells in the other pools would average twice the cost in the Stephens County pools, so that the net revenue per well would average higher for this county than for any of the other pools in the state listed in the table. The county has probably produced about 25,000,000 barrels of oil since the completion of the first well.

18. Swigart, T. E., and Schwarzenbek, F. X., Petroleum Engineering in the Hewitt Oil Field, Oklahoma. U. S. Bureau of Mines, Bull. Jan., 1921, p. 34.

General Production Table

POOL	COUNTY	PER ACRE YIELD TO 1-1-26	PER WELL AVERAGE TO 1-1-26
Empire	Stephens	9,389	47,356
West Duncan	Stephens	6,847	39,618
North Duncan	Stephens	6,826	40.554
Healdton	Carter		72,273
Hewitt	Carter		60,335
Graham	Carter		35,134
Burbank	Osage	7,000	70,000
Cromwell	Seminole	5,500	55,000
Wewoka (Lyons-Quinn sand)	Seminole	7,000	70,000
Papoose	Hughes-Okfuskee	6,500	65,000

NOTE: Figures on outside pools from Krohn Oil Review and the Oil and Gas Journal.

The majority of the wells in the western part of the county flow naturally when completed. In fact, all wells excepting the edge wells that were drilled during the early development were natural producers. From two-thirds to three-fourths of the total production of all wells which were completed as natural producers has been made by flowing. For this reason the average lifting cost per barrel of oil produced is extremely low for the life of the average well in those pools. On the few leases where the lifting cost is known to the writer none have exceeded twenty-five cents per barrel after the wells were put on the pump. These are all leases having five or more producing wells. By considering the distance to the surrounding wells, a pretty fair idea of the total ultimate production any well will make can be ascertained from its initial production.

DRILLING PROGRAM

When it is realized that in most sands more oil is left in the ground after the abandonment of the lease than has been extracted, even after the use of the vacuum and other such methods, we begin to feel that there is decided room for improvement in draining the sands. Although there is no apparent danger of an early exhaustion of our petroleum reserves, yet it is but a question of time when our national production will not supply our needs. The whole problem of getting as much oil as possible out of the sands resolves itself into a question of producing as little gas as possible for each barrel of oil produced. This is a problem on which the U. S. Bureau of Mines has been doing a lot of study and experimenting. Once the gas pressure in a sand has been dissipated, an extremely small percentage of the oil in the sand can be extracted by ordinary pumping methods even though the sand may be saturated, for the dissolved gas is the expulsive agent which forces the oil from the sand into the well[19]. Experiments on back pressure—checking the flow of oil by means of reduced openings at the mouth of the well—have not yet brought forth worth-while results as each well seems to

19. Dow, D. B., and Calkin L. B., Solubility and effects of natural gas and air in crude oils. U. S. Bureau of Mines, Serial 2732, 1926.

be a study in itself. The one system known to accomplish more than all other production methods to increase the recovery of oil from a sand, is that of rapidly drilling up a pool when first discovered. If a few wells are allowed to produce in a pool for any length of time they will so reduce the gas pressure that a large percentage of oil in the sand that should be recoverable, will be lost by present methods of production. This has been demonstrated so many times that it cannot be disputed. In many fields operators with large leases have drilled the necessary offset line wells reserving the development of the interior of the lease until a period of better market conditions, only to find that the eventual drilling up of the interior of the lease resulted in the completion of small wells. In that wonder field of the Mid-Continent, Burbank, covering thousands of acres with a sand body from fifty to over one hundred feet in thickness, the acre yield to date has been less than in the Empire pool of Stephens County where the sand body averages less than ten feet in thickness. The extremely slow development at Burbank, together with the wide spacing of the wells, are the main factors in the difference. The yield could easily have been doubled if the development had been carried on as rapidly, and wells spaced as closely as in the Wortham or Powell fields of Texas. About the only solution to the problem of the discovery of a new pool during periods of overproduction is the shutting in of the discovery well. This is a method now being practiced in the Salt Creek field of Wyoming since the discovery of the productiveness of the Lakota sand. Operators there, in attempting to maintain a fairly consistent daily production, are drilling wells to the Lakota sand and then shutting them in.

DRILLING METHODS

In all pools of the county, with the exception of the shallow Permian pools in the eastern part, practically all drilling is done by rotary method. Casing cemented on top of the sand after the sand has been found by means of feeling ahead with a reduced hole when the sand is thought to be near, and then taking a core when the sand is touched. Casing 8¼ inches in diameter is usually used although 6⅝ inch casing is often used on the deepest producing sands in any pool. A joint or two of 12½ inch casing is cemented for surface pipe, and an 11½ inch hole drilled when it is intended to cement 8¼ inch casing on the sand, while 10 inch surface casing is used and a 9½ inch hole drilled when it is intended to cement 6⅝ inch casing on the sand. Standard tools are rigged up while the cement is setting and the well drilled in with these tools.

It has been the practice since the first wells were completed in these pools to cement the casings and it has proved to be the most satisfactory method. The soft formations in this area do not permit of a casing seat that is permanently tight without the use of cement. Within the past two years some operators have come into the district from other places where it has not been the rule to cement casings, and have completed wells without cementing the casing by using the formation shut-off method. They have been successful in a majority of their wells in keeping a tight seat until the cream of the production was secured, but the attempts that were unsuccessful would have made it more economical to have cemented all wells, not to mention the early abandonment of those wells in which this operation was only temporarily successful. The few dollars spent in cementing is an extremely low rate of insurance to protect the investment represented by the well as a whole. In some instances the casing has not been cemented because it was not certain that the sand would produce profitably so that in this event, the casing could be recovered. However, the many sands in the Permian tend to freeze pipe in a very short time and the cases where more than one half the pipe has been recovered are very much in the minority. Also, if water is found after bailing the hole, one is never quite sure whether the water is from the sand or leaking from behind the pipe.

The best practice has been found to drill wells in with cable tools. In the early stages of development in any particular sand when the gas pressure is still high, wells can be completed with rotary tools without harm, but as soon as the gas pressure begins to decline the pressure of the column of mud laden fluid on the sand has a plastering effect on the walls of the hole in the sand that is hard to overcome by the pressure in the pay sand. Several such cases where it can be proved that this is true have happened in the Graham field of Carter County.

In the shallow pools of the eastern part of the county, all drilling to the shallow sands is done with Star machines. Wells are completed in a period of six to fifteen days at a cost of $4,000 to $6,000 for the average depth of the sands.

WILDCATTING

Probably three-fourths of the wildcat work done in the county is by the use of the rotary. This is due to the fact that the soft formations which make up most of the section of rocks drilled in southern Oklahoma are exceedingly difficult to drill with cable tools as the casing has to be underreamed and carried to within a few feet of the bottom of the hole at all times. If much open hole is drilled the caving from the open hole usually is sufficient to prevent the continuation of the drilling. The underreaming and subsequent cleaning out necessary after each time the pipe is moved consumes over half the drilling time on the average well. Wildcatting work with the rotary has been done in a haphazard manner, in the past with no special attention paid to the formation being drilled excepting the sands. The increased knowledge of the formations in the district, together with the recent improvements in coring tools, has made it possible to do some very careful work by this method of drilling. There is still much haphazard drilling being done, but it can be said to the credit of the operators who have been in the district for some time, that this class of drilling is being done for the most part by the people rather new to the district.

Too little attention has been paid in the past to the character of the formations penetrated in wildcat wells[20 21 22] Cuttings should be taken continuously from a point high enough above the expected base of the red beds that the actual base can be determined down to the total depth of the well. From a lithological standpoint alone one can tell the interval, if any, between the base of the red beds and the top of the Glenn formation. The thicker this intervening formation, the lower down one is regionally on the Glenn. If the first few wells drilled off the main regional highs of the county had been drilled in this manner and the formations logged as interpreted from the cuttings, it would have meant the saving of many thousands of dollars, spent later in drilling other wells and in buying leases in these same localities. More carefully watched wells recently have revealed the exceptionally steep dip to the east, northeast and southwest of the Glenn formation off the Wichita Uplift in Stephens County. After the Glenn formation is encountered, the horizons being drilled can be correlated only by a geologist familiar with the fauna and more especially the micro-fauna of this formation. By this method of keeping the cutting box in the ditch at all times, there is almost no danger of going through a sand without knowing it, for if one has inadvertently drilled through a sand the cuttings will appraise him of that fact.

The recent improvements in the patented core drills, several of which are on the market, have revolutionized rotary wildcat work. By the use of these double-barreled core drills as much as nine feet of core can be taken at one time. While the core is being taken the hole is also being drilled to guage; or if desired, the hole can be drilled so as to leave a seat for casing. The mud never touches the core, which is a wonderful aid in deciding the often difficult problem of whether a sand carries gas or salt water. When it is possible to estimate about where sands might be expected, it is well to start coring above this point and core continuously until the sand is either found or its absence determined. The old method of coring with home-made core barrel produced, on the average from four to six inches of core that was soaked with the mud in the hole. When one of these cores was brought out of the hole the guess work started. The guess really began before the core was taken out of the hole, for in many cases the core was never recovered after being cut. To properly interpret any core taken from a well, one should have a wide experience in comparing many cores from wells from which the results were later studied after casing was cemented and the wells drilled in. Too often the writer has seen pipe cemented on a sand, the core of which did not justify wasting a string of pipe to test out.

20. George, H. C., and Bunn, Jno. R., Petroleum Engineering in the Fox and Graham Oil and Gas Fields, Carter County, Oklahoma: U. S. Bureau of Mines, Bull. 1924.
21. Kraus, Edgar, Logging wells drilled by the rotary method: Am. Assoc. Pet. Geol., Bull. vol. 8, No. 5, 1924.
22. Gouin, Frank, The log of the well: The Atlantic Seal, July, 1924, Published by the Atlantic Refining Company, Philadephia, Pa.

When using the rotary it is the tendency for almost every one to "make hole". While the writer has received some wonderful cooperation from the contractor in various wildcat wells it is really more satisfactory for the wildcatter to have his own tools. Drilling, then, can be done as desired. The procedure in rotary wildcatting recommended in this chapter is the result of actual experience in drilling wells in which the writer has been interested. Wildcatting with either type of tools requires extreme care. Too many cases have been noted where cable tool tests have been unable to shut off water in order to test a sand, so drilling was contained through the sand without testing it. This method of drilling is not entirely fool proof. Cases have also been noted where the hole was caving so badly, the cavings sloughing in round the bottom of the pipe, that the operators were at a loss to know into what formation the drill penetrated.

FUTURE POSSIBILITIES

It seems best to divide the subject of future possibilities into three radically different geological divisions in which production is being found in this county. These are (1) pre-Glenn; (2) Glenn and (3) post-Glenn.

1. Pre-Glenn

The future possibilities for finding production in these rocks seem rather limited. The Simpson formation is the only producing formation known below the Glenn formation and it has been removed from the tops of many of the known highs. The southeast quarter of the county should offer the best possibilities for testing to this formation. In the north half of the county, with the exception of the Cruce anticline, the Simpson is probably too deep for present drilling, although there is always the chance of discovering a buried hill not reflected on the upper formations. The southwest quarter of the county would be excluded for the same reason. The folds of these rocks are not necessarily reflected at the surface, but will coincide to some extent with Glenn folds.

2. Glenn

Although the Glenn formation probably underlies most of the county, it is probably too deep in the northern and southwestern parts to make drilling economically profitable under present prices of oil.

The chances are best for finding the Glenn at reasonable depths through the central and southeastern parts of the county. Surface folding is not necessarily indicative of folding in this formation.

3. Post-Glenn

Chances for finding producing pools in this division of rocks are favorable throughout the county. However, it should be borne in mind that the yields will average much lower than the Glenn formation production and the gravity in most cases will be much lower. What surface exposures are sufficient for control, surface folds are the primary consideration for locating wells to test this section of rocks.

THE EMPIRE POOL

LOCATION AND TOPOGRAPHY

The Empire pool, situated some ten miles southwest of Duncan, lies in the south-central portion of T. 1 S., R. 8 W., and in the extreme north-central edge of T. 2 S., R. 8 W. Parts or all of secs. 27, 28, 29, 32, 33, 34, T. 1 S., R. 8 W., and secs. 3, 4 and 5, T. 2 S., R. 8 W., are included in this pool.

The topography is gently rolling with a flat topographic high that is hardly noticeable except from a distance. About two thirds of the pool was at one time covered with a thick growth of scrub oak, but most of this has been cleared away on account of the development.

HISTORY OF DEVELOPMENT

This, the banner high gravity pool of southern Oklahoma, was discovered by the Empire Gas and Fuel Company in April, 1920. The discovery well was the Surber No. 1, located in the southwest corner of sec. 33, T. 1 S., R. 8 W., which was completed with an initial production of about 1,200 barrels in a sand at 1,700 feet. Development of this sand in the pool was very rapid, for at this time oil was selling for the highest price in the history of the oil industry. By the close of the summer the pool was well defined, with virtually all locations drilled. Late in December of the same year the Climax Petroleum Company, in seeking a deeper sand completed a well to the northwest of the 1,700 foot sand development in the southeast corner of NW.¼ NE.¼ sec. 32, T. 1 S., R. 8 W., which started off at 2,400 barrels a day in a sand at 2,200 feet. Unfortunately for the producers this discovery was made on a falling oil market, but the large flush production was too great an incentive to overlook, so the same rapid development took place which was seen in the drilling to the 1,700 foot sand. By June, 1921 the main portion of the productive area of the 2,200 foot sand was developed. Development since that time has consisted of drilling to several very productive sands between these two first discovered sands which were passed up in the rush to the deeper sand, in discovering sands still deeper, and in proving up productive areas on the edge of former production. This later development has been carried on during periods when the price of oil was such that this work could be carried on profitably. During the winter of 1925-26 considerable development was made with very profitable results, this being almost six years since the pool was discovered.

STRATIGRAPHY

The surface rocks in the pool are composed of the lenticular reddish sandstones and red shales belonging to the red sandstone group of the Wichita-Clear Fork formation of Permian age. Exposures are rather meager over most of the pool. It is thought that the base of the Permain is at a depth of between 1,100 and 1,200 feet from the surface. The writer believes that the section between this depth and the Surber sand (1,700 feet) is of post-Glenn Pennsylvanian. The only cable tool hole in this immediate area which was drilled from the top of the ground by that method of drilling, is a well drilled by the Champlin Refining Company one mile northwest of the northwest limits of this pool, being located in the southwest quarter of sec. 20, T. 1 S., R. 8 W., in the West Duncan pool. This well logs the base of the typical Permian red beds just below 1,100 feet, while the section below that down to the Surber sand consists of dark brown shales and sandstones. The section from this depth to the Blaydes sand (2,200 feet) consists almost altogether of blue shales and sandstones. From the Blaydes sand to the Arbuckle limestone, about 3,400 feet, the section is essentially the same excepting that there are occasional thin limestones. Beds of brown shale make up possibly a third of the shale section between the base of the Permian and the top of the Arbuckle limestone. This interval is the lower part of the Glenn formation as discussed under Subsurface Geology.

STRUCTURE

The structure of the surface rocks of the pool is quite obscure, due to lack of definite control. The location of the discovery well was made due to the alignment on the supposed buried axis of the Wichita Uplift, rather than to any definite evidence of surface folding. Now that there is production in the area, it is possible to imagine that the pool is located on a surface dome, but prior to the development it is doubted if any one would get unduly enthusiastic over the area from a surface standpoint alone.

The underground structure can be worked best on the Blaydes sand for there have been many wells drilled to that sand for control. By using a combination of the structure on the Surber and Blaydes sands, excellent control can be obtained. The structure on each sand proves the presence of a very pronounced dome with some complex minor folding on the top. The center of the dome lies near the center of the east line of the SE.¼ sec. 32, T. 1 S., R. 8 E., being elongated north and southeast from this point. Minor synclines and domes on the top of the main dome add to the complexity of the whole fold. The dip to the southwest off the dome is very steep into the geosyncline of northern Jefferson County. The dip to the east is also quite steep through sec. 35, T. 1 S., R. 8 W., into a regional syncline plunging to the north through the center of T. 1 S., R. 7 W. To the northeast, due to some minor folding in secs. 15 and 22, the dip does not become steep until a point just northeast of these sections is reached where there is a sharp dip into the same regional syncline mentioned above. To the northwest and southeast, which is in the alignment of the Wichita axis upon which this pool is located, there are definite narrow synclines between this pool and those on either side, namely the Comanche pool to the southeast and the West Duncan pool to the northwest.

PRODUCING SANDS

Besides being the most prolific high gravity pool of southern Oklahoma, the Empire pool has perhaps more producing sands than any other pool in this section of the State. Named from the top down, with the average depth at which they are found, they are: the 1,000 foot gas sand, the Miller sand (1,500 feet), the Nigh sand (1,600 feet), the Surber sand (1,700 feet), the Cantrell sand (1,800 feet), the Shelton sand (1,900 feet), the Smith sand (2,000 feet), the Brown sand (2,100 feet), the Blaydes sand (2,200 feet), the Kagay sand (2,300 feet), and the Maloney sand (2,600 feet). Of these sands the Surber and the Blaydes have contributed the bulk of the production. The 1,000 foot gas sand is producing in one well in sec. 34, but has been noted in other parts of the field. The Miller sand is also a gas sand having been tested only in a few places in the pool on account of the deeper gassers with higher pressures in adjacent pools. The Nigh (1,600 foot) sand has produced small quantities of oil in the few wells which have been tested out at this depth. A few small wells in secs. 27 and 34 are producing from this sand. Development to the sands between the Surber and Blaydes has just been going on during the past two years resulting in wells with initial productions of from 50 to 250 barrels. However, one well was completed in the Shelton sand as early as the summer of 1920. The Kagay and Maloney sands are only productive at this time in the southwest corner of sec. 34 and the corners of the three adjoining sections. There has not been development to this sand in other portions of the pool, so one cannot say that these two sands will not produce in other areas.

All sands from the Surber sand down, are medium fine grained, sub-angular, soft sands with very little cementing material. They are surprisingly uniform throughout the pool, and are so free from cementing material that they will come out as loose sand grains when drilled slowly by the rotary with the mud pump wide open. Even when drilled fast with the pump slowed down it is often difficult to obtain chunks. The extreme porosity of these sands is further demonstrated both by the high yields from sands which are thin when compared to the producing sands of northeastern Oklahoma, and by the fact that it is necessary to drill into only the very top of the sand to obtain all the production that it is possible to get. The sands above the Surber seem to be characteristic of most pre-Glenn sands of the county in that they are not so evenly sorted and are cemented to some extent with lime.

The Glenn sands in all of the pools of the western part of the county are sandy zones in the shales. The thickness and number of the pay streaks in the zones vary from well to well. It should therefore be borne in mind that when reference is made to any sand the sand zone is meant rather than one thin pay streak in the zone.

PRODUCTION

The production table (see page 29) includes every producing lease in the pool proper. Several leases in secs. 27, 28, 34, and 35

which have been principally producers of gas are not included as figures are not available for the amount of gas produced although the returns from gas production from the deeper sands have been very remunerative. There were six producing wells on lease No. 9 as of January 1, 1926, but two of these wells were not completed until late in 1925 so they were not included. On lease No. 16 a second well was completed to the same sand producing in number one well long after the flush was off. Since the initial production of this well was but ten barrels it was not figured in the per-well average for it produced but a small fraction of the total production on this two and one-half acre lease. With these two exceptions, the number of producing wells in the table check with the actual number of wells on each lease.

Production Table Empire Pool

(Figures as of Jan. 1, 1926.)

COMPANY	LEASE	LOCATION	Prod. Acres	Prod.	Wells	Total Prod.	Pres. Prod.	Per Acre Yield	Total Prod. Per Well
Amerada	Blaydes	32-1-8	40	3-21	10	728,768	68	18,219	72,877
Black et al	Blaydes	29-1-8	18	3-21	5	292,073	6	16,225	58,414
Brown	Voss	28-1-8	10	5-21	2	123,408	40	12,341	61,704
Carter Oil	Blaydes	32-1-8	40	7-20	9	398,316	150	10,000	44,257
Carter Oil	Forgy	5-2-8	15	7-21	3	144,021	40	9,401	48,007
Carter Oil	Glass	33-1-8	40	9-20	5	388,210	166	9,705	77,642
Climax	Smith	32-1-8	30	1-21	6	369,244	40	12,308	61,541
Crump et al	Smith	32-1-8	40	2-21	9	651,781	114	16,294	72,420
Crump et al	Shelton	32-1-8	10	4-21	4	221,656	278	22,165	55,331
Crump et al	Eakes	32-1-8	10	6-21	3	59,430	171	5,943	19,810
Empire	Burkloe	4-2-8	10	6-20	2	39,537	Abd.	3,953	19,769
Empire	Cantrell	32-1-8	80	7-20	13	626,989	124	7,837	44,814
Empire	Miller	5-2-8	40	6-20	13	455,917	144	11,398	34,763
Empire	Story	32-1-8	10	6-21	2	54,634	42	5,463	27,317
Empire	Surber	33-1-8	120	4-20	26	1,129,946	250	9,416	43,459
Gordon et al	Gin Lot	28-1-8	2½	3-21	1	57,766	Abd.	23,107	57,766
Gant et al	Shelton	32-1-8	40	2-21	11	909,267	270	22,731	82,661
Gant et al	Voss	28-1-8	10	10-21	3	32,280	33	3,228	10,760
Hamon et al	Glass	33-1-8	80	1-21	10	317,689	129	3,971	31,769
Healdton	Burkloe	4-2-8	20	6-20	3	165,322	6	8,266	33,064
Lorraine	Shelton	32-1-8	30	3-21	7	303,028	64	10,101	43,290
Lorraine	Potts	32-1-8	10	9-21	2	35,788	40	3,579	17,894
Lone Star	Bush	3-2-8	10	1-22	4	95,250	18	9,525	23,812
Magnolia	Glass	33-1-8	20	1-21	2	39,124		1,956	19,562
Magnolia	Bush	3-2-8	10	1-21	2	66,213	14	6,621	33,106
Magnolia	Kagay	34-2-8	60	10-20	10	362,005	145	6,033	36,200
Magnolia	School Land	33-1-8	80	8-20	11	982,761	200	12,284	89,342
Magnolia	Stephens	33-1-8	60	8-20	10	251,707	100	4,192	25,170
McMan Oil	Blaydes	29-1-8	10	3-21	2	31,182	Abd.	3,118	15,591
McMan Oil	Pitts	3-2-8	10	9-21	2	63,260	8	6,326	36,630
McMan Oil	Stephens	33-1-8	80	6-20	10	402,125	137	5,026	40,212
Old Colony	Blaydes	29-1-8	12	3-21	4	111,635		9,303	27,909
Old Colony	Kagay	34-1-8	10	9-20	4	239,963	52	24,000	57,993
Skelly	Peilsticker	5-2-8	10	10-20	2	27,693	2	2,769	13,846
Shamrock	Burkloe	4-2-8	17	6-20	5	180,027	2	10,590	36,005
Westheimer	Maloney	4-2-8	35	6-20	7	246,712	12	7,049	35,244
TOTALS			1129½		224	10,604,728	2865	9,380	47,356

Some very interesting information can be gleaned from a study of these production figures. Since this is a multiple sand pool, one might think at first glance that the leases which have made the highest per acre yields are those which are producing from several sands, but this is only partially correct. Of the 20 leases which have produced over eight thousand barrels to the acre, 13 leases produced from one sand only at the time of this report. Ten of these 13 produced from the Blaydes sand, while the other three produced from the Surber sand. Rapid development of leases after the discovery of each sand is mainly responsible for high recoveries from one sand. All leases which have made an average of thirty thousand barrels or less per well are edge leases. While many leases are producing from several sands, no single well is producing from more than one sand, so the total average production per well shown in the table is an average of one well from one sand. The initial gravity of the oil produced from these various sands averages between 38 and 42 degrees A.P.I. with the general average being a fraction over 39 degrees. This gravity commands a price of $2.53 per barrel at this writing (June, 1926).

Perhaps the best way to illustrate the returns which might be expected in pools in this general area of the county is to compare the cost of completing wells with the average production per well. A well to the Blaydes sand, drilled by contract, with casing cemented on the sand with rotary tools, drilled in with cable tools, will cost about $15,000 for the first well. This cost can be reduced almost one-third since the majority of operators in this district have their own tools. There are many cases where wells have been completed for less than $10,000. Naturally a completion in a shallower sand will reduce the cost. Wells can be completed in twenty days. These figures will apply equally as well for the West Duncan, North Duncan and other producing areas in this part of the county. By assuming a lifting cost of twenty-five cents per barrel, which seems to be an average figure for this district, a well which will produce a total of ten thousand barrels gross, or 8,750 barrels net, will more than repay the cost of completion at the highest figure mentioned above. A well would have only to produce a daily average of slightly less than twenty-eight barrels for a year to reach this figure. All leases in the table have made a per well average in excess of this figure. From this information it is not hard to understand why this pool is such a prolific revenue producer when crude is selling at anything like reasonable prices.

FUTURE POSSIBILITIES

A pool, now six years old, in which wells have been completed during the past winter with initial productions of from two to three hundred barrels in sands between the Surber and Blaydes sands in the heart of the pool, and extension wells to the northeast have been completed in the shallow Surber sand with initial productions of from fifty to one hundred barrels, it can hardly be said that this pool has seen its day. There are many possibilities for the completion of paying producers in the sands between the Surber and Blaydes that were drilled through in the rush to get the flush from the Blaydes sand in 1921. The Kagay and Maloney sand zones should also offer some possibilities in various parts of the pool, although it is not thought that these sand zones can be depended upon to produce consistently throughout the pool. Between the Maloney sand zone and the Arbuckle limestone are sands which should be thoroughly tested in the more favorable areas in the pool before the pool as a whole is finally abandoned no matter how remote the chances seem for production in such sands at this time.

While the pool at this time is quite definitely defined on all sides, there is development going on to the northeast in secs. 27 and 28 where production is being obtained from the Surber sand. The early development in these two sections was for the most part done by small operators inexprienced with rotary drilling and many dry holes were drilled in territory which is now proving to be productive. Leases now producing in the pool should have an average life of at least five years more by present methods of production. With just average results from the future completions in the pool there should be an ultimate yield in excess of 12,000 barrels per acre.

THE WEST DUNCAN POOL

LOCATION AND TOPOGRAPHY

The West Duncan pool is located about 12 miles southwest of Duncan in the west-central portion of T. 1 S., R. 8 W., and in the east-central portion of T. 1 S., R. 9 W. The productive area covers all or a part of secs. 7, 18, 19, 20, 29, 30 and 31, T. 1 S., R. 8 W., and secs. 13, 24, 25 and 36, T. 1 S., R. 9 W. The topography is that of a slightly hilly, rolling plain. The area covered by the pool is comparatively open with very little brush in evidence.

HISTORY OF DEVELOPMENT

This pool was first discovered in 1919 when the Ft. Ring Oil and Gas Company drilled into an oil sand slightly below 2,100 feet in the northeast corner of SE.¼ sec. 30, T. 1 S., R. 8 W., Considerable difficulty was encountered in getting the well on production, so the showing encountered failed to attract further exploratory work until after the opening of the Empire pool, just two miles southeast, encouraged the Lone Star Gas Company to drill a well a quarter of a mile to the northwest of the initial test. By that time it was apparent that a syncline existed between the Ft. Ring well and the Empire pool. The result was that the Lone Star well was completed for an initial production of over 400 barrels in the 2,100 foot sand. This well was located on the Brown farm, hence the name of the sand, Later developments proved the fact that the original well was an extreme edge well on the southeast side of the pool. The remainder of the year 1920 saw the development of the present productive portion of sec. 30 in the Brown sand. The same year a number of gas wells were completed in sec. 24, T. 1 S., R. 9 W., in various sands from the Surber sand (1,700 foot) down to the Smith sand (2,000 foot). After the discovery of the Blaydes sand (2,200 foot) in the Empire pool, this sand was drilled to in the West Duncan pool during 1921 which resulted in the drilling of many twin locations. By the close of 1922, most of what now constitutes the present limits of the pool were defined. Development since that time has consisted mainly in drilling inside locations, in drilling to sands not producing on particular leases and to making minor extensions. The last extention was early in 1926, when a half mile extension to the south was made in the completion of a seventy million cubic foot gas well along the center of the north line of sec. 36, T. 1 S., R. 9 W., and a hundred barrel well, producing 44 gravity oil, was discovered in the southeast corner of sec. 25 of the same township.

STRATIGRAPHY

Practically the same section of surface rocks is exposed over the area of this pool as over the Empire pool, with the exception that some gray sandstones overlie the red shales and sandstones in the northeastern part of the pool in secs. 18, 19 and 20, T. 1 S., R. 8 W. The subsurface stratigraphy is essentially the same as in the Empire pool with the exception that the old buried hill of pre-Pennsylvanian rocks is evidently a little higher in elevation than in the latter pool, for these rocks were encountered at a depth of 3,017 feet or 1,977 feet below sea level in a test drilled by the Magnolia Petroleum Company in the southeast corner NE.¼ NW¼, sec. 25, T. 1 S., R. 9 W. This hole logs limestone from 3,017 feet to a total depth of 3,102 feet. It is the opinion of the writer that this is the Arbuckle limestone on account of the fact that the Amerada test in the Empire pool showed that the lower Paleozoics were removed down to this age of rocks before the deposition of the Pennsylvanian rocks, this pool being on the same ridge, and from the fact that several wells just northwest of this hole have encountered volumes of fresh water in presumably Pennsylvanian rocks at depths of 2,600+feet. Since fresh water is characteristic of the Arbuckle, the presence of this water in apparently Pennsylvanian sands suggests a source stratigraphically close to them.

STRUCTURE

The structure of the surface rocks, although not quite so obscure as the structure of the Empire pool, is far from being simple to work, due to the unsatisfactory nature of the surface rocks. One can work out enough data to show the presence of a rather flat dome, agreeing to some extent with topography, with a definite east dipping nose on this dome in secs. 17 and 20, T. 1 S., R. 8 W.

It is necessary to work the subsurface structure on several sands although the Blaydes sand is the most satisfactory horizon to use, the west and northwest parts of the pool are producing from higher sands. The top of the subsurface fold is a flat dome, with the apex in sec. 19, T. 1 S., R. 8 W. A nose from this dome extends east in sec. 20 and another, north into sec. 7 of the same township. Another nose extends south into sec. 36, T. 1 S., R. 9 W. The west dip is very steep for folds in this area, attaining a rate of about two hundred feet

to the mile for a short distance in secs. 13, 24, and 25, T. 1 S., R. 9 W. There seem to be a few minor faults present.

PRODUCING SANDS

The same series of sands present here are found in the Empire pool, the only difference being in the production from these sands. Practically the entire pool in T. 1 S., R. 9 W., produces gas only in all sands, with the exception of a few isolated wells here and there which produce small amounts of oil in sands between the Surber (1,700 foot) and the Brown (2,100 foot). This is also true of secs. 18 and 19, T. 1 S., R. 8 W. Oil production in the Surber and Brown sands is limited to sec. 30, T. 1 S., R. 8 W., while the Blaydes sand produces oil in secs. 20, 29 and 30 of the same township.

All of the sands become quite thin on top of the dome in sec. 19. This has been quite a factor in the pool for, although the section is on the top of the pool structurally, due to the thinness of the sands, it has been impossible to drill to the oil level before drilling out of the sand, thereby resulting in gas production only. The Blaydes sand is the lowest producing sand in the pool.

Production Table West Duncan Pool

(Figures as of Jan. 1, 1926.)

COMPANY	LEASE	LOCATION	Prod. Acerage	Beg. of Prod.	Wells	Total Prod.	Pres. Prod.	Per Acre Yield	Total Prod. Per Well
All American	Brown	30-1-8	40	10-20	8	366,175	83	9,154	45,772
Carter Oil	Wade	20-1-8	15	1-22	3	53,060	6	3,537	17,687
Champlain	Brittain	20-1-8	40	7-21	8	297,755	26	7,444	37,220
Huff State	Hall	29-1-8	20	7-21	3	121,415	25	6,070	40,472
Lone Star	Brown	30-1-8	80	6-20	18	791,770	222	9,896	55,000
Magnolia	Brooks	25-1-8	20	10-20	3	148,735	28	7,436	49,578
Magnolia	Bartley	20-1-8	40	6-23	5	149,420	125	3,735	29,884
Magnolia	Hall	29-1-8	20		3	72,050	10	3,603	24,017
Margay	Brown	30-1-8	20	12-20	4	352,925	51	17,646	88,231
Margay et al	Brown	30-1-8	20	7-21	3	72,129	25	3,606	24,032
Malernee	Brittain	20-1-8	30	12-21	3	226,130	191	7,534	75,343
Old Colony	Brittain	20-1-8	30	6-21	4	188,731	63	6,291	47,183
Roxana Pet.	Clarkson	30-1-8	25	12-20	4	96,734	30	3,869	24,183
Roxana Pet.	Hall	29-1-8	40	7-21	6	226,165	90	5,654	38,694
Safety First	Brittain	20-1-8	20	5-23	4	65,792	53	13,289	16.448
Skelly	Brigham	30-1-8	6	5-21	1	26,370	13	4,411	26,470
Wallace et al	Clarkson	30-1-8	20	5-21	4	92,470	3	4,623	23,118
TOTALS			486		84	3,327,926	1034	6,929	39,618

The production table of this pool does not reveal the yields that are obtained in the Empire pool. There are several contributing factors for this variance. The chief reason is due to the fact that the fold is so much higher than the average for this district that the top sands contain gas only. The area covered by the gas filled sands includes a large part of the producing area, thus leaving a fairly narrow belt of oil containing sands between the gas and water levels. Another very important reason is the fact that the pool as a whole was drilled much more slowly than the Empire pool. The three leases which have produced in excess of nine thousand barrels to the acre were drilled up rapidly after the opening of the pool. All three of these leases are in sec. 30, T. 1 S., R. 8 W. Development has been especially slow in sec. 20, T. 1 S., R. 8 W.

It is unfortunate that a compilation cannot be made of the total amount of gas produced from this pool since the first gas well was discovered in 1920, however, it can be safely said that there has been more gas produced from this pool than from any other pool in the county. After the decline of the Walters field in Cotton County and the Fox field in Carter County in 1920, this pool was the main standby and for three years supplied the Lone Star Gas Company line to Ft. Worth and Dallas and the Oklahoma Natural Gas Company line to Oklahoma City. Initial production of the gas wells range all the way from five to seventy million cubic feet a day. These wells are drilled, casings cemented on the sand and drilled in, all with a rotary. This can be done at a total expense of from five to ten thousand dollars per well, depending upon the depth and the kind of casing used (new or second hand). With gas selling at ten cents per thousand cubic feet at the well, and the twenty-five percent of the total volume —the maximum allowed to be taken at any one time by state law—often being taken during the coldest months of the winter, it can be seen that the total revenue which has been derived from the output of gas in this pool has been a considerable sum.

FUTURE POSSIBILITIES

At this time most of the west side of the pool, that part in T. 1 S., R. 9 W., has been pretty thoroughly drilled and most of the present producing horizons pretty well explored with the exception of a very small area at the south end. In the east half of the pool, that part which lies in T. 1 S., R. 8 W., secs. 30 and 29, has been rather thoroughly drilled into the present producing sands. There is room for many more locations in sec. 19 and for some in sec. 18, but these will probably be good for gas only. The pressure would be quite low this late in the development, unless stray lenses of sand not connected to any outside source now producing are found. That part of sec. 20 which is productive, lies almost altogether below the gas level and it is in this section that development has been quite slow. On June 4, 1926 a well was completed in what is probably the equivalent of the Smith sand in the SW.¼ sec. 20 T. 1 S., R. 8 W., for an initial production of 590 barrels of 44 gravity oil. Coming almost exactly six years since the discovery of the pool such a well indicates that there are still possibilities for worth while development in sands between the Surber and the Brown in this section as well as in secs. 29 and 30.

While at the present time there are no sands producing in this pool below the Blaydes sand zone with the exception of sec. 31, T. 1 S., R. 8 W., numerous sands have been logged by wells which have been drilled below this horizon in scattered portions of the pool. In all cases these wells were carried below the present producing levels after they had failed to encounter production in the regular pay horizons. A well drilled by Westheimer and Daube just below the water level for the Blaydes sand in the NW.¼ NE.¼, sec. 29, T. 1 S., R. 8 W., cored what appeared to be a series of gas sands below three thousand feet, but the hole was lost while running a measuring line inside the drill pipe preparatory to running casing. A well drilled at the extreme north end of the pool at the south line of sec. 7 in the same township had showings of oil and gas below 2,700 feet. It is not at all impossible when considering the age of the section between the Blaydes sand and the top of the Arbuckle limestone and the fact that sands are known to be present in this interval, that producing sands could be discovered when the testing to these sands is done at favorable places on the fold. This pool should have a future life of about the same duration as the Empire pool so that the ultimate yield recoverable from present methods should exceed eight thousand barrels per acre.

THE NORTH DUNCAN POOL

LOCATION AND TOPOGRAPHY

The North Duncan pool is located about ten miles northwest of Duncan in the southwest part of T. 1 N., R. 8 W., and in the southeast part of T. 1 N., R. 9 W. All or part of secs. 19, 29, 30, 31, 32 and 33, T. 1 N., R. 8 W., and secs. 14, 23, 24, 25, 26 and 36, T. 1 N., R. 9 W., cover the productive area of this pool. The pool is located in a rolling open country.

HISTORY OF DEVELOPMENT

The Parsons-Gant Oil Company completed the discovery well of this pool in November, 1920, with a twenty million cubic foot gasser in sand at 2,070 feet near the center of sec. 32, T. 1 N., R. 8 W. At that time, there was so much gas being produced in the general district this did not cause any undue excitement until the same company completed a well making 1,600 barrels a day in the SE.¼, sec. 25, T. 1 N., R. 9 W., on the Thomas farm in sand at 2,000 feet, during January of 1921. By the end of that year the pool was defined in a general way and most locations drilled up. The only noteworthy extension since that time has been the development of an oil sand found at a depth of 2,300 feet in the east portion of sec. 26 and the extreme west line of sec. 25, T. 1 N., R. 9 W.

STRATIGRAPHY

The surface rocks over this pool are a portion of the red sandstone horizon of the Wichita formation of the Permian. They consist of gray to reddish calcareous sandstones and reddish shales, the whole horizon consisting of lenticular beds of these formations. The Permian and post-Glenn Pennsylvanian extends to an average depth of about 1,600 feet. Below this depth the section consists of blue shales with some brown shales, sandstones and thin bedded limestones. The Ordovician has been encountered in only one well in the pool, this being a well drilled by the Magnolia Petroleum Company on the northwest edge of the pool which had limestone from a depth of 2,880 feet to a total depth of 3,250 feet. It is the opinion of the writer that the section between the base of the red beds and the top of this limestone is of Pennsylvanian age, the section so represented probably being the age equivalent of the section of rocks between the base of the red beds and the top of the limestone in the Empire and West Duncan pools. This limestone is thought to be the Arbuckle, for the reason that the pool is on the buried portion of the southeast extension of the Wichita Uplift and is closer to the exposed part of the Uplift than is the Empire pool where the lime has been proved to be Arbuckle in age.

STRUCTURE

There is an indication of wrinkling of the surface rocks in the eastern part of the pool, but the lack of exposures in the alluvial bottom of Beaver Creek and its tributaries prevents satisfactory mapping of the structure. However, in the west half of the pool there is a high in the surface rocks in the center of the NW.¼ sec. 24, T. 1 N., R. 9 W., with a very flat nose to the south through sec. 25 into sec. 36 of the same township.

The structure on the main producing sand, the Thomas, is that of a low flat dome, elongated in a northwest-southeast direction. On the top of this dome are many irregularities in the form of minor domes and lows. The major features in general conform remarkably well to the structure of the surface rocks where the surface structure can be interpreted. The highest part of the dome is in sec. 24, T. 1 N., R. 9 W., The tops of other highs on this dome are in the easternmost portion of sec. 25 of the same township and the western most portion of sec. 30, T. 1 N., R. 8 W., and in the NW.¼, sec. 32.

Dips off of the main structural high are very gentle to the south and to the southeast which is the direction of the regional line of folding upon which this pool is located. The dip to the west is also quite gentle, since this pool is just to the east of the axis of the Wichita Uplift. The dip to the northeast is exceptionally steep, probably continuing with but very little interruption into a southward synclinal reentrant of the Anadarko Basin.

PRODUCING SANDS

While there are a few wells producing from a sand zone at a depth of 1,800 feet or some 800 feet below sea level, the first main producing sand is found at a depth between 2,000 and 2,125 feet, depending upon the surface elevation. This is the Thomas sand in which the water level during the early development of the pool was found at an average elevation of 1,000 feet below sea level. This sand produces over the entire productive area of the pool, with the exception of secs. 14, 23 and 26, T. 1 N., R. 9 W., where it becomes very tight and shaly. In this portion of the pool the main production, until the summer of 1925, was a gas sand found some forty feet stratigraphically below the Thomas

sand. The only other sand of any consequence in this portion of the pool is a sand producing oil at a depth of slightly below 2,300 feet, which would be a subsea elevation of about 1,200 feet. One hundred feet below the Thomas sand in the main portion of the pool is a sand which has produced considerable quantities of oil in scattered wells. Another sand two hundred feet below the Thomas sand has produced large volumes of gas in a few wells.

The Thomas sand is probably the stratigraphic equivalent of the Brown sand in the Empire and Oil City pools. The Thomas sand is producing from two small isolated oil wells in the northwest corner, sec. 15, T. 1 S., R. 8 W. In this last named area the top of the fold is so low and the water level is so close to the top that the productive area is extremely limited.

Production Table, North Duncan Pool

(Figures as of Jan. 1, 1926)

COMPANY	LEASE	LOCATION	Prod. Acre	Beg. of Prod.	Wells	Total Prod.	Pres. Prod.	Per Acre Yield	Total Prod. Per Well
Carter Oil	Dew	30-1-8	20	7-21	4	151,147	82	7,556	37,787
Carter Oil	Funk	30-1-8	20	7-21	5	294,934	84	14,746	58,987
Carter Oil	Morgan	32-1-8	15	2-22	2	49,918	12	3,381	24,959
Coline Oil	Harris	25-1-9	12	12-21	3	76,811	59	2,134	25,604
Coline Oil	Malicky	31-1-8	6	2-21	1	50,510	36	8,418	50,510
Coline Oil	Slaving	29-1-8	10	3-22	3	37,858	19	4,786	23,929
Gypsy Oil	Brown	24-1-9	30	4-21	4	234,680	19	7,823	58,670
Gypsy Oil	Maxey	30-1-8	30	8-21	5	284,490	49	9,483	56,898
Gypsy Oil	McFatge	24-1-9	10	2-51	2	39,690	Abd.	3,969	19,845
Haynes et al.	Funk	30-1-8	10	4-21	3	68,450	Abd.	6,845	22,817
Homa-Okla.	Spears	32-1-8	20	1-22	3	131,089	23	6,184	43,696
Harrigan et al.	Burns	31-1-8	20	4-21	3	179,899	13	8,994	59,963
Humble Oil	Ketchum	25-1-9	30	5-21	5	120,619	31	4,021	24,124
Magnolia Pet.	Cook	30-1-8	80	6-21	11	818,417	230	10,230	74,401
Magnolia Pet.	Funk	30-1-8	35		9	317,265	95	9,065	35,252
Magnolia Pet.	Harris	25-1-9	30		4	182,743	65	6,091	45,686
Magnolia Pet.	Sch. Morg	32-1-8	12	6-21	2	111,140	7	9,262	55,570
Magnolia Pet.	Thomas	25-1-9	40	2-21	10	341,403	7	8,535	34,140
Magnolia Pet.	G. Young	29-1-8	12	4-21	2	139,125	40	11,600	69,562
Magnolia Pet.	S. Young	29-1-8	20	6-21	6	162,680	35	8,134	27,113
Moran-Fuller	Sch. L.	36-1-9	10	5-21	2	43,679	Abd.	4,368	21.839
Priddy	Cook	30-1-8	40	6-21	5	217,458	13	5,436	43,492
Priddy	Thomas	25-1-9	15	4-21	2	62,894	6	4,192	31,447
Priddy	Sch. L.	36-1-9	6	7-21	1	24,736	10	4,122	24.736
Priddy	Sch. L.	36-1-9	10	4-21	3	65,035	5	6,503	21,678
Priddy	McFatge	24-1-9	30	6-21	3	121,145	6	4,038	40,382
Roxana	Cook	30-1-8	80	5-21	7	162,470	5	2,031	23,210
Smith-Law	Spears	32-1-8	20	7-21	4	124,121	34	6,206	31.030
Texas Drug Co.	Spears	32-1-8	40	9-21	6	242,501	10	6,041	40,417
TOTALS			713		120	4,867,017	995	6,826	40,554

Comparing the production table of this pool to that of the Empire pool, it is seen that there is considerable difference in the yields. This is almost entirely due to the fact that on most leases in the North Duncan pool only one sand is producing. Comparing the average production per well it is also seen that these also are lower for the North Duncan pool. This is no doubt due to the low structural position of the south end of the pool where the water level was but a few feet below the top of the sand in many of the wells. Many wells were drilled too deeply into the sand when completed. The gravity of the oil is on a parity with that produced in the Empire pool averaging above 39 degrees A.P.I.

FUTURE POSSIBILITIES

There is still a chance in scattered portions of the pool for the completion of small wells in the sand now producing but with the exception of the northwest portion of the pool these chances are few in number. All wells which have been drilled below the present producing horizons have logged sands with the exception of the one hole carried to the Arbuckle (?) limestone, none have gone much deeper than 3,000 feet and all of these without exception were carried on down after failing to get production in the regular producing horizons. While results so far in this and other pools producing from the same horizons have been anything but encouraging for deeper production, it cannot be said that there is no chance at all for deeper production.

THE COMANCHE POOL[23]

LOCATION AND TOPOGRAPHY

The Comanche pool is located in secs. 17, 18, 19 and 20, T. 2 S., R. 7 W., and in secs. 11, 12, 13, and 24, T. 2 S., R. 8 W., being situated immediately north and northwest of the town limits of Comanche in the south-central portion of the county.

The topography gradually rises to the northwest from the southeast part of the pool with a maximum relief averaging 100 feet. The pool is wooded with black jacks in the northwest but open to the southeast.

HISTORY OF DEVELOPMENT

The Comanche pool was discovered when the Comanche Petroleum Company completed their Clara Wilson No. 1, located in the center of the west line, NW.¼ NW.¼ sec. 20, T. 2 S., R. 7 W., as a twenty million cubit foot gas well in sand from 1,286 to 1,324 feet in August of 1918. The well was located just to the north of the top of the surface dome upon the strength of which the well was drilled. The next test was made by the same company on the south side of the dome in the SE.¼ NE.¼ sec. 30, being abandoned after getting a hole full of water in sand at 1,937 feet in December of the same year. The first oil well completed was the third test, also being drilled by the same company, located in the center NE.¼ NW.¼ sec. 19, with an initial production of 30 barrels in sand at 1,390 feet. This well was completed late in December, 1918. The completion of this well started several other tests in the vicinity to the same sand.

In October, 1919 the Comanche Petroleum Company discovered the 1,800 foot sand when their John Wilson No. 1 in the NW.¼ NE.¼ sec. 19 was completed as a 15 barrel pumper in sand from 1,780 to 1,810 feet. The small initial production of this well deterred

23. Swigart, T. E. Underground Problems in the Comanche oil and gas field, Stephens County, Oklahoma: U. S. Bureau of Mines in cooperation with the State of Oklahoma, 1919.

operators from any further exploration of this zone until January, 1920, when the Comanche Petroleum Company completed their J. O. Wilson No. 3 in NE.¼ sec. 19 with an initial production of 350 barrels natural. The active development in the county dates from the completion of this well as it demonstrated the potential possibilities of the district to the producing fraternity. By the close of 1920 the completion of several dry holes, together with the sharp decline in the price of crude oil put a stop to further development in the pool. During 1923 and 1924 the 1,400 foot sand was extended to the east in secs. 17 and 20, and to the north into sec. 18, while in 1925 both the 1,400 foot and 1,800 foot sands were extended to the northwest into secs. 11, 12 and 13, T. 2 S., R. 8 W. This latter area is still being developed at this writing (June, 1926).

STRATIGRAPHY

The surface rocks exposed over the pool are reddish sandstones and red clays and shales lying within the red sandstone series of the Wichita-Clear Fork formation of the Permian. The Permian extends from the surface to an average depth of 1,400 feet, or to the Wilson sand. From this sand to a depth of about 3,400 feet the section consists of blue shales, some brown shales, sandstones and thin bedded limestones. Just below 3,400 feet the section consists of massive limestone. The writer tentatively places the base of the Permian at the Wilson or 1,400 foot sand, in keeping with his correlations in the other pools on the line of folding upon which this pool is located. In the Comanche Petroleum Company's deep test, located in the southeast corner NE.¼ NE.¼ sec. 19, T. 2 S., R. 7 W., drilled to a depth of 3,635 feet, the Arbuckle limestone was encountered immediately below what appears to be Pennsylvanian rocks at a depth of 3,410 feet or a subsea elevation of 2,427 feet. A test drilled in the southwest corner NW.¼ sec. 19 had a similar section so it is presumed that the limestone encountered at a depth of 3,505 was also the Arbuckle limestone. The writer, therefore, presumes that the section between the Wilson sand at 1,400 feet and the top of the Arbuckle at 3,400+feet is of Pennsylvanian age. All of the pre-Pennsylvanian section that was originally deposited down to and including some of the Arbuckle limestone was evidently eroded before the deposition of the Pennsylvanian rocks.

STRUCTURE

The surface structure of the Comanche pool is that of an elongated dome with a northwest-southeast axis, the top of which is located at about the center of the east line of sec. 19, T. 2 S., R. 7 W. The reverse dip is very noticeable from the main paved highway on the southern limits of Comanche where the rocks can be seen dipping to the south and southwest at the rate of about fifty feet to the mile. Going north from the town of Comanche on the paved highway to Duncan, the road goes down a dip slope between the northwest quarter of sec. 17 and the NE.¼ sec. 18, T. 2 S., R. 7 W. The east dip can be seen in secs. 21 and 28 east of Comanche.

The underground structure on the Wilson sand is very similar to that of the surface structure excepting that the axis has shifted about a quarter of a mile to the north. The pool does not produce southwest of the axis of the surface fold.

PRODUCING SANDS

There are three producing sands in the Comanche pool. The highest sand in the section is one that is encountered between 800 and 900 feet which produces gas. The next lowest sand is the Wilson or 1,400 foot sand which produces oil in most cases. The lowest producing sand is the 1,800 foot sand which produces oil in all cases.

The 800 foot gas sand is present throughout the field. It originally had a pressure of over 300 pounds per square inch with volumes of from one to five million cubic feet per day. This pressure is now lowered appreciably because of the withdrawal of the gas from the sand since it was first discovered in 1919. Of the two oil sands the Wilson sand seems to be the most consistent over the area of the pool. While the initial production for wells in this sand has been as high as 160 barrels, the general average is closer to 30 barrels. Production in the 1,800 foot sand is limited to sec. 19 of T. 2 S., R. 7 W., and to small areas in secs. 12, 13 and 24, T. 2 S., R. 8 W. Initial production of wells in this sand has been as high as 400 barrels with several making around 300 barrels. The remainder of the Pennsylvanian section has been explored, with one exception, only down the flanks of the dome after the present producing sands had been encountered too low to produce, so it cannot be said that the pool has been explored for producing horizons below those now producing.

The following table gives production data on the principle producing leases in the pool. Leases in the northwest end of the pool which have just been producing for a year or less are not given in this table.

Production Table, Comanche Pool.

COMPANY	LEASE	LOCATION	Prod. Acre	Wells	Total Prod.	Prod. Pres.	Per Acre Yield	Per Well Average
Mid-Kansas	Barnett	19-2-7	20	3	116,835	80	5,842	38,945
Mid-Kansas	Bristow	18-2-7	18	3	25,613	20		8,538
Mid-Kansas	I. Thomas	19-2-7	25	5	249,790	75	10,000	49,958
Mid-Kansas	C. Wilson	20-2-7	25	4	187,890	70	7,516	49,222
Mid-Kansas	P. D. Wilson	19-2-7	50	8	413,935	78	8,278	51,742
Magnolia	Andrea	24-2-8	5	1	13,520	5	2,704	13,520
Magnolia	Carter	17-2-7	10	2	107,025	30	10,702	53,512
Magnolia	Redick	13-2-8	5	1	22,710	5	3,785	22,710
Magnolia	F. Wilson	17-2-7	30	5	159,870	70	5,329	31,972
TOTALS			188	32	1,297,188	433	6,900	40,537

These figures would indicate that the pool will ultimately produce between 8,000 and 9,000 barrels per acre, or somewhere around 50,000 barrels per well.

FUTURE POSSIBILITIES

Small minor extensions to the sands now producing are possible along or close to the axis of the fold. A small amount of development lately has been with the idea that the Empire pool would connect with this pool, but there is apparently a flat saddle in between with the water level near the top of the sand. A well in the center of sec. 2 and another in the NW.¼ sec. 11, T. 2 S., R. 8 W., are both producing small quantities of oil from the Blaydes sand zone. Two dry holes drilled offsetting the well in sec. 2 demonstrates the uncertainties of drilling this saddle. Better possibilities would seem to be in trying for production from sands known to be present below the 1,800 foot sand zone. As to whether any of these sands will produce is difficult to say in advance of drilling.

THE LOCO POOL

LOCATION

The Loco Pool located in the southeastern part of the contry, in secs. 4, 9, 10, 14, 15 and 16, T. 3 S., R. 5 W.

HISTORY OF DEVELOPMENT

According to Wegemann[24], the first development in this pool resulted from the asphalt deposits, which are present in the southeastern part of this township, as well as in the southwestern part of T. 3 S., R. 4 W. He states that in 1903 a refinery was built to develop these asphalt deposits. However, the refinery was burned down soon afterwards, so that nothing more was done with this venture. Soon after this, some shallow dug wells were put down, but these operations were not successful in securing oil in sufficient quantity for economic production. Drilling was begun in the pool by the Oklahoma Diamond Oil and Gas Company, early in 1913 in secs. 10 and 14, resulting in the completion of several gas wells of capacity ranging up to twenty million cubic feet, in sand at an average depth of around 700 feet. Oil in commercial quantities was first obtained late in 1915 by the Owl Oil Co., in sec. 9. These wells produce from a sand found between 850 and 900 feet, with initial production from 10 to 25 barrels per day of 24° A.P.I. gravity. Due to the low price of crude oil, development was very slow until the high prices of 1919. In 1919 the pool received renewed development and from that time until the close of 1923 development was rather active. During the last named period, the Owl Oil Co., completed quite a number of oil wells in the 850 foot sand in secs. 9, 14 and 15. Development in the pool has been slow since that time due principally to the low initial production of the wells and to the extremely low gravity of the oil.

24. Wegemann, C. H., The Loco gas field, Stephens and Jefferson counties, Oklahoma: U. S. Geol. Survey, Bull. 621-C., pp. 31-42, 1915.

STRATIGRAPHY

The surface rocks in the Loco pool are part of the Wichita-Clear Fork formation of the Permian, consisting of red shales and sandstones. These rocks are a part of the calcareous shale group shown on the Oklahoma geological map and mentioned in Bulletin 35 of the Oklahoma Geological Survey. The Permian has a thickness of about 600 feet on the axis of the fold, with increasing thickness to the northeast and southwest down the flanks. The thickening is very rapid to the southwest, toward the regional basin of central Jefferson County.

The Pennsylvanian rocks begin at a depth of about 600 feet from the surface, consisting of blue shales, sandstones and thin limestones. It is in the upper part of this section that the producing sands are present. The thickness of the Pennsylvanian section depends upon the position on the fold, for there is no doubt but that this pool is located on one of the many buried hills of southern Oklahoma. Unfortunately, as in most of southern Oklahoma one has to rely upon drillers logs for the stratigraphy as samples of cuttings are rarely saved. The Lone Star Gas Co., in Ida Billy No. 2½ in the SE cor., NW.¼ SE.¼ sec. 9, T., 3 S., R. 5 W., drilled into lime at 1,550 feet and abandoned the well while still in the lime at 2,520 feet. The section of rocks penetrated between these depths, evidently is of pre-Pennsylvanian age. This buried hill is as steep as the average, as is shown by the fact that a well drilled to 2,250 feet in the SW. cor. sec. 4, a well drilled to 2,149 feet in the NW.¼ sec. 15 and one drilled to a depth of 2,150 feet in the NW.¼ sec. 16, were apparently still in Pennsylvanian rocks when finished.

The main producing horizons are the 700 foot gas sand and the 850 foot sand. These sands are probably in the upper part of the Glenn formation. Showings have been found in the deeper sands, but the results have been very discouraging. A sand between 950 and 1,000 feet has produced oil in small amounts. Another just above 1,500 feet has done likewise.

A sand at 1,910 feet in the southwest corner of sec. 11, produced 15 barrels initial, but the increasing depth hardly makes such production commercial.

STRUCTURE

The structure of the surface rocks has been so well described by Wegemann that no attempt will be made to discuss it here.

The structure of the 850 foot oil sand, in the light of development which has taken place since Wegemann's report, is the same with reference to the axis, in the southeast part of the pool. However, development in secs. 4, 5 and 9, shows that the fold closes to the northwest, with the SE.¼ sec. 5 being lower structurally than the top of the fold in sec. 9. The structure on the base of the Pennsylvanian has been described under Stratigraphy. The northwest-southeast axis

of this fold is in keeping with the direction of most of the producing pools of Stephens County. There are several subsurface faults on this fold.

PRODUCTION

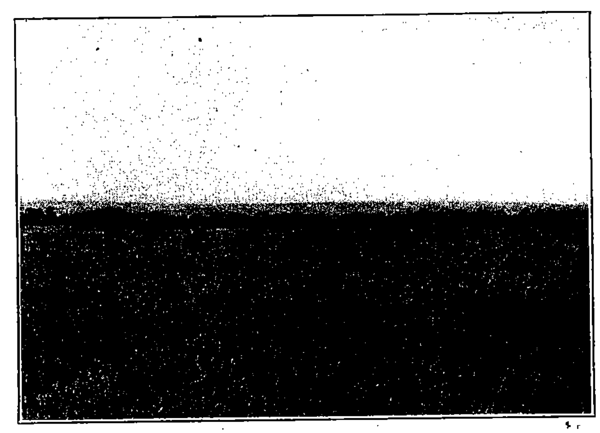
The oil produced in the pool averages around 24° A.P.I. The initial production of wells has been from five to twenty barrels. Both of these factors has made development work in the pool very unattractive. Some little gas has been piped from the field but the pressure is now so reduced that this is no longer renumerative. The faulting in the pool is no doubt an explanation of the low gravity of the oil. The pool does not seem to have a very bright future for in order to get a thicker section of Pennsylvanian rocks one would have to go down the flanks of the fold where the sands would probably be encountered too low to produce.

THE CRUCE POOL

LOCATION AND TOPOGRAPHY

The Cruce pool is located in sec. 12, T. 1 N., R. 6 W., about two miles north of the post ofice of Cruce, in the east-central part of the county. The relief in the pool itself is not over fifty feet, but escarpments to the east and west of the pool have a relief of from fifty to one hundred feet.

PLATE IV

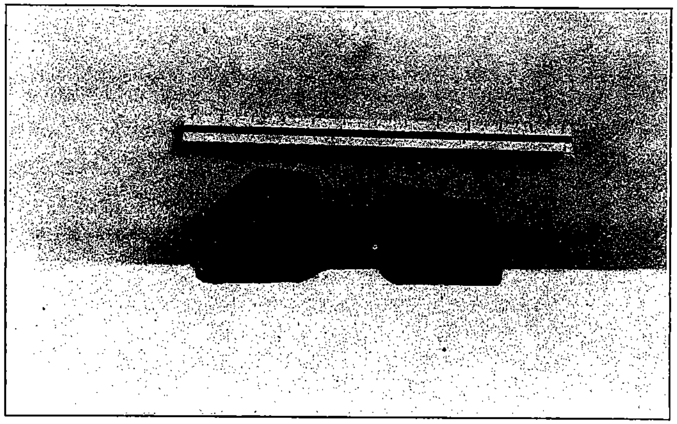


EAST FACING ESCARPMENT OF DUNCAN SANDSTONE ON WEST SIDE OF CRUCE ANTICLINE.

STRATIGRAPHY

The surface rocks exposed in the pool are of the gray shale horizon of the Wichita formation, while the escarpments to the east and west are composed of the sandstones and shales making up the Duncan sandstone section. Here the rocks of the Duncan sandstone are essentially gray in color. The Permian and post-Glenn Pennsylvanian extends to a depth of some 1,900 feet from the surface. All of this section is made up almost entirely of red and brown shales and gray sandstones. The only deep test drilled in the pool went to a depth of 2,750 feet. From a depth of about 1,900 feet to the bottom of the hole the section penetrated was composed entirely of a hard, black calcareous shale which is probably the equivalent of the Pennsylvanian portion of the Caney shale. The logs of the few deep tests on the west flanks of the fold suggest a normal Pennsylvanian section present on the flanks.

PLATE V



CORES FROM WELL WEST OF CRUCE ANTICLINE IN SEC. 1, T. 1 S., R. 6 W. Cores from top and base of a sand found at 3,100 feet. Well drilled by the Garvin Drilling Company. Note the dip which exceeds 50 degrees.

STRUCTURE

The description of the surface structure together with a map of this area has been so well described by Wegemann[25] that it will be discussed only briefly here. The Cruce anticline, on which the Cruce pool is located, is a northwest plunging anticline. The Duncan sandstone series is exposed on the flanks but has been truncated along the axis. The open nature of the country, together with the relatively steep dips for the Permian rocks makes this fold the most prominent of any Permian fold in southern Oklahoma. Lack of good control on the surface rocks makes the southeast end of the anticline indefinite, but it is quite likely that this end of the anticline may be as far south as sec. 5, T. 1 S., R. 5 W. The anticline begins to plung quite rapidly to the northwest in the NW.¼ sec. 12, T. 1 N., R. 6 W.

The underground structure based on the 850 foot gas sand suggests a dome in the NE.¼ sec. 12, on the anticline. The probable

25. Wegemann, C. H., The Duncan gas field, Stephens County, Oklahoma: U. S. Geol. Survey, Bull. 621-D, pp. 43-50, 1915.

absence of most of the Pennsylvanian section on this dome is proof of another buried hill.

It is quite likely that there is a deep seated fault parrallel to the axis of the anticline and very close to the axis. The truncation on the axis of the fold is suggestive of this. In addition all sands penetrated in the deep test in sec. 12 metioned above, were filled with a dead oil, the higher hydrocarbons having evaporated long since.

DEVELOPMENT AND PRODUCTION

According to Wegemann, the first gas wells were not completed until 1912, although drilling in the pool took place as early as 1907. After that several gas wells were drilled in the 850 foot gas sand with initial production of from three million to almost eighteen million cubic feet per day. These wells supplied the towns of Duncan and Marlow with gas for a number of years. The wells are now almost completely exhausted and some of them are used at present for fuel in nearby farm houses. Southeast of this pool along the axis a well was drilled in 1919 which had a volume of twenty million cubic feet of gas at 1,720 feet, but was drilled into water. This well was located near the center of sec. 19, T. 1 N., R. 5 W. In the southwest quarter of this section a well was completed with an initial production of 10 barrels of low grade oil at 883 feet in 1924. Farther southeast toward the south end of what is probably the axis of this same anticline a well was completed in April, 1926 with an initial production of 25 barrels of 28 gravity oil at a depth of 1,700 feet. This well is located in sec. 32, T. 1 N., R. 5 W.

FUTURE POSSIBILITIES

With most of the Pennsylvanian section absent on the axis of the fold, aside from the possibility of getting very small wells of low grade oil in the red bed section, the only other chance seems to be for a Simpson test, providing the Viola limestone has not been eroded. The subsurface fold is apparently so steep that one would be too low structurally if a well were drilled on the east or west flank low enough to encounter some additional Pennsylvanian section.

THE DOYLE POOL

LOCATION AND TOPOGRAPHY

The Doyle pool lies in the northeastern part of the county, just southwest of the post office of Doyle in secs. 2, 11 and 12, T. 1 N., R. 5 W. The pool is located on a topographic high with considerable relief to the east and northeast.

HISTORY OF DEVELOPMENT

The discovery well was completed in september, 1922 in sec. 11, T. 1 N., R. 5 W., by Clark and Cowden, with an initial production of 75 barrels at 1,090 feet. Most of the development work in the pool was completed during the following year.

STRATIGRAPHY

The surface rocks over the pool belong to the Duncan sandstone series of the Enid formation of the Permian. The section down to the producing sands at 1,200 feet consists of red shales and sandstones, with some gray shales. The section below the sands to a depth of about 1,500 feet is essentially the same. The section below the producing sands to a depth of at least 2,500 feet and possibly to a greater depth, consists of the typical brown shale section of the post-Glenn Pennsylvanian of this area.

STRUCTURE

The structure of the surface rocks in the pool is that of a small flat dome, the apex of which is in the center of sec. 11. The reverse dip (south) amounts to some 20 to 25 feet, while the dips to the northeast, north and northwest are quite steep. The flat portion of the top of the dome is almost entirely contained within the north half of sec. 11. The structure on the producing sands is very similar to that on the surface rocks with the sand dipping about the same rate as the surface rocks.

PRODUCING SANDS

There are three main sands in the pool found between 950 and 1,250 feet. There is only about two hundred feet of interval between the highest and lowest sand but the differences in surface elevation accounts for the extra hundred feet.

PRODUCTION

On May 1, 1926 there were 24 producing wells in the pool making a total daily production of 150 barrels which is about six barrels per well. The pool had produced up to January 1, 1926 a total of 197,924 barrels or 8,247 barrels per well.

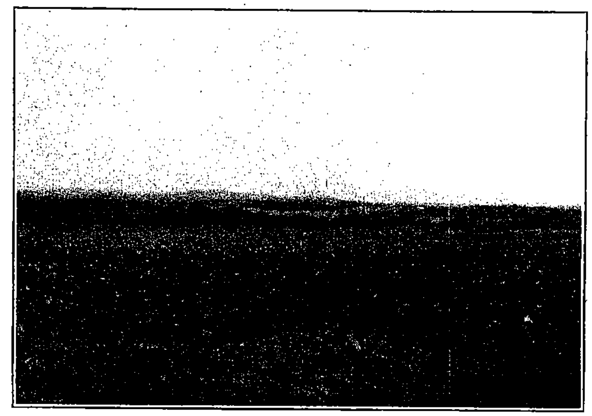
THE VELMA FIELD[26]

LOCATION AND TOPOGRAPHY

The Velma field is located in the southeastern part of the county, lying principally in the south part of T. 1 S., R. 5 W., and the northeast quarter of T. 2 S., R. 5 W. All or parts of the following sections form the present producing area of the field; sec. 22, 23, 25, 26, 27, 34, 35 and 36, T. 1 S., R. 5 W., secs. 1, 2, 3, 10, 11, and 12, T. 2 S., R. 5 W., sec. 31, T. 1 S., R. 4 W., and secs. 6, 7, and 8, T. 2 S., R. 4 W. This field derives its name from the village of Velma which is located some two miles east of the north end of the field.

26. Storm, W., The "2-4" shallow field Oklahoma, and the Velma oil and gas field: Am. Assoc. Pet. Geologists, Bull., vol. 5, No. 5, p. 626, 1924.

PLATE VI



TOPOGRAPHIC HIGH OF THE VELMA FIELD LOOKING SOUTHWEST.

This field has the highest topographic elevation of any area in the Addington quadrangle, attaining an elevation of 1,300 feet at its highest point. A northwest-southeast ridge through the center of the field which has a relief of about 250 feet in less than a mile is, in many places, a feature which is very noticeable for miles from all directions. The field is heavily covered with brush and jack oaks.

STRATIGRAPHY

The surface rocks exposed are a portion of the red sandstone series of the Wichita-Clear Fork formation, consisting of gray to brown calcareous sandstones and vari-colored shales. The base of the red beds, which is possibly the base of this formation, is reached at a depth of from 850 to 1,000 feet from the surface on the axis of the fold with increasing thickness down the flanks. The section below this consists of blue shales, sandstones and a few thin limestones, presumably of Pennsylvanian age, the thickness of the Pennsylvanian section being dependent upon the position on the fold. A deep test on the top of the fold encountered what may be Ordovician rocks at a depth of 1,745 feet, while a test down the west flank about two miles from the axis was still in Pennsylvanian rocks at a depth of 3,340 feet where it was abandoned.

STRUCTURE

The surface structure of the field consists of a long northwest-southeast anticline, the axis of which coincides to a remarkable extent with the topography. The steep side of this anticline is to the northeast, while the southwest flank slopes off gently into the syncline between this fold and the Loco anticline. Several surface faults can be traced while the presence of others is suggested in places, but due to the nature of the surface rocks these latter can not be definitely tied down. Since most of the production is from the Permian section, there is definite control only for subsurface structure on this age of the rock section present. Naturally the subsurface on the lower portion of the Permian section merely substantiates the surface structure, excepting that the faulting is more definite. A well drilled by the Huntley Company in the SW. cor. NE.¼ sec. 1, T. 2 S., R. 5 W., encountered the base of the red beds at a depth of 900+feet. This well drilled into what may be Ordovician limestone at a depth of 1,745 feet to 1,920 feet with a possible Simpson section to a total depth of 2,509 feet, thus suggesting that the core of this anticline is another of the many buried hills of southern Oklahoma, for wells drilled much deeper farther down the flanks of the fold failed to drill entirely through the Pennsylvanian section.

DEVELOPMENT

The Texas Company completed the discovery well of the field in their Frensley No. 1 in the SW¼ SE¼ sec. 36, T. 1 S., R. 5 W., in July, 1917 with an initial production of 20 barrels. Lack of pipeline transportation retarded development until late in 1920 when the first pipeline was built into the field. Since that time the development of the field has spread rapidly to its present limits.

PRODUCING SANDS

The producing sands in the field proper are found at depths from about 350 feet to 900 feet. Oil wells are completed in these sands with an initial production of about five to twenty-five barrels with the majority at the present time having an initial production more closely approximating the lower figure. Gas wells are completed with a volume of from one to five million cubic feet but with pressures of a hundred pounds to the square inch or less. The average gravity of the oil is about 28° A.P.I., commanding a price of $1.65 per barrel. Per acre yields will probably not exceed two to three thousand barrels for the field as a whole. During the year 1925 several wells were completed down the southwest flank of the fold in secs. 33 and 34, T. 1 S., R. 5 W., and sec. 3, T. 2 S., R. 5 W., producing from Pennsylvanian sands at depths of from 2,200 to 2,600 feet with initial productions of 25 to 50 barrels per day. Similar tests in secs. 10 and 11, T. 2 S., R. 5 W., have failed to find production in paying quantities although at about the same structural position. While there appears to be a chance for Pennsylvanian production along the southwest flank of the fold at points near where the lower beds abutt against the buried hill the successful completions to date in such formations do not have an initial production sufficient to compensate for the failures that are inevitable in the lenticular sands of this age of rocks. The best chance for deeper production would seem to be in thoroughly testing the Ordovician core on the axis of the fold.

All shallow drilling in the pool is done with Star machines. Drilling to the Pennsylvanian sands has been done with cable tools, which is an expensive operation when considering the production obtained. The pool is now producing about 2,000 barrels per day from about 450 wells. To January 1 of this year (1926) it had produced a total of about 2,500,000 barrels. There is still considerable development work to be done before the field is entirely drilled up.

THE MILROY POOL[27]

LOCATION AND TOPOGRAPHY

The Milroy pool is located in the extreme southeast portion of the county in secs. 13, 14, 23 and 24, T. 2 S., R. 4 W. The topography is very rugged with considerable relief as a fork of Caddo Creek traverses the center of the pool with a hill some 150 feet higher immediately to the south in section 24. The pool is quite thickly wooded with jack oaks.

STRATIGRAPHY

The surface rocks consist of gray sandstones, brown mudstones, and pink to reddish shales, all of which are a part of the sandstone horizon of the Wichita formation. The underground portion of the Wichita-Clear Fork formation is composed essentially of rocks of the same character. This formation extends to a depth of some 900 feet from the surface. Below the Wichita-Clear Fork rocks is a section of the Pennsylvanian rocks. Too little drilling has been done into these rocks in this pool for discussion.

STRUCTURE

The surface structure is that of a dome elongated east and west, truncated by a fork of Caddo Creek. The dip to the north and to the south is unusually steep for Permian rocks of southern Oklahoma, which, with the truncation makes the folding very apparent from a distance. As in the case of the Velma field the subsurface folding is merely a substantiation of the surface for the production is from Permian horizons.

DEVELOPMENT

Development in this pool took place from 1916 to 1920 with little if any development work going on since that time. Depths to sands and production of the wells are both similar to the Velma field. The pool at this time is producing about 200 barrels per day from about 70 wells. The chances for production in Pennsylvanian sands are probably slight, due to the extreme sharpness of the fold and the limited area that it covers.

27. Storm, W., Op. cit.

MISCELLANEOUS SMALLER POOLS

MAGNOLIA POOL

In T. 1 S., R. 9 W., there is a small pool which extends from the southeast corner of sec. 16, through the center of sec. 22 and thence almost due east into the west-central edge of sec. 23, being hardly more than two locations wide. It was discovered by the Magnolia Petroleum company in July, 1918 when they completed a well in sec. 22 with an initial production of about four hundred barrels in the Blaydes sand. Later completions made from 25 to 100 barrels initial. There are now some 12 producing wells in the pool making a total daily production of about 150 barrels. Due to the rather small initial production of the wells the total production probably will not average over 20,000 barrels per well.

RAINOLA POOL

In sec. 22, T. 1 S., R. 8 W., there is a small pool, the center of which is, just to the north of the center of the section. This pool was discovered late in 1921 by the Rainola Oil Company when they completed a well with an initial production on the pump of 20 barrels in what is probably the horizon of the Smith sand found here at slightly below 2,000 feet. This happened to be an edge well on the fold. Later wells completed first made gas until the pressure was reduced, after which they produced oil. Initial production of the wells has been from 20 to 100 barrels on the pump. There are now some 10 producing wells in the pool making a combined daily production of about 150 barrels. The total average production per well in this pool will probably not exceed 15,000 barrels although several of them paid for themselves out of the gas produced before going to oil.

WOOLSEY POOL

In secs. 23 and 26, T. 2 S., R. 6 W., there is a small pool which was discovered by the Magnolia Petroleum Company in 1922. The discovery well made about 75 barrels natural from sand at 1,750 feet. Later completed wells averaged about the same amount. There are at this time about 14 wells making a total daily production of about 130 barrels. The producing horizon is no doubt in the Glenn formation but just what part is unknown. The base of the red beds is encountered at a depth of about 1,300 feet. Below this depth and above the producing sand numerous fossils have been reported in the drill cuttings.

Production Data on the Woolsey Pool.

COMPANY	Lease	Sec.	Wells	Tot. Prod.	Pres. Prod.	Per Well Av.
Magnolia	Ferris	23	5	149,120	40	29,824
Roxana	Willis	23,26	4	87,585	32½	21,896
Magnolia	James	23	5	200,510	40	40.102
TOTALS			14	437,215	112½	31,320

NELLIE GAS AREA

Late in 1925 two gas wells were completed in the southeast corner of T. 1 N., R. 9 W., one in sec. 25 with an initial production of about 5,000,000 cubic feet per day in a sand at 1,840 feet, the other in sec. 36 with an initial production of about 15,000,000 cubic feet per day in sand at 1,840 feet. This horizon is post-Glenn, in what the writer would correlate as the Pontotoc group. A well lately abandoned at 4,550 feet just east of the gas well in sec. 25 was still in post-Glenn rocks at a depth of 4,100 feet where a sample was obtained. The section down to the latter depth consisted chiefly of the brown shales and coarse arkosic gravels typical of the locality in which the well is located.

LAWTON-HANBURY AREA

An area that is just outside the county, but which is mentioned here, both because it will probably not be covered by the report on any of the other counties, and because of its unique interest as to producing horizons, is the Lawton-Hanbury area of Comanche County. The production at present in this area lies in sec. 30, T. 2 N., R. 9 W., and in secs. 24 and 36, T. 2 N., R. 10 W. The easternmost producing well is some two miles west of the western line of Stephens County. The area lies some ten miles due east of the town of Lawton. The surface rocks in the area belong to the red sandstone group of the Wichita-Clear Fork formation of the Permian.

DEVELOPMENT

In the summer of 1920 the Gladys-Belle Oil Company completed a well at a depth of 1,530 feet, which made an initial production of something over one hundred barrels of 42 gravity oil, in the southwest corner of NW.¼ sec. 32 T. 2 N., R. 9 W. Three offsets were drilled to this well, one of them producing from the same sand, while the other two produced from a sand at about 1,640 feet. These wells all declined very rapidly so that within two years they had all been abandoned. Other wells drilled during this time to the northeast, east and south, but none closer than half a mile to the discovery well were all unsuccessful. In August, 1925, Mr. Hanbury completed a well in the NE¼ sec. 30, in sand at 2,010 feet which made an initial production of about four hundred barrels. This was the only direction that had not previously been condemned. This started a development which is now going on.

STRATIGRAPHY

The Wichita-Clear Fork formation extends to an average depth of about 1,400 feet. The section below this is probably the equivalent of the Pontotoc group. It consists of blue and brown shales, thin sands and gravels. The thickness of this group depends upon the position any well bears to the Wichita Uplift, varying from zero in the western part of T. 2 N., R. 10 W., where the Permian rocks are resting directly upon the Arbuckle limestone, to a thickness of at least 3,000 feet in the eastern part of T. 2 N., R. 9 W., with the base not yet reached. No well in this area has gone into the Glenn formation. The gravels in this formation are composed of fragments of all rocks from pre-Cambrian granites to and including the Viola limestone.

STRUCTURE

The surface structure in this area is a flat dome with the apex about the center of the west line of sec. 19, T. 2 N., R. 9 W. Control for subsurface structure is not yet sufficient to delineate, but production to date is agreeing remarkably well with the surface fold.

PRODUCTION

The unique feature of this area is in the character of the producing sands. The sands are numerous from a depth of 1,500 feet to below 2,500 feet. Present producing sands are at 1,530 feet, 1,640 feet, 1,860 feet, 2,000 feet, and 2,100 feet. With one exception, every well completed to date has declined to a daily production of less than twenty-five barrels in about two weeks' time. Many have thought that the producing horizon was a gravel, hence the cause of the rapid decline but the evidence seems to be conclusive that there is a thin sand at every producing horizon which contains the oil and gas and that immediately below the sand is a dry gravel. The pay sand drills hard as if one were drilling a "shell", while the tools drop when the gravel is being drilled which is the reason that many have believed that the gravel is the pay. It is now the opinion of many who have studied the area that the dry gravel takes up a large part of the production from the sand, thus explaining the extremely rapid decline of the wells. The one exception noted above is a well which was completed before the gravel was penetrated. This well pumped an average of fifty barrels a day soon after completion last September and is today pumping about forty barrels. The correct procedure would seem to be to cement casing with the rotary before the sand is reached and then to complete with cable tools by drilling as little of the real sand as possible, making sure that the gravel is not penetrated. By this method there is quite an area which should evidently make possible the completion of some fair wells. While the initial production will not be high, the sand should be rather long-lived. The fact that the oil is over 40 gravity is an asset to the area.

FUTURE POSSIBILITIES

With this area in its infancy there is room for many more locations. The area to develop would be a strip paralleling the Wichita axis in the eastern part of T. 2 N., R. 10 W., probably not farther west than a north-south line through the center of the second tier of sections from the east line of the township, and the extreme west tier of sections in T. 2 N., R. 9 W. Starting at the west line of this zone of play one would have to shift slightly east for each succcessive deeper sand sought. As to how deep one could expect to continue to find producing sands it is impossible to state this early in the development.